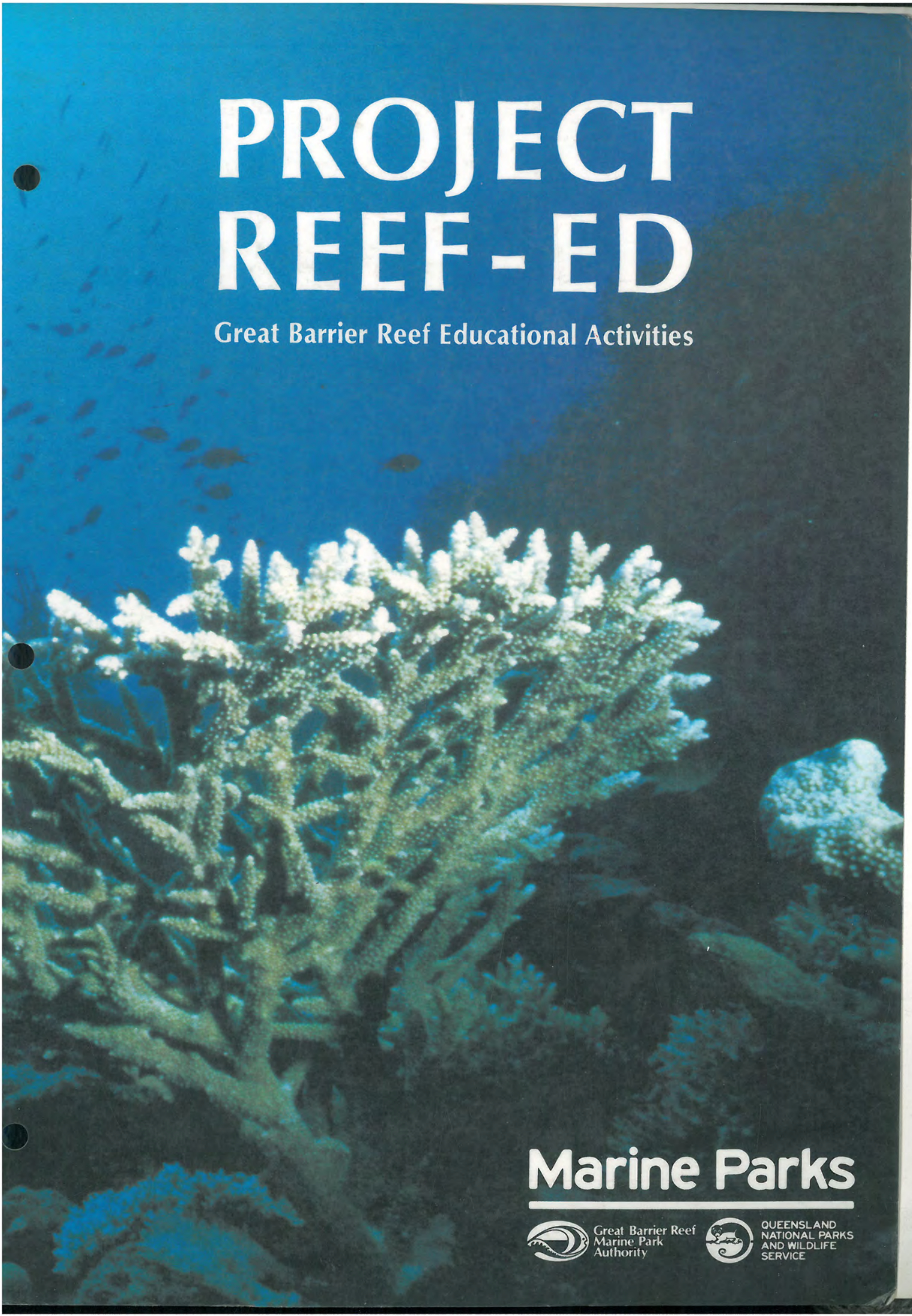

PROJECT REEF-ED

Great Barrier Reef Educational Activities

Marine Parks

Great Barrier Reef Marine Park Authority

QUEENSLAND NATIONAL PARKS AND WILDLIFE SERVICE

PROJECT REEF-ED

Great Barrier Reef Educational Activities

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Great Barrier Reef Marine Park Authority

Preface

The Great Barrier Reef Marine Park Authority has produced **Project Reef-Ed, Great Barrier Reef Educational Activities** to encourage study of the Reef and to assist educators organise visits to the Reef area.
As well as being of personal benefit to those involved, Reef activities undertaken by schools and other organisations can make an important contribution to promoting community understanding of the Great Barrier Reef Marine Park.
This book does not set out a particular course of Reef study. Rather, the aim has been to provide educators with a wide range of resource material from which they can select according to their own needs.
The activities set out here have been designed with students from school years 10 to 12 in mind. However, many will be found interesting and enjoyable by other groups. Although most of the activities are designed for those visiting the Reef, many can be carried out in classrooms away from the Reef.
The Great Barrier Reef is an excellent resource for education and these initial materials will be of assistance in developing programs which have the Reef as their focus.

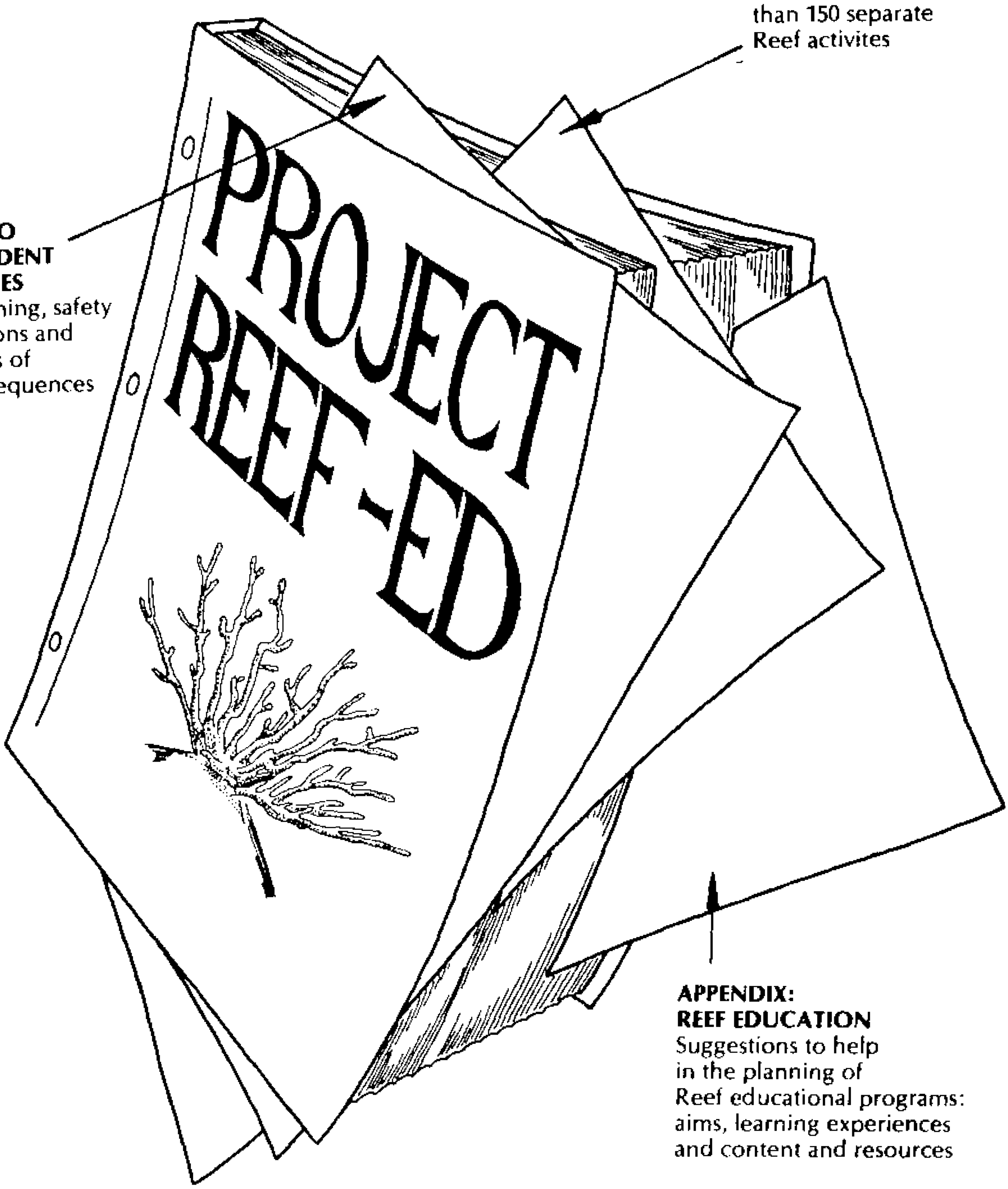
Graeme Kelleher
Chairman

Great Barrier Reef Marine Park Authority
Townsville

What's in this book?

STUDENT ACTIVITY OUTLINES
Sheets for more than 150 separate Reef activites

GUIDE TO THE STUDENT ACTIVITIES
Pre-planning, safety precautions and examples of activity sequences



APPENDIX: REEF EDUCATION
Suggestions to help in the planning of Reef educational programs: aims, learning experiences and content and resources

Acknowledgments

Many individuals and organisations helped generously in the preparation of these materials. The Project Team acknowledges gratefully the part played by all those who contributed ideas, energy, advice and assistance.

In the early stages of the Project, those who contributed ideas for student activities or who helped by commenting on early drafts include, amongst others, Leo Bartlett, Geoff Conolly, A.B. Cribb, John Fien, Peter Flood, John S. Jell, J. Nan Kelly, Gayle Mayes, Athol Rose and Tony Sperring.

Groups of teachers attending Reef-Ed workshops in Brisbane and Sydney helped shape the directions of the Project and the scope and form of activities subsequently developed.

Staff and students of a number of New South Wales and Queensland secondary schools took part in the reviewing of activities at the Reef. Those involved included Queensland students from St Aidan's School, Brisbane; Benowa, Clontarf, Corinda, Gladstone, Miriam Vale and Woodridge State High Schools; Star of the Sea College, Southport and Toowoomba Grammar School. New South Wales groups included those from Woolgoolga and Grafton High Schools; Strathfield Girls and Sydney Girls High Schools and Newcastle Grammar School.

Others who helped to develop and evaluate activities in the field were participants in professional development programs for teachers organized at the Reef by the Queensland Science and Geography Teachers Associations and Sydney College of Advanced Education. Students from teacher education and leisure studies programs at Sydney and Brisbane Colleges of Advanced Education also worked on the activities during reef visits.

Teachers who helped organize field reviews of activities included Jim Baker, Richard Banner, Ted Brambleby, Dennis Bridger, Earl Boyd, Glen Courteney, Ted De Boer, Laurie Jackson, David Kopelke, Greg Martin, Pat Offord, Ethel Smith and Greg Worth. Staff of the Heron Island Research Station, and staff from Heron and Lady Elliott Islands gave assistance.

Representatives of the New South Wales and Queensland Education Departments provided advice to the Project and reviewed activity material at several stages. Personnel included Alan Clayton, Robert McAllister and Robert Herschell of Queensland and Frank Haddon, Geoff Young, Anne Skinner and Brian Ralph of New South Wales.

Others who reviewed Project activity material in its final stages of development were Jim Baker, Gladstone State High School; Peter Flood, University of New England; Annette Greenall, Department of Arts, Heritage and Environment; Noel Gough, Victoria College, Rusden; Greg McGarvie, Mackay State High School; Miriam Preker, Heron Island Research Station and staff; Carden Wallace, Queensland Museum.

Jan Chee is thanked for use of her unpublished poem and Daniel Cunnington for his "music". The activity **User roles and zoning game** has been adapted from the ideas of Brian Armour and **Reefscape aesthetics** from those of Rob Simson.

Thanks to Peter Flood for the use of his diagrams on the formation and development of a coral cay featured in **Formation and development of a cay.**

The co-operation of the Department of Harbours and Marine and Flinders University in releasing the tidal data for February 1988 for **Tidal changes** is gratefully acknowledged. Thanks also to the Port Authorities of Gladstone, Mackay, Townsville and Cairns.

Past and present personnel of the Queensland National Parks and Wildlife Service and the Great Barrier Reef Marine Park Authority offered continued advice and support. The early encouragement of Steve Domm, Peter Hunnam, Geoff Mercer, Graham Morris, Peter Ogilvie, David Savage and Len Zell was especially valued. Special thanks go to Kirk Peterson who was associated with the Project over a long period. The task of finally transforming activities material from the Project into published form has rested with a production team headed by Lesley Murdoch at GBRMPA. Their work is greatly appreciated by all members of the Project Team.

Ann Byrnes
Project Co-ordinator
12 September 1988

GUIDE TO THE STUDENT ACTIVITIES

Introduction

This **Great Barrier Reef Educational Activities** section of **Project Reef-Ed** presents marine environmental activities from a multi-disciplinary perspective. Not only are the wonders of the Reef explored from a scientific perspective in the **natural world** but also in the **human dimension** issues of conservation and management are investigated as well as opportunities for creative and artistic expression.

Select from more than 150 activities those which will enhance your group's Reef-Ed learning experiences. Use them as they are, or adapt or modify them to suit your audience and purposes.

Examples of reef trips and programs using a combination of these activities are given later in this section. Appropriate aims, content and learning experiences are discussed in more detail in the Appendix as well as a very comprehensive bibliography of resources for teaching and learning about the Reef.

In terms of content, the activities are not mutually exclusive. There is overlap among them.

In designing the activities, an effort was made to introduce students to ways of observing, recording and evaluating which may be new to them. Coupling of fun and enjoyment with learning has been seen as an important goal for these reef experiences.

The majority of enquiries are open-ended. Educators using these activities will be cast in the role of learners along with their students. The emphasis of the activities is on the process of finding-out, encouraging students' confidence in their own ability and to investigate their environment.

Target group

The activities have been designed with Year 10 to 12 students in mind. Most of the activities are related to Reef fieldwork, and it is students in Years 10 to 12 who belong to the school-age group most likely to be able to make a Reef visit.

Some items in the activity collection will be found useful by teachers of more junior students and some by educators of post-school groups.

Sites of Activities

Most of the activities are designed to be carried out while on a field trip to a locality on the Great Barrier reef. These involve making observations in the field, working on material collected in the field, or considering data, feelings or ideas gained through fieldwork. Of these field trip activities, some are intended to be carried out in base camp (e.g. involving discussion or laboratory work); some are marine field activities (e.g. involving reef walking, snorkelling or boating); some are island field activities (e.g. involving cay walking).

A few of the activities are school-based. For a group going to the Great Barrier Reef, such activities can be used in pre- or post-field trip work. The table below shows symbols used on the activity sheets:

Reef walking

Island

Snorkelling

School

Base camp

Sea

Arrangement of the Activities

Activities in this volume have been grouped according to the main divisions of the conceptual framework given in the appendix. Some are designated as "natural world activities" and some as "human dimension activities" according to their main emphasis. But the arrangement is somewhat arbitrary.

Formats of activity sheets

A variety of formats has been used for the activities. Some classroom activities are highly structured, and stimulus material is often included. By contrast, most field trip activity outlines are set out briefly. In some cases, there is an identikit or fieldsheet on which to record answers in the field. For water work, this can be photocopied on to sheets of plastic drafting film, or laminated between sheets of plastic.

Duration and demand of activities

The activities vary in the length of time they take to carry out and the demand they make on students. Some are designed to be completed in a single session; others are to be worked on intermittently over an entire field trip. Some presuppose access to particular field equipment or facilities; others do not. Careful inspection of the activity outlines will enable educators to make a selection of activities which matches the needs and abilities of their students, the expertise of staff and the facilities, time and equipment which will be available.

Symbols with each activity indicate the approximate duration of the activity and the degree of relative difficulty.

- ● Easy. Can be accomplished by most Year 10 to 12 students.
- ● ● Some difficulty, especially for students not following the subject specialty related to the activity.
- ● ● ● Greatest difficulty. Suited to students undertaking studies in subject specialty related to the activity.

References

In most cases information needed by educators to organise activities can be found on the activity sheets themselves or in the basic list of readings in the Appendix. This basic list includes Mather and Bennett (1984), **A Coral Reef Handbook**, available from Wonderland Aquarium Shop, Townsville, which is a must for anyone who intends running a Reef field trip. In cases where reference must be made to other literature, e.g. Great Barrier Reef Marine Park Authority publications, or articles in popular magazines, this is indicated clearly on the activity sheets.

On some activity sheets, ideas for further reading are given, but unless stated otherwise this reading is for enrichment purposes only and is not essential.

Visitors to the Heron Island Research Station will have some access to the station's library which can be expected to have a copy of items on the basic list as well as many other items of book and journal material with them. One way to do this is to have students take responsibility for transporting items in their luggage.

For those interested in further pursuing specific topics related to the activities, the Great Barrier reef Marine Park Authority's computer-based guide to current and past reef literature may be useful. This on-line database, REEF, is available to members of the public through the CSIRO's public access network, AUSTRALIS, and can be accessed at many major libraries, e.g. at universities and colleges of advanced education.

Environmental protection

In designing this material, activities which involve collecting of specimens (marine or non-marine) or manipulating the environment have been avoided as much as possible. Any collecting, experimentation or other manipulation of environments on reefs or island national parks can be carried out only if a suitable permit is held. This applies both to biological and non-biological material. Collecting should be minimised at all times. See details concerning permits below.

Being prepared

"Be prepared" is an important motto for any educator planning to use the field trip activities. It is essential to read activities carefully before the trip; to make sure that staff understand how activities will be organised; to check that activities fit the features of the site being visited; to make sure that suitable equipment is being taken on the trip or will be available at the field site; and to check up on any reference material needed. Students and staff may have to be prepared with new skills or knowledge to carry out the activities. Enough time should be allowed before the field trip and/or during the field trip program to review activity procedures. Provision should be made, when selecting activities, for unexpected or unpredictable circumstances, e.g. bad weather, non-availability of boats.

Before using the field activities, educators should ensure that staff understand and are competent in safe procedures for reef walking, snorkelling and boating as appropriate.

Ten basic safety rules for the Reef

Field trips can be quite free of even minor injury or accident if basic safety precautions are observed. This set of rules ensures that everyone can enjoy the whole field trip without mishap. Discuss with your students at the beginning of the excursion.

1. Never wander over the reef or island by yourself. A 'buddy-system' operates on land as well as in the water.
2. Only go reef-walking, swimming or snorkelling if a responsible person is keeping a look out.
3. Always wear sandshoes or other protective footwear when reef-walking. Avoid going barefoot on land, too.
4. Use gloves if you have to handle an animal unless you definitely know it's harmless. Learn to recognise toxic and venomous reef-top animals and don't touch these at all. Don't rub your eyes with your hands after touching marine life.
5. Don't harrass animals. Defensive mechanisms are likely to operate if creatures are disturbed (eg A ray will normally move quietly away or remain stationary if it detects your presence, but if cornered it will defend itself).
6. Don't swim in the sea at night.
7. Be careful of currents when swimming or snorkelling. Swim into the current. Don't swim where currents are strong.
8. Act cautiously in small boats and observe all necessary safety precautions.
9. Inform a responsible person in the event of **any** injury. Make sure all coral cuts and scratches are cleaned-up and treated promptly.
10. Sunburn/heat exhaustion is a health hazard. "**SLIP** on a shirt; **SLOP** on some cream; **SLAP** on a hat". Make sure you drink extra water before any reef activities.

Getting permits

Several types of permits may be required for a field trip in the Great Barrier Reef area. Apply for permits well in advance.

(a) To enter the Great Barrier Reef Marine Park and conduct an education activity in it, a permit must be obtained from the Great Barrier Reef Marine Park Authority. One of the conditions attached to the issuing of this permit is that you fill in a report on the educational activity carried out. This will help the GBRMPA to find out about the way in which educational groups wish to make use of the Reef. Application forms for this permit can be obtained by writing to the Great Barrier Reef Marine Park Authority, Townsville, or to offices of the Queensland National Parks and Wildlife Service.

Executive Officer
Great Barrier Reef Marine Park Authority
P.O. Box 1379
TOWNSVILLE QLD 4810 Phone 077 81 8811

Director
Queensland National Parks and Wildlife Service
P.O. Box 190
NORTH QUAY QLD 4000 Phone 07 224 0414

Regional Superintendent
Queensland National Parks and Wildlife Service
212 Quay Street
ROCKHAMPTON QLD 4700 Phone 079 27 6070

Regional Superintendent
Queensland National Parks and Wildlife Service
Marlowe Street, Pallarenda
TOWNSVILLE QLD 4810 Phone 077 74 1411

Regional Superintendent
Queensland National Parks and Wildlife Service
41 Esplanade
CAIRNS QLD 4870 Phone 070 51 9811

(b) In addition, if you plan to camp on an island which is a Queensland national park, then a permit to camp must be obtained from Q.NPWS.

(c) Some islands in the Reef area have camping areas controlled by the Queensland Department of Lands. Permission to use these areas must be obtained from the Lands Department.

(d) Collecting of any kind of natural material, dead or alive, either within the marine park or within island national parks, can be carried out only if an appropriate Collecting Permit is obtained. Only very limited collecting is allowed for educational purposes.

Assistance in the field

Although Q.NPWS rangers and research station personnel may be able to offer some help during a student field trip, group leaders should ensure that they are prepared to conduct their programs essentially independently. If assistance, advice, or use of equipment is required for a field trip, arrangements for this should be made well beforehand. Heron Island Research Station has some equipment, e.g. microscopes and aquaria, which can be used by student groups, and the services of a boat driver is available to a limited extent. At some islands, officers of the Q.NPWS may be able to be present during part of a field trip to advise group leaders on local conditions and possibly to help organise one or more field activities or to give a talk to a group.

Organisation of activities

The key role of tides and weather in planning a field program must always be kept in mind. In preparing for field activities, it is suggested that time for a briefing and review session be allowed before and after each field study. Some of this briefing and review can ake place at school before and after the trip. But some time also needs to be set aside for this purpose during the field trip itself. All data gathered in the field should be plotted and written up as soon as possible after it is collected.

A field trip program based on a core of activities which all students do and a series of elective activities which are carried out by small groups of students working semi-independently seems to work well. However, in planning for elective project work, the following points are important:

- No fieldwork should be carried out in reef or island locations by a lone student. A buddy is essential at all times and, for reef-top or snorkelling work, two pairs of students are a minimum. In snorkelling activities, close surveillance of students by a responsible adult is necessary.
- For reef-walking activities, general adult surveillance is recommended with the possibility of visual contact and hand signals between dispersed student groups.

The table below shows an example of a schedule for a field tirp organised at Heron Island Research Station for a Year 12 school group.

Example of field trip schedule (Year 12 school group — Heron Island Research Station)

DAY 1	High tide 9.00 a.m. Low tide 3.00 p.m.
9.00	Arrive at Heron Island
9.30-11.00	Unpack; set up kitchen
11.00-12.00	First cay walk (4)
1.00- 2.00	LUNCH
2.00- 4.00	Reef walk: core activity (2)
4.00- 5.00	Initial perception responses (6), (125)
5.00- 6.00	DINNER
6.00- 7.30	Free time
7.30- 8.30	Program outline. Set up logs, food webs (78), dangers (111), (112)
9.00	Bed
DAY 2	High tide 9.30 a.m. Low tide 3.40 p.m.
7.30- 8.30	BREAKFAST
9.30-10.30	Snorkelling (3), (58)
10.30-11.00	Morning tea
11.00-12.00	Cay walk: core activity (4)
12.00- 1.00	LUNCH
1.00- 2.30	Free time
2.30- 4.30	Reef walk: core activities on coral, algae (41), (28)
5.00- 6.00	Set up Graffiti Wall (124)
6.00- 7.00	DINNER
7.30- 8.30	Ranger talk
9.30	Bed
DAY 3	High tide 10.05 a.m. Low tide 4.15 p.m.
7.45- 8.30	BREAKFAST
9.00-12.00	Snorkelling around wreck (109); fish spotting (59), (66), (69), (72)
12.00- 1.00	LUNCH
1.00- 2.30	Tour of museum and library
2.30- 4.30	Reef walk: core activities (3), (9), (10)
5.00- 6.00	DINNER
6.00- 7.30	Free time
7.30- 9.00	Creative activites (118), (119), Turtle watching (96), (121)
DAY 4	High tide 10.40 a.m. Low tide 4.50 p.m.
7.45- 8.30	BREAKFAST
9.00-11.00	Trip to the bommie for snorkel (77), (36), (37)
11.00-12.00	Free time
12.00- 1.00	LUNCH
1.00- 5.00	Cay walk: core activities (77), (87), (89), (90), (98)
5.00- 6.00	DINNER
6.00- 8.00	Introduction to the lab: microscope examination of reef organisms
DAY 5	High tide 11.12 a.m. Low tide 5.23 p.m.
7.45- 8.30	BREAKFAST
9.00-12.00	Plan elective projects (work in pairs)
12.00- 1.00	LUNCH
1.00- 5.00	Further work on elective projects, using aquaria, laboratory, reef flat and/or library
5.00- 6.00	DINNER
6.00- 7.30	Free time
7.30- 9.00	Nocturnal studies: core activities (5), (76)
DAY 6	High tide 11.40 a.m. Low tide 6.20 p.m.
7.45- 8.30	BREAKFAST
9.00-10.00	Prepare for role game (143)
10.00-12.00	Snorkelling
12.00- 1.00	LUNCH
1.00- 4.30	Further work on elective projects
5.00- 6.00	DINNER
6.00- 7.30	Free time
7.30- 9.00	Talk by visiting scientist or present role game (143)
DAY 7	High tide 12.20 p.m. Low tide 6.00 p.m.
7.45- 8.30	BREAKFAST
9.00-12.00	Complete projects
12.00- 1.00	LUNCH
1.00- 4.00	Group discussions (102), (115), (127), (141)
4.00- 6.00	Free time
6.00- 8.00	DINNER
8.00-10.00	Reef quiz (101)
DAY 8	
7.45- 8.00	BREAKFAST
9.00-11.00	Clean up, pack up
12.00-	Evaluation
	Depart island for home

EXAMPLES OF REEF ACTIVITY PROGRAMS

Some suggested learning programs are summarised in this section. Symbols for activities are as follows:

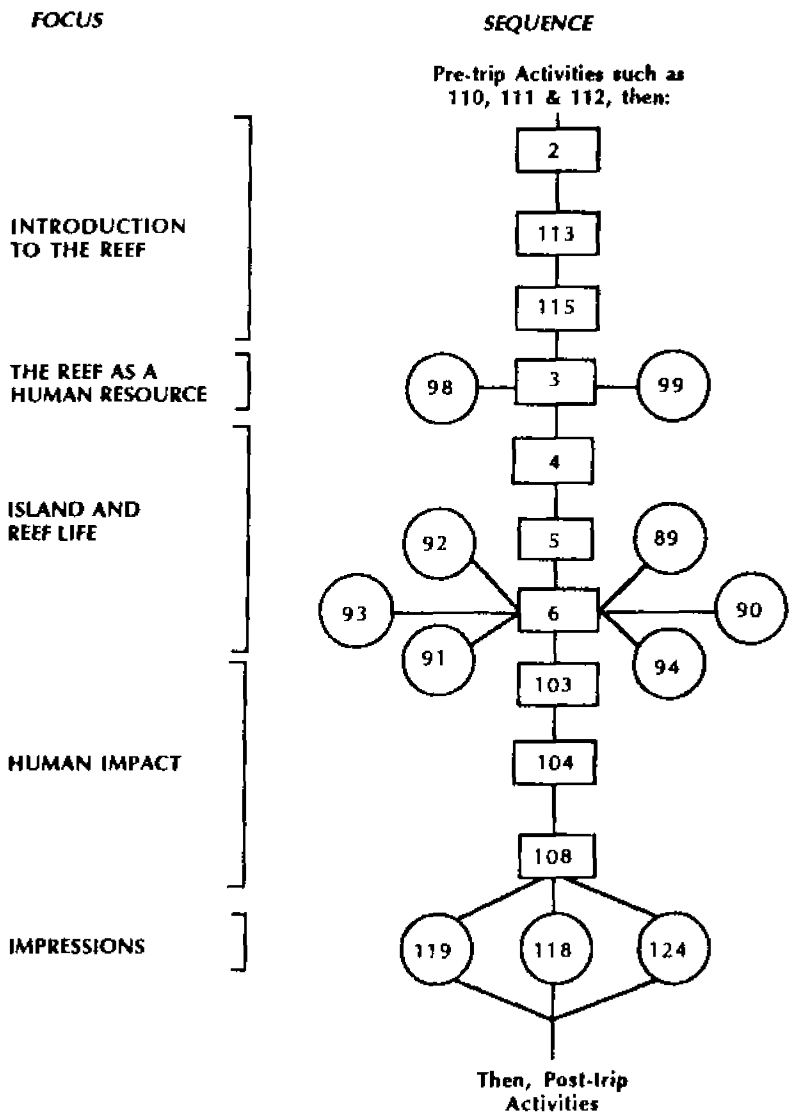
□ ***Core activity***—to be done by entire group

○ ***Elective activity***—to be done by small groups

Numbers refer to the activity numbers suggested. The programs are "flow diagrams" rather than field-trip schedules. Some activities shown early in each program may continue on and off throughout the field trip.

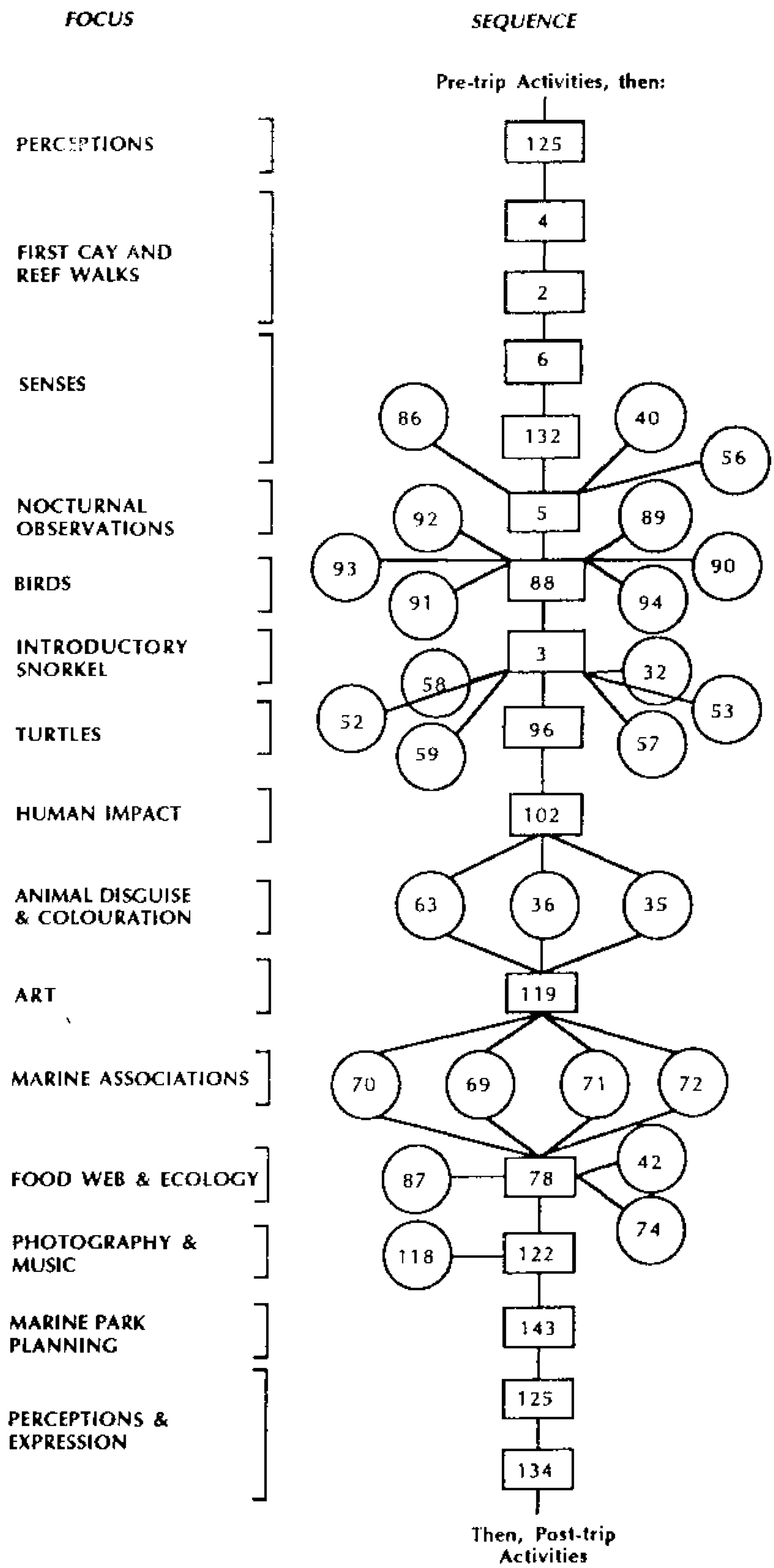
PROGRAM 1: MARINE SCIENCE - 5 DAYS, YEAR 11

This is a 5-day program designed for Year 11 students studying a marine science unit in a Queensland multistrand science course. It is suitable for a group camping on a wilderness island.



PROGRAM 2: INTERDISCIPLINARY - 7 DAYS, YEAR 11

This week-long program is suggested for a group of Year 11 and 12 students with a variety of school backgrounds. It is designed to provide students with an experience of the reef which relates to many areas of school curricula and which helps students develop a greater awareness of themselves, their environment and their responsibility to that environment.



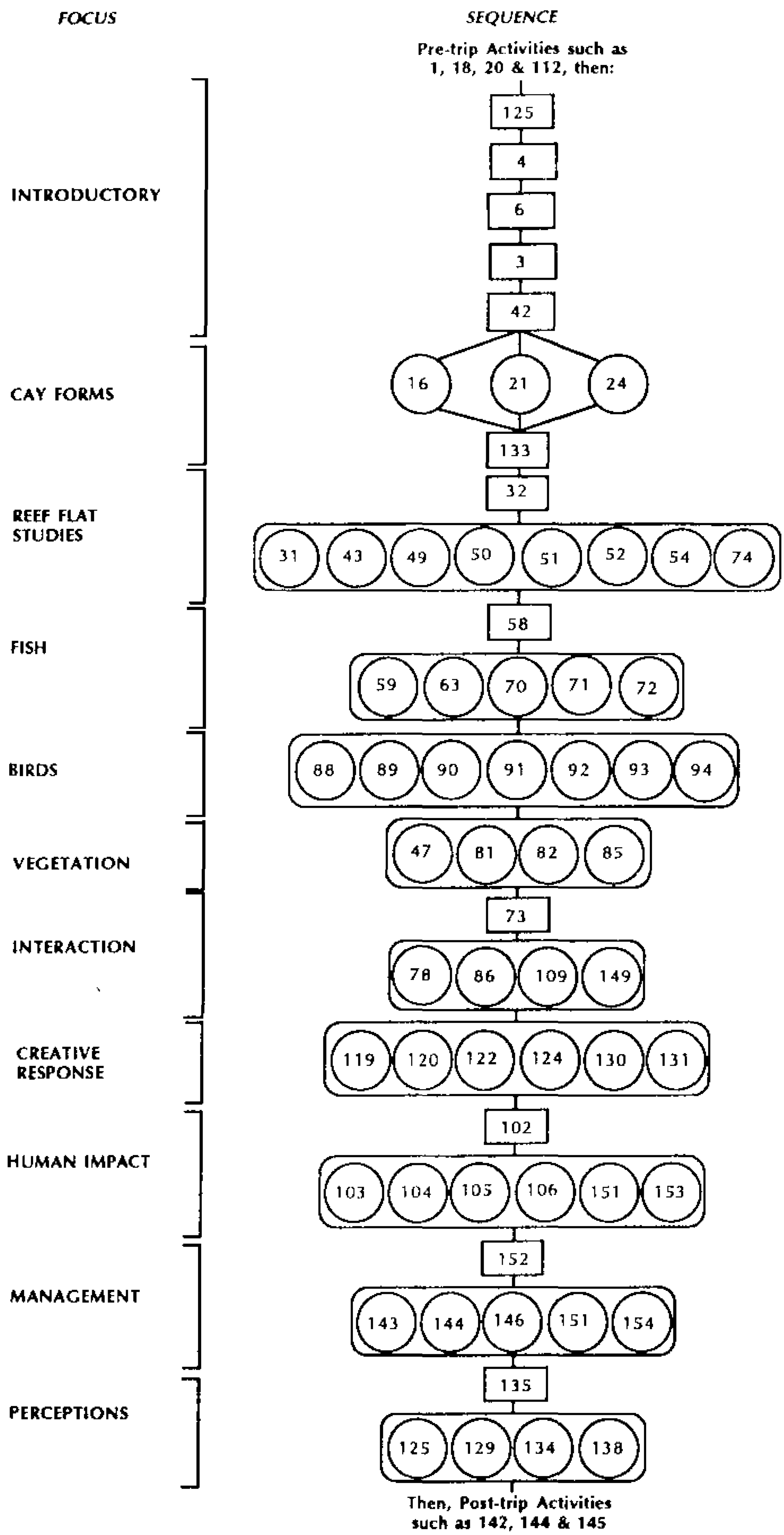
PROGRAM 3: GEOLOGY - 7 DAYS, YEAR 11

This is a week-long program suitable for students following a geological course such as the New South Wales Year 11 and 12 Geology 2 Unit course. The program has a fairly strong discipline focus and assumes that students have been well prepared for a tightly organised study week.

FOCUS	*SEQUENCE*
INTRODUCTION TO THE GREAT BARRIER REEF	**Pre-trip Activities, such as 1, 11, 15, 17, 19, 112 & 150 then:** 2&4
EVALUATION	141
REEF BIOTA	28&3
NOCTURNAL STUDIES	5
HUMAN IMPACT	102
SEDIMENT	21
REEF INVERTEBRATES	32, 33, 36, 52
REEF STRUCTURE	18, 73
SEDIMENTARY MATERIALS	23, 25, 24
CORALS	41
CAY FORMATION	20
ISLAND PLANTS	84&80
REEF INVERTEBRATES	38, 69, 45, 47
REEF MANAGEMENT	142&143
REEF & CAY LIFE	48
COMMUNITY	74
EVALUATION	101&141 **Then, Post-trip Activities such as 155 & 159.**

PROGRAM 4: GEOGRAPHY - 7 DAYS, YEAR 11

This is a suggested activity program for senior school geography students at Heron Island.



PROGRAM 5: BIOLOGY - 7 DAYS, YEAR 11

This is a sequence of activities focusing on plant and animal diversity. A unit on diversity of life is a feature of probably all senior school biology courses. The selection of activities listed here would be appropriate, for example, as part of study for the New South Wales Year 11 and 12 biology 2 unit syllabus (1980) core unit entitled Diversity and Evolution. The great variety of life on a reef flat makes it an especially suitable location for introducing students to representatives of most major animal phyla.

FOCUS	*SEQUENCE*
	Pre-trip Activities, then:
INTRODUCTORY CLASSIFICATION	2, 34
CORALS & ALGAE	28, 30
CORALS	43, 41, 42
WORMS	49
MOLLUSCS	50
CRABS	56, 57
FISH	61, 62
CAY PLANTS	79, 81, 82
BIRDS	88
TURTLES	96
	Then, Post-trip Activities

LIST OF STUDENT ACTIVITIES

The Natural World

Introductory	Location
1. On location	School
2. Your first reef walk	Reef walking
3. Snorkelling over the edge	Snorkelling
4. Your first cay walk	Island
5. Introductory nocturnal studies	Island
6. Sensations	Island
Sky, ocean, atmosphere	
7. Night skies	Island
8. How clear is the water?	Island
9. Reef waters — temperature	Sea
10. Reef waters — oxygen and pH	Sea
11. Tidal changes	School
12. *Endeavour*, reef and tides	School
13. Monitoring tides	Sea
14. Measuring currents	Sea
15. It's tropical	School
16. Weather station	Island
17. Wind and waves	School
Reef, cay, island structures	
18. Air photo interpretation	School
19. Reef and island cross-sections	School
20. Formation and development of a cay	School
21. Getting down to the nitty gritty	Island
22. Sediment rain	Reef walking
23. Sand patterns — sedimentary structures	Reef walking
24. Sediment-organism interaction	Reef walking
25. Beach rock	Island
26. High island rocks	Island
27. High island beach sediments	Island
Life on the reef	
28. Identifying algae	Reef walking
29. Pressing algae	Reef walking
30. Algae are important	Reef walking
31. Map an algae forest	Reef walking
32. Getting to know an active reef creature	Reef walking
33. Animal roll call	Reef walking
34. Classifying can be fun	Reef walking
35. Animal survival tricks	Reef walking
36. Colour in invertebrates	Reef walking
37. Getting food	Reef walking
38. Foram studies	Reef walking
39. Drifters	Sea
40. Luminous life	Sea
41. Coral polyp — architect of the reef	Reef walking
42. Love a coral clump	Reef walking
43. Coral colonies	Reef walking
44. Coral fingerprints	Reef walking
45. Microatolls	Reef walking
46. Corals in space	Reef walking
47. Growth forms — corals and algae	Reef walking
48. Coral-tree comparison	School

Island life

The Human Dimension

Management and conservation

Scientific investigation

List of student activities

THE NATURAL WORLD

Introductory	Location
1. On location	School
2. Your first reef walk	Reef walking
3. Snorkelling over the edge	Snorkelling
4. Your first cay walk	Island
5. Introductory nocturnal studies	Island
6. Sensations	Island

1. On location 1½ hr •

Concepts
Location
Scale
Distance

Skills
Graphing
Measuring

Attitudes
Interest in natural environments

Aim

- To become familiar with the location of the Great Barrier Reef and with some places and features in the reef area.

You will need

- Map of Queensland coast and Great Barrier Reef (e.g. 1:2 200 000, Great Barrier Reef Marine Park Authority, 1983)
- Ruler, protractor, coloured pencils
- Calculator (optional)
- Published map of inland Queensland (optional)
- Coloured pictures or slides of some reef scenes (optional)

The Great Barrier Reef is a collection of more than 2900 separate coral reefs which lie in shallow water on the continental shelf off the Queensland mainland. It occupies a strip of sea greater in area than the state of Victoria and is one of the earth's largest biologically created features. Widely considered to be a natural wonder of the world, the Great Barrier Reef is one of Australia's leading tourist attractions. The waters around its reefs are used by the fishing industry and by shipping. It is of great economic importance to many Queensland coastal communities and is an area of immense interest to scientists.
Today, most of the reef is part of the Great Barrier Reef Marine Park. This has been established to protect the reef while allowing people to use the reef area in a reasonable way.

1. The best known

When you think about the Great Barrier Reef, which places first come into your mind? What about the others in your group — which reef places are they most aware of? At the beginning of this activity, before you start looking at the maps, make a list of the first five towns or cities you can think of on the mainland near the reef area and of the first five islands or reefs.
(a) Compare your list with others from your group. How many places, in all, are mentioned? Which are most frequently mentioned? List commonly mentioned ones in table 1.1.
You might also like to draw a histogram (column graph) of the data on a separate piece of graph paper.

Table 1.1

Mainland town or city	Number of mentions	Reef or island	Number of mentions

(b) Why do you think that some of these places are better known than others? Discuss possible reasons.

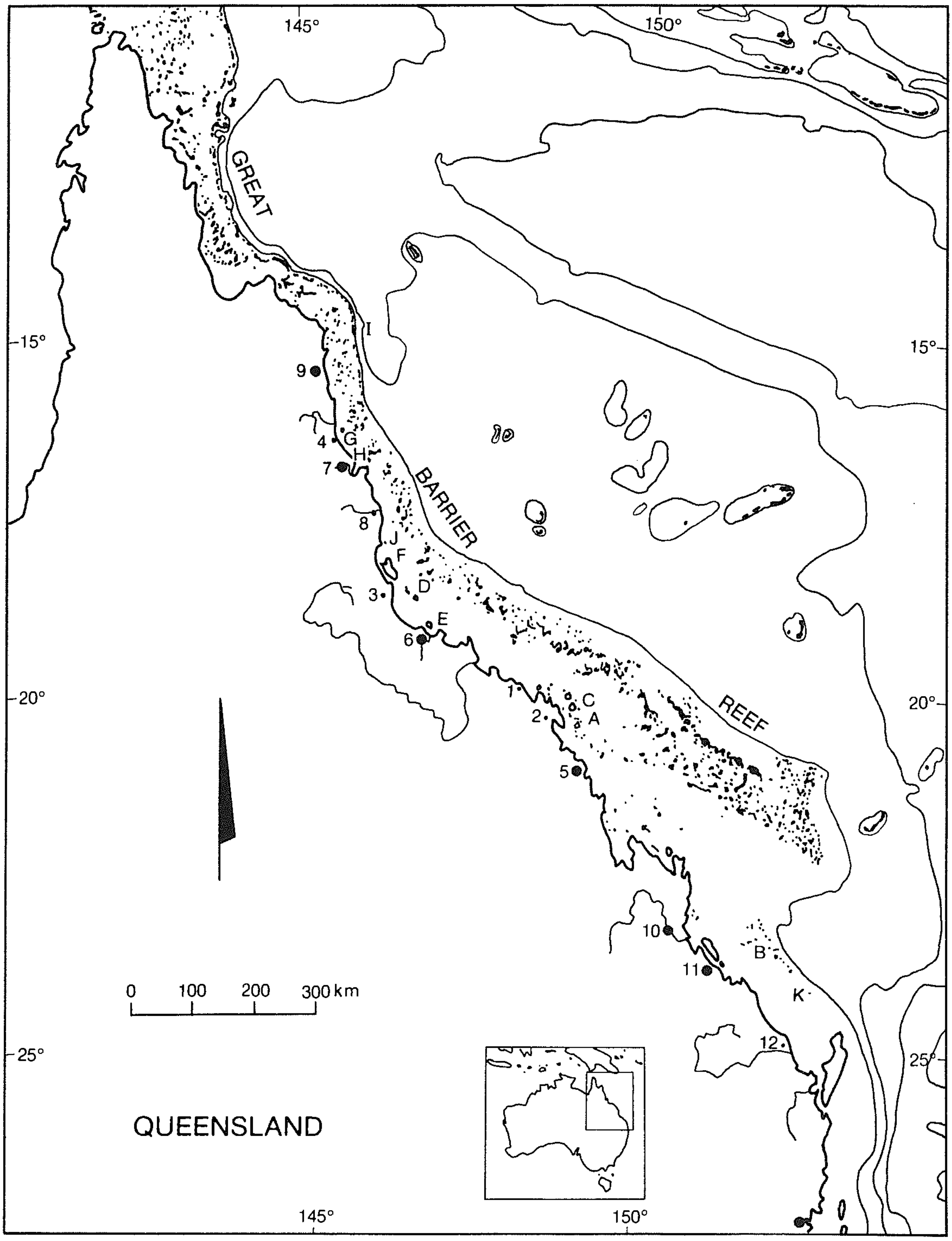


Fig. 1.1. Some towns, reef localities and bathymetric contours of the Great Barrier Reef region.

2. Where are some important towns and cities on the east Queensland coast situated?

On figure 1.1, some places on the Queensland mainland coast are marked by the numbers 1 to 12. Using the published map of the Great Barrier Reef area to help you, answer the following questions.

(a) Write down the number (1 to 12) which marks each of the places listed below:

Place	**Number**
Bundaberg	
Bowen	
Gladstone	
Proserpine	
Townsville	
Mackay	
Ingham	
Innisfail	
Cairns	
Rockhampton	
Port Douglas	
Cooktown	

(b) Of these places, Townsville has the largest population. Judging from the printing on the map, which of the places has the smallest population?

(c) Which of the places on the list cannot be reached by train?

3. What are the locations of some of the well-known reefs and islands in the Great Barrier Reef area?

On figure 1.1, some well-known islands and reefs are shown by the letters A to K. Use the published map of the Great Barrier Reef area to help you do the following:

(a) Write down the letter (A to K) which marks each of the reefs and islands listed below.

Island or reef	**Letter**	**Nearby mainland town or city**
Capricorn-Bunker Group		
Whitsunday Group		
Lindeman Group		
Magnetic Island		
Palm Islands		
Hinchinbrook Island		
Dunk Island		
Green Island		
Low Island		
Ribbon Reef no. 10		
Lady Elliott Island		

(b) For each island or reef, give the name of the closest mainland place listed in question 2(a).

4. Your reef visit

Have you been to the Great Barrier Reef area recently or are you going soon?

(a) What is the name of an island or reef you've been to, or will soon be visiting?

(b) From what place on the mainland do people leave to get to this island or reef?

(c) Try to find these places on the coloured map.

5. How big is the Great Barrier Reef?

Look at the published map which shows the Great Barrier Reef.

(a) The scale of any map can be shown as a ratio (e.g. 1:1000). What is the scale of the map you are looking at expressed as a ratio?
What distance on the earth's surface does 1 cm on this map represent?
If two places are 1000 km apart on the earth's surface, what would be the distance between them on this map?

(b) The northernmost end of the Great Barrier Reef is near Anchor Cay. Its latitude is approximately 9°S and its longitude is approximately 144°E. The southernmost end of the reef is near Lady Elliott Island at approximately latitude 24°S.
Approximately how many kilometres apart are the northern and southern ends of the Great Barrier Reef?

(c) Most of the Great Barrier Reef region which is marked on figure 1.1 is now part of the Great Barrier Reef Marine Park. The immense area of this park creates many difficulties for those who have to manage it.
- What do you think might be some of these difficulties?
- Can you suggest how some of these difficulties could be overcome? How can people in the community help?

6. How much of the Great Barrier Reef is in a tropic zone?

Most people have the idea that the Great Barrier Reef occurs in the tropics. It's an idea fostered by many travel advertisements. But how correct is it? We'll now see.

> *The tropic zones are the zones between the equator and the Tropic of Capricorn (23½° south of the equator) and the equator and the Tropic of Cancer (23½° north of the equator).*

(a) Find the Tropic of Capricorn on the map. It is latitude 23½°S. Is most of the Great Barrier Reef north or south of this line?

(b) What is the nearest reef island to the Tropic of Capricorn?

(c) Name two parts of the Great Barrier Reef which are south of the Tropic of Capricorn.

7. Where is the continental shelf?

Many published maps of the reef area show submarine contour lines. Each bathymetric contour line joins places of equal depth below sea-level. Sometimes the depths are given in metres, sometimes in fathoms. (A fathom is 1.8288 metres.)
Use a published map with submarine contours shown in metres to help you answer the following:

(a) On figure 1.1, three bathymetric depth contours have been drawn but not labelled. The contours show depths of 200, 2000 and 4000 metres. Use the published map to check out which is the 200-metre contour on figure 1.1. Label the contour. Using two different coloured pencils, shade in the area on figure 1.1 which is shallower than 200 m and the area which is between 200 and 2000 metres in depth.

> *Reefs of the Great Barrier Reef rise up from the continental shelf or occur as fringes around the mainland or some nearby islands. The 200-metre depth contour is close to the outer edge of the continental shelf.*

(b) The width of the continental shelf varies.
- Approximately how many kilometres east of the mainland is the 200-metre contour along the Tropic of Capricorn near Rockhampton?
- Approximately how many kilometres east of the mainland is the 200-metre contour along latitude 16°S (near Port Douglas)?
- Is the continental shelf wider in the north or in the south?
- Do you think it is easier to take visitors to reefs near the shelf edge from Cairns or from Gladstone?

8. Where do the place names come from?

(a) Captain James Cook sailed northwards along the Queensland coast in 1770, coming aground on a reef near the present position of Cooktown. What do you think might be the origin of each of the names Cook gave to places in the reef area? Talk about this with others. A book on Australian history might help you check your answers.

- Whitsunday Passage
- Magnetic Island
- Endeavour River
- Cape Tribulation

(b) On a map of the reef area, find an island or reef whose name matches each of the following descriptions:

- a colour
- a land-living reptile
- a long-necked bird
- an accident to a ship
- a ship name after a woman
- a long strip of cloth
- not high
- singer from myths of Ancient Greece

(c) Look at the names given on the 1:2 200 000 map for islands and reefs and for places on the Queensland coastline.

- Can you find place names which seem to be of Aboriginal origin?
- Why do you think so few names on the map seem to be of Aboriginal origin?
- You might like to get a map of another part of Queensland (e.g. southwest Queensland). Is the situation regarding Aboriginal names the same as in the reef area? What is a possible explanation?

(d) Feel like naming an island yourself? Look at pictures of two different places on the reef. Think up some new names for them. Give your reasons.

2 Your first reef walk 2 hr •

Concepts
Reef flat
Reef crest
Sediment
Corals
Algae

Skills
Observing
Using all senses
Handling living things

Attitudes
Appreciation of natural environment
Enjoyment of outdoor experience

Aim

- To see the reef for the first time and to experience the changes as you walk from the beach across the reef flat to the edge of the reef.
- To develop skills and confidence in observing, and handling living things on the reef.

When

Start when the tide is going out.

You will need

- Suitable reef-walking footwear and clothing, gloves, hat and sunscreen
- Underwater viewers and/or face mask

> *SAFETY*
> *Avoid touching your eyes during a reef walk. Some marine creatures, e.g. sea-cucumbers, produce substances which can irritate our eyes. Before the reef walk discuss dangerous living things of the reef with your leader.*

Sandy Beach

What to do

1. Each person should pick up a handful of sand from the beach.
2. Look carefully through the sand and try to decide what it is made of. Discuss and share information. Where do you think all the "bits" came from? How did they get here?
3. Walk out from the beach across the reef flat towards the reef edge where you should see water breaking and some large coral boulders.
4. Look for changes as you walk out:
   - Notice changes in water depth.
   - Notice changes in material you tread on as you walk out: is it sandier close to the island or close to the reef edge? Walk carefully in the coral zone to avoid hurting the coral or yourself.
5. Look for colour variations; listen for sounds.
6. Pick up and feel the textures of animals such as a sea-cucumber, a blue sea star, a sea hare.
7. Stand still for a few minutes, then use a coral viewer or face mask to look into a pool. Is anything moving about?
8. Try to distinguish between hard coral, soft coral and algae. Feel each one with your gloved hands.
9. Can you find four types of corals which look different?
10. When you reach the outer edge of the reef, carefully lift a few boulders and observe the variety of life and colour beneath these drab-looking boulders. Always return the boulders to their original positions. Organisms on boulders left upside down will quickly die.
11. Look down over the reef crest at the sea. What do you see? How does it make you feel? Look back at the cay.
12. Observe the tide situation. It may be beginning to come in again.
13. Walk back to the beach in your own time but be aware that the tide may be coming in.
14. When you get back either write down or discuss with your group:
    - your two outstanding impressions from the reef walk
    - whether the reef was as you expected
    - where the easiest and most difficult places to walk were
    - your favourite animal.

    You might like to tape-record your discussion.

Ideas for further things to do

15. Just before you leave the island at the end of your trip, discuss again:
    - your outstanding impressions of your visit to this reef
    - your feelings on the first day
    - your feelings and knowledge now.

Reading

Edmonds, C. 1978. *Dangerous marine animals of the Indo-Pacific region.* Newport: Wedneil Publications.

3. Snorkelling over the edge 2 hr •

Concepts
Reef edge
Current
Equalising
Snorkel-clearing

Skills
Snorkelling
Cooperation

Attitudes
Appreciation of natural environment
Self-confidence
Responsibility
Enjoyment

Aim

- To become more confident in using snorkelling equipment
- To gain confidence in snorkelling over the reef edge.

You will need

- Face mask, snorkel, sandshoes, gloves
- Fins
- Wetsuit (optional)
- Safety boat, motor
- Safety line (20 m float rope)
- Vinegar and Stingose in boat

To be done during a low-tide period.

Before this activity, revise your snorkelling skills in the lagoon on the reef-top close to the beach. Show your buddy that you can fin correctly, keep your hands at your sides, clear your mask, and duck dive.
The next stage is to snorkel over the edge of the coral crest in an organised group.

Safety Precautions

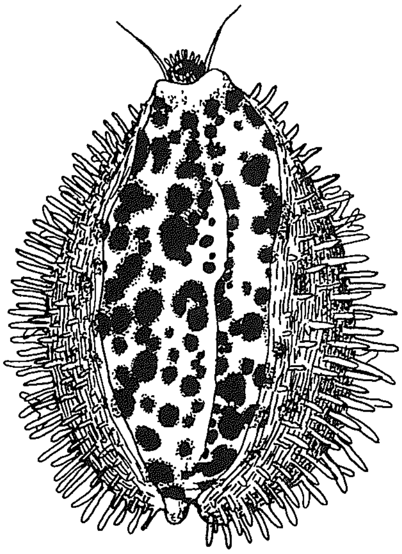
- *Stay with your buddy in a group.*
- *Do not go snorkelling in strong currents.*
- *An adult observer must remain on the reef crest.*
- *Sandshoes and first aid equipment can be stored in a small boat; plastic tidy bins or buckets can be tied to dead coral on the crest.*
- *Less-confident swimmers should snorkel in reef crest pools.*
- *A safety boat with driver and observer should anchor about 10 metres off the reef crest. One or two float ropes should be run out from the boat.*

What to do

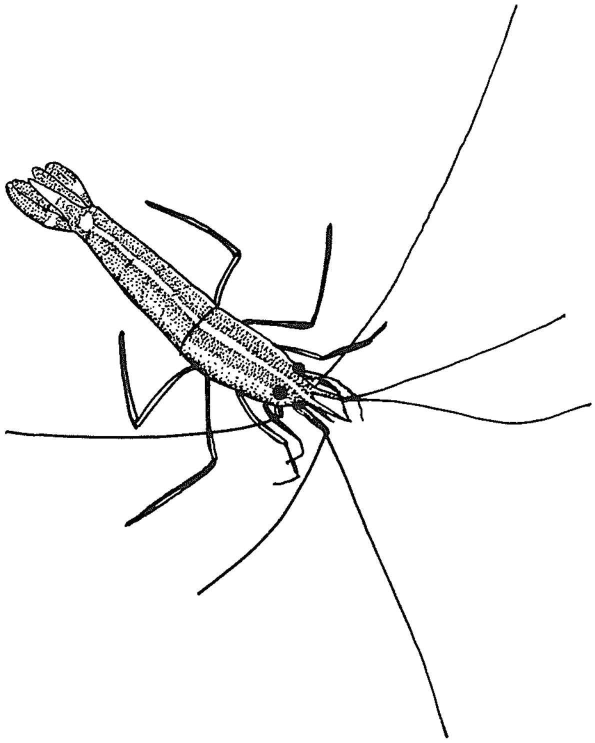
1. Walk across the reef-top to the reef edge with the rest of your party. Put on snorkelling gear and carefully enter the water outside the reef crest. Take care not to get cut by corals. Avoid breaking corals.
2. In groups of eight, snorkel around the float ropes — keep with your buddy. Gain confidence with your gear and try diving to see the reef below. Be careful of dangerous animals you have learned about. Swim and snorkel up-current.
3. After 10 to 15 minutes, check your buddy out in the following skills:
   (a) duck-diving (bend at the waist, legs straight, legs raised to thrust you below the surface)
   (b) effective equalising
   (c) effective underwater swimming, legs only providing propulsion
   (d) effective snorkel-clearing upon surfacing.

Reading

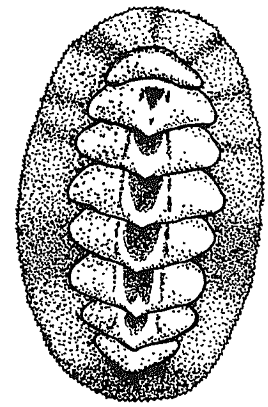
Moffatt, R.D. 1988. *Snorkelling.* Ashmore: Wetpaper Publications.



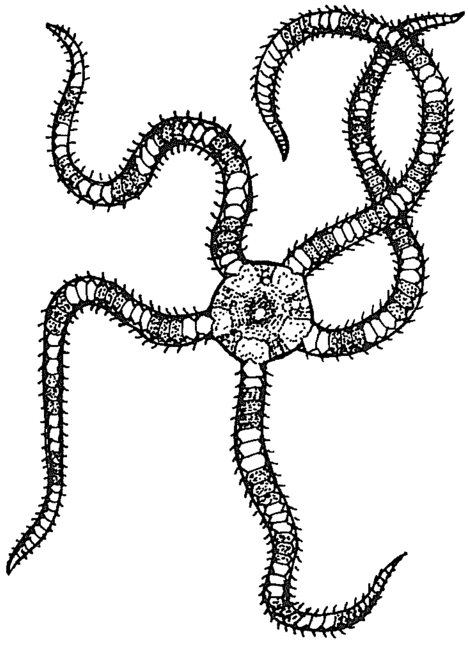
Tiger Cowrie - Cypraea tigris



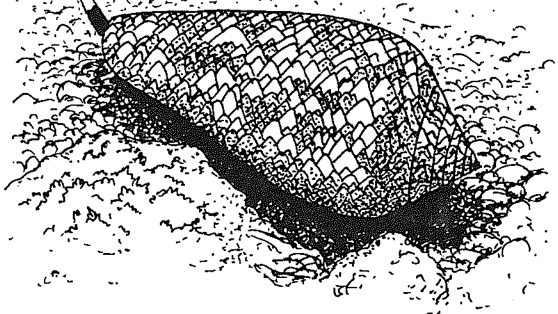
Cleaner shrimp - Hyppolysmata grabhami



chiton - Acanthopleura sp.



Brittle star - Ophiarachnella gorgonia



Textile Cone Conus textile

4. Your first cay walk ½ hr + •

Concepts/topics
Area
Perimeter
Vegetation
Direction
Distribution
Windward
Leeward

Skills
Observing
Using equipment

Attitudes
Confidence
Appreciation of natural environment
Enjoyment of outdoor experience

Aim
- To develop skills and confidence in knowing your way around the cay
- To become aware of some features of the cay environment.

You will need
- Hat, sunscreen
- Suitable footwear and clothing for walking on the beach
- Camera (optional)
- Binoculars (optional)
- Magnetic compass (optional)
- Outline map of reef and island (optional)

What to do
1. Walk around the edge of the cay, noting the time you leave and return.
2. As you walk around the cay, think about the following questions and make observations.
   (a) Where are the directions north, south, east and west?
   (b) How far out is the edge of the reef from here? (Look for waves breaking.)
   (c) How far up the beach do you think the water comes at high tide? Can you see tide lines?
   (d) Where did the sand on this beach come from?
   (e) Is there any rock on the beach? Where?
   (f) Where is the wind coming from? Can you notice different wind effects on different sides of the island?
   (g) Which is the leeward and which is the windward side of the island?
   (h) What kinds of living or dead animals or plants can you spot on the beach as you go along?
   (i) Does vegetation on the windward side of the island seem different from that on the leeward side? How?
   (j) How many different kinds of birds can you see? What are they doing?
   (k) What signs are there on the cay of human activities, past or present?
   (l) Can you see any tracks leading into the cay from the beach?
3. When you get back, have a group discussion about what you've seen.
   (a) Decide which looked like interesting spots to go back to next time.
   (b) On a piece of paper on the wall at base camp, start a list of birds which your group has seen. Don't worry about names, brief descriptions will do! You could add to the list throughout the trip.
   (c) Decide: Is the cay as you expected?

Ideas for further things to do
4. Take photographs of the main plants you see along the edge of the cay.
5. Make some sketches or paintings of beach views.
6. Take a set of photographs on "Beachcombing".
7. Make up a summary in pictorial or table form comparing your impressions of four different sides of the cay.

CONSERVATION NOTES
- *Be careful not to disturb birds while walking on a cay.*

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5. Introductory nocturnal studies 1 hr+ •

Concepts/topics
Nocturnal behaviour
Change in diversity

Skills
Observing
Recording
Questioning

Attitudes
Self-reliance
Curiosity
Appreciation of need for safety
Interest in natural environments

Aim

- To find out what a cay is like at night.

You will need

- Sandshoes
- Torch
- Hand lens (optional)

Do this activity after you have walked around the cay in daylight.

> *WARNING*
> - *On many islands, the Queensland Department of Geographic Information has left star pegs. These are small, often inconspicuous, sharp pieces of metal which stick out of the sand and can severely damage your feet. Wear shoes.*
> - *In summer, turtles come up on to the beach to lay eggs. Don't shine your torches into their eyes as they will return to the sea and may not lay for another year — consult information on turtle watching.*

What to do

1. Walk around the cay at about 7.30 p.m. noting crabs, turtles, mutton-birds, stingrays, sharks, spiders, luminous life, shells.
2. If it is the appropriate season, get up early, about 5.00 a.m., and find a mutton-bird runway. Observe the mutton-bird take-off patterns.
3. Depending on what you see, try to answer some of these questions:
   (a) **Ghost crabs.** Where are they going? What are they doing? What is their reaction to light? How do they behave when frightened? Are there different populations from one side of the island to the other? What was the biggest one you saw?
   (b) **Fish.** Can you spot any small sharks or fish in the shallows? What do they appear to be doing? Do they seem to be affected by your torch light?
   (c) **Spiders.** Spider spotting can be fun! Do their eyes glow? Are the eyes different colours? Can you identify species by eye-glow colour? How many different species can you spot?
   (d) **Luminous life.** Look back at your footprints in the sand. Can you see glowing dots in the sand? Can you still see them when you shine the torch on them? Pick them up, observe with a hand lens. Who can find the largest and the brightest? Put them on your face, hands, arms. Make yourself a glowing skeleton. How long does each animal glow? Do different areas have greater abundance (wet sand, dry sand, north, south, east or west aspect)?
   (e) **Molluscs.** Look on the beach rock. Can you find any giant chitons? How many? What are they doing? Who can find the largest one? What other molluscs are active at night?
   (f) **Reptiles and mammals.** Can you find any land reptiles or mammals?
   (g) **Turtles.** If you are visiting in the laying season, how many turtles were seen during your walk round the island? What species? Did there seem to be different numbers at different places on the island? Can you track a turtle? Can you tell the difference between tracks of animals heading for the land or the sea?
   (h) **Mutton-birds.** How do they arrive back to the island? Are they affected by obstacles, or by light? How do they land? What social interactions occur among the birds on the island? How do they take off in the morning? How many take off at once? Is there any leadership in the take-off sequence?

6. Sensations

Concepts
Sensations
Perceptions
Individual differences

Skills
Collecting data

Attitudes
Appreciation of environmental qualities

Aim

- To use all your senses in experiencing the reef.

You will need

- Writing materials

What to do

1. At four different places, sit in silence for 10 minutes by yourself, out of sight and sound of others.
2. Use all your five senses to gain an impression of your surroundings:
   - sight
   - touch
   - smell
   - sound
   - taste.
3. Write down key words about your feelings about the surroundings, e.g. hot, smelly, noisy.
4. Return to base and compare your findings with others.
5. Which sense dominated?

Ideas for further things to do

6. Go for a blindfold walk.
7. Carry out some of the arts and crafts activities such as "Art and the reef" (no. 119) and "Art and photography" (no. 122).

Sky, ocean, atmosphere

7. Night skies ½ hr + •

Concepts
Direction
Constellations
Planet
Star
Phases of the moon
Neap tide
Spring tide

Skills
Observing
Communicating
Mapping
Identifying
Using compass

Attitudes
Curiosity
Awareness and appreciation of natural environment

Aim

- To identify some planets and constellations and become aware of the significance of constellations for navigation.
- To observe the moon and become aware of the relationship between moon phases and tides.

You will need

- A star chart for the month (these are printed in the "Australian" on the first weekend of the month; also available from newsagents)
- Binoculars (optional)
- Telescope (optional)
- Pocket torch
- Magnetic compass
- Tide table

What to do

Moonwatch

1. Using information from the newspaper or calendar, try to find out what time the moon is due to rise on this day. If the moon is predicted to rise after dark, keep a watch out for it rising above the horizon. Use your compass to find out the direction in which it rises. In what direction does it move across the sky? Keep a note of your observations and try to make a diagram to illustrate them later.
2. What shape is the visible part of the moon? Make a rough sketch. Discuss with your teacher: In what phase is the moon — full moon, half moon, or ...? (You could repeat this on the last night of your trip and make a comparison).
3. Afterwards, look at tide charts for this area. How are tides related to moon phases?

Star and planet watch

4. Identify the Milky Way. Discuss with your teacher and others: What is this feature? How do you account for the way it looks? Why is it significant to us?
5. Study the star chart and identify five constellations, e.g. Orion's Belt.
6. Discuss differences between a star and a planet. Does a planet differ in appearance from a star?
7. Use the star chart to identify planets visible this month.
8. Watch the sky carefully for about 10 minutes for satellites, space debris or meteors.
9. Locate the Southern Cross and pointers and determine the position of the south pole as illustrated in figure 7.1.
10. How could the Southern Cross and pointers help you decide the way to sail if you were trying to make a trip back to the mainland from this island?

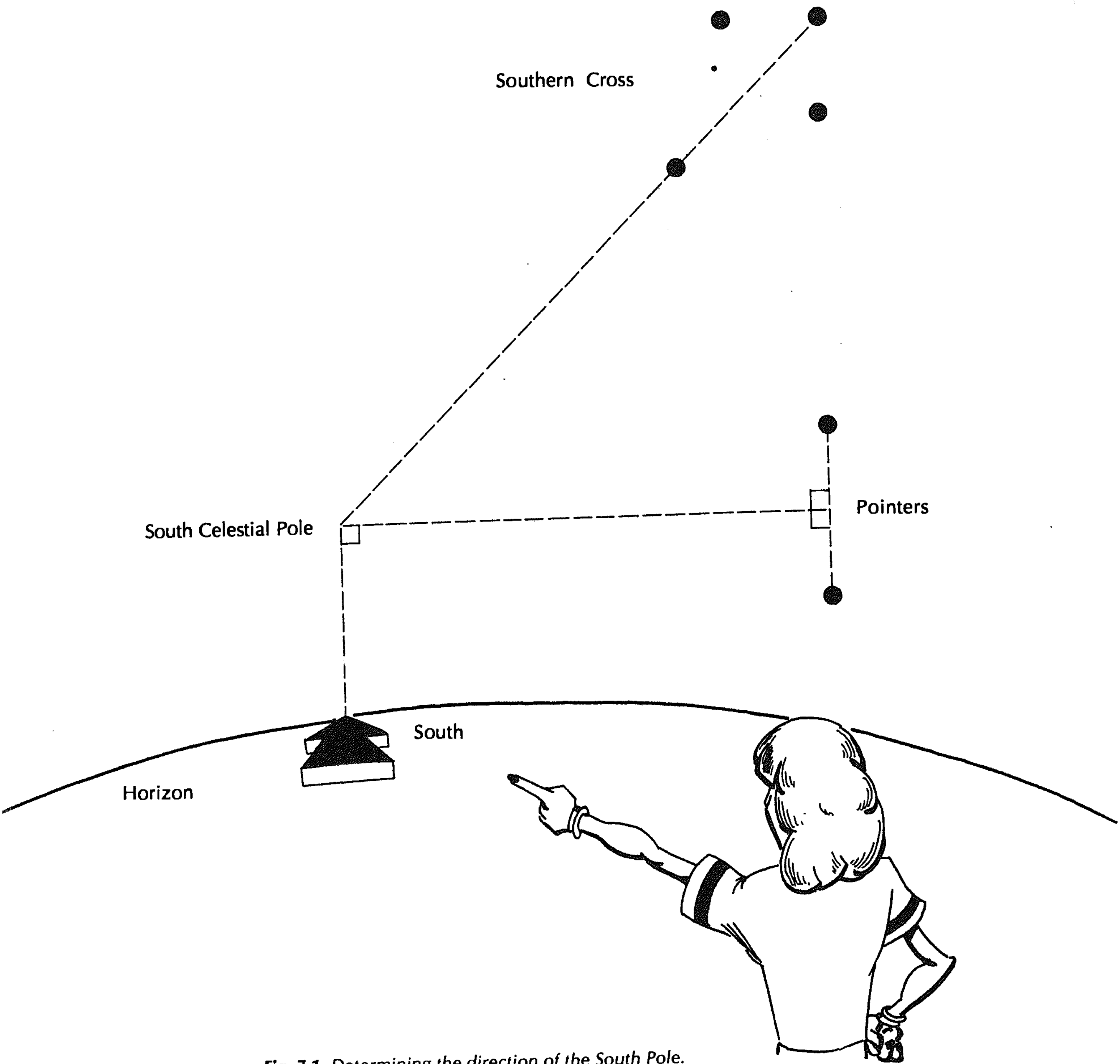


Fig. 7.1. Determining the direction of the South Pole.

8. How clear is the water? ¼ hr each reading

Concepts
Light absorption
Photic zone
Turbidity

Skills
Observing
Measuring
Recording

Attitudes
Interest in methods of science
Willingness to work with precision

Aim

- To measure the clarity of water using a Secchi disc.

You will need

- A boat or rubber float
- A cord marked at quarter-metre intervals (perhaps with coloured ties) wound on to a creel
- A metre or half-metre rule or plastic measuring tape
- A Secchi disc (a white plastic lid of an ice-cream container or a white metal disc of 30 cm diameter)
- Lead sinkers or belt weights attached to the bottom of the Secchi disc
- Underwater camera (optional)
- Scuba gear (optional)

> *A Secchi disc is used to measure the clarity of water. Clarity at different places and at different times can be compared. Water clarity or transparency is affected by suspended material such as plankton or sediment. Cloudiness of water caused by suspended material is known as turbidity.*

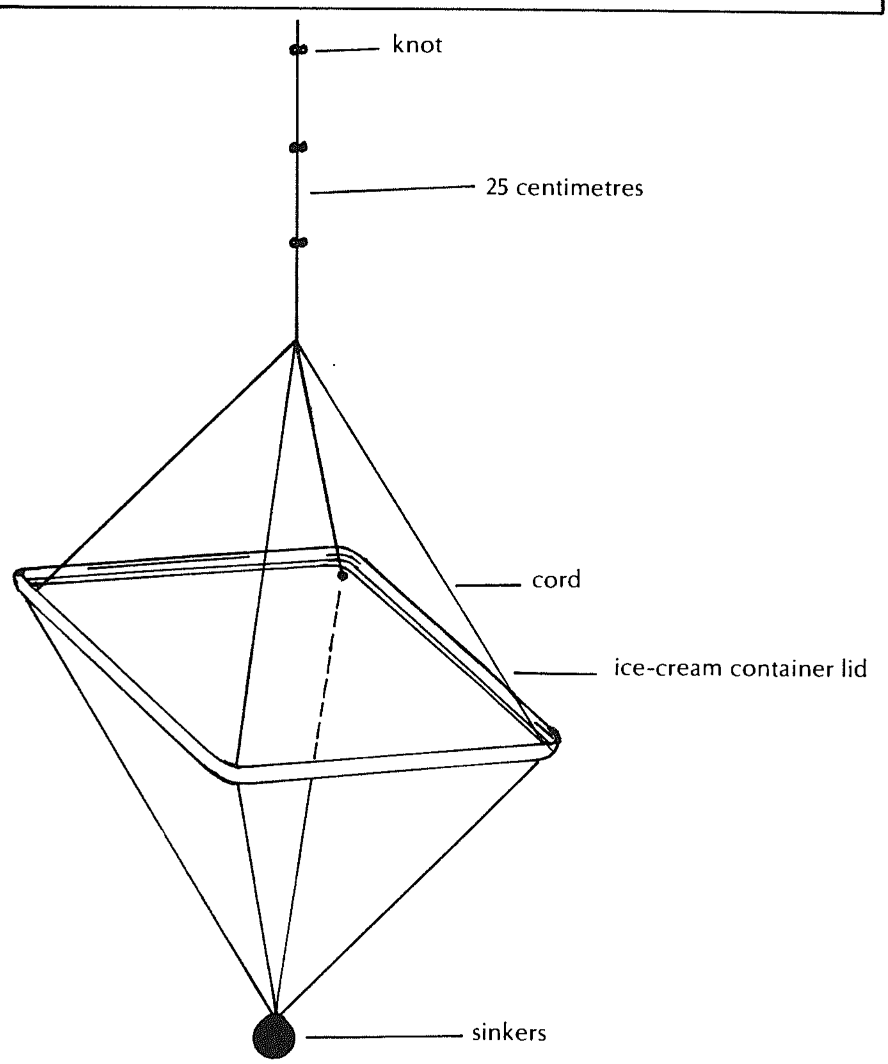


Fig. 8.1. *A home-made Secchi disc.*

How to use the Secchi disc

Two people are needed. One person unreels the cord. The other person lowers the disc into the water counting the metre marks at the waterline as the disc goes down. The first reading taken is the depth at which the Secchi disc first disappears from sight. The disc is now lowered another metre then raised slowly. The second reading is the depth at which it becomes visible again. The two readings are averaged and the average is recorded as the Secchi disc depth.

In carrying out the procedures from a small boat, it is important to keep the boat stable. If possible, take readings on the shady side of the boat; glare on the top of the water would affect your readings.

What to do

1. Before you go out to a reef, take some readings with a Secchi disc near the mainland. You could make some readings in a bay near your home by lowering the disc from a bridge or wharf. Better still, try out the Secchi disc in the port from which you are travelling out to the reef. Also, you might be able to take some readings offshore, on the way out to the reef.
2. At the reef you are visiting, paddle or motor out past the reef crest in a boat. Take a Secchi disc reading at one or more points. Does the disc disappear? If the disc does not disappear, this means the water is very clear. Simply record the maximum depth at which you can see the disc.
3. Try to repeat the readings at the same spots at different tide conditions, especially at low tide.
4. Compare the readings you have taken:
   (a) How does the clarity of reef waters compare with the clarity of inshore waters?
   (b) Does the clarity of water just off the reef seem to differ at low tide and high tide?
   (c) What are some possible explanations for the differences you observe?

> *The photic zone in the sea is the surface zone in which enough light can penetrate to allow photosynthesis to occur. It can be considered as the zone below which no light, except about 1 per cent, is able to penetrate. The bottom of the photic zone in any place is about 2.5 times the depth of a Secchi disc reading (Pipkin et al. 1977).*

5. Why is water clarity an important factor affecting the distribution of life in the sea? Consider particularly corals and algae.

Ideas for further things to do

6. If it is a safe scuba-diving area and you have competent scuba divers in your group with an underwater camera, ask them to dive down to the Secchi depth and take a colour photo. Take one near the surface and, if possible, one below the Secchi level for comparison. When developed, compare and discuss results.
7. Using reports from others or your own observations, find out about the distribution of life forms at some of the spots where you took Secchi readings.
8. Through reading and discussion, make a list of factors which affect water turbidity.

Reference

Pipkin, B.W., Gorsline, D.S., Casey, R.E., and Hammond, D.E. 1977. *Laboratory exercises in oceanography*. San Francisco: W.H. Freeman.

9. Reef waters – temperature 2 hr +

Concepts
Temperature
Abiotic factors
Variation

Skills
Measuring
Recording
Hypothesising

Attitudes
Questioning
Interest in natural environment
Persistence
Interest in method of scientific investigation

Aim
- To measure temperature in reef waters at various times and places.

You will need
- Reef-walking gear and boating gear
- A bucket
- A thermometer (in shield)
- Outline map of the reef and cay
- Clipboard with paper or recording sheet
- Pencil

What to do
1. (a) Select a number of sample sites (e.g., pool in beach rock, moat, reef flat, lagoon, reef slope) and record these on a map of the reef.
   (b) Draw up a data table with columns for: site, temperature and time.
   (c) At each site at low tide record the temperature (°C) of the water with a thermometer.
   (d) Tabulate (or graph) these results on the data sheet.
2. Where possible, repeat your tests at high tide.

Questions to answer
3. At low tide: Are some places warmer than others? Why might this be?
4. At any particular place, do high-tide values for temperature differ from those at low tide. If so, why might this be?
5. At high tide: Are some places warmer than others? Why might this be?

Ideas for further things to do
6. By reading, find out how the values you've found here for temperature compare with those in the open ocean and with other coastal environments.
7. By reading, find out something about how temperature is an important factor in affecting the distribution of life in the sea.
8. By reading, find out something about how temperature affects movement of water in the ocean.

Reading
Hopley, D. 1982. *The geomorphology of the Great Barrier Reef.* New York: John Wiley.

10. Reef waters – oxygen and pH 2 hr + • •

Concepts
Solution
Gas
Solubility
Oxygen
Respiration
Carbon dioxide
Acidity
Alkalinity
pH
Abiotic factor
Photosynthesis

Skills
Recording
Graphing
Hypothesising

Attitudes
Curiosity
Interest in natural environment
Persistence
Interest in methods of scientific investigation

Aim

- To measure dissolved oxygen and pH in reef waters at various times and places.

You will need

- Reef-walking gear
- Boat (optional) or snorkelling gear
- Buckets
- Test kit or an environmental probe instrument for dissolved oxygen and pH (e.g. by Hach — test kits by Hach are available from Selby-Anax suppliers in major Australian cities)
- Map of cay and reef
- Clipboard with paper or recording sheet
- Pencil

In the sea, animals and plants and many bacteria need oxygen for respiration, just as living things on land do. Because there is a large percentage of oxygen in the air, for land-dwellers there is usually no problem in getting enough oxygen. However, water will hold only a limited amount of dissolved oxygen. Normally there are about 8 p.p.m. (parts per million) of oxygen in sea water but the amount can vary widely.
pH is a measure of how acidic or alkaline a solution is. The pH scale runs from 7 to 14: pH 7 is neutral; a solution with pH below 7 is acidic; one with pH above 7 is alkaline. The pH of ocean water is slightly alkaline, usually between 8.0 and 8.4 at the surface. However, the values vary in different environments and at different times. Marine life cannot survive if pH is too far from the range 7.0 to 8.5.

What to do

1. Select a number of sample sites (lagoon, moat, reef pool, reef crest, reef slope) and record these on a map of the reef.
2. Draw up a data table for site, oxygen (p.p.m.) and pH.
3. Collect samples of surface water at these sites at low tide, measuring pH and oxygen.
4. Tabulate or graph these results and answer the following questions:
   (a) Are there any differences in oxygen and pH values between the sites selected?
   (b) If differences are found, suggest possible reasons for these variations.
5. Fill two buckets with water. Leave one in the sun and the other in the shade and carry out the tests above. Does this help explain differences found?
6. What role do you think photosynthesising plants have in affecting the values measured in this activity?

Ideas for further things to do

7. Test water on the inner reef flat at high tide for oxygen content. Compare your results with the low-tide results for this location. Suggest possible reasons for your results.
8. You may be able to arrange to collect water samples at a particular locality at similar tide conditions both during the day and at night (just before dawn). If so, test for oxygen and pH, and compare results. Suggest possible reasons for your results.
9. Get two beakers of water — either sea water or fresh. Test the water in one beaker for pH. Now blow into the water in the other beaker for about a minute, using a drinking straw. Test this water for pH. What do you notice? Does this help explain the results of any tests you have carried out in the field?

Some factors which affect oxygen content
- *Raising temperature or salinity lowers oxygen solubility.*
- *Photosynthesis adds oxygen to water.*
- *Turbulence at top of water allows oxygen to enter water.*

Some factors which affect pH
- *Respiration and decomposition make water more acidic by adding carbon dioxide.*
- *Photosynthesis makes water more alkaline by removing carbon dioxide.*

11. Tidal changes 1½ hr

Concepts
Neap and spring tides
Diurnal, semidiurnal and mixed tides
Phases of the moon
Tide levels

Skills
Plotting data on graphs
Interpreting graphs and maps

Attitudes
Interest in natural environments
Interest in interrelations of people and their environment

Aim

To explore for the following questions:

- How often do high and low tides occur at any particular place on the coast?
- How do the heights of tides change over a month?
- How are tides related to the phases of the moon?
- What effects do tides have on the marine life of reefs?
- How are people's activities influenced by tides?
- How do tides vary in different parts of the Great Barrier Reef area?

You will need

- Millimetre graph paper
- Ruler, pencil
- A set of tide tables for the Queensland coast

Most people know about tides. These regular rises and falls in sea-level are extremely important to anyone who is spending time on a beach, rocky shore or reef, or who is using the sea for boating or swimming. The edge of the sea changes its position throughout each day because of tides. In channels, tides alter the depth of water and change the speed and direction of currents.

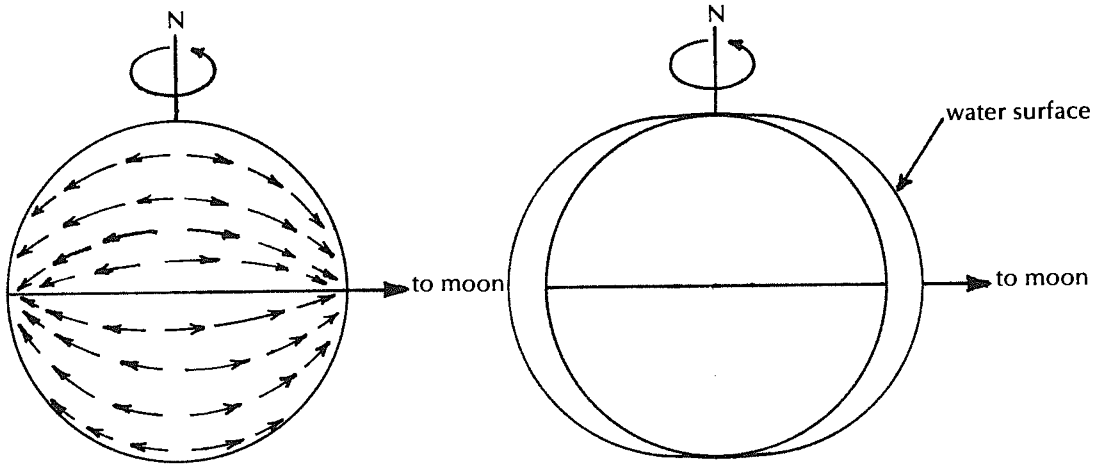


Fig. 11.1. *The effect on tides of the gravitational pull of the full moon.*

DAY 1		DAY 2		DAY 3	
Time	Metres	Time	Metres	Time	Metres
0019	2.12	0116	2.08	0223	2.06
0618	0.58	0713	0.79	0823	0.96
1244	2.57	1336	2.34	1435	2.13
1942	0.59	2037	0.61	2131	0.61

Figure 11.2: Tide table for Bundaberg for three days (time given in the 24-hour clock notation).

DAY 1		DAY 2		DAY 3	
Time	Metres	Time	Metres	Time	Metres
0050	0.29	0136	0.22	0220	0.23
1614	3.06	1707	3.03	1759	2.94

Figure 11.3: Tide table for Weipa for three days (time given in the 24-hour clock notation).

For many marine plants and animals which live on reef tops and along the shoreline, tides mean being alternately submerged in water and exposed to the drying effects of the atmosphere.
Tides vary from place to place and from time to time. At any particular location, the tidal range (i.e., the difference in height between a high tide and the next low tide) gradually changes from one day to the next. The gravitational pull of the moon and sun on the earth's oceans are a major cause of tides (figure 11.1) Changes in tide heights throughout each month, and throughout the year, are linked to changes in position of earth, sun and moon.
The Great Barrier Reef is an area of the earth where tidal ranges are big and the influence of tides is great. People who visit the reef need to be aware of tidal activity.
Tides can be predicted well in advance by experts. Tables of predicted tide heights and times for most main coastal ports can be obtained easily through harbour authorities. Local boat sheds and fishing gear shops usually have tide tables.

What to do

Tide patterns

Figures 11.2 and 11.3 are tide tables for three days at two different places in Queensland: Bundaberg and Weipa (on the Gulf of Carpentaria).

1. Using the information in these tables, plot tide curves for each place on graph paper. For convenience, you can use straight lines to join points on the graph. (Plot days on the horizontal axis and tide height on the vertical.)
2. Read the information below and then label each tide curve you have drawn according to whether it shows a diurnal or semidiurnal pattern.

There are three major kinds of tide patterns:

- *Semidiurnal tide pattern*
  This is a "twice-daily" pattern. There are two high and two low tides each time the moon goes around the earth (i.e., each 24 hr 50 min.). The two high tides are similar or fairly similar to each other in height, and so are the low tides.
- *Diurnal tide pattern*
  This is a "once-daily" tide pattern. There is one high and one low tide approximately each 24 hours.
- *Mixed tide pattern*
  Mixed tide patterns are complex. There are (usually) two highs and two lows each day, but they are very dissimilar in height.

Tidal range

The difference in height between one high tide and the next low tide is known as the tidal range.

3. (a) What is the greatest tidal range on the tide curve you have just drawn for Bundaberg?
   (b) On what day does it occur?
   (c) Are tidal ranges shown on these curves greater at Bundaberg or Weipa?

Monthly changes in tides

In the tide tables find the tides for twenty-eight days at Gladstone in the Great Barrier Reef area.

4. Notice how the tidal range changes throughout the month.

> *The tidal range at any place changes throughout each lunar month (29.5 days). Tides with greatest tidal range come twice each month at times of new moon and full moon. These are called spring tides. Tides with the smallest tidal range also come twice each month, at times of half moon. These are called neap tides.*
> *Changes in tide height throughout a month are caused by regular changes in the relative positions of the sun, moon and earth. At each full moon and new, the moon, earth and sun are aligned and the force of the sun is added to that of the moon in producing tides. At times of half moon, the sun and moon act at right angles to each other and the tidal effect of the sun tends to counteract that of the moon (see figure 11.4).*

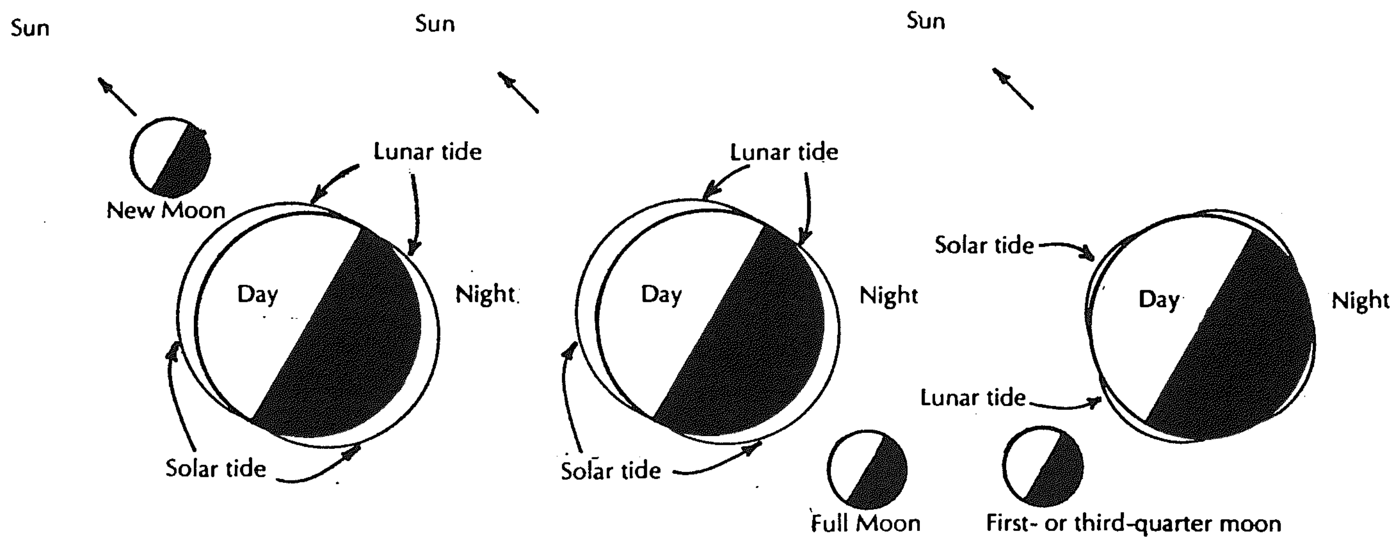


Fig. 11.4. Positions of the Sun, Moon and Earth at (a) spring and (b) neap tides (after Pipkin et al., 1977).

5. Use the tide curve given for Gladstone and the information provided above to fill in table 11.1 about tides on different days of the month.

Table 11.1: Tides at Gladstone

	Tidal range in metres (approx.)	*Phase of moon (new, full or half)*	*Type of tide (spring or neap)*
Day 8			
Day 16			
Day 23			
Day 27			

Tide levels

Mean tide levels of various kinds are calculated by tide experts who average tide occurences over a long period. Descriptions of some mean tide levels are given in table 11.2.

Table 11.2: Mean tide levels and their definitions

Tide level	*Abbreviation*	*Simple definition*
Mean high water spring	MHWS	Long-term average of high tides which occur at full moon or new moon.
Mean high water neap	MHWN	Long-term average of high tides which occur at half moon.
Mean high water	MHW	Long-term average high-tide level. (This is used for land survey purposes.)
Mean sea-level	ML	The average level of the sea over a long period. This is an average level which would exist if there were no tides.
Mean low water	MLW	Long-term average of low-tide level.
Mean low water neap	MLWN	Long-term average of low tides which occur at half moon.
Mean low water spring	MLWS	Long-term average of low tides which occur at full moon or new moon.

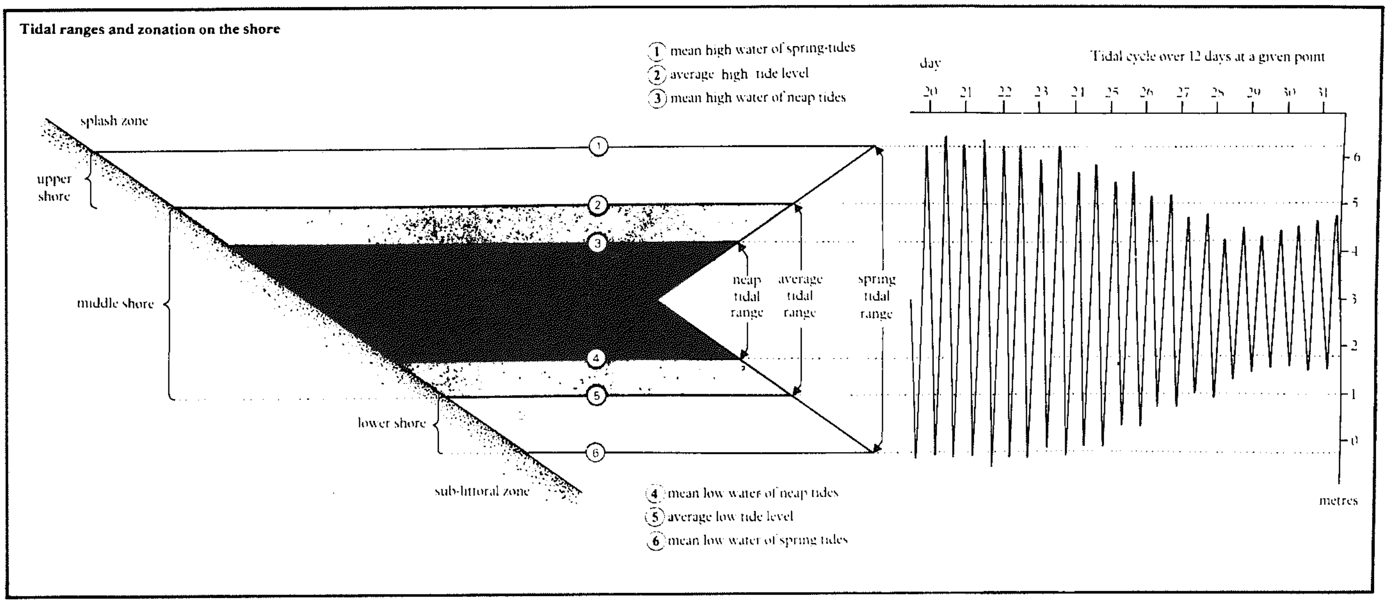
6. Figure 11.5 shows mean tide levels labelled 1 to 6. Read table 11.2 and decide which of the tidal ranges, marked A, B and C, corresponds to: neap tidal range; average high tidal range; spring tidal range. Fill in the letters below figure 11.5.

Shoreline exposure at low tide

Answer the following questions.

7. Suppose you are helping to organise a class excursion to study marine plants and animals which live in the littoral zone (i.e., the intertidal zone) of a nearby island. Will it be better to have the excursion in part of the month when there is a new moon or when there is a half moon? Why?
8. Imagine you are a barnacle living on top of a coral reef. Suppose you are at MHWS level. You are briefly covered with water each day on days 20, 21, 22 and 23. After day 23, about how many days will you be likely to have to wait to be covered again by high tide?
   But what if you were a sea anemone? Would you be likely to be able to survive in this spot? Why?

Fig. 11.5



Tidal currents

A map of a reef in the southern part of the Great Barrier Reef is given in figure 11.6. Along the north-western side of this reef, an area which is excellent for snorkelling and scuba diving is shown. In this area, tidal currents during an incoming tide (i.e., flood tide) move towards the south-west; those during an outgoing tide (i.e., ebb tide) move towards the north-east. Their maximum speed is about 2 km/hr.

9. On the map, draw arrowheads to show the direction of movement of currents during ebb and flood tides.
10. If your group wanted to snorkel along this area during a flood tide, would it be easier if you entered the water near the lighthouse and swam towards the marker buoys, or vice versa?
11. If an oar was accidentally dropped in the water at point A during an ebb tide, what is the shortest time you could expect it to take to reach point B?

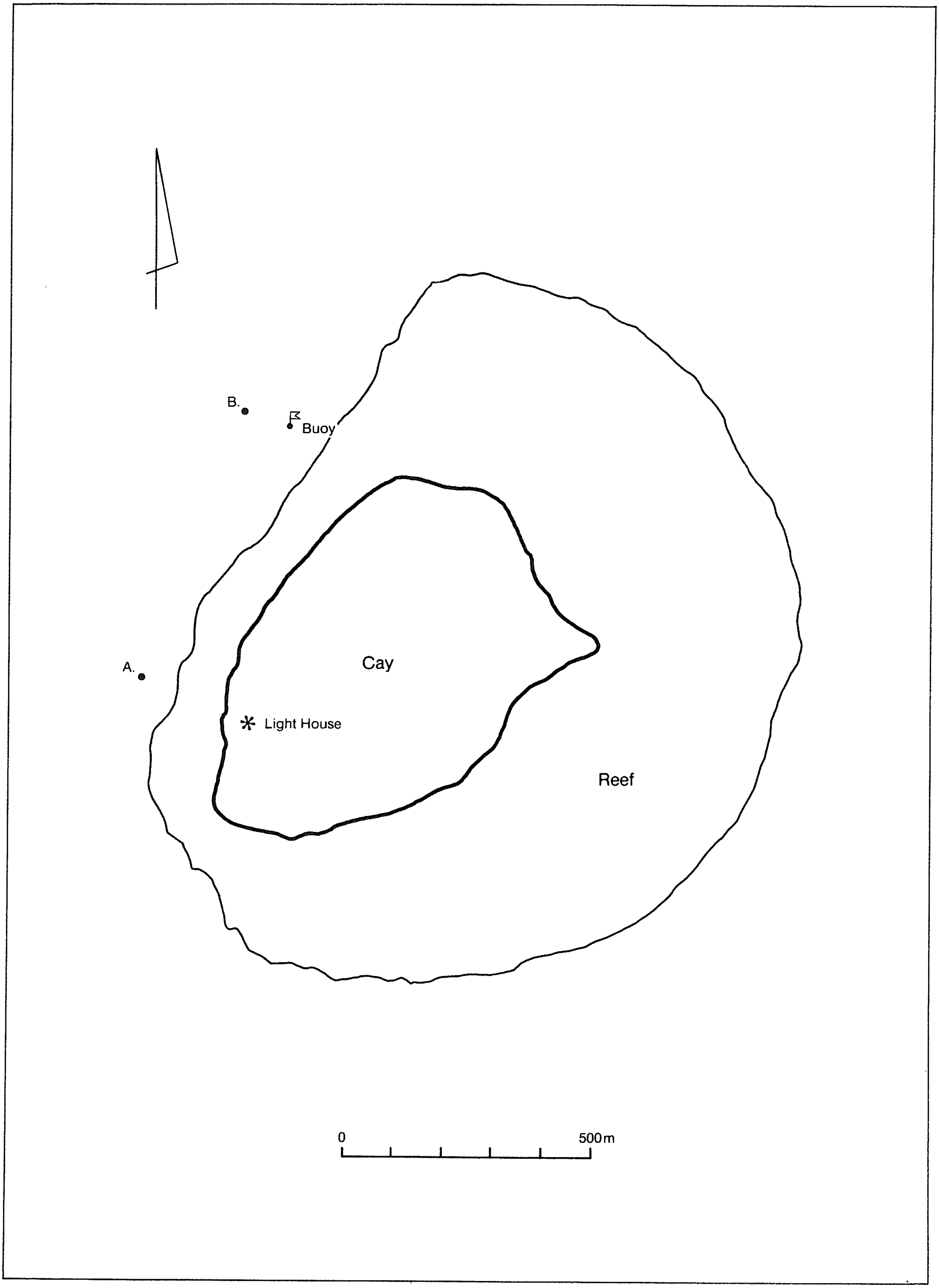


Fig. 11.6. Lady Elliott Island.

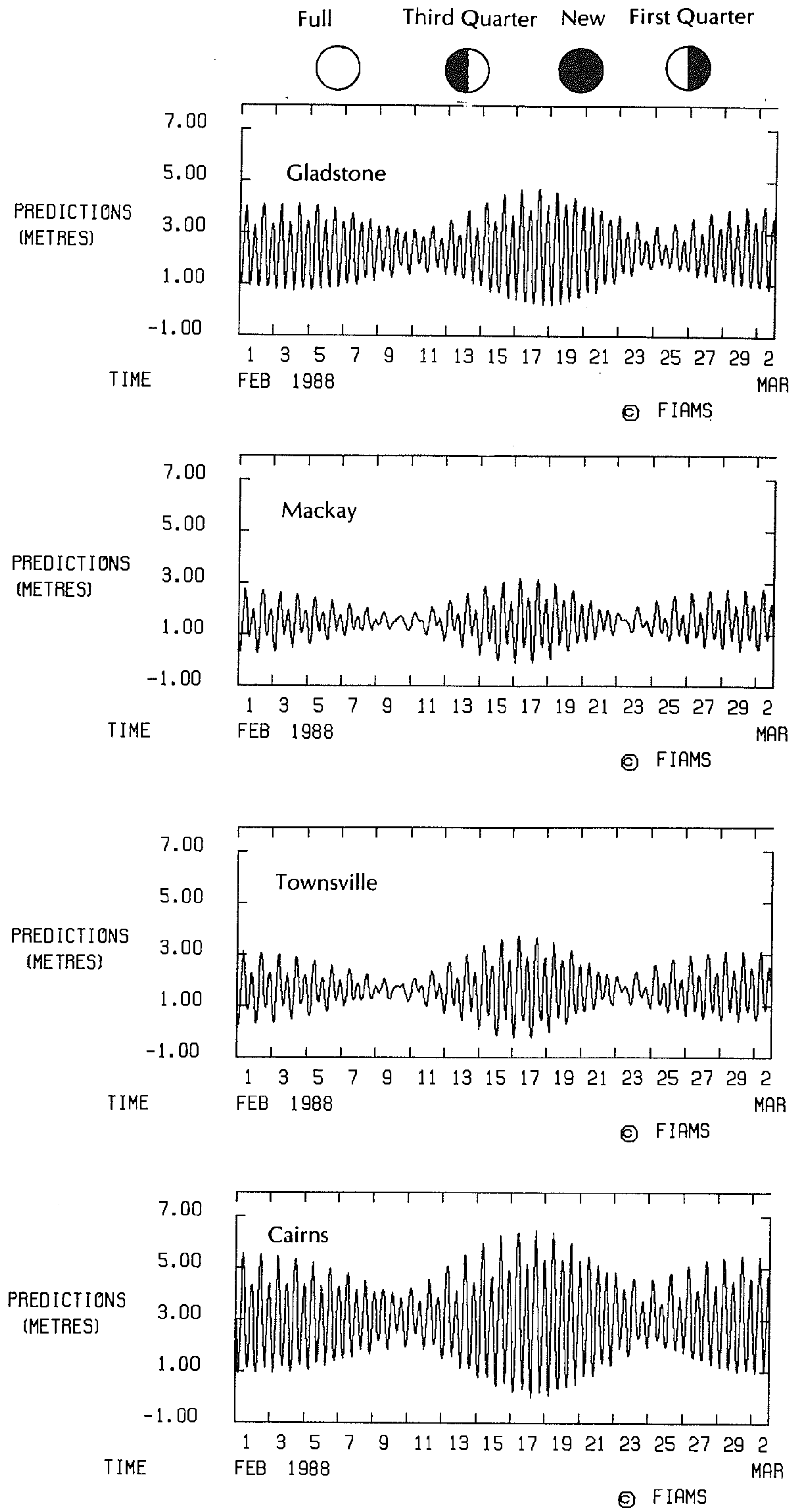


Fig. 11.7. *Curves showing one month of tides at Gladstone, Mackay, Townsville and Cairns (February, 1988)*
Vertical axis — tide height in metres.
Horizontal axis — time in days.
Phases of moon shown.

Differences in tides in the Great Barrier Reef area

Tide characteristics vary throughout the Great Barrier Reef area.

12. (a) Figure 11.7 shows February tide curves for Cairns, Townsville, Mackay and Gladstone. Which place has the greatest tidal range during this month?
    (b) Which has the smallest tidal range?
13. Figure 11.8 is a map showing lines of equal tidal range for the Great Barrier Reef area. From this map, what can you say about tidal ranges at Green Island and Heron Island?

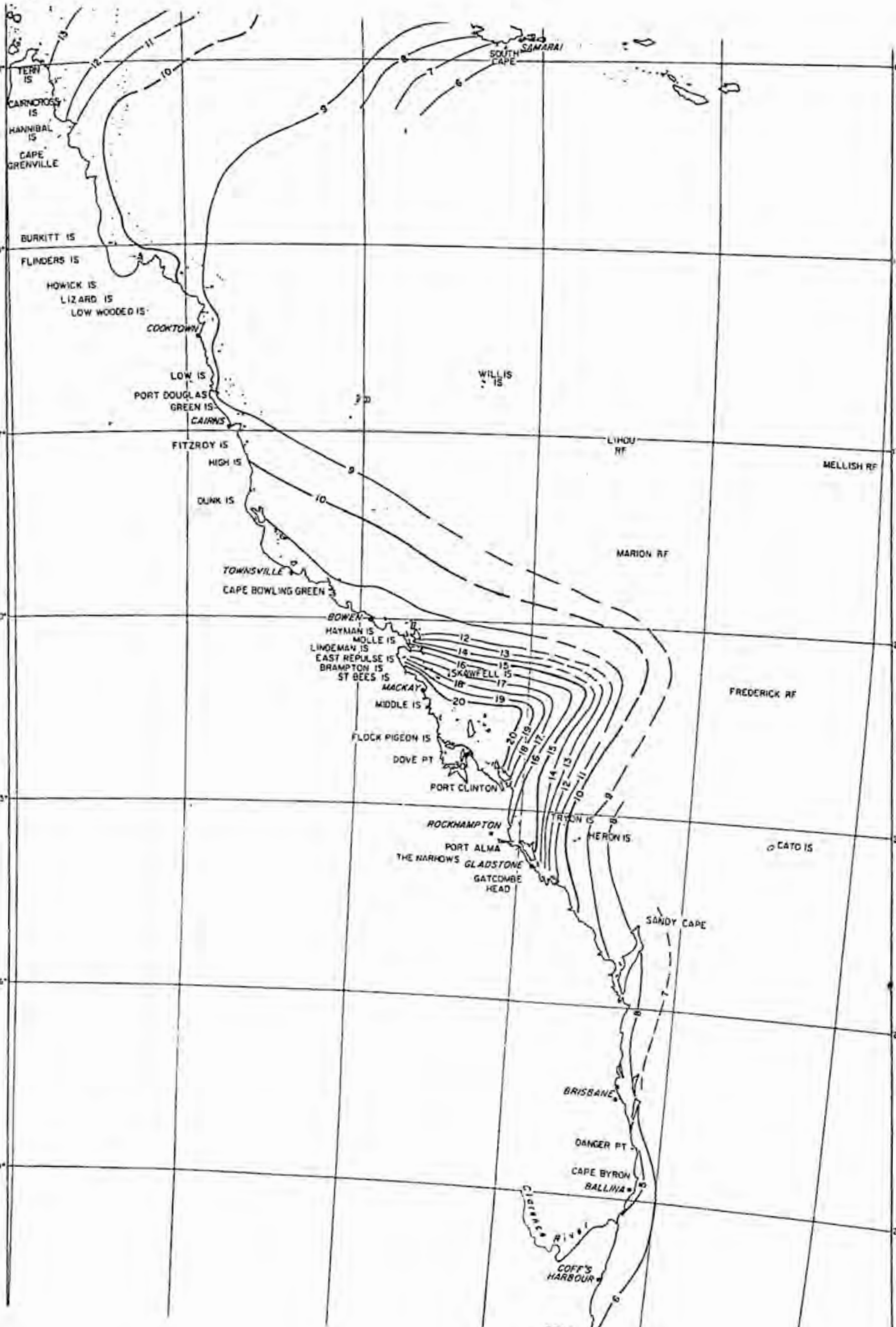
> *Most parts of the Great Barrier Reef have semidiurnal tides but successive high tides are somewhat different, especially in the north. In winter time, daytime high tides are not as high as night-time high tides. In summer, daytime high tides are higher than night-time ones.*

A mishap!

One fine June afternoon some people who had been out in a small aluminium dinghy on North West Island Reef finished with their gear for the day and took it out of the water. They left it high on the beach well above the level where high tide had reached that afternoon. But next morning it had washed away.

16. What do you think might have happened?

Fig. 11.8


TERN IS
CARNCROSS IS
HANNIBAL IS
CAPE GRENVILLE
SOUTH CAPE
SAMARAI
BURKITT IS
FLINDERS IS
HOWICK IS
LIZARD IS
LOW WOODED IS
COOKTOWN
WILLIS IS
LOW IS
PORT DOUGLAS
GREEN IS
CAIRNS
FITZROY IS
HIGH IS
LIHOU RF
MELLISH RF
DUNK IS
MARION RF
TOWNSVILLE
CAPE BOWLING GREEN
BOWEN
HAYMAN IS
MOLLE IS
LINDEMAN IS
EAST REPULSE IS
BRAMPTON IS
ST BEES IS
SKAWFELL IS
MACKAY
MIDDLE IS
FREDERICK RF
FLOCK PIGEON IS
DOVE PT
PORT CLINTON
ROCKHAMPTON
TRYON IS
HERON IS
CATO IS
PORT ALMA
THE NARROWS
GLADSTONE
GATCOMBE HEAD
SANDY CAPE
BRISBANE
DANGER PT
CAPE BYRON
BALLINA
Clarence River
COFF'S HARBOUR
PORT

12. *Endeavour*, reef and tides ¾ hr

Concepts
Diurnal tides
Semidiurnal tides

Skills
Comprehension
Analysis

Attitudes
Interest in natural environments and historical events

Aim

- To consider the influence of tides in an event important in Australian history.

You will need

- Writing paper and pen
- Figure 11.7 from previous exercise

> *James Cook's ship the Endeavour struck a coral reef just east of the position of Cooktown at 11 p.m. on 10 June 1770. The event is described in the extract below from Cook's journal.*

What to do

Read the extract from the journal and, on separate paper, answer these questions:

(a) What tide changes does Cook record here?
(b) How did the tide changes affect attempts to save his ship?
(c) Why do you think Cook expected there to be a high tide at about noon on 11 June?
(d) Do you think Cook would have anticipated getting his ship free at this tide if he had been able to study a tide curve for the area (such as the one given here for Cairns in figure 11.7)? Why?

Extract from Cook's journal of 10 June 1770 to 12 June 1770. (Italic sections tell about the tidal changes.)

We had the advantage of a fine breeze, and a clear moonlight night, and in standing off from six till near nine o'clock, we deepened our water from fourteen to twenty-one fathom, but while we were at supper it suddenly shoaled, and we feel into twelve, ten, and eight fathom, within the space of a few minutes; I immediately ordered everybody to their station, and all was ready to put about and come to an anchor, but meeting at the next cast of the lead with deep water again, we concluded that we had gone over the tail of the shoals which we had seen at sun-set, and that all danger was past: ***before ten, we had twenty and one and twenty fathom, and before the lead could be cast again, the ship struck, and remained immoveable***, except by the heaving of the surge, that beat her against the craggs of the rock upon which she lay.

In a few moments everybody was upon the deck, with countenances which sufficiently expressed the horrors of our situation. We had stood off the shore three hours and a half, with a pleasant breeze, and therefore knew that we could not be very near it, and we had too much reason to conclude that we were upon a rock of coral, which is more fatal than any other, because the points of it are sharp, and every part of the surface so rough as to grind away whatever is rubbed against it, even with the gentlest motion. In this situation all the sails were immediately taken in, and the boats hoisted out to examine the depth of water round the ship: we soon discovered that out fears had not aggravated our misfortune, and that the vessel had been lifted over a ledge of the rock, and lay in a hollow within it: in some places there was from three to four fathom, and in others not so many feet.

As soon as the long-boat was out, we struck our yards and top-masts, and carried out the stream anchor on the starboard bow, got the coasting anchor and cable into the boat ... having taken ground, our utmost force was applied to the capstern, hoping that if the anchor did not come home, the ship would be got off, but to our great misfortune and disappointment we could not move her: during all this time she continued to beat with great violence against the rock, so that it was with the utmost difficulty that we kept upon our legs; and to complete the scene of distress, we saw by the light of the moon the sheathing boards from the bottom of the vessel floating away all round her, and at last her false keel, so that every moment was making way for the sea to rush in which was to swallow us up.

We had now no chance but to lighten her, *and we had lost the opportunity of doing that to the greatest advantage,* ***for unhappily we went on shore just at high water, and by this time it had considerably fallen, so that after she should be lightened so as to draw as much less water as the water had sunk, we should be but in the same situation as at first; and the only alleviation of this circumstance was, that as the tide ebbed the ship settled to the rocks,*** and was not beaten against them with so much violence.
This however was not time to indulge conjecture, nor was any effort remitted in despair of success: that no time might be lost, the water was immediately started in the hold, and pumped up: six of our guns, being all we had upon the deck, our iron and stone ballast, casks, hoop staves, oil jars, decayed stores, and many other things that lay in the way of heavier materials, were thrown overboard with the utmost expedition, every one exerting himself with an alacrity almost approaching to cheerfulness, with the least repining or discontent; yet the men were so far imprest with a sense of their situation, that not an oath was heard among them, the habit of profaneness, however strong, being instantly subdued, by the dread of incurring guilt when death seemed to be so near.
While we were thus employed, day broke upon us, and we saw the land at about eight leagues distance, without any island in the intermediate space, upon which, if the ship should have gone to pieces, we might have been set ashore by the boats, and from which they might have taken us by different turns to the main: the wind however gradually died away, and early in the forenoon it was a dead calm; if it had blown hard, the ship must inevitably have been destroyed. ***At eleven in the forenoon we expected high water, and anchors were got out, and every thing made ready for another effort to heave her off if she should float, but to our inexpressible surprize and concern she did not float by a foot and a half, though we had lightened her near fifty ton, so much did the day-tide fall short of that in the night.***
We now proceeded to lighten her still more, and threw overboard every thing that it was possible for us to spare: hitherto she had not admitted much water, but as the tide fell, it rushed in so fast, that two pumps, incessantly worked, could scarcely keep her free. At two o'clock, she lay heeling two or three streaks to starboard, and the pinnace, which lay under her bows, touched the ground: we had now no hope but from the tide at midnight ...
About five o'clock in the afternoon, we observed the tide begin to rise, but we observed at the same time that the leak had gained upon us so considerably, that it was imagined she must go to the bottom as soon as she ceased to be supported by the rock: this was a dreadful circumstance, so that we anticipated the floating of the ship not as an earnest of deliverance, but as an event that would probably precipitate our destruction.
We well knew that our boats were not capable of carrying us all on shore, and that when the dreadfull crisis should arrive, as all command and subordination would be at an end, a contest for preference would probably ensue, that would increase the horrors even of shipwreck, and terminate in the destruction of us all by the hands of each other; yet we knew that if any should be left on board to perish in the waves, they would probably suffer less upon the whole that those who should get on shore ...
To those only who have waited in a state of such suspense, death has approached in all his terrors; and as the dreadful moment that was to determine our fate came on, every one saw his own sensations pictured in the countenance of his companions; however, the capstan and windlace were manned with as many hands as could be spared from the pumps, and the ship floating about twenty minutes after ten o'clock, the effort was made, and she was heaved into deep water.

Source:

Hughes, Thea S. 1981. *James Cook*. Sydney, Movement Publications pp. 39-43. (Italics added).

13. Monitoring tides 10-15 min. each • •

Topics/concepts
Tidal range
Diurnal tides
Semidiurnal tides

Skills
Snorkelling
Gathering data
Graphing data
Interpreting data

Attitudes
Interest in natural environment
Interest in methods of scientific enquiry

Aim

To consider the following questions about tide changes on the reef-top during your field trip:

- How far apart, in time, are high and low tides experienced on this reef-top?
- What is the difference in height between low- and high-tide water levels on this reef-top?
- Does water level on the reef-top change at a constant rate? If not, how does the rate of change vary?
- Is there a period of "slack" water on this reef-top? If so, how long does it last?
- Are the heights of two successive high tides the same? (optional)
- Are daytime high tides on two successive days the same height?
- Do daytime high tides occur at the same time each day?
- How does the tide data you've gathered compare with tide time predictions for your nearest main port?

Of all the processes which take place on the top of the reef, tide changes are among the most important. The growth and distribution of marine plants and animals are strongly influenced by tides. Tides affect the movement and depositing of sediments. For people, tides affect boating, reef-walking and other activities.

- *At high tide, water from the open ocean flows across the top of a reef bringing a supply of nutrients and dissolved oxygen to reef-top organisms. During a falling tide water flows in all directions off the reef-top until ultimately the reef rim, and some other parts of the reef-top, become exposed (figure 13.2). At low tide, the sea outside the reef may be at a lower level than water which is dammed up in pools or a lagoon on the reef-top. During the rising of a tide, water may not flow on to the top of a reef until it has risen as high as the reef rim. Then it may flood across the reef-top rather rapidly (figure 13.3).*
  For about half the tidal cycle, water in pools or a lagoon on a reef-top may stay at "slack water" — neither rising nor falling — for many hours. During this time, this water is isolated from the open ocean and cannot exchange materials with it.
- *On top of any reef, the pattern of water-level change owing to tides is likely to be unique and is unlikely to be the same as the pattern predicted for nearby mainland ports on tide tables.*
- *Official tide observations are made with automated tide gauges which are designed to record tides over long periods of time. However, useful observations of tide changes can be made with simple equipment.*

You will need

- Reef-walking and snorkelling gear
- Plastic string or tape marked in metres and with a heavy fishing sinker attached to one end
- Fieldsheet and pencil
- Tide tables for mainland port near reef
- Graph paper
- A waterproof watch
- Equipment as listed for measuring tide height by either of the two methods given below.

Equipment for method I

- A wharf pile, or one or more other vertical structures, fixed in reef-top. These could be stakes driven into the reef flat and sloping beach. If stakes are used, a hammer to drive them in will be needed and a clinometer or level.

- Measuring scale(s) marked in metres and tenths of metres. A thin strip of plastic or wood can be used as scale.
- Plastic tape to attach measuring scale to vertical support(s)
- Transparent plastic tube(s) about 1.25 cm diameter (see figure 13.4) (optional)

Equipment for method II

- Heavy weight — a loose boulder or even a lead weight from a weight belt
- A piece of string about 3 metres long
- A sealed empty plastic bottle to act as a float (e.g. 2-litre drink bottle)

This activity calls for hourly measurement of tide heights during daytime hours of two successive days. Each tide measurement may take about 10-15 minutes.

What to do

Setting up equipment (field work)

Method 1

If a wharf pile or other fixed vertical structure is available on the reef flat, it should be used for this activity. Otherwise, drive one or more stakes firmly into the reef-top at low tide. The location of one stake should be on the reef flat no more than 30 m from a beach and should be covered by some water at low tide (about 0.5 m depth is ideal). One or more other stakes could be driven into the lower part of the beach to allow for the full tidal range.

Attach a measuring scale to the vertical support(s) so that the lower end of the scale dips into the water. Attach the transparent plastic tube, if being used, and drop a coloured plastic bead into the tube so that it floats on the water surface.

Method II

Select a monitoring site about 10-30 m offshore at low tide. Place the loose boulder or heavy weight on the reef-top at this point. Attach about 2-3 m of string to the weight and tie the floating bottle to it as a marker buoy.

Gathering tide data (field work)

Every hour during daytime, record water levels at your monitoring point. Record data on the fieldsheet. Try to measure between small waves. (The job of collecting data can be shared out among group members. Two people will be needed to take each reading.)

Method I

Before starting, find out the distance from the base of the measuring scale on the stake or pile on the reef flat to the bottom of the water. Record. (If also using a stake or series of stakes driven into the beach, use a levelling line and clinometer or spirit level to help find out how high the base of the scale is above the bottom of the water at the reef flat stakes.)

Each hour, note water height on the measuring scale.

Method II

Using marked tape or string and a small weight to act as a plum-bob, measure total water depth at the monitoring site.

Analysing data

Plot your data on graph paper to produce tide curves for this reef-top. Answer the following:

1. Tide range
   (a) What was the difference in height between low- and high-water levels on day 1? on day 2?
   (b) What was the average difference?
2. Tide times
   (a) About how many hours apart were the high and low tides you measured on each day?
   (b) Approximately how many high tides do you think occur each 24-hr period at this reef?

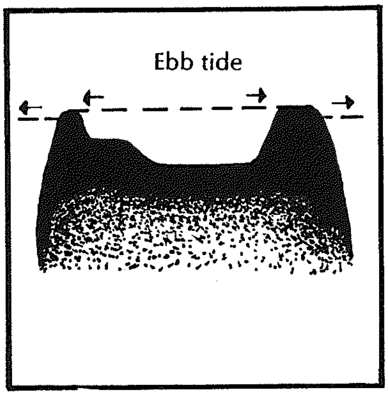


Fig. 13.1. Water flowing off reef-top as tide falls.

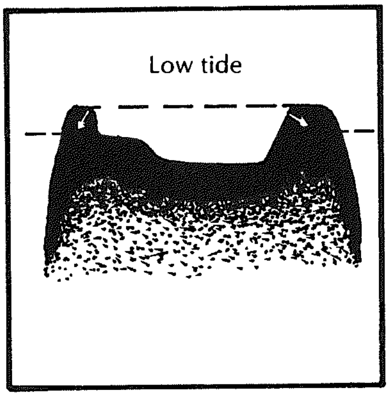


Fig. 13.2. Reef rim and other parts of reef-top exposed. Water leaking out through reef framework.

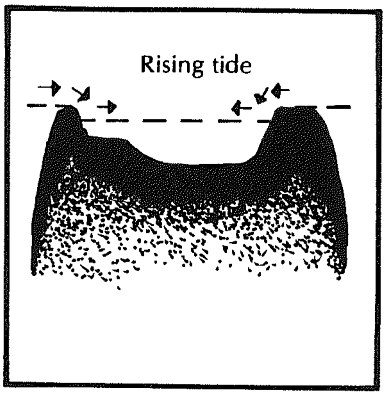


Fig. 13.3. Rapid flooding of reef-top when tide rises as high as the reef rim.

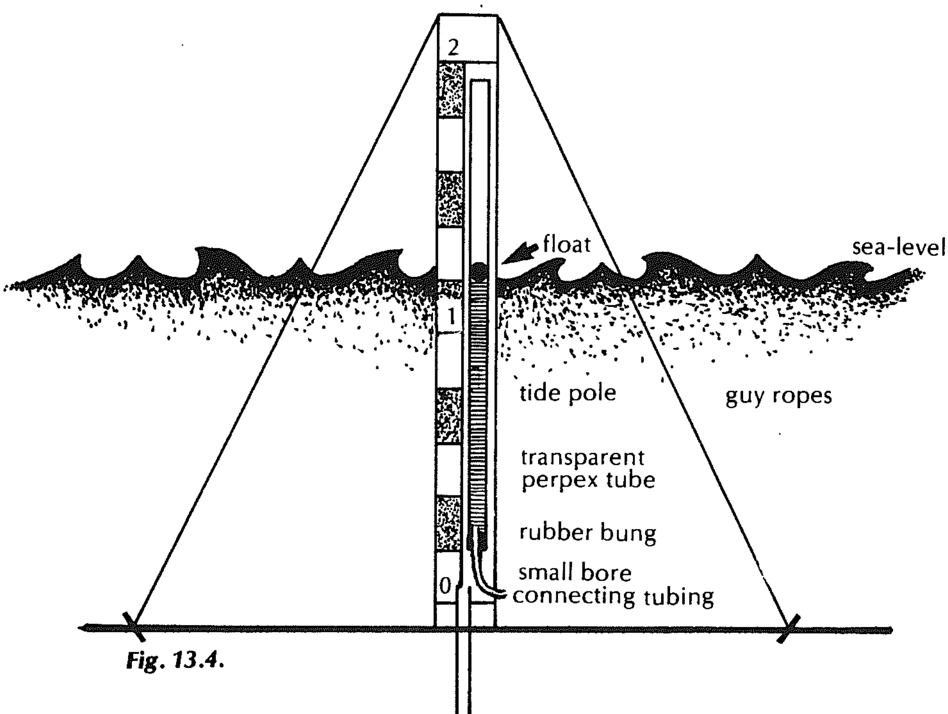


Fig. 13.4.

3. Rate of change of water level
   (a) Look at the tide curves you have drawn. Are some parts of the curves much flatter or steeper than others?
   (b) If so, use two coloured pencils to mark in the flattest and steepest parts of the curves.
   (c) When does water height change most rapidly on this reef-top?
   (d) Why is this important to people walking on reefs?
4. Exposure of the reef
   (a) From what you have seen of this reef at low tide, what zone of the reef-top, normally covered at high tide, is uncovered for the longest period of time during the tidal cycle?
   (b) Consider a clam living on the reef-top about 0.3 m above the lowest tide level you have measured. After being exposed on a falling tide, about how long would it be before this clam was covered again with water on the rising tide?
5. Comparison with tidal predictions for mainland
   Look at the tide chart for the mainland port nearest the reef you are visiting. Note the information given for the two days you've been making observations at the reef.
   (a) Do high tides at this reef occur at the same time as high tides at the nearest mainland port? If not, what is the difference in time?
   (b) How does the tidal range given for the mainland port compare with the differences in tide height you've measured on the reef top?
   (c) Suggest two reasons the values you've recorded might differ from those noted in the published tide chart.
6. Comparison with tide levels on reef slope
   (a) Do you think that height differences between one low tide and the next high would be the same on the reef-top as on the reef slope?
   (b) Why might this be worthwhile investigating?
   (c) How could you go about finding out?

Ideas for further things to do

7. Beach-width changes
   (a) Make hourly measurements of daytime changes in the width of a beach.
   (b) Make a graph showing how width of the beach changes during one daytime period.
   (c) Think of a way to measure the average angle of slope of the beach at this point.
   (d) Explain carefully how beach slope and changing beach width measurements can be used to calculate rises and falls in tide levels.
8. Tide changes in the reef slope area
   (a) Make some measurements of changes in water depth in a particular locality on the reef slope (for example, this could be done beside a particular buoy or a particular bommie). A depth line or diver's gauge could be used.
   (b) Ideally some of these measurements would be made at the same time and on the same day as the reef-top monitoring. Try to obtain some measurements when you anticipate the tide will be low or near low and some when you anticipate the tide will be high.
   (c) Compare the data with that obtained for the reef-top. What similarities and differences do you notice?
9. Reef-top corals
   (a) At a particular time (as close as possible to low tide) on the reef-top, measure heights to which coral colonies are exposed above water on the reef-top.
   (b) What is the maximum height?
   (c) Does the height vary with type of coral (e.g. colony of branching coral vs colony of smooth coral)?

   (A group of people could share the job of measuring a number of different colonies at the one time.)

10. Depth profile of reef-top
Have different members of your group spread out at stations along a transect across the reef-top. At a particular time, each person should measure the max. and min. depth of water present within a 1-metre-radius area around him/her. Use the information to make a depth profile of the reef-top.

13. Monitoring tides

Recorders: Locality: Date:

Day 1 Reading no.	Time	Date: Reading on scale*	Total depth**	Day 2 Reading no.	Time	Date: Reading on scale*	Total depth**

Note:
* If method I using pole(s) and scale is being used, distance between bottom of scale and reef floor must be recorded:
** If method II using depth line is being used, then total depth can be read directly.

14. Measuring currents 1½ hr • •

Concepts
Current
Direction
Speed
Tide

Skills
Observing
Using equipment
Recording and processing data

Attitudes
Persistence
Willingness to work in scientific manner

Aim

- To develop an awareness of water current patterns on and around the reef.

You will need

- Some empty plastic bottles with coloured caps, partly filled with sand so that they float mostly submerged
- A watch with second-hand
- A recording sheet
- Outline map of the reef
- Magnetic compass
- 50 m tape

What to do

1. Select a number of sites about 5 m offshore from a cay. Mark these on your map.
2. Select the times of two high tides to record your observations.
3. Draw up a data table for recording current speed and direction for the sites you choose.
4. (a) Working in small groups at each of the recording sites, estimate current speed by finding out the time a floating drink bottle takes to travel a set distance (say 50 m).
   (b) Observe the approximate direction of movement using a compass.
   (c) Collect all bottles used.
5. (a) Compile all data from class members and make two maps showing your data (arrows of different sizes for different speeds could be used as symbols on the map).
   (b) Is any pattern evident? Were results different on different days? If so, what is a possible explanation?
6. Repeat the procedure above, but carry out observations at various spots on the reef flat as the tide is falling and when water is shallow enough for wading. Is a pattern evident?

Ideas for further things to do

7. (a) At low tide, look at broken sticks of dead coral on the reef-top near the rim.
   (b) Do they appear to be aligned? Using a compass, make measurements of alignment at a number of places on the reef and plot these on a map.
   (c) Is any pattern evident? If so, might it be related to currents, do you think? What other kinds of water movement might be involved?
8. (a) In a boat moored at a spot over the reef slope, perform some simple current speed and direction measurements during falling and rising tides. Time the movement of something which floats attached to a line.
   (b) What is the maximum speed you record? Does the current direction on a rising tide differ from that during a falling tide?
9. Do some reading to help you find out how currents in the Great Barrier Reef are produced and how currents are important to people and other living things in the Great Barrier Reef.

15. It's tropical 1½ hr

Topics
Climate
Weather

Skills
Making graphs
Analysing data
Interpreting graphs

Attitudes
Appreciation of importance of collecting data
Interest in interrelationship of people and their environment

Aim

To explore the following questions:

- What temperature and rainfall conditions occur in the reef area?
- How are climates at the reef different from those in some other parts of Australia?
- How are people and other living things affected by rainfall and air temperature in the reef area?

You will need

- Millimetre graph paper
- Ruler
- Map of Queensland coast and Great Barrier Reef
- Calculator (optional)

Weather and climate are vital to anyone who lives in the Great Barrier Reef area or who goes there for a holiday. How much rain there is and how hot the weather is are two factors which certainly have a big effect on our comfort and enjoyment at the reef. The plants we see growing on reef islands or on the nearby mainland are also strongly influenced by rainfall and temperature and rain affects marine life by causing freshwater run-off from land.
Most of the Great Barrier Reef region lies north of the Tropic of Capricorn and has hot, moist climates. However, because the reef is more than 2000 km long, it spans several climatic zones, and climatic conditions vary considerably along its length.

What to do

A. Rainfall

1. Look at table 15.1 which shows rainfall of some places around Australia.
   (a) How does the yearly average rainfall of Cairns in north Queensland compare with the rainfall of the state capital city nearest your home? Can you find out the yearly average rainfall of the place where you live? How does this compare with Cairns rainfall?
   (b) Rainfall in Cairns is greater than that in Sydney. However, not only are the yearly totals rather different but the distribution of rainfall over the year is dissimilar.
   For each of these two cities, work out the percentage of the yearly total rainfall which occurs in each month of the year. Plot your data on two histogram graphs. Now write a few lines comparing rainfall distribution in the two places. (You might like to consider the following: What is the wettest four-month period in each city? What percentage of annual rainfall occurs in these periods?)
   (c) Look at the graphs of rainfall distribution at some places in the reef area (figure 15.1). Make sure you know where these places are on the map. How does the rainfall pattern at Lady Elliott Island in the south compare with that at Thursday Island, off Cape York, and Low Islands, off Port Douglas? Which of these islands' patterns least resembles that of Cairns?

Table 15.1: Mean annual rainfall and mean monthly rainfall for some Australian places.

	Mean annual	*Mean monthly data*											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Cairns	2032	424	441	449	190	94	47	28	27	34	38	87	173
Brisbane	1213	173	182	150	79	85	83	64	43	34	100	98	122
Sydney	1212	102	113	135	124	121	131	100	80	69	78	81	78
Melbourne	656	48	48	52	58	58	49	48	51	59	68	59	58
Adelaide	575	13	4	32	55	52	57	81	85	66	38	34	23
Perth	869	8	12	19	45	123	183	173	137	80	54	21	14
Darwin	1535	393	330	285	103	14	3	1	2	13	52	124	242
Alice Springs	285	38	45	34	14	17	15	17	12	10	22	25	36
Canberra	625	60	57	54	49	48	37	39	48	52	69	61	51

Source: Australian Bureau of Meteorology

The strong seasonality of rainfall in northern parts of Queensland is largely due to tropical cyclones which are common in the area between December and March. The influence of these diminishes to the south.

2. Look at the map of annual rainfall distribution in Queensland coastal areas of the reef region (figure 15.2).
   (a) What are the lines on the map called? What do they represent?
   (b) Isohyets in the area between Bundaberg and Cooktown run roughly parallel to the coast. Read the values of these isohyets carefully. What do they suggest to you about the general direction of origin of moisture which falls on the mainland coast?
   (c) Highest annual rainfall values of over 4000 mm occur in the Innisfail district. Here, high ranges occur close to the coast. What effect do you think these ranges might have on rainfall?
3. But do we know how much rain falls over the Great Barrier Reef itself? Rainfall maps of north Queensland area generally do not show isohyets over the sea. This is because not enough information has been able to be collected in the offshore areas. There are, however, recording stations on a few islands. Data collected at these give us some idea of whether rainfall in the offshore area is similar to that in the nearby coastal areas. The table below compares the rainfall at three islands with that at three nearby mainland points. Ratios of the rainfalls at three sets of places are given.

Low Islands/Port Douglas	=	1.02
Green Island/Cairns	=	1.09
Heron Island/Gladstone	=	0.98

   What is the maximum percentage difference shown here between rainfall of an island and a mainland point?

B. Temperature

4. North Queensland has a reputation for having a hot climate. Just how hot is it? What temperature statistics do you think we can use to get a good picture of temperature condition there?
   Look at table 15.2 which shows temperatures at some places in Australia.
   (a) Plot the monthly mean minimum and mean maximum temperatures for Cairns as two curves on a graph. Calculate the mean temperatures for each month and plot these as a third curve on the graph. From the monthly temperatures, calculate a figure for the mean annual temperature.
   (b) Repeat the processes above for the state capital city nearest where you live.
   (c) In a few lines, describe the main differences between temperature conditions in the two places.
5. Do temperature conditions change from north to south along the reef area? To help you answer this question, look at the diagram of temperature data from Thursday Island in the north and Lady Elliott Island in the south (figure 15.3).
   What do these graphs suggest about temperature differences between north and south of the reef area?
6. Are temperatures on islands of the reef noticeably different from those of the mainland? Examine the graphs of temperatures at Lady Elliott Island and nearby Gladstone (figure 15.4). How do the maximum temperatures of the two places differ? How do the minimum temperatures of the two places differ?
   At which place is the difference between maximum and minimum monthly temperatures less?
   What do you think might be the main reason for this?

C. Climate and people

7. For many overseas visitors to Australia, two musts are a trip to north Queensland to see the Great Barrier Reef and a visit to central Australia to see Ayers Rock.
   (a) How different is the total annual rainfall in Alice Springs from that in Cairns?
   (b) What major contrast in the scenery in these two areas do you think might be related to rainfall difference?
   (c) What kinds of temperature conditions would a person visiting Heron Island and Alice Springs in July need to be prepared for?
8. (a) As a publicity gimmick, travel companies have sometimes offered refunds to tourists whose holidays are spoiled by rain. From the data given in table 15.3, at which of the island tourist resorts listed is there most chance of having a rainy day?

Table 15.3: Rainfall data for various islands

	Mean annual rainfall (mm)	Mean number of rain days
Brampton Is.	1571	98
Lindeman Is.	1671	108
Hayman Is.	1496	105
Dunk Is.	3129	147
Green Is.	2139	109
Heron Is.	1069	136

   (b) From your other knowledge of Queensland climate, do you think your chance of having a rainy day at this resort might be higher in January or July?
9. People's needs are affected by climate. What are some household and personal things which people buy to make life enjoyable and comfortable in a tropical coastal city but which are not so imporant in a cool coastal city? What are some things more needed in a cool coastal city than in a tropical place? Make a short list for each kind of area.

D. Climate and vegetation

10. In the reef area, some islands such as Dunk Island support lush growth of tropical rainforest. Tropical rainforest is also widespread on the mainland coast. Some tourist operators offer "Reef and Rainforest" travel packages.

> *Tropical rainforest grows only in areas where total annual rainfall exceeds 1270 mm.*

   (a) On the rainfall map of north-eastern Australia (figure 15.2) mark in those areas where there is sufficient rainfall to allow tropical rainforest to grow.
   (b) What other factors do you think might limit the distribution of tropical rainforest at the present time?

E. Rainfall and the reef

11. Look at the graph in figure 15.5 which shows how salinity varies throughout the year in surface waters of the reef off Cairns.
   (a) Compare this graph with one which shows rainfall throughout the year in the same area (figure 15.6). What similarity is there in the main trends shown on the two graphs? What possible explanation can you offer for this?
   (b) Salinity measurements across the continental shelf indicate that salinity changes throughout the year are greatest close to the mainland. Why might this be?
   (c) Look at a map of the Queensland coast. Why do large freshwater inputs to reef waters occur at about latitudes 14° S, 20° S and 24° S?
   (d) What factor, apart from direct rainfall and run-off from the mainland, do you think might affect salinity of surface water in this area?

> *It is thought that many corals have a low tolerance to falls in salinity and to silt. This run-off after rain may be an important factor affecting coral distribution.*

Readings

Hopley, D. 1982. *The geomorphology of the Great Barrier Reef.* New York: John Wiley.

Pickard, G.L., Donguy, J.R., Nenin, C., and Rougerie, F. 1977. *A review of the physical oceanography of the Great Barrier Reef and western Coral Sea.* Australian Institute of Marine Science monograph series, vol. 1. Canberra: AGPS.

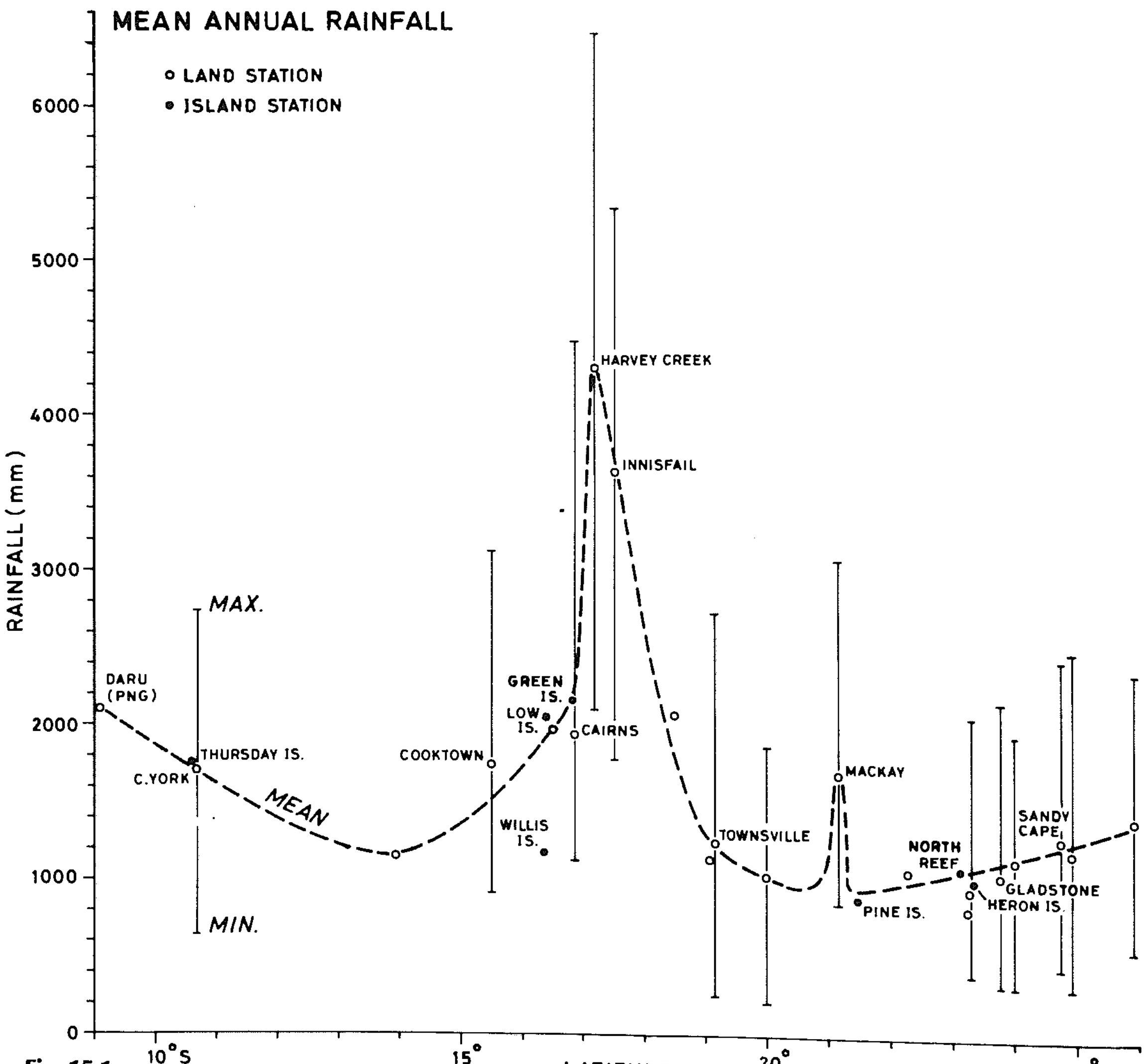


Fig. 15.1

Table 15.2:
Temperatures for some Australian places (monthly mean maximum and minimum temperatures, °C)

	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Cairns	31	24	31	24	30	23	29	22	27	20	26	18	26	17	26	17	28	19	29	20	31	22	31	23
Heron Island	30	25	30	25	29	24	27	23	25	21	22	18	21	17	23	18	25	19	27	21	28	22	30	24
Brisbane	29	21	29	21	28	20	27	17	24	14	21	11	21	9	22	10	24	13	26	16	27	18	29	20
Sydney	26	19	26	19	25	17	22	15	19	11	17	9	16	8	18	9	20	11	22	13	24	16	25	17
Melbourne	24	14	26	14	24	13	20	11	17	8	14	7	13	6	15	7	17	8	20	9	22	11	24	13
Adelaide	29	17	29	17	26	15	22	12	19	10	16	8	15	7	17	8	18	9	22	11	25	14	27	16
Perth	30	18	30	19	28	18	25	14	21	12	19	10	18	9	18	9	20	10	22	12	25	14	27	16
Darwin	32	25	32	25	33	25	33	24	33	23	32	21	31	20	32	21	33	23	34	25	34	26	34	26
Alice Springs	36	21	35	21	33	17	28	13	23	8	20	5	19	4	22	6	27	10	31	15	34	18	35	20
Canberra	28	13	27	13	25	11	18	7	15	3	12	1	11	0	13	1	16	2	19	6	23	8	26	11

Source: Australian Bureau of Meteorology

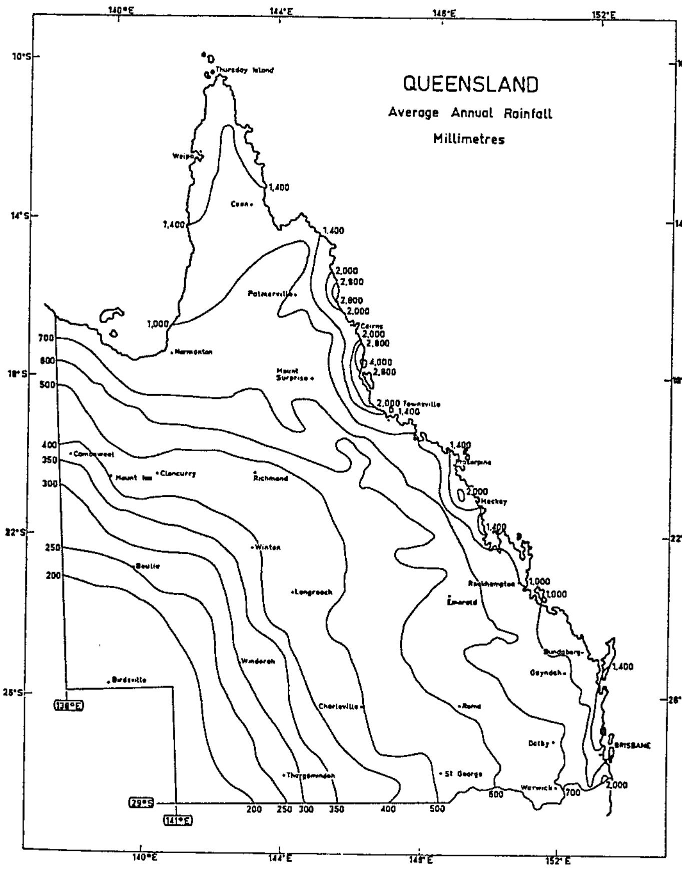


Fig. 15.2

The lines on the map show the average annual rainfall based on all years of record for selected stations.

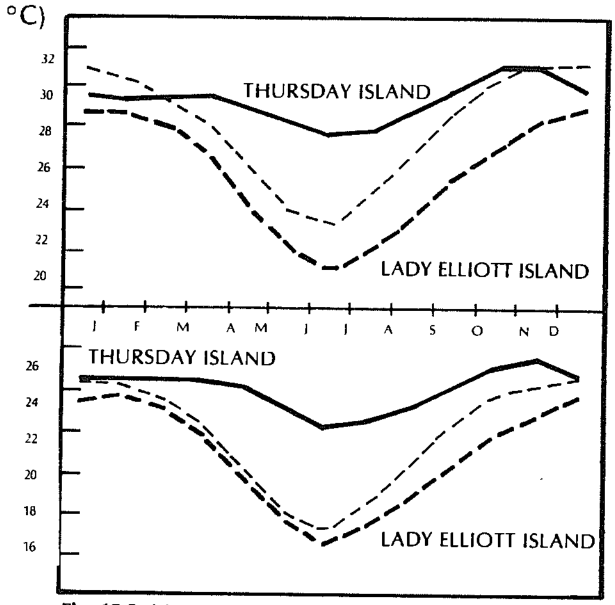


Fig. 15.3. *Mean maximum and minimum monthly temperatures for Thursday Island and Lady Elliott Island.*

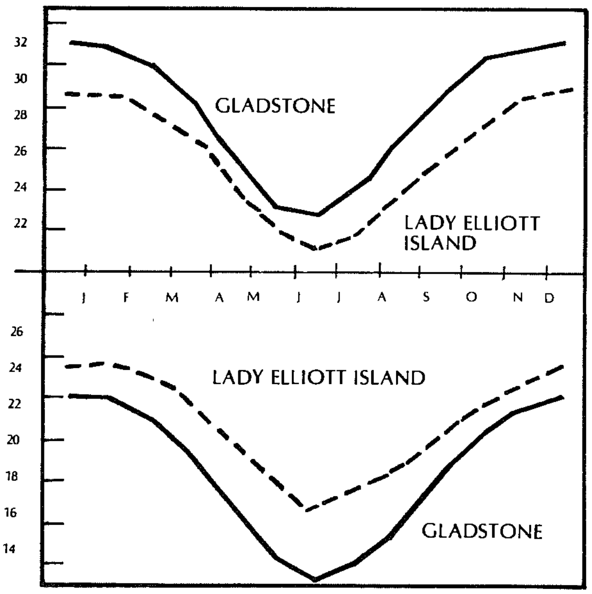


Fig. 15.4. *Mean maximum and minimum monthly temperatures for Lady Elliott Island and Gladstone.*

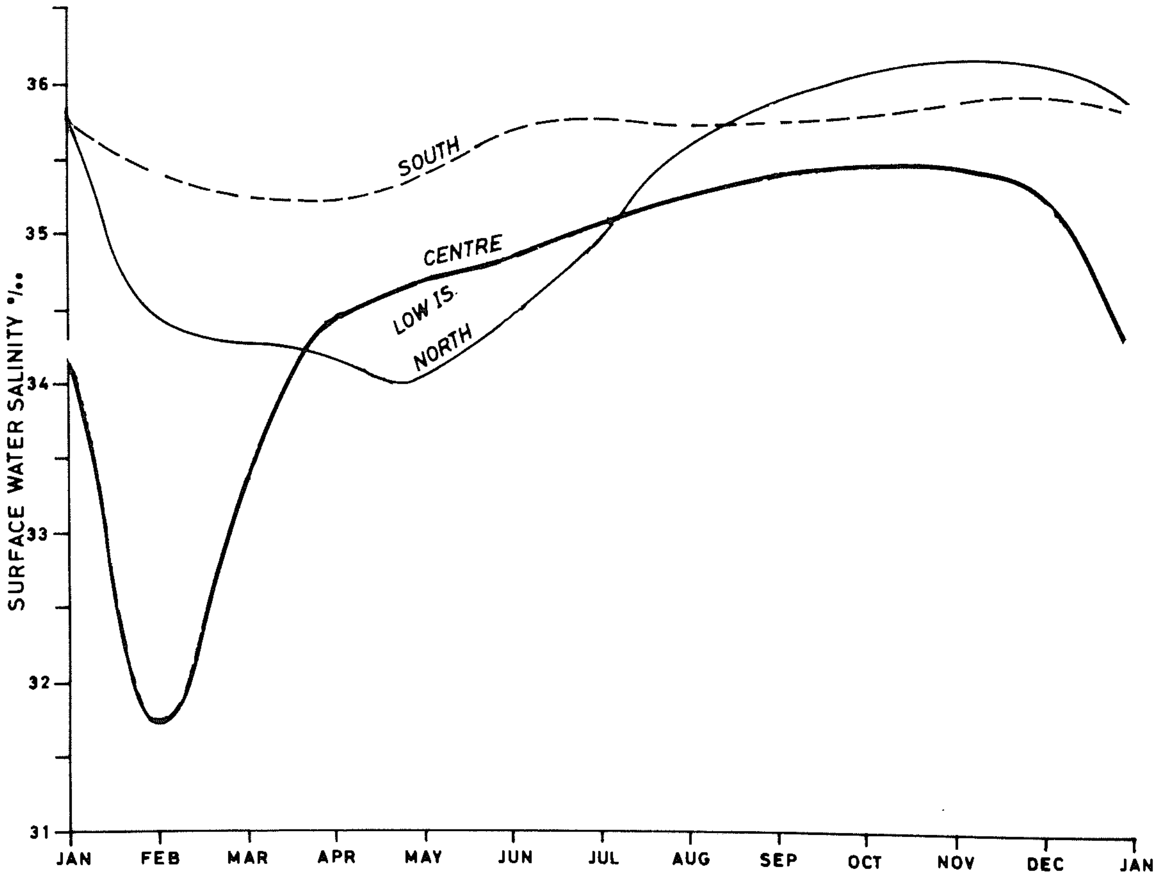


Fig. 15.5. Seasonal variations of water salinity in various parts of the Great Barrier Reef (from Pickard et al., 1977). The line labelled "centre" represents the Cairns region.

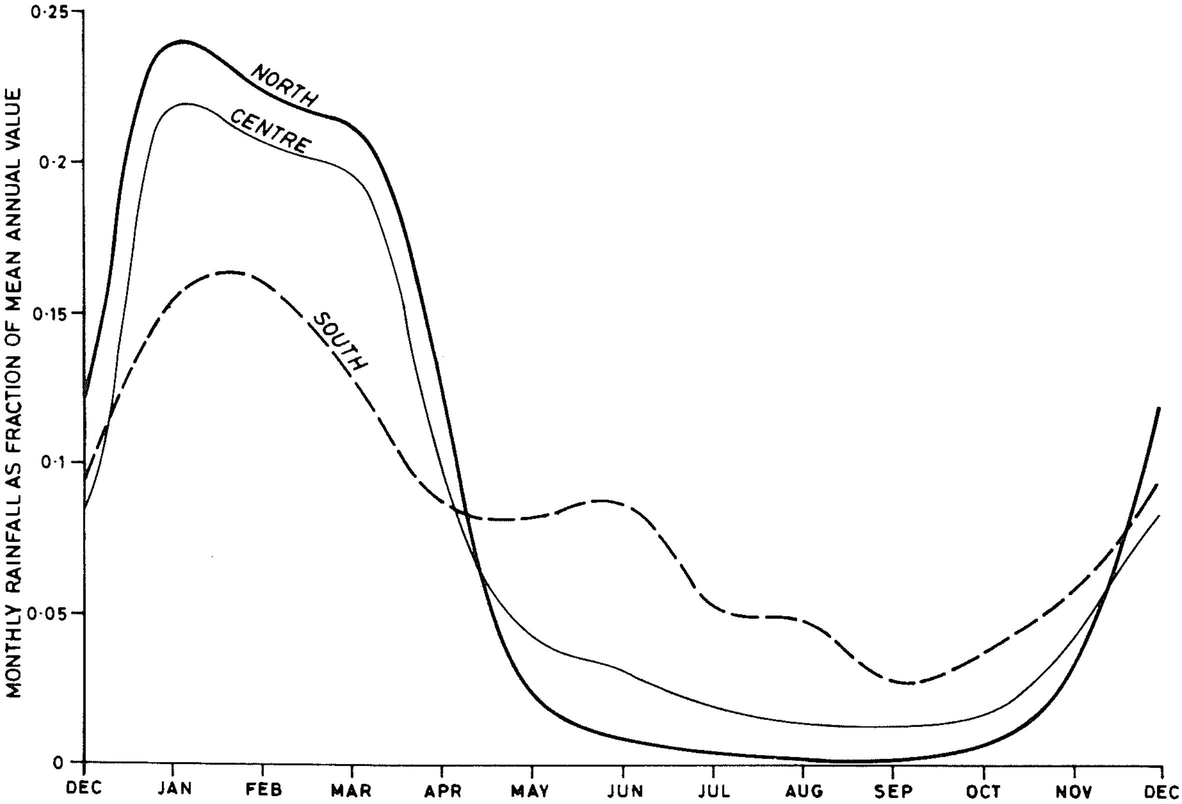


Fig. 15.6. Seasonal variations of rainfall in various parts of the Great Barrier Reef (from Pickard et al., 1977). The line labelled "centre" represents the Cairns region.

16. Weather station 20 min. twice each day •

Concepts
Temperature
Direction
Pressure
Relative humidity
Barometer
Ventimeter
Anemometer
Windrose

Skills
Observing
Measuring
Comparing
Graphing
Using equipment

Attitudes
Persistence
Responsibility
Appreciation of importance of gathering data

Aim

- To use equipment to collect data on weather variations during a visit to a reef island.
- To compare the weather conditions at this island during your visit with conditions at other places, and at other times, in the reef area.

You will need

- Watch
- Pencil
- Sheet to record data
- Weather instruments:
  - ventimeter, cup anemometer or other wind gauge
  - compass
  - wet-and-dry bulb thermometer or ordinary thermometer
  - simple barometer (optional)
  - rain gauge or an ordinary container to catch rain

What to do

1. Decide which of the following weather variables you will monitor during your trip:
   - air temperature (only an ordinary dry thermometer needed)
   - humidity (use wet-and-dry bulb thermometer)
   - wind speed
   - wind direction
   - atmospheric pressure
   - rainfall (amount can be measured if you have a rain gauge; otherwise, just record whether rain has fallen or not)
   - cloud cover percentage.
2. Make a plan to make measurements and record data twice throughout your trip each day (9 a.m. and 3 p.m. are best). Members of the group can take turns doing this. Draw up a table on which to record the data.
3. Make measurements and record data on graphs.
4. Construct morning and afternoon windroses to show the windspeed and wind direction data you've gathered (see figure 17.1 in activity 17).
   (a) What is the prevailing wind direction during your field trip?
   (b) Are morning and afternoon winds different?
   (c) Compare the windroses you've drawn up with those given in the literature (e.g. Hopley 1982) or Bureau of Meterology records:
      - for this or a nearby island at other times of the year.
      - for other parts of the Great Barrier Reef at this time of the year.
   (d) What might be the significance of those differences for people?
5. On how many days did rain fall during the trip?
6. Were morning and afternoon temperatures different?
7. What was the maximum temperature and the minimum temperature recorded during your trip?
8. Did morning and afternoon air pressure readings differ? Did changes in air pressure seem to be related to changes in other weather conditions?
9. Compare the temperature and humidity data you obtain with nearby mainland data for the same days (if obtainable). (Try the post office.) What differences do you note? How might people there have been feeling?
10. Using literature, compare your temperature data with that obtained in other parts of the reef at the same month of the year. What difference do you note? How might people have felt in those places?

11. Compare your temperature data with the temperatures which usually occur at this island or a nearby island at other times of the year. How much hotter and colder does the weather here usually get than it is now? Would that be comfortable?

Ideas for further things to do

12. The activity "Human Comfort on a Cay" (no. 116) could be done with this activity.

Readings

Bureau of Meteorology. 1984. *Observing the weather.* Canberra: AGPS.
Hopley, D. 1982. *The geomorphology of the Great Barrier Reef.* New York: John Wiley.

Notes

1. *Observing the Weather* shows the weather recording equipment and outlines the method for obtaining weather data used by the Bureau of Meteorology's network of cooperative weather observers.
2. Contact the Bureau of Meteorology in your nearest capital city regarding its data. Some reef islands have weather recording stations.
3. Hopley (1982) gives some regional climatic data.
4. Relative humidity is determined using difference between wet and dry bulb thermometer readings and a relative humidity data table (see Observing the Weather, p. 30).

17. Wind and waves 1½ hr

Concepts
Windrose
Prevailing wind
Swell
Windward
Leeward
Cay
Wave

Skills
Making and interpreting graphs

Attitudes
Interest in interconnections of abiotic and biotic components of ecosystems

Aim

To explore the following questions:

- How can we use graphs to show the patterns of winds which occur at a particular place?
- What are the predominant winds in the reef area?
- How are waves in reef waters related to wind?
- How is the structure of a reef related to prevailing winds?
- How is the distribution of living things on a reef related to prevailing winds?

You will need

- Protractor
- Ruler
- A published map of the Great Barrier Reef Region

It is hard to overexaggerate the importance of wind in the reef area. Winds bring rain to the reef, wind action affects plants on reef islands and wind blowing on the surface of the sea produces waves. For people using boats, winds are extremely important; they have a major effect on comfort and safety at sea.
Waves caused by wind are a major factor influencing the way marine plants and animals are distributed on a reef. They play a big part in the breaking-up of corals and other hard skeletons. They carry fragments of pulverised material across the top of a reef. The structure of a reef, and the way it develops, are thought to be greatly influenced by the action of waves.

What to do

Wind patterns

Feel the wind! Where is it coming from? How fast is it? How long will it blow for? A windrose is a graph which summarises wind information collected at a particular weather recording station. On the simple windrose shown in figure 17.1, the main winds observed at a station are shown as spoke-like lines. Wind directions are indicated by the directions of these lines (wind blows towards the dot). The length of a line indicates how frequently wind blows in that direction. The number beside the line indicates mean wind speed (km/hr).

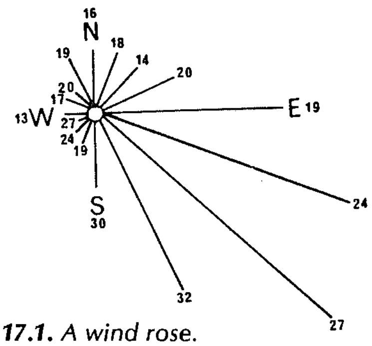


Fig. 17.1. *A wind rose.*

1. Figure 17.2 shows a windrose for September winds at Heron Island (3 p.m. readings).
   (a) What are the two main directions from which wind blows here?
   (b) What is the frequency (i.e., % occurrence) of September winds from each of these directions?
2. On the map in figure 17.3, winter windroses are given for a number of places in the reef area. From the windroses and the published map, find out which are the two directions from which the winter winds most frequently blow at each place.
   - Thursday Island
   - Holmes Reef
   - Willis Island
   - Lihou Reef
   - Cato Island
3. Figure 17.4 (a), (b) and (c) are proportional graphs which illustrate another way of showing the wind direction patterns throughout the year. From the graph, draw July windroses for each of these three places. Show only the two dominant wind directions on each windrose.

The regional wind pattern in the Great Barrier Reef area is for winds from the south-east or east to dominate throughout the year. (These south-east winds are sometimes called Trade Winds.) In the north of the area, north-west winds (sometimes called North-west Monsoons) are also important in summer.
Wind speeds in the reef area are generally less than 20 km/hr. In summer time, occasional tropical cyclones may pass through the area. Very high wind speeds may occur in these cyclones — as high as 150 km/hr or even more — and often great destruction is caused.

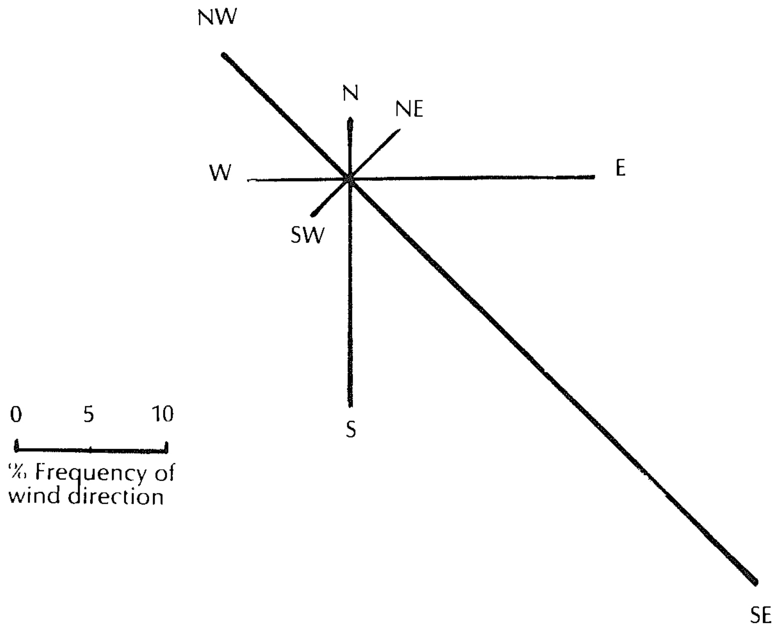


Fig. 17.2. *Windrose for Heron Island. September 3 p.m. readings.*

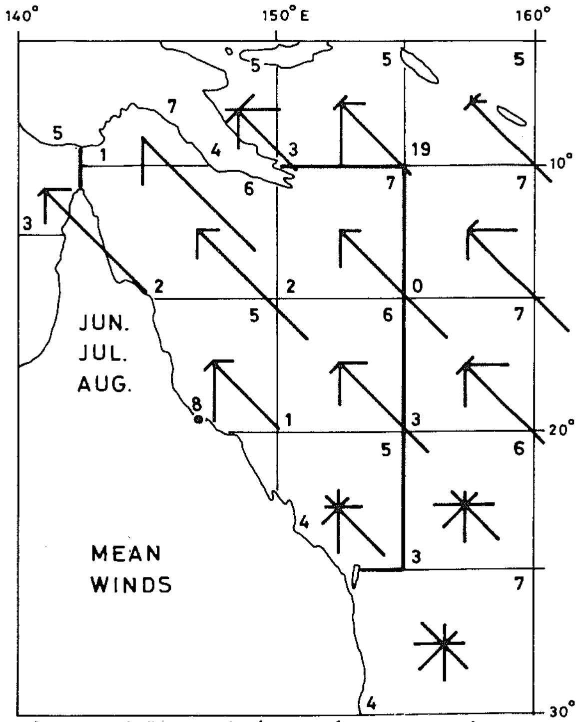


Fig. 17.3. Winter wind roses for various places in the Reef area (from Pickard et al., 1977).

Wind and waves

4. Get a dish of water and blow gently across the top of the water. What do you notice?

> *Wind blowing on the sea produces waves. The waves produced in a storm are short and choppy. The maximum height they can reach depends on wind speed, the length of time the wind keeps blowing and the distance wind blows across open water. Waves produced in a storm become transformed outside the storm area into long waves called swell which can travel long distances.*

5. Considering the prevailing wind direction in the area off the Queensland coast, what sides of a reef are most likely to be affected by the action of swell?

Wind, waves, reefs

Figure 17.5 shows maps of a number of different reefs in the Great Barrier Reef Marine Park. Cays are islands built up from sand or shingle (gravel) which is moved about on the reef top by waves. Prevailing winds are from the south-east.

6. On the maps, mark with arrows the prevailing wind directions and label the windward and leeward sides of each reef.
7. Are sand cays located closer to the windward or leeward sides of the reef-top?
8. Are gravel cays located close to the windward or leeward sides?
9. How do the leeward and windward sides of a reef differ?
   (a) On which side is the reef slope steeper?
   (b) On which side are pinnacles or bommies developed?
10. For visitors to a reef, snorkelling or scuba diving along the reef front is a favourite way to view underwater scenery. On which side of a reef do you think this is safer — the windward or leeward side?

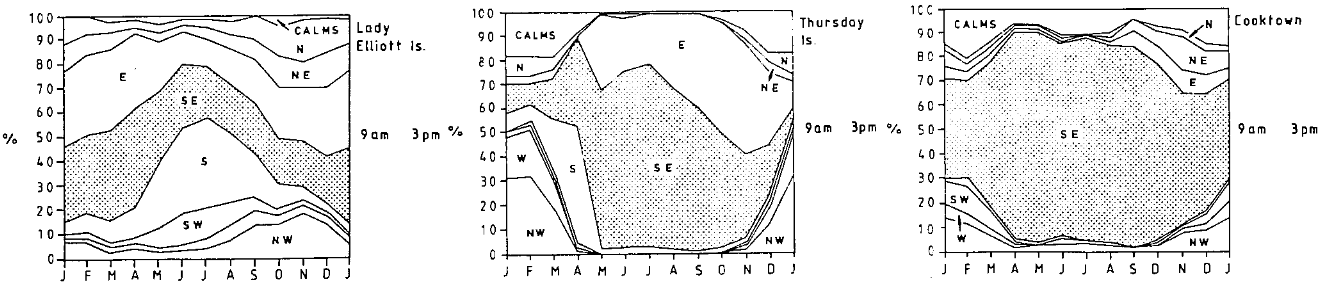


Fig. 17.4

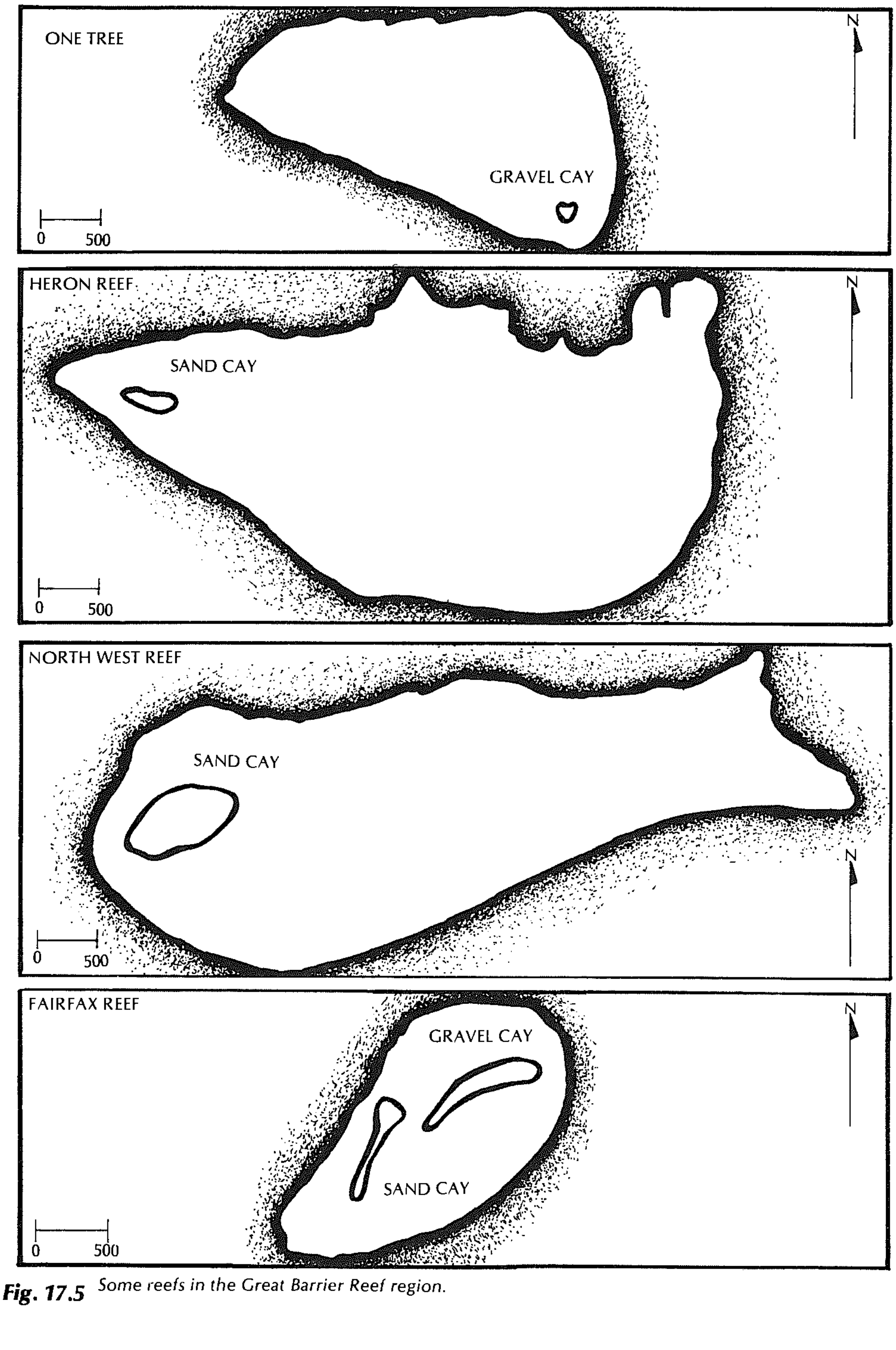


Fig. 17.5 *Some reefs in the Great Barrier Reef region.*

Reef, cay, island structures

18. Air photo interpretation 1½ hr • •

Concepts
Aerial photograph
Scale
Direction
Reef-top
Zone
Ground truth
Satellite imagery

Skills
Interpreting air photo
Using stereo viewer
Hypothesising

Attitudes
Willingness to work with new technology

Aim

- To use an air photo to make a preliminary map of reef-top features. Then to check out the truth of the map by looking at the reef itself.

You will need

- Air photo(s) of the reef or island you are visiting (vertical photos, taken from directly above, are needed)
- Pocket stereoviewer (optional)
- Clipboard
- Piece of plastic tracing film or good-quality tracing paper
- Compass and tape for field work (optional)
- Sharp pencil, rubber
- Reef-walking gear

This activity can be done in conjunction with other reef-walking activities.

To understand the Great Barrier Reef, we need to look at it in many different ways. Some of its features can be seen only at close range. But, for other features, a "bird's-eye" view may be better.
Photographs taken from planes or satellites are now used extensively to provide information about natural features of the Great Barrier Reef and about human activities in the reef area. As in mainland areas, air photos are used in the making of maps of the Great Barrier Reef.
An air photo is an important tool in any field study of an individual reef or island. Air photographs of most reefs and islands in the Great Barrier Reef area can be obtained from government authorities.

What to do

A. Beginning to explore the air photo (classroom)

1. Try to find out the following information about any air photo you are using. Make a record of it. (The margin of the photo may help.)
   (a) When was the photo taken?
   (b) What is the direction of magnetic north on the photo?
   (c) From how high above sea-level was the photo taken?
   (d) What is the scale of the photo? This can be worked out as follows:
   $$\text{Scale} = \frac{\text{Height above ground level}}{\text{Focal length of lens used}}$$
   (Focal length is given on the margin of the photo.)
   (e) What is the reference number of the photograph? The run number and the number of the individual photo should be noted.
2. If you, or other members of your group, are using several adjacent or overlapping photos of the reef-top, it's a good idea to spend a few minutes arranging all the photos on a table to get a composite picture of the reef's top.
3. If you have two overlapping photos of a particular area of the reef top, you can use a pocket stereoviewer to give you a three-dimensional (stereo) image of the area. Try it out!

B. Making a preliminary map (classroom)

4. (a) Look at one air photo. It should show part of the reef-top extending from beach to the seaward edge of the reef.
   - Pick out the beach and the seaward edge of the reef.
   - Are there any areas of apparent deep water, such as pools or a lagoon, on the reef-top?
   - Do there seem to be any distinct zones on the other parts of the reef-top? What do you think these zones might be? (Discuss with others.)

   (b) Make a tracing of the air photo showing the beach and reef edge.
   - Draw in the boundaries of any zones you can see on the reef-top.
   - Dot in the position of any apparent deep-water areas.

When tracing from an air photo, use tracing paper big enough to cover the whole photo. Hold it in place with sticky tape. Trim it to fit. Draw the margins of the air photo on your tracing. Show north.

C. Ground-truthing (field work)

5. Walk out across the reef-top from the beach to the reef edge in the area covered by your map. (If possible, take the air photo with you — but it should be sealed in plastic.) Try to check out what the apparent zones you have seen in the air photo really are. How do they differ from one another? (Are they, for example, high areas; low areas; areas covered with coral growth; bare areas; sandy areas; gravel banks; boulder banks; algae growths or ... what?) You may like to use a compass and a tape measure to find out exactly the direction you're walking from the beach — and the distance.
6. Check out apparent deep-water areas on your map. What are they?

D. Finalising the map (classroom)

7. On your tracing paper, label the zones and other features you've observed in the field. Write brief notes on the features which make each zone distinctive.
8. How did your preliminary ideas about these zones compare with the "ground truth"?
9. What do you think are the advantages of using an air photo to help in the making of a map? (Discuss with others.)

Ideas for further things to do

Now your group could try activity no. 73, "Reef-top Transect".

Reading

Green, C., and Milne, T. 1979. *The stereo atlas of Australia — aerial photographs and map interpretation.* Adelaide: Rigby. (The introductory section of this book provides useful information on using air photos.)

19. Reef and island cross-sections 1-1½ hr • •

Concepts
Scale
Distance
Topography
Bathymetry
Contour line
Profile
Vertical exaggeration
Shelf reef
Cay
Continental

Skills
Map reading
Measuring
Calculating
Drawing

Attitudes
Willingness to work with precision

Aim

To draw, and compare, topographic profiles of:

- a shelf reef and cay
- a continental island.

You will need

- Topographic maps showing a reef with cay and a continental island (e.g. Heron Island and Lizard Island)
- Ruler, pencil
- Graph paper

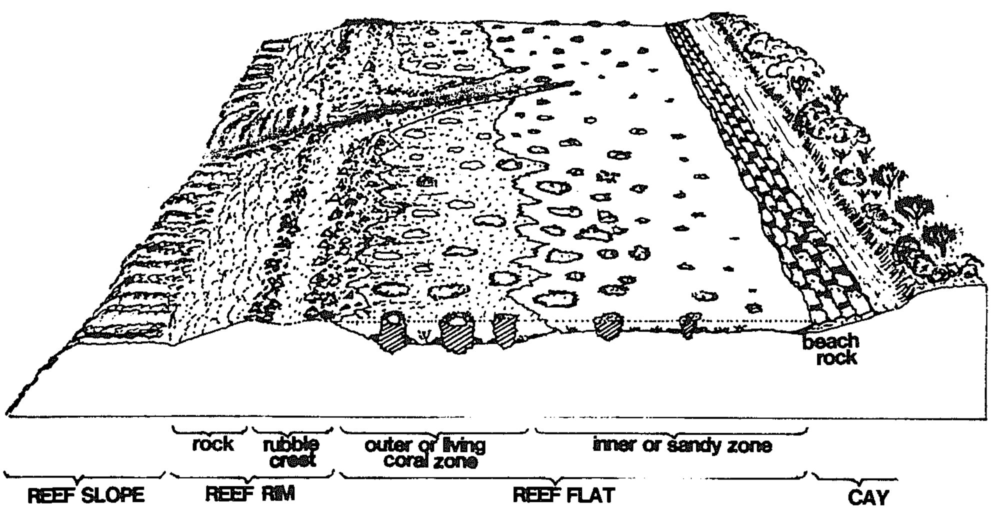
What to do

1. Look at each map and decide where you will draw your cross-section. A line A-B drawn across the map is used to indicate the position of the cross-section.
2. On graph paper draw horizontal and vertical axes for your profile, making allowance for the maximum height and greatest depths which occur. The horizontal axis represents distance A-B on the map. The vertical axis represents the height above and below sea-level in metres. (You will need to decide whether to use the same scale for both vertical and horizontal axes. It will probably be best if at first you draw the cross-section with a large vertical exaggeration —see information at the end of the activity. Later, for comparison, you could repeat the cross-section using the same scale for both axes so that there is no vertical exaggeration.) (figure 19.1)
3. Lay the edge of a piece of loose paper along the section line A-B on your map. With a pencil, mark off each point where the paper crosses a contour line. Label each contour line value. Then transfer the points on to the horizontal of the graph you've drawn (figure 19.2).
4. Above each of the points marked on the horizontal axis of your cross-section, draw in a light cross. Join the crosses to form the topographic cross-section (figure 19.3).
5. Draw cross-sections of the other map(s).
6. If time allows, repeat, using less vertical exaggeration.

Questions to consider

7. Think about advantages and disadvantages of using vertical exaggeration greater than 1. Does a profile drawn with a considerable vertical exaggeration give a true picture of slopes, or is steepness exaggerated? If two profiles are drawn with the same vertical exaggeration, can they be used for comparing slopes?
8. Using the profiles you've drawn, compare the underwater slopes around a continental island with those around an offshore reef. What differences do you notice?
9. How does the height above sea-level of the cay differ from that of the continental island? Why are cays so vulnerable during storms?

> *INFORMATION*
> *The vertical exaggeration (VE) of a cross-section is the ratio of the vertical scale to the horizontal scale.*
>
> $$VE = \frac{\text{Vertical scale}}{\text{Horizontal scale}}$$
>
> *If both scales are identical, then VE = 1; if the vertical scale is greater than the horizontal scale, then VE will be greater than 1. For example, if both scales are 1 cm = 100 metres, then VE = 1, but if the horizontal scale is 1 cm = 100 metres and the vertical scale is 1 cm = 500 metres, then VE = 5.*



Schematic cross-section of reef

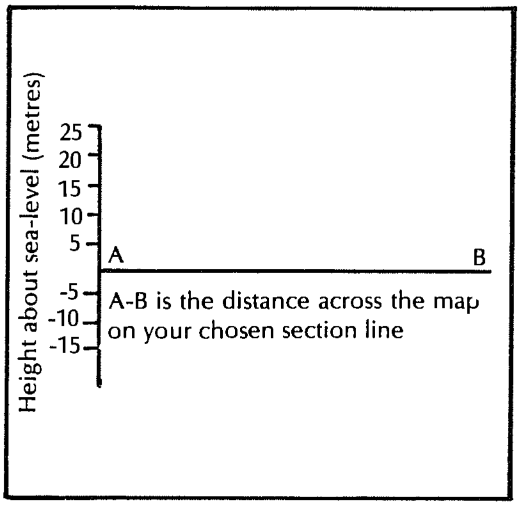


Fig. 19.1.

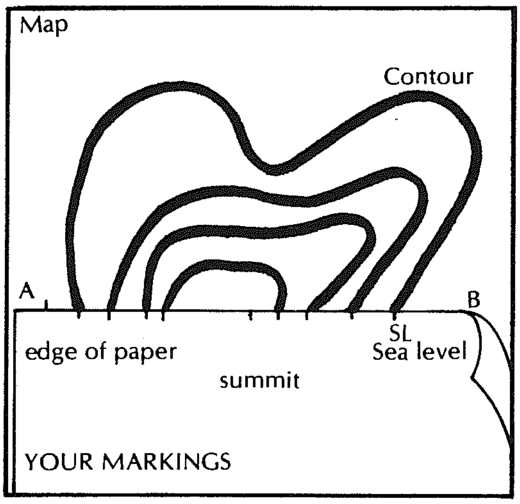


Fig. 19.2.

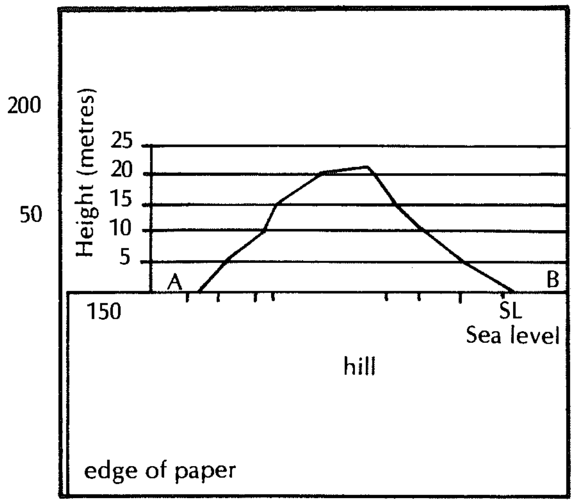
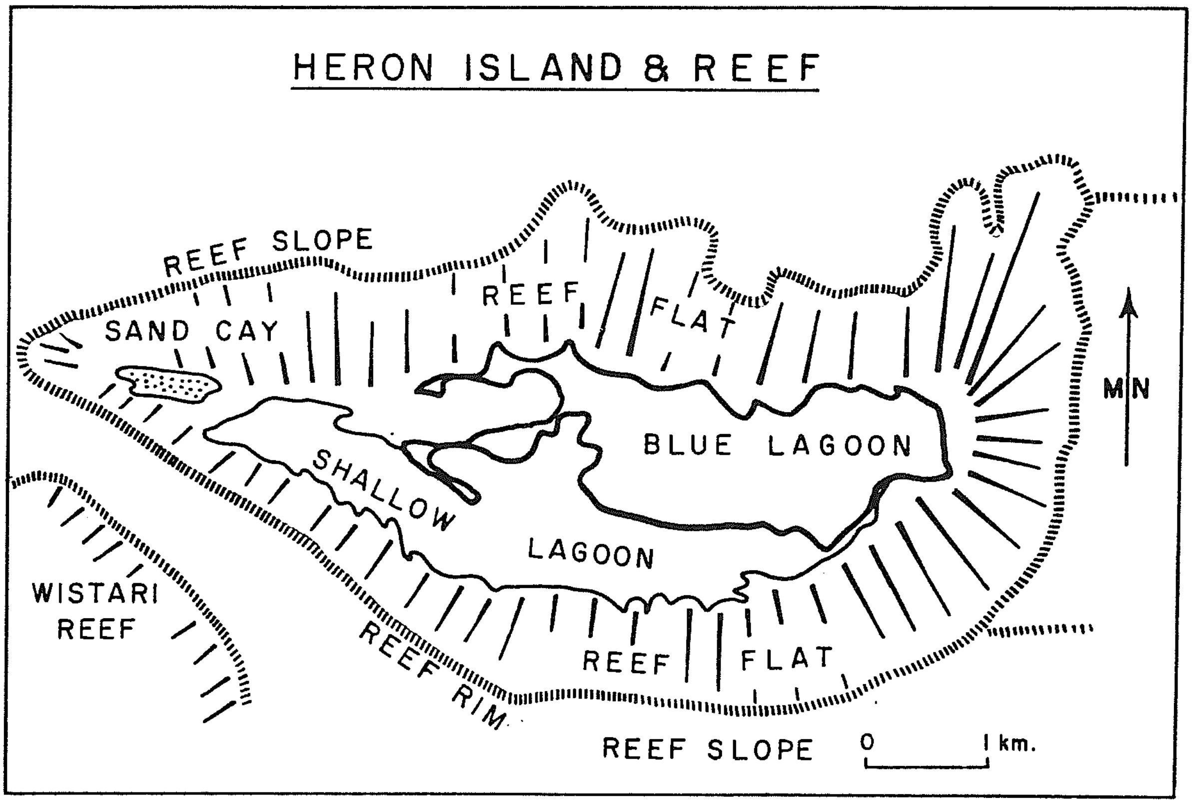
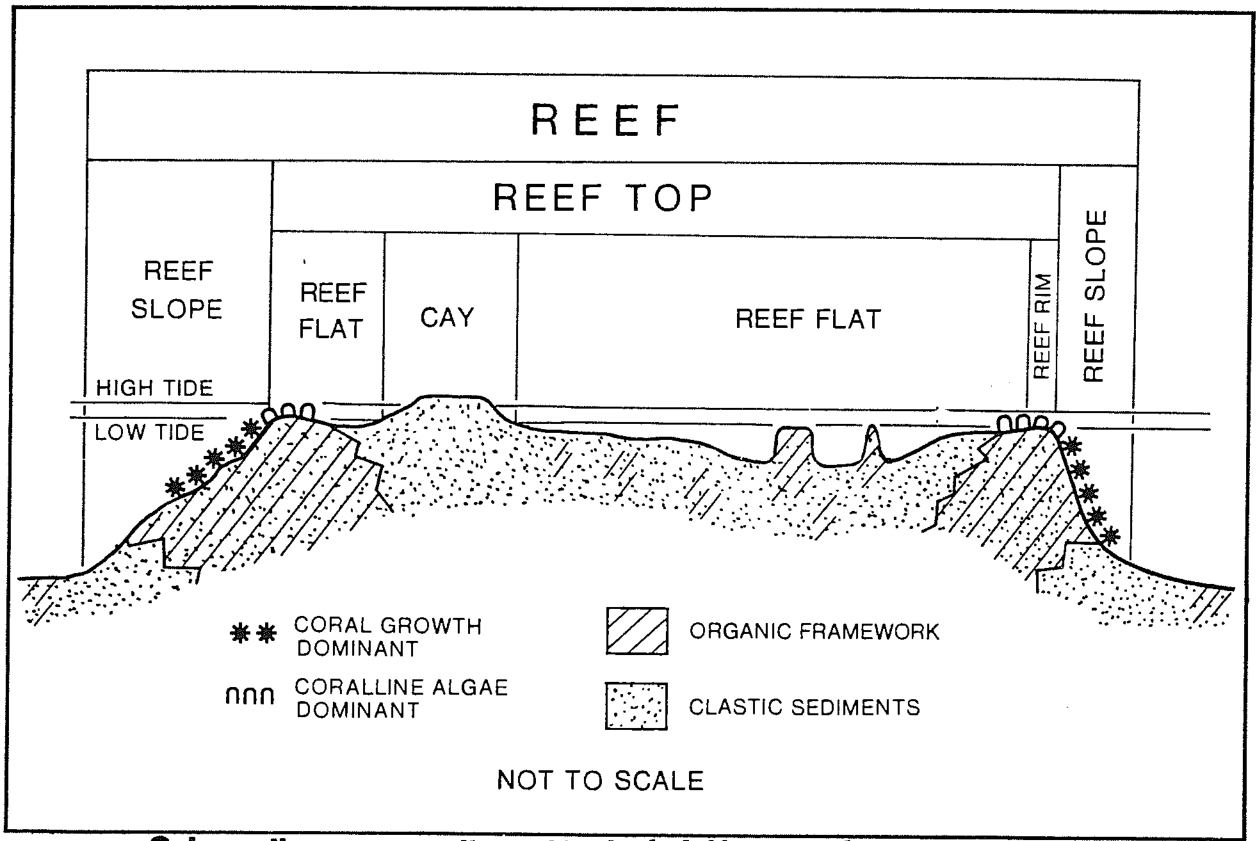


Fig. 19.3.





Schematic cross-section of typical platform reef in Capricorn-Bunker Group

20. Formation and development of a cay 1½ hr

Concepts
Cay
Prevailing wind
Leeward
Windward
Refraction
Shingle
Sand
Humans
Succession
Climax
Zone

Skills
Analysing
Applying information

Attitudes
Interest in natural environments

Aim

To explore the following questions:

- How does a cay form?
- What changes take place as a cay develops?

You will need

- Pencil and paper
- Airphoto of a reef (optional)
- Shallow tray (e.g. baking dish) and water (optional)
- Plasticine or wood (optional)
- Clipboard

> *A cay is a low island formed on the top of a reef from broken-up skeletons of coral and other reef life. Some cays are made of sand; some from coarse debris, shingle; others are mixed sand and shingle.*

What to do

Waves are important in forming a cay

Words to choose from:
south-east
break up
north-west
gain
refraction
lose

1. Read the following paragraphs and, after discussion among your group, choose the appropriate words or phrases from the list given at left to fill the gaps:
   (a) Waves beating on the front of the reef   coral and other living things and bring debris up on to the reef-top, especially during storms.
   (b) Since prevailing winds in the Great Barrier Reef area are from the   , greatest wave attack comes from this direction.
   (c) As waves approach the reef front, they are bent as they enter shallowing water. This process of bending is called   .
   (d) Waves which break on the reef rim   most of their energy. They pass on to the reef into shallow water and travel across the reef-top. In the shallow water they are transformed into smaller waves and are refracted (bent).

Words to choose from:
leeward
sand cay
shingle cay
diverge
greater
less
converge

2. Read the following paragraphs and, after discussion with others, choose the suitable words or phrases from the list given at left to fill the gaps:
   (a) Moving water can transport sand, gravel and other reef sediment. The   the energy of the water, the coarser the sediment it can carry.
   (b) Most of the coarse debris brought up by waves on to a reef is dumped near the reef rim on the windward side of the reef. This coarse debris may build up to form a   .
   (c) Finer debris, such as sand, is transported across the reef-top to the   side of the reef-top.
   (d) Because of the refraction of waves, waves coming from different directions may meet (i.e.,   ) at a point on the leeward side of the reef-top.
   (e) If this happens (i.e., if the waves "bump into one another"), water velocity is reduced. Water no longer has enough energy to carry the sand, so it is deposited forming a

Wind also moves sediment

3. Wind blows some sand up on to a cay from the reef-top at low tide. Find out the name for ridges of windblown sand.
   Do you think windblown sand is likely to be coarser or finer than beach sand deposited from water?

Storms are important

4. Much of the movement of sediment on a reef-top seems to take place during major storms. During a storm, waves may bring much sediment up on to the edges of a cay forming a ridge. Do you think that sediment transported in waves in storm conditions is likely to be coarser or finer than sediment transported in non-storm conditions?

Stages of development of a cay

5. Look at table 20.1 showing information about three cays in the Great Barrier Reef area near Cairns.
   (a) Which of these cays:
   - is smallest?
   - is largest?
   - has trees in its vegetation?
   - has the greatest area of bare sand?
   - has some plants but no trees?
   - is most likely to be unstable?

   (b) Which of these cays is most like a newly formed cay?
   (c) Which of these cays seems to be at the most mature stage of development?
   (d) Which of the cays corresponds to each of the following cay development stages:
   - Early-stage cay
   - Intermediate-stage cay
   - Mature-stage cay

   (e) Find out the names of two other mature-stage cays in the Great Barrier Reef area.

Table 20.1: Information on three cays near Cairns

	Area m^2	*Vegetation*	*% area vegetated*
Green Is.	139 100	heavy vegetation including a forest zone (114 species of vascular plants)	84
Michaelmas Cay	29 030	herbs and grasses (5 species of vascular plants)	26
Arlington Is.	4 600	generally unvegetated	0

The coming of birds and plants

Words to choose from:
quartz
guano
nesting place
phosphates
gravel
dead
calcium carbonate

6. Read the following sentences and, after discussion, complete the sentences by choosing appropriate words from the list at left to fill the spaces:
   (a) The sand which makes up a newly formed sand cay is almost entirely which comes from the hard skeletons of coral and other forms of reef life.
   (b) As the cay becomes larger, and rises above sea-level, seabirds begin to use it as a .
   (c) They help to change the island's composition by adding their waste droppings, , and by leaving scraps of food.
   (d) bodies of birds and seashore creatures may also be added to the cay.
   (e) Gradually a thin layer of humus develops on the cay. Important materials present in the humus include some nitrates and .

Words to choose from:
wind
birds
flotsam
digestive tract
jetsam

7. Choose words from the list given at left to complete each of the statements below:
   (a) Plant parts or seeds which can travel to a cay by floating in sea water, e.g. octopus bush, coconut, are referred to as .
   (b) Plants which have seeds that are sticky or have hooks can arrive at a cay attached to .
   (c) Some seeds are carried to a cay via the of a bird or other animal.
   (d) The can carry winged seeds to an island.

Words to choose from:
humus
grasses and creepers
ring
shifting
bind
salt-tolerant
shrubs
animals
Pisonia

A vegetation succession

8. Choose words from the list at left to fill the spaces below:
   (a) The first plants to colonise a cay are   which can cope with harsh conditions. They are   and drought-resistant. They are able to withstand high temperatures, sand and wind. They can live in the sand even though it is poor in phosphates and nitrates. They provide food for some   which migrate to the cay. They also contribute material to the   of the cay when they die. The changes to the island brought about by the first colonies create conditions in which other types of plants can grow.
   (b) Then   may begin to grow: octopus bush *(Argusia)* and fan flower *(Scaevola)* may be among these.
   (c) Finally, a forest of tall trees such as   , *Cordia* and *Casuarina* may become established on the interior of the island.
   (d) The final pattern of vegetation may be an interior forest zone, surrounded by a   of shrubs, surrounded by an outer zone of herbs and grasses.
9. Survival problems for plants on a cay include the seven listed in the left-hand column in table 20.2. Changes brought about by early colonisers of a cay help to reduce these problems for later arrivals.
   Use lines joining the columns to show which of the survival problems each of the changes listed helps to reduce for later plants. (Each letter may be used more than once.)

Table 20.2

Survival problems for plants	Changes produced by early plants
1. Exposure to drying winds. 2. Exposure to high temperatures. 3. Risk of being sand-blasted. 4. Low concentrations of nitrates in soil. 5. Exposure to salt spray. 6. Poor moisture holding capacity of soil. 7. Risk of being buried or totally uncovered by moving sand.	A. Some plants 'fix' nitrogen from the atmosphere using bacteria which live in lumps (nodules) on their roots. When plants die, their bodies form humus. B. Foliage of plants create shade. C. Roots of grasses and other plants help to bind sand. D. Vegetation acts as a wind break.

10. As different plant types follow one another in becoming established on the island, distinct vegetation zones may form on the island.
    (a) Figure 20.1 shows a sketch and cross-section of an island with a beach and the following vegetation zones:
        - grass and herb zone
        - shrub zone
        - forest zone.

        Label each of the zones on the diagrams.
    (b) What do you think might happen to each of these zones if the cay was to get larger?

Animals on cays

Words to choose from:
insects
waves
wind
swim
blown
fly
fish
parasites
logs

11. Animals arrive at a cay in a variety of ways. In the sentences below, choose suitable words from the list given at left to fill the spaces.
    (a) Seabirds mostly   in.
    (b) Land birds and shore birds fly in or are   in.
    (c) Winged   also arrive by air.
    (d) Some flightless insects, spiders and other arthropods are probably blow in by
    (e) Some invertebrates which are   arrive attached to birds or other animals.
    (f) A few animals arrive by swimming there (e.g. turtles) or by floating on objects such as

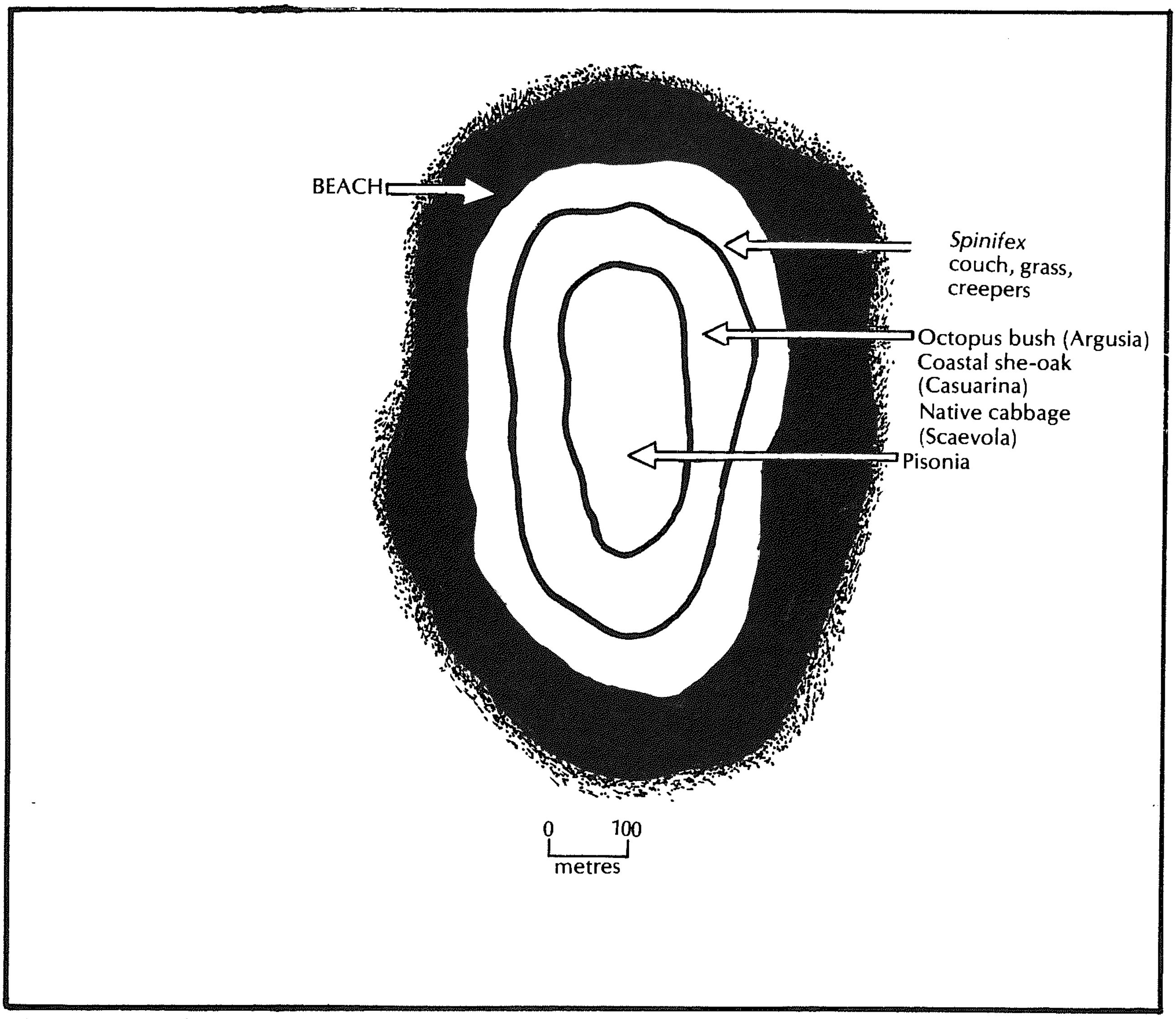


Fig. 20.1. *Vegetation zones on a cay.*

12. Below are shown food chains involving living things found on islands.

A. Algae → fish → seabird

B. Algae → fish → seashore crab → seabird

C. Tree → leaf-eating insect → land bird

(a) A producer is a living thing which makes its own food by trapping sun energy during photosynthesis. A consumer cannot make its own food. It consumes other living things to get energy.
Label the living things shown in the food chains above to show whether they are producers or consumers.

(b) A herbivore eats plants; a carnivore eats animals; an omnivore eats plants and animals.
Label any consumers in the food chains shown which are herbivores.

(c) Which of the food chains shown above could not occur on a newly formed cay? Why?

(d) Why is it that carnivores are the dominant animals in early formed cays?

(e) From what environment does the material eaten by the cay animals in food chains A and B come?

Fresh water changes cays

13. Fresh water which falls on a cay helps vegetation to become established by:
    - providing moisture which plants absorb through their roots.
    - seeping down through the sand washing away sea-salt.
    - dissolving humus material and taking it underground.

    (a) On cays which have minium diameters of greater than 100 m, a lens of fresh water develops in the subsurface. Which of the cays in figure 20.2 below is likely to have a lens of fresh water?

    (b) If a cay does not have a subsurface fresh water lens, the only plants which can grow on it are salt-resistant herbs and grasses. Of the islands shown in figure 20.2 which will not develop a vegetation of shrubs and trees?

14. Fresh water also dissolves calcium carbonate and phosphate from cay material and deposits it elsewhere. This calcium carbonate and phosphate form cement which joins sand or other debris together to form rock.

    (a) What do you think is the major source of the phosphate on a coral cay?

    (b) Find out the names of some ocean islands from which Australia imports phosphate rock for fertiliser.

Cays change shape

15. (a) Small unconsolidated cays are very mobile. Figure 20.3 shows how one cay moved about over an 8-year period. Use coloured pencils to show the different positions of the cay and number the cay positions from oldest (1) to youngest (5).

    (b) The edges of large vegetated cays also change. Figure 20.4 shows a cay before and after a cyclone. Use coloured pencils and labels on the diagram to highlight what happened to this cay.

    (c) Beaches on cays may also change shape because of seasonal change in wind direction. Figure 20.5 shows a cay in two seasons. Use coloured pencils and labels to highlight what happened to the cay.

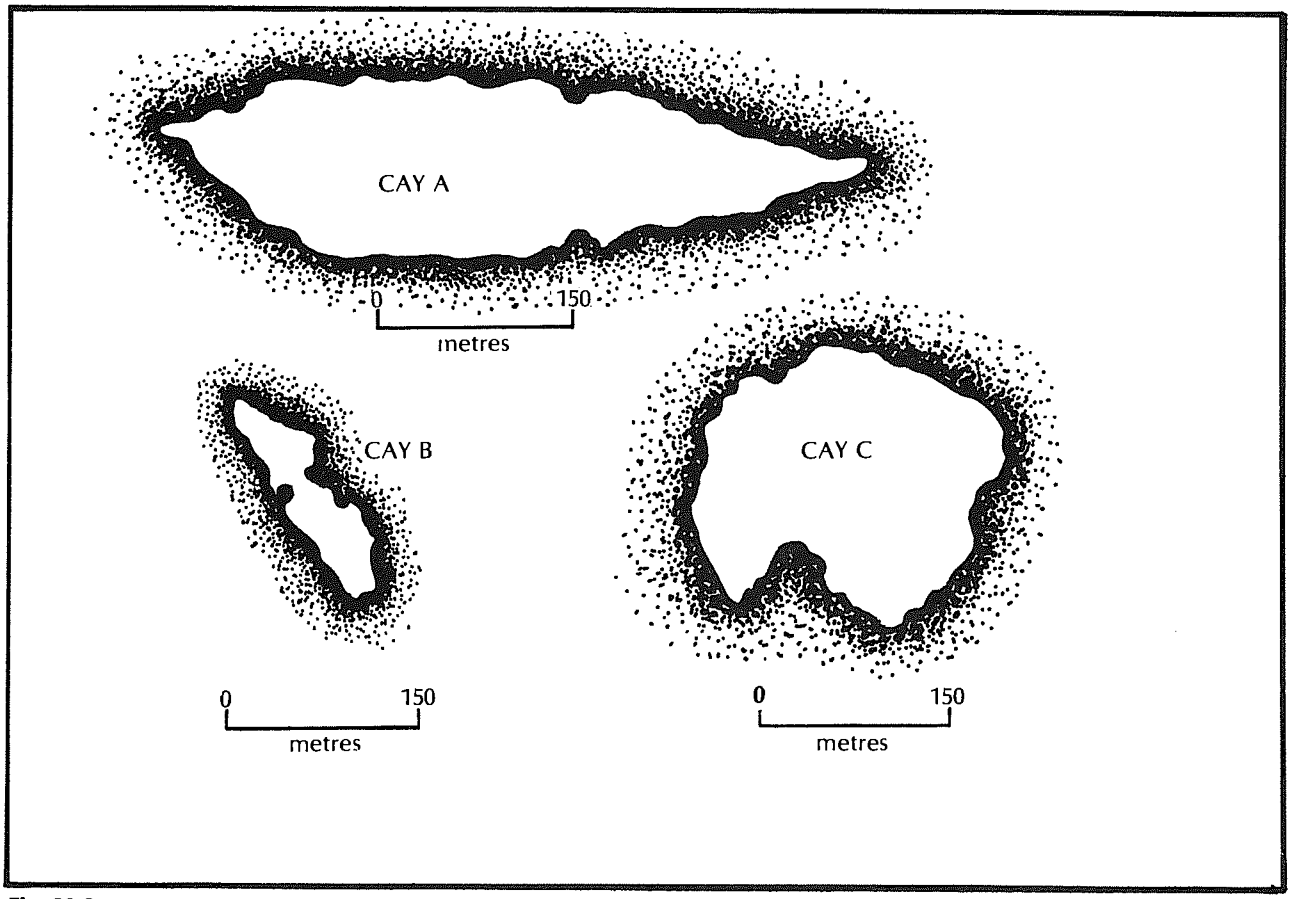


Fig. 20.2.

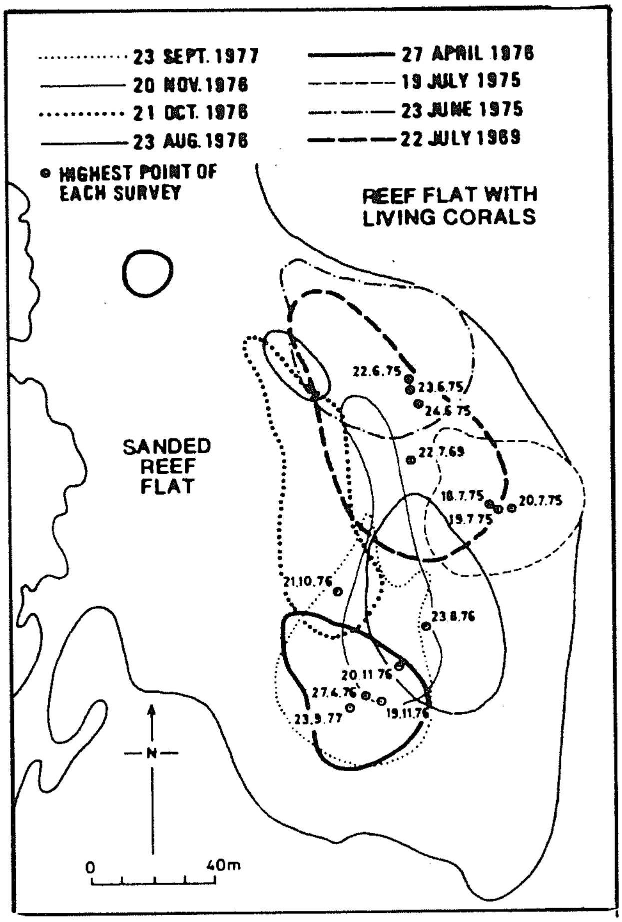


Fig. 20.3

Rock on a cay

16. Sand or other material can become cemented together in several ways to form rock on a cay. Three important types are shown in table 20.3.

Table 20.3

Type of rock	Where generally found	Type of cement and how deposited
Dune rock	Cay interior	Calcium carbonate deposited from fresh water
Cay rock	Cay interior	Phosphate from bird guano
Beach rock	On beach	Aragonite (a type of calcium carbonate) deposited from sea water

(a) If rock develops on a cay, do you think this helps make the cay more stable? Why or why not?

(b) Beach rock is thought to develop under cover of sand in the intertidal zone (i.e., between high- and low-tide level). But on many cays, this rock is exposed to our view on the beach. What kind of change to the cays does this possibly indicate?

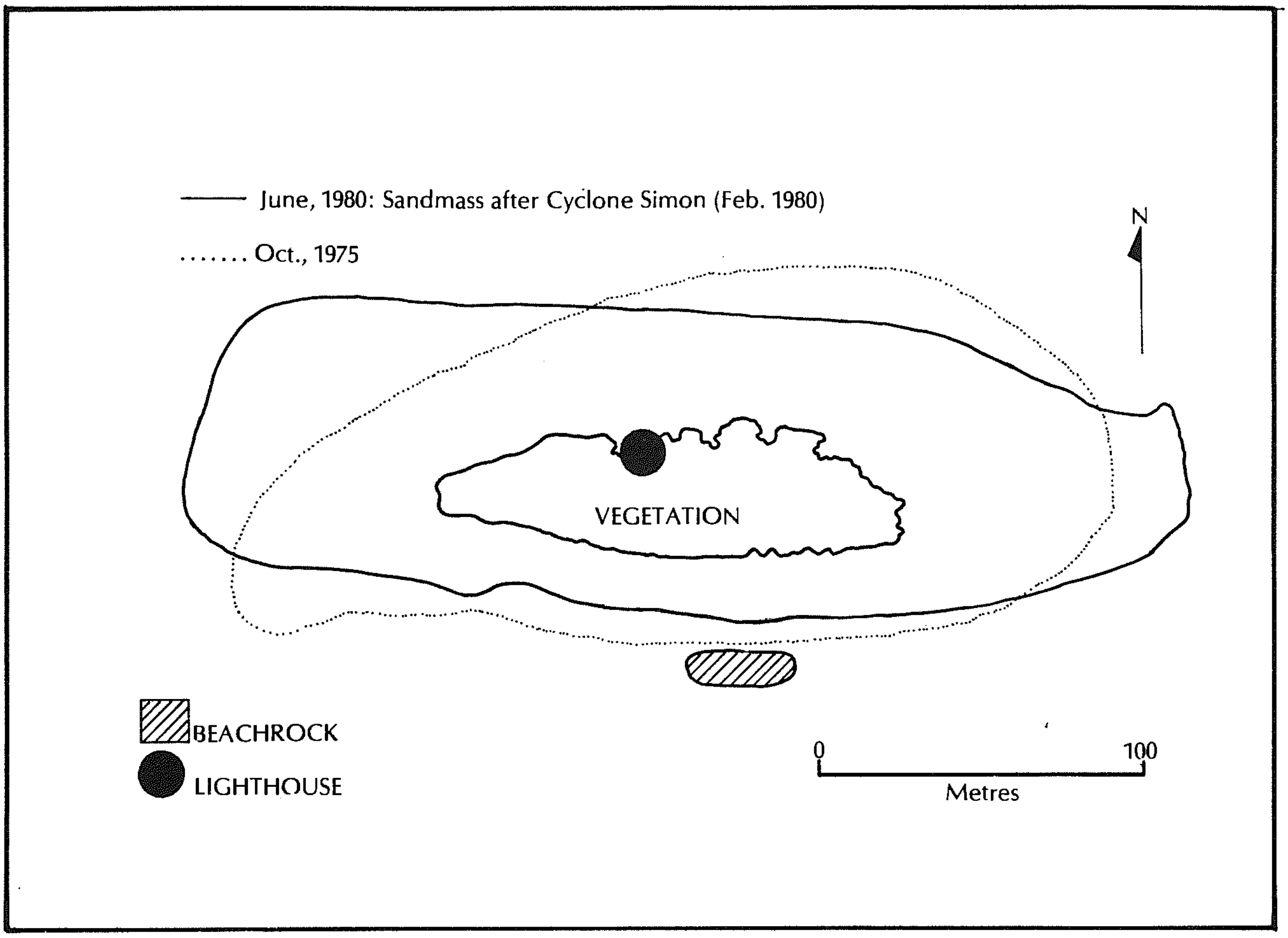
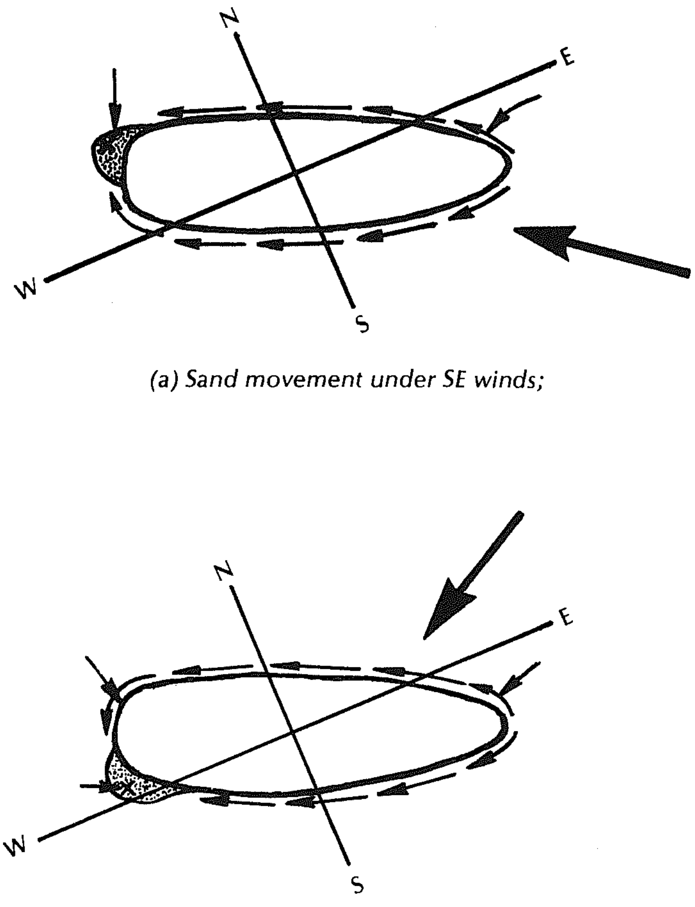


Fig. 20.4. *North Reef sand cay, 1974-1980.*

Ideas for further things to do

17. Obtain a vertical air photo which shows waves approaching a reef. Can you see waves bending and changing direction in the air photo? If possible, make a tracing of the outline of the reef, and draw in some of the most easy-to-see wave crests. Attach your tracing to these sheets.
18. Get a shallow tray of water and put into it a flat slab of plasticine or wood, or some other solid material, to represent a submerged reef. The "reef" should be just below the surface of the water in the tray. Using a ruler, make waves which travel towards the reef. Look at what happens to the waves. Do you see bending? You could make a sketch of the wave pattern.
19. Make a series of labelled diagrams showing how a cay might change from the time it forms initially to the stage when it has a tall forest.
20. Once a cay has formed as a bare sand island, how does it need the sea to help it become a heavily vegetated cay?
21. People change cays. Make a list of some ways in which people have caused and are causing change to cays in the Great Barrier Reef. If possible, read literature to help you (e.g. Hopley 1985).
22. Read some literature (e.g. Hopley 1985) to find out how old some Great Barrier Reef cays are. What technique is used to help us find the age of a cay?



(a) Sand movement under SE winds;

(b) Sand movement under NE winds.

Fig. 20.5.

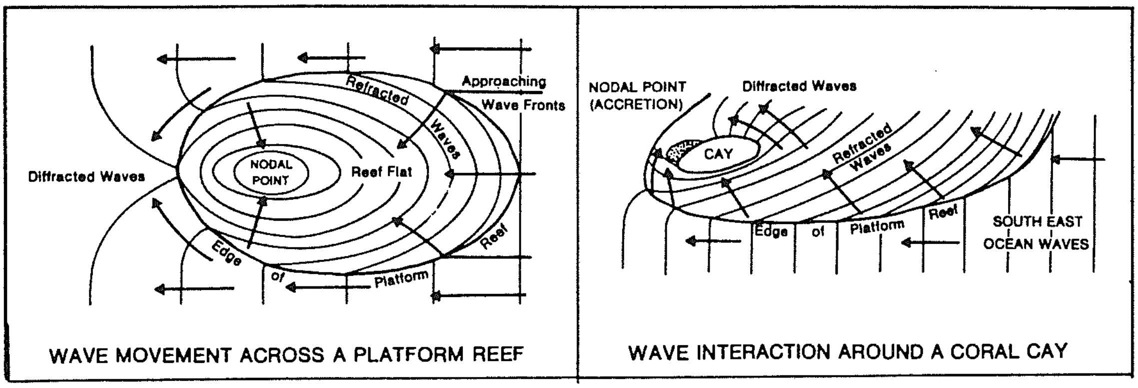


Fig. 20.6

Readings

Fosberg, F. 1976. Coral island vegetation. In *Biology and geology of coral reefs,* ed. O.A. Jones and R. Endean, vol. 3, Biology 2. New York: Academic Press.

Heatwole, H. 1976. The ecology and biogeography of coral cays. In *Biology and geology of coral reefs. See* Fosberg 1976.

Hopley, D. 1982. *The geomorphology of the Great Barrier Reef.* New York: John Wiley.

Hopley, D. 1985. *Coral cays.* Townsville: Great Barrier Reef Marine Park Authority.

Talbot, F., ed. 1984. *Reader's Digest book of the Great Barrier Reef.* Sydney: Reader's Digest.

21. Getting down to the nitty gritty 2 hr

Concepts
Sediment
Sand
Gravel
Calcium carbonate

Skills
Using lens or microscope
Classifying

Attitudes
Interest in natural phenomena

Aim

- To consider the composition, size, shape and origin of sand grains and other sediment on a cay beach.

You will need

- Two small plastic bags
- A hand lens (or a stereo microscope, if available)
- A piece of transparent self-adhesive plastic about 10 cm square
- A plastic dropper bottle of dilute hydrochloric acid (optional)
- A piece of plastic fly-mesh
- A piece of mm graph paper

Feel that crunch beneath your feet as you walk around the beach! Brush yourself down after sitting on the sand. Look closely now — what is the sand made up of? Where does it come from?

What to do

1. Walk around the beach and collect two samples of dry beach material (a very small handful of each will do).
   One sample should be sand and the other coarser material if you can find it. (You might like to use your sieve to get the coarser material.)
2. Look at the material carefully, using your hand lens (or microscope).
   (a) What size are the coarsest grains you've collected and what size are the finest?
   (b) Do all the grains seem to be made of the same chemical substance. Think up some ways you might find out. Smell? Crush? Look at the colour? One thing which might help is to add a little acid to some of the grains. How do they react? What does the result mean?
   (c) Can you see any clues as to the origin of this material. Do all the grains have the same shape? Can you recognise fragments of the skeletons of reef animals or plants? If so, is it easier to recognise these in the fine or coarse material?
   (d) What kinds of living things produced any skeletal fragments in your sample? Where do you think the material has come from and how has it reached the beach?

Some years ago, reef research workers attempted to find out if there had been severe infestations of crown-of-thorns starfish on the Great Barrier Reef in the past. The way they did this was to look for fragments of crown-of-thorns skeletons in samples of ancient Great Barrier Reef sediments collected from drill holes. Before they could do this, they had to become thoroughly acquainted with the kinds of pieces which a crown-of-thorns skeleton breaks up into and how these pieces change in appearance as they are tumbled about on the reef.

3. Would you be able to recognise different-sized pieces of a particular kind of skeleton? Test yourself by looking out on the reef for different-sized (large, medium, small) pieces of broken:
   - gastropod ("snail") shell or
   - clam shell or
   - honeycomb coral or
   - fine coral or
   - staghorn coral or
   - sea urchin or
   - tube worm.

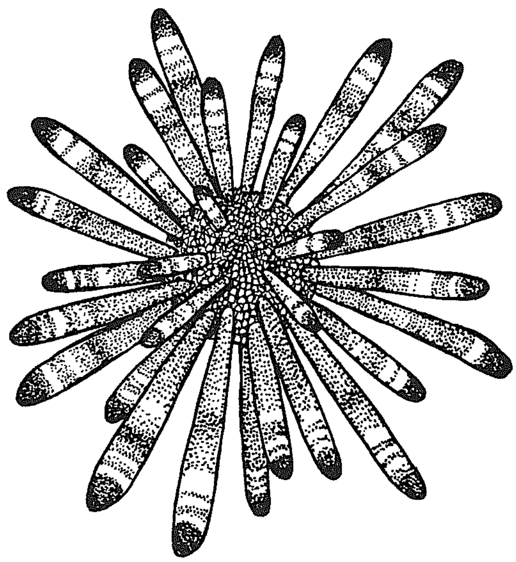
   Make a series of sketches showing how one of these skeleton types breaks down into smaller pieces.

Ideas for further things to do

4. Design a simple experiment to find out which types of reef skeletons break up most easily as they are carried around on the reef.
5. Use reference material to find out the relative contribution different organisms make to reef sediment (per cent composition).
6. Use a set of sieves with different mesh sizes to work out the grain size distribution of a beach sand sample. (To do this you will also need something to measure sand fractions — either by mass or by volume.) Plot your size data on a histogram. Compere grain size distributions of sediments from different parts of cay and reef. Can you find any systematic pattern?

Reference

Hopley, D. 1982. *The geomorphology of the Great Barrier Reef.* New York: John Wiley.



Urchin - Heterocentrotus mammillatus

22. Sediment rain 1-1½ hr x 2 ● ●

Concepts
Sediment
Distribution
Interaction

Skills
Observing
Measuring
Recording
Analysing

Attitudes
Interest in methods of enquiry in science

Aim

- To find out whether the amount of sediment raining down is different on different parts of the reef flat.

You will need

- Reef-walking gear
- Small plastic specimen tubes (about 2 cm diameter) with holes drilled near upper rim (35 mm film canisters or cut down vinegar bottles can be used. The holes can be drilled with a hot nail.)
- Strong twine or wire
- Air photo of reef-top (optional)
- Knotted 20 m rope (optional)
- A suitable permit
- Small boat for use at night tide (optional)

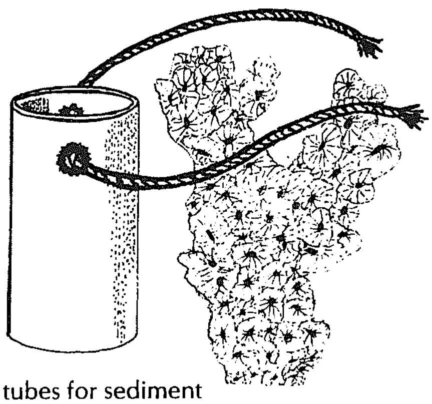
This activity requires two sessions each of about 1-1½ hours on the reef flat at low tide. One session should be at the beginning of your trip, the other at the end.

> *The amount of sediment raining down from above may affect the distribution of plants and animals on a reef. If different amounts of sediment rain down on different parts of the reef, this could possibly be one factor influencing the relative distribution of corals and fleshy algae on a reef flat.*

What to do

1. Across the reef flat, put out a series of open plastic tubes attached to fixed objects (e.g. boulders, iron slabs). The tubes should be held in place using, for example, wire or tape threaded through holes near the top of the tube.
   The mouths of the tubes should all be at the same tidal level (e.g. slightly below the upper limit of coral growth on the reef flat). It may be useful to set out the sediment traps along a transect line if used for other study.
2. After a number of days, collect the tubes. (Or check the tubes daily at low tide and, if a boat is available, at high tide.)
3. Compare the amount of sediment in the tubes. Is there any systematic variation in amount across the reef flat? Is there any variation in the size of the sediment in the tubes, i.e., do some tubes contain coarser sediment than others?
4. Discuss your findings and their possible significance with others in your group.

We acknowledge the help of A. Cribb, Botany Department, University of Queensland with this activity.



Attach collecting tubes for sediment to dead coral at low tide water level.

23. Sand patterns: sedimentary structures 2 hr • •

Concepts
Inorganic sedimentary structure
Organic sedimentary structure
Bed
Ripple mark
Burrow
Trail
Classification

Skills
Measuring
Recording
Observing

Attitudes
Appreciation of natural environments
Interest in methods of science

Aim

- To gain some understanding of the way structures in reef-top sediment deposits are produced by moving water and air, and by living things.

You will need

- Reef-walking gear
- Snorkelling gear
- Clipboard and paper
- Plastic ruler
- Camera (optional)
- Transparent viewing box

This activity requires approximately 2 hours — part of which should be at time of low tide and part at higher tide level. It could be carried out over a number of days.

> *In places where deposits of sand or other sediments are forming, air, water and living things act on the sediment to produce distinctive features known as sedimentary structures. These include various kinds of ripple marks, grooves, burrows, tracks and trails.*

What to do

1. As the tide goes out, walk along the beach and also through the water on the inner reef flat.
   (a) Look for structures produced on the surface of the sand by moving water. You might find grooves, or ripple marks, or other similar structures. How many different kinds can you find? A transparent viewer will help you look through shallow water to the sandy bottom.
   (b) Try to make a pictorial catalogue of all the different kinds of sedimentary structures produced here by water movement. Make labelled sketches with a scale. Use a camera, too, if you have one.
   In each case, try to work out which way the water currents or waves moved to produce the structure. Show this on your sketches with arrows.
   (c) If you see ripple marks, note their wavelength (i.e., distance between crests) and amplitude (i.e., difference in height between trough and crest). Are the crests, in plan view, straight or curved? Are the marks, in profile view, symmetrical or asymmetrical? Draw sketches. Do you think they were produced by currents (asymmetrical) or waves (symmetrical)?
2. While walking on the beach or reef flat, keep your eyes open for sedimentary structures made by living things. Look for trails, tracks, burrows, holes or mounds. Do you know what animals made these and how they were produced? Make some pictures of the features you've seen.
3. While snorkelling over the reef flat or looking out from a "submarine" or glass-bottomed boat, keep your eyes out for ripple marks on the bottom and especially for ripples of moving sand. Look at the moving sand carefully and notice how the ripples change. Make a sketch to show what you see.

Ideas for further things to do

4. Look for sedimentary structures made by wind. You might see them on sand dunes at the back of your beach. Add sketches of them to your pictorial catalogue of sedimentary structures.
5. Look for sedimentary structures made by turtles, people and birds. How good a detective are you? Can you work out what each animal was doing at the time it made the structures? Which way was it going, for example?
6. While walking on the reef crest at low tide, look for patches of loose, dead, coral sticks which have been lined up nearly parallel to one another. This is one type of sedimentary structure. Could it help us to work out which way water moves on the reef-top? What other process, apart from movement of water current, might be involved here?
7. Can you invent a classification scheme for all the sedimentary structures you've seen? Explain the basis for the classification you use. Is it based on the way you think the structures originate? on features of the structures you can actually see? on both?

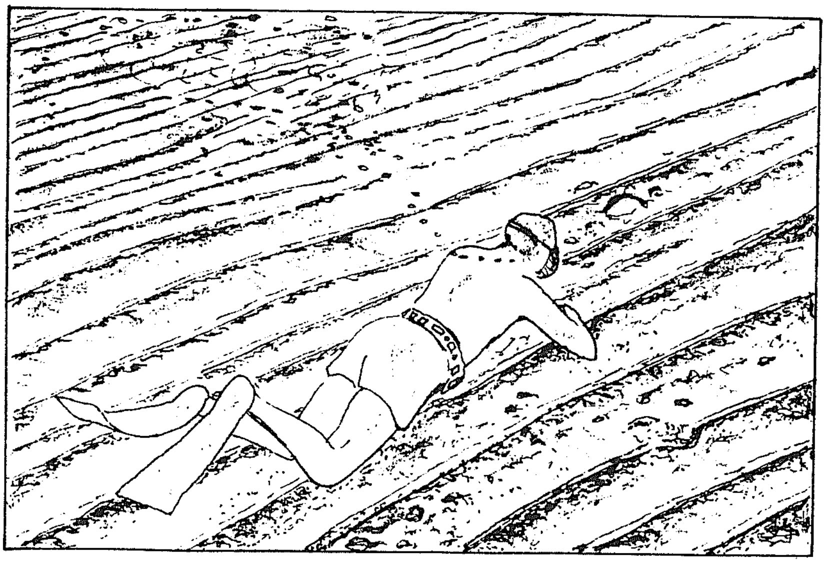
A final question to think about

8. Sedimentary structures are often found in ancient rocks. They are very useful in helping geologists work out what was happening in the ancient environments in which the sediment was deposited.
   (a) How would sedimentary structures such as the ones you've observed at the reef look if we saw them in ancient sedimentary rocks — say, in a road cutting, or quarry?
   (b) If sedimentary structures such as the ones you've observed were found in some ancient sedimentary rocks, just what clues could they give us about past environments and events? Make a list of things they could tell us.

Readings

Clark, I., and Cook, B. 1983. *Geological science: perspectives of the earth.* Canberra: Australian Academy of Science.

Reineck, H.E., and Singh, I.B. 1975. *Depositional sedimentary environments.* New York: Springer Verlag.



24. Sediment-organism interaction 2 hr

Concepts
Sediment
Biogenesis
Bioerosion
Boring
Burrowing
Binding
Turbidity
Adaptation

Skills
Observing
Recording

Attitudes
Interest in natural environments

Aim

- To explore some relationships between living things and sediment in reef environments.

You will need

- Reef-walking gear
- Snorkelling gear
- Field sheet and pencil
- Camera (optional)

This activity requires about 2 hours in total but this could be spread over a number of days of your trip.

Sediments include materials such as mud, sand, pebbles and boulders. On reefs, there is a close link between sediments and living things. Some plants and animals contribute to sediments by building calcium carbonate skeletons. Some animals help in sediment production by biting, boring and scraping solid reef material so that smaller fragments are produced. Some animals consume sediment, or graze on top of it. Some animals shelter in sediment; some burrow through it. Some animals use sediment to help build themselves protective coatings.
Plants of the reef hold sediment in place in a variety of ways. Some act as baffles — trapping loose sediment (among tufts or filaments). Some bind sediments together using roots or holdfasts. Some grow over and encrust loose sediments, "welding" them together forming solid rock. These actions help to stabilise a reef.
For many fixed organisms, loose sediment is a threat: it can engulf them: it can prevent light reaching them. Having some way of coping with loose sediment is an important survival factor for some organisms.

What to do

1. Read the list on the field sheet of some processes carried out by reef organisms.
2. While reef-walking or snorkelling over the reef, look for the following living things. You may not be able to find all of them at the reef you are visiting.
   On beach rockchiton
   On reef flat: goby; Christmas tree worms; spaghetti worm; *Halimeda* (disc-weed) (several types); sea grapes; clam; red-lipped stromb; sea-cucumbers (various types); sea grass (if present)
   On reef crest: turf-like algae; pink-encrusting algae
   On reef slope: parrotfish
3. Observe these organisms and their surroundings to try to find out which of the processes listed on the field sheet they carry out. Note this on the sheet and record your observations in a brief note and/or sketch.
4. Can you add to the list of organisms which carry out some of these processes?

Ideas for further things to do

5. How do sea-cucumbers consume material from the reef flat? Observe sea-cucumbers and describe the process carefully. Be patient!
6. Look to see if different species of sea-cucumber produce different kinds of faecal pellets.
7. Try to find out what effect chitons have on beach rock. Design and carry out an experiment to measure the amount of change they produce.
8. Look at plate-like corals growing on the reef slope. Are they mostly horizontal or tilted? Would their orientation assist them in coping with sediment which falls on to them?

9. Try to find grains of sediment (coarse or fine) which are derived from skeletons of different organisms. Perhaps you will be able to find pieces of coral, disc-weed (*Halimeda*), foram, mollusc, echinoderm and others. You could glue them on to some cardboard or mount them between two sheets of self-adhesive plastic, as a reference collection. (A permit is required to collect specimens.)

Research through reading

10. Read about studies of reef-top sediment to find out about the relative contribution made by the skeletons of different groups of plants and animals.
11. *Halimeda* is a major producer of sediment in the Great Barrier Reef region. Find out some place where *Halimeda* is dominant in sediment.
12. Although animals which consume sediment, bite skeletons or scrape rock may take in large amounts of calcium carbonate, it is not actually the calcium carbonate which they use for food. Find out what is used as food by: parrotfish, sea-cucumbers, chitons on beach rock.
13. How do molluscs bore into solid material?
14. One of the most important processes which helps the break-up of reef material is boring by sponges. Find out the name of any type of sponge which does this and the method used.
15. Mushroom corals (*Fungia* sp.) have some ability to get rid of sediment which falls on them. Find out something about the process.
16. Many reef-building organisms cannot survive in water which is made too cloudy by sediment. Find out why this is so, and how the fact limits the geographic distribution of coral reefs.
17. Like marine organisms, many land-living animals and plants interact with sedimentary material (soil, etc.) in the ocean environment. Can you think of terrestrial counterparts for some of the marine processes and organisms listed on the field sheet?

References and further reading list

Bakens, G.J., 1973. Biology and ecology of tropical holothurians. In *Biology and geology of coral reefs,* ed. O.A. Jones and R. Endean, vol. 2, pp. 326-67. New York: Academic Press.

Hopley, D. 1982. *The geomorphology of the Great Barrier Reef.* New York: John Wiley.

Orme, W. 1977. Aspects of sedimentation in the coral reef environment. In *Biology and geology of coral reefs,* ed. O.A. Jones and R. Endean, vol. 4, pp. 129-82. New York: Academic Press.

Schumacher, H. 1977. Ability in fungiid corals to overcome sedimentation. In *Proc. Third Intern. Coral Reef Symposium.* Miami, Florida.

Talbot, F., ed. 1984. *Reader's Digest book of the Great Barrier Reef.* Sydney: Reader's Digest.

FIELD SHEET

24. Sediment-organism interaction

Process	*Example(s) of organisms which carry out process*	*Notes* (make further notes and sketches on separate sheet)
Building rigid skeletons		
Boring into skeletons		
Scraping rocks		
Biting skeletons		
Consuming sediment		
Sheltering in sediment		
Using sediment as body covering		
Grazing on the surface of sediment		
Binding sediment together using holdfast		
Trapping sediment in tufts or filaments		
"Welding" together loose reef material to form a rigid mass		

25. Beach rock 1½ hr • •

Concepts
Fragmental rock
Lithification
Cement
Erosion
Time
Change
Slope
Dip

Skills
Observing
Inferring
Map reading

Attitudes
Appreciation of natural environments
Interest in methods and products of science

Aim

- To study the location and composition of beach rock and to make inferences about the origin of this rock type.
- To observe organisms which live on beach rock and to consider processes which are causing beach rock to be destroyed.

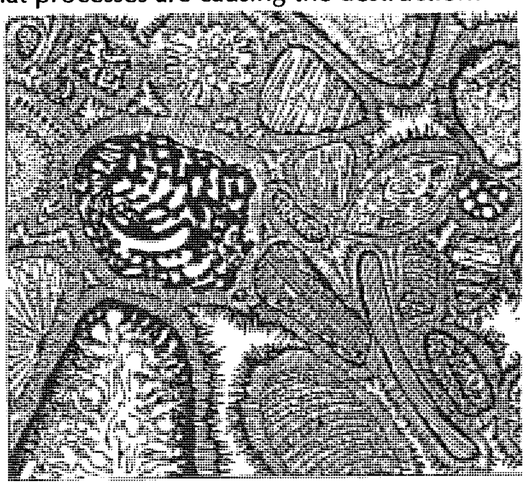
You will need

- Outline map or air photo of island
- Hand lens
- Plastic dropper bottle of dilute hydrochloric acid (optional)
- Clinometer (optional)

On the edges of some reef islands and at some spots on the mainland coast in the reef area, large, low masses of a distinctive type of rock, known as beach rock, can be found exposed among or close to beaches of coral sand and gravel.

What to do

1. Find a place where there is beach rock on the beach you are visiting.
   (a) Look carefully at the surface of the beach rock, using a hand lens. (If possible, choose a whitish-coloured patch of rock to look at. Most beach rock has a blackish-coloured surface because of algae growing on it.)
   (b) Put a few drops of dilute hydrochloric acid on the beach rock and watch what happens.
   (c) Can you see fragments in the rock? Based on the acid test, what do you think the composition of the fragments is? What do you think is the origin of the fragments? How does the general size and shape of the fragments compare with the fragments of the nearby beach? Based on your observations, how do you think the beach rock formed?
2. (a) Mark outcrops of beach rock on an outline map of the island. (A vertical air photo may be helpful.) Are layers visible in the beach rock? Are the layers sloping? If so, measure or estimate the slope and direction of slope (i.e., dip) and mark this on your map.
   (b) How do the slopes on the beach rock compare with those on the nearby beach? Does this comparison throw any light on the way beach rock forms and the location in which it forms?
3. (a) What animals and plants can you see living on beach rock?
   (b) What effect, if any, do animals and plants seem to have on beach rock?
   (c) What signs are there that beach rock is being destroyed?
   (d) What processes are causing the destruction?



Schematic diagram of magnified view of thin section of rock

Ideas for further things to do and think about

> *There have been many ideas about the way beach rock forms. Present accepted scientific theory about Great Barrier Reef beach rock is that:*
> - *Beach rock is formed by the cementing together of calcium carbonate beach sand. This sand is largely derived from broken-up skeletons of living things.*
> - *The cementing process takes place in the intertidal area of a beach.*
> - *The cementing takes places in sand deep in the beach, under cover of loose material.*
> - *The cement is calcium carbonate which has been deposited from solution in sea water.*
> - *Sloping layers in beach rock are present because there were sloping sand layers in the beach from which the rock formed.*

4. Read the ideas given above about beach rock origin. For which of these ideas have you seen some supporting evidence during your field trip?
5. Look at the map of beach rock outcrops at the place you are visiting.
   (a) If beach rock forms deep in a beach under cover of sand, why is it now exposed at the surface for us to see? What might have happened?
   (b) Cays are thought to change in shape and position through time. If you are visiting a cay, does the location of beach rock here give any clues to the cay having a different position or shape in the past?
6. Some people think of rock as something which forms only very slowly. But Coca-Cola bottles and World War II plane debris have been found embedded in beach rock in some places, indicating a recent origin. If beach rock is forming today in the area you are studying, where might it be forming?

Readings

Barnes, D.J. 1983. *Perspectives on coral reefs.* Canberra: Clouston/Aus. Inst. Marine Science.

Hopley, D. 1982. *The geomorphology of the Great Barrier Reef.* New York: John Wiley.

Stoddart, D.T. and Steers, J.A. 1977. Nature and origin of reef islands. In *Biology and geology of coral reefs.* ed. O.A. Jones and R. Endean, vol. 4, Geology II, pp. 78-80.

Further reading

Davies, P.J., and Kinsey, D.W. 1973. Organic and inorganic factors in recent beach rock formation, Heron Island, Great Barrier Reef. *Journal of Sedimentary Petrology* 43(1): 59-81.

Jell, J.S., and Flood, P.G. 1977. Guie to the geology of reefs of the Capricorn and Bunker groups, Great Barrier Reef province, with special reference to Heron Reef. Dept. Geology, Univ. Qld., *Papers* 8(3): 32-33.

26. High island rocks 1½ hr+ • •

Concepts
Sedimentary rock
Igneous rock
Metamorphic rock
Outcrop map
Interpretation map
Dip
Cay
Continental shelf

Skills
Observing
Using a key
Identifying rocks
Interpretating data
Map making
Map reading

Attitudes
Interest in natural world
Perseverance
Willingness to suspend judgment

Aim

- To find out what rock types occur on a continental island and to make a map of their distribution.

You will need

- Sketch map of island attached to field board and/or air photo of island and piece of good tracing paper to fit over it
- Pencil or fine pen
- Hand lens
- Clinometer (optional)
- Geological hammer (optional)
- Compass

What to do

1. Select part of the island for study. Where possible, walk around the edge of this part of the island observing outcrops of different rock types along the shoreline and marking them on the map (or tracing paper) using different symbols. Indicate where you think the boundary between one rock type and another occurs.
2. Observe each different rock type with a lens and, using the key given in the field sheet, try to decide whether it is a rock of igneous, sedimentary or metamorphic origin. Can you identify any minerals? Try to identify the rock.
3. If the rock has sloping layers, measure the dip of these if you have a compass and clinometer.
   If you have an appropriate collecting permit, you may be able to take specimens of the rocks back to base camp for closer observation.
4. Try to find out what kinds of rocks are outcropping away from the shoreline on the part of island you are studying. You could do this by walking back and forth across the area along several traverse lines looking at outcrops and marking symbols on your map. Look carefully at the air photo, too. It might give you clues as to what rock type occurs where.
5. The data you have now plotted on your map forms a geological outcrop map of part of the island. With the help of your leader, try to convert this into a geological interpretation map. This is a kind of best-guess map!
6. Try to obtain a published geological map of the nearby mainland. Look carefully at the shading and symbols on this. Do any of the rock types which occur on the mainland nearby also occur here? Does the map help you decide the approximate age of the rocks you have seen on the island?
7. Coral cays are islands made up only of reef debris whereas the island you are studying is made up of continental rocks. Discuss with other members of your group: Why do the rocks on the high islands of the Great Barrier Reef resemble types of rocks found on the mainland? How has the island become cut off from the mainland? Where do the minerals in each of the rocks you've found come from? Do any of the rocks appear to have formed from reef debris?

26. High island rocks

A key to help distinguish rocks

1.	(a)	Fizzes strongly when hydrochloric acid is added	Go to 2
	(b)	Does not fizz strongly or at all when hydrochloric acid is added	Go to 3
2.	(a)	Has recognisable pieces of skeletons of living things visible	Limestone (sedimentary rock)
	(b)	Sugary texture; perhaps wavy patterns; probably no recognisable pieces of living things	Marble (metamorphic rock)
	(c)	Does not fit clearly into (a) or (b)	Limestone or marble
3.	(a)	Has grains mostly or entirely too small to be seen with naked eye	Go to 4
	(b)	Has grains large enough to be seen with naked eye	Go to 8
4.	(a)	Has no layering	Go to 5
	(b)	Has layering	Go to 7
5.	(a)	Has rounded or oval holes and/or has largely columnar structures and/or	Igneous rock of volcanic origin (If dark-coloured, may be basalt; if light-coloured, may be rhyolite)
	(b)	No holes, columnar structures or large crystals	Go to 6
6.	(a)	Has fine grains which rub off easily	e.g. mudstone (sedimentary rock)
	(b)	Grains cling together and do not rub off	Hornfels (metamorphic rock produced by heat): Igneous rock of volcanic origin (If dark-coloured, may be basalt; if light-coloured may be rhyolite)
7.	(a)	Grey or fawn-coloured; grains rub off fairly easily; layers slightly irregular	Shale (sedimentary rock)
	(b)	Layers regular; somewhat shiny; rock tends to split along layers	Slate (metamorphic rock produced by pressure)
	(c)	Irregular layers in light-coloured or reddish rock; grains do not rub off easily	Rhyolite (igneous rock)
8.	(a)	No layers present	Go to 10
	(b)	Layers present	Go to 9
9.	(a)	Layers made of flakes of shiny minerals	Schist (metamorphic rock produced by pressure)
	(b)	Alternating layers of flakey and blocky mineral grains	Gneiss (metamorphic rock produced by pressure)
	(c)	Layers made of angular or rounded fragments of broken up material	Go to 14
10.	(a)	Grains mostly irregular in shape and interlocking; two or more kinds of minerals present	Go to 11
	(b)	Grains mostly regular in shape, often with hexagonal outlines; texture sugary; perhaps only one type of mineral present	Hornfels (metamorphic rock produced by heat)
11.	(a)	Generally light-coloured rock, perhaps pink, grey or cream	Go to 12
	(b)	Generally dark-coloured rock, black or nearly black	Go to 13
12.	(a)	Grains mostly greater than 2 mm in size; mostly glassy transparent grains (quartz) and pink or white grains (feldspar); occasional black grains	Granite (igneous rock of deep-seated origin)
	(b)	Grains mostly smaller than 2 mm; different composition from (a)	(another type of igneous rock)

13. (a)	Grains mostly greater than 1 mm in size; Mostly black and colourless or white grains	Gabbro (igneous rock)
(b)	Grains mostly smaller than 2 mm in size	(another type of igneous rock of deep-seated origin)
14. (a)	Grains are sand-sized (less than 2 mm in size)	Sandstone (sedimentary rock)
(b)	Grains are gravel-sized and rounded (greater than 2 mm in size)	Conglomerate (sedimentary rock)

27. High island beach sediments 1½ hr + • •

Concepts/topics
Sediment provenances
Mineral properties

Skills
Observing
Using equipment
Working with precision
Making inferences

Attitudes
Interest in natural environment
Interest in processes of science

Aim

- To find out the composition of sand on the beaches of a high island and to make inferences about the origins of the sand.

You will need

- Hand lens
- Small plastic bags
- Dilute hydrochloric acid in plastic bottle
- Stereomicroscope (optional)
- Several plastic containers e.g.
  — graduated medicine cups, about 30 ml;
  — beaker, about 250 ml
- Plastic kitchen sieve

What to do

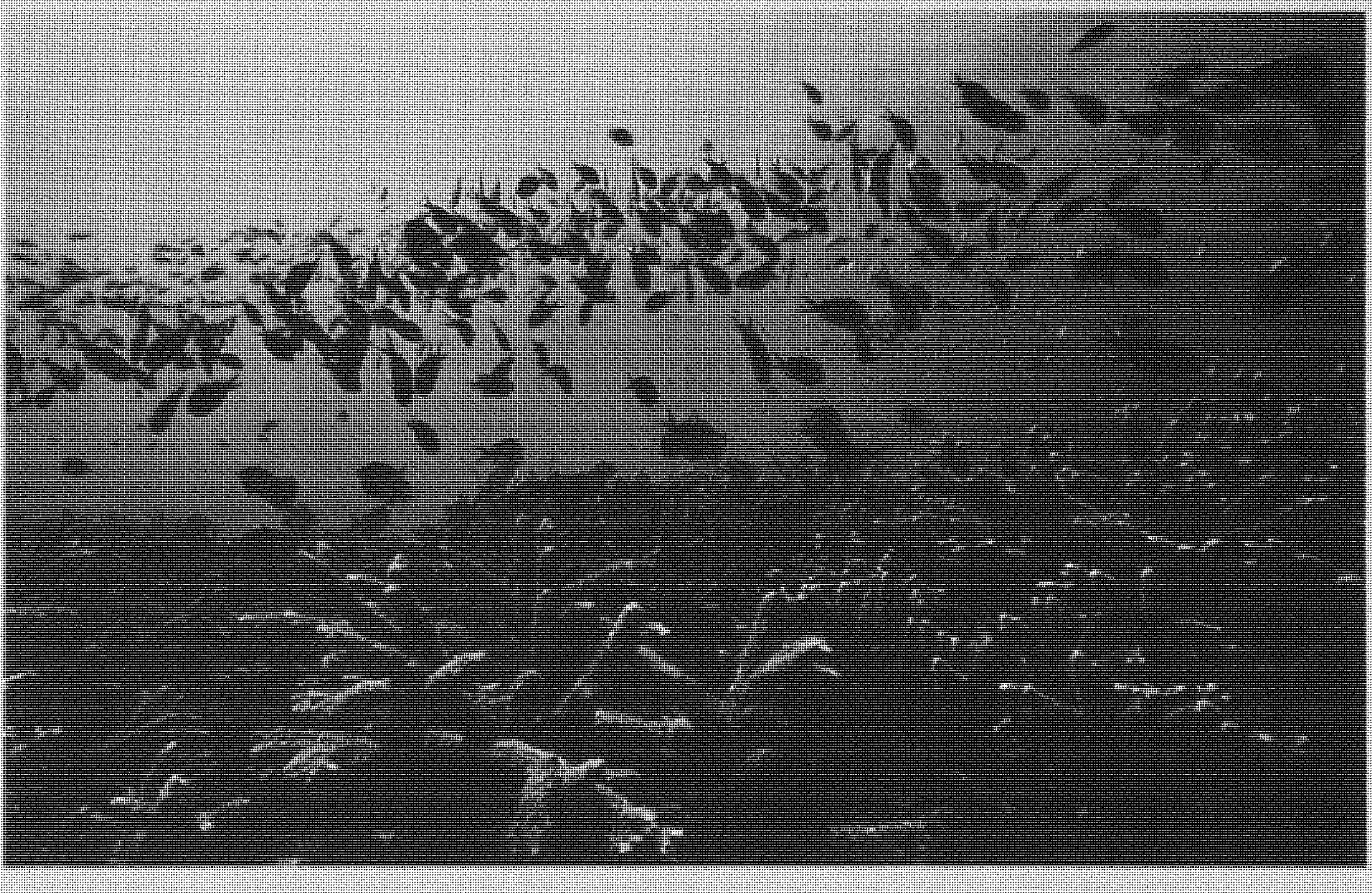
1. (a) Collect samples of beach sand from several places on the island (about 75 cc from each place will do). Use the sieve to keep out any large fragments from your samples.
   (b) Try to find out approximately what percentage of each sand sample is composed of calcium carbonate. Measure out some sand by dropping it into a measuring cup filled with water, until the sand reaches the 25 ml mark. Transfer the sand to a larger container and add hydrochloric acid gradually until the fizzing stops. Measure the volume of residue, if any. What percentage by volume of the original sample has dissolved away?
2. The dissolved-away portion of each sample was probably calcium carbonate.
   (a) What could originally have produced this calcium carbonate?
   (b) Look at the untreated samples with a lens to help test out your ideas about this.
3. Look at the undissolved residue of each sample using a lens or microscope.
   (a) How many different kinds of particles are present?
   (b) What are their characteristics?
   (c) Are any of the particles mineral grains which you can identify using table 27.1?

Table 27.1

Clear or white, shiny jagged grains	Quartz
Clear or white or pink shiny grains with one or two flat sides	Feldspar
Light-coloured shiny flaky grains	Mica
Black or dark-green shiny grains with one or two flat sides	Augite or Hornblende
Black or rust-coloured opaque grains	Iron oxide

   (d) Where could these undissolved minerals have come from? Does your knowledge of rocks on the island help you answer this?
4. Is the percentage of calcium carbonate different in different samples you have collected? If so, consider why this might be the case.

Life on the reef	Location
28. Identifying algae	Reef walking
29. Pressing algae	Reef walking
30. Algae are important	Reef walking
31. Map an algae forest	Reef walking
32. Getting to know an active reef creature	Reef walking
33. Animal roll call	Reef walking
34. Classifying can be fun	Reef walking
35. Animal survival tricks	Reef walking
36. Colour in invertebrates	Reef walking
37. Getting food	Reef walking
38. Foram studies	Reef walking
39. Drifters	Sea
40. Luminous life	Sea
41. Coral polyp — architect of the reef	Reef walking
42. Love a coral clump	Reef walking
43. Coral colonies	Reef walking
44. Coral fingerprints	Reef walking
45. Microatolls	Reef walking
46. Corals in space	Reef walking
47. Growth forms — corals and algae	Reef walking
48. Coral-tree comparison	School
49. Worm watching	Reef walking
50. Clams big and beautiful	Reef walking
51. Homing chitons?	Island
52. Looking at *Linckia*	Reef walking
53. Cucumbers are cute	Reef walking
54. Cucumber count	Reef walking
55. Sea-cucumber habitats	Reef walking
56. Ghost crabs	Island
57. Hermit crabs	Island
58. Following a friendly fish	Snorkelling
59. Pursuing a parrotfish	Snorkelling
60. Super spotter	Snorkelling
61. Who's who in the fish families	Snorkelling
62. Colour patterns in reef fishes	Snorkelling
63. Movement in fishes	Snorkelling
64. Schooling of fishes	Snorkelling
65. Fish distribution	Snorkelling
66. Fish territoriality	Snorkelling
67. Fish-bird comparison	School
68. Whale watch	Sea
69. Associations between species	Snorkelling
70. Goby and shrimp	Snorkelling
71. Clownfish and anemone	Snorkelling
72. Cleaner wrasse	Snorkelling
73. Reef-top transect	Reef walking
74. Boulder communities	Reef walking
75. Ecology of a reef pool	Reef walking
76. Inner coral zone by night	Reef walking
77. Map a bommie scuba project	Snorkelling
78. Food web of a coral cay and reef	Base camp



28. Identifying algae 2 hr + •

Concepts
Pigment
Chlorophyll
Calcium carbonate
Red algae
Brown algae
Green algae

Skills
Observing
Handling living things
Using literature

Attitudes
Interest in natural environments
Willingness to suspend judgment

Aim

- To identify algae from different reef-top habitats.

You will need

- Reef-walking gear
- Bucket or plastic bags to carry specimens in water
- Collecting permit (essential)
- Felt pen with permanent ink
- Knife
- Reference material, e.g. Cribb and Cribb (1985)
- Numbered plastic or metal tags for attaching to specimens
- Aquarium

Up to two hours will be required at low tide. This activity could be carried out in conjunction with other activities. About an hour at base camp will be required.

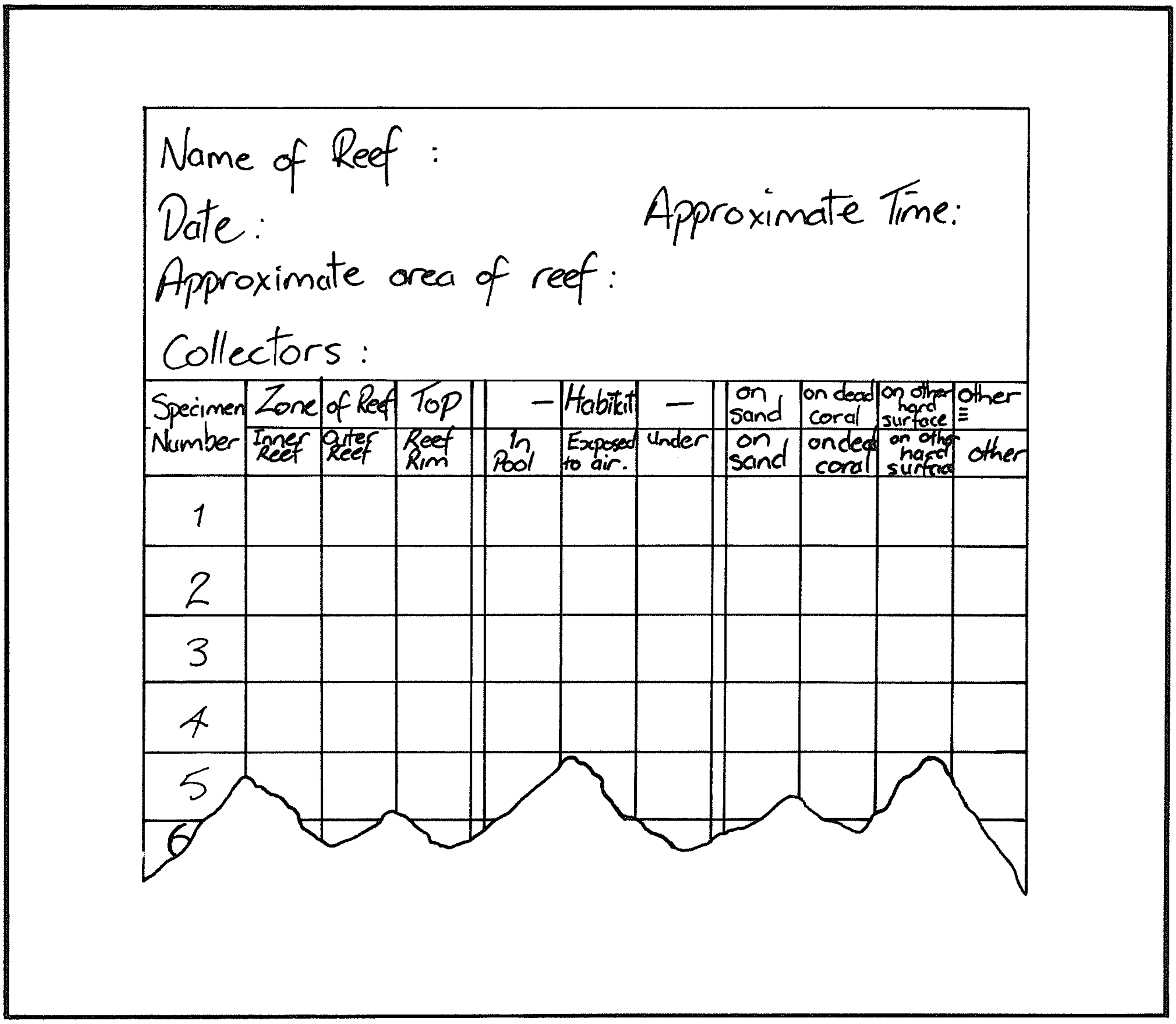
What to do

1. Walk out across the reef-top at low tide. Collect small specimens of as many different kinds of algae as you can. (In most cases, samples need not be any bigger than 100 cc and could be much smaller.) Don't forget the encrusting algae. Attach a numbered tag to each specimen or place each specimen in a small tied plastic numbered bag.
2. If possible, keep a record of where you see each type and whether it was on the inner reef flat, outer reef flat, or reef rim; whether in pools, growing in sand, or attached to hard surfaces under boulders. Draw up a field sheet similar to the sample in figure 28.1 to help you.
3. At base camp, arrange the specimens in an aquarium. Display to other members of your group.
4. Consider these questions:
   (a) Which of the algae are: red; green; brown?
   (b) Which of the algae seem to have calcium carbonate stiffening?
   (c) Which of the algae are adapted for growing in sand?
5. Try to identify as many of the algae as possible using Cribb and Cribb (1985) and/or Mather and Bennett (1984).
6. Do your field observations suggest to you that different algae live in different zones of the reef-top? Are certain habitats, such as sandy surfaces, preferred by some algae? Could you devise a method of obtaining more reliable answers to these questions?
7. Use the specimens you have collected to make a reference collection of pressed, dried algae (see activity 29 "Pressing Algae").
8. If facilities are available, extract pigment from some green, brown and red algae using methylated spirits. Dip the end of some filter paper or blotting paper into the coloured liquid. Notice what happens as the liquid is soaked up. Are there noticeable differences between the material from the green, pink or brown forms of algae? Why is the colouring matter important to algae?

References

Cribb, A.B. and Cribb, J.W. 1985. *Plant life of the Great Barrier Reef and adjacent shores.* St Lucia: Univ. Qld Press.

Mather, P., and Bennett, I. 1984. *A coral reef handbook.* Brisbane: Australian Coral Reef Society.



Name of Reef :

Date : Approximate Time:

Approximate area of reef :

Collectors :

Specimen	Zone	of Reef	Top	—	Habitat	—	on sand	on dead coral	on other hard surface	other =
Number	Inner Reef	Outer Reef	Reef Rim	In Pool	Exposed to air.	Under	on sand	on dead coral	on other hard surface	other
1										
2										
3										
4										
5										
6										

Fig. 28.1. A field sheet you could use to record your findings.

29. Pressing algae 1½ hr •

Concepts
Algae
Binomial nomenclature
Division
Genus
Species
Herbarium

Skills
Manipulation of materials and equipment
Using literature
Observing

Attitudes
Interest in methods of science

Aim

- To make a reference collection of dried, pressed algae.

You will need

- Reef-walking gear
- Collecting permit (essential)
- Algae specimens collected from reef-top (see activity 28 "Identifying algae") and information about where they were collected
- A set of file cards or stiff drawing paper sheets (at least 12 cm x 20 cm)
- Box to store cards flat
- Wax paper
- Newspapers
- Dissecting needle
- Blotting paper (optional)
- Sticky tape
- Plant press (plywood with straps or cords to tie)
- Pieces of thick cardboard from the sides of cartons

About 1½ hours are required initially in the field; then time each day.

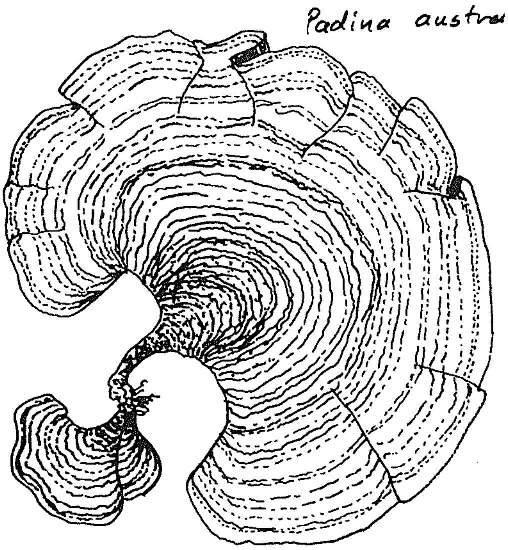
What to do

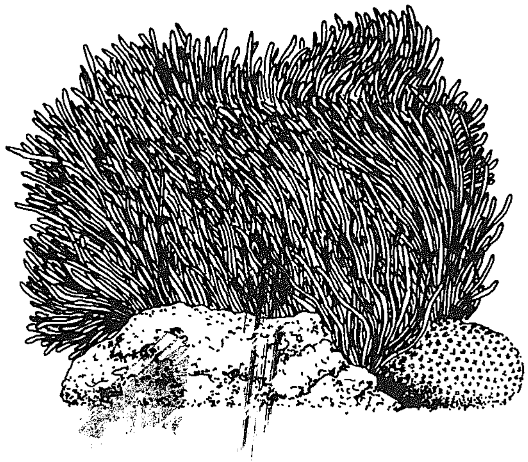
1. Identify each specimen using reference material (e.g. Cribb and Cribb 1985). This is easier to do when the specimen is wet.
2. Wash the specimen to remove all sediment and loose debris. Trim the specimen so that, when spread out, it will fit on the card, leaving about 8 cm at the bottom for writing information.
3. Arrange the specimen on the card. If it is coarse, it can be spread out with your fingers, or teased out with the dissecting needle. If it is delicate, it should be "floated" into position. Put the algae into a shallow tray filled with water and arrange in a natural-looking position. Place the card under the algae and lift carefully so that the water drains away from the card without disturbing the specimen. In pencil, place an identification number on the card.
4. Place the card on blotting paper or a newspaper. Cover the specimen with a piece of wax paper.
5. Stack the specimens in a sandwich as shown in figure 29.1.
6. Stack the sandwiches one above the other and place in a plant press.
7. If possible, place the press in a warm, dry, draughty place. The newspaper and blotting paper should be changed each day until the specimens are dry.
8. When dry, the algae will probably be stuck to the card. If not, tape into place with small strips of sticky tape.
9. Print on the card information such as:
   Scientific name: (division, genus, species)
   Common name:
   Reef on which found:
   Habitat in which found on reef:
   Collectors name(s):
   Date:
10. Discuss with others how a herbarium like this can be used.
11. Is the usefulness a sufficient justification for removing material from the reef?

Reference

Cribb, A.B., and Cribb, J.W. 1985. *Plant life of the Great Barrier Reef and adjacent shores.* St Lucia: Univ. Qld Press.

Padina australis





chlorodesmis fastigiata

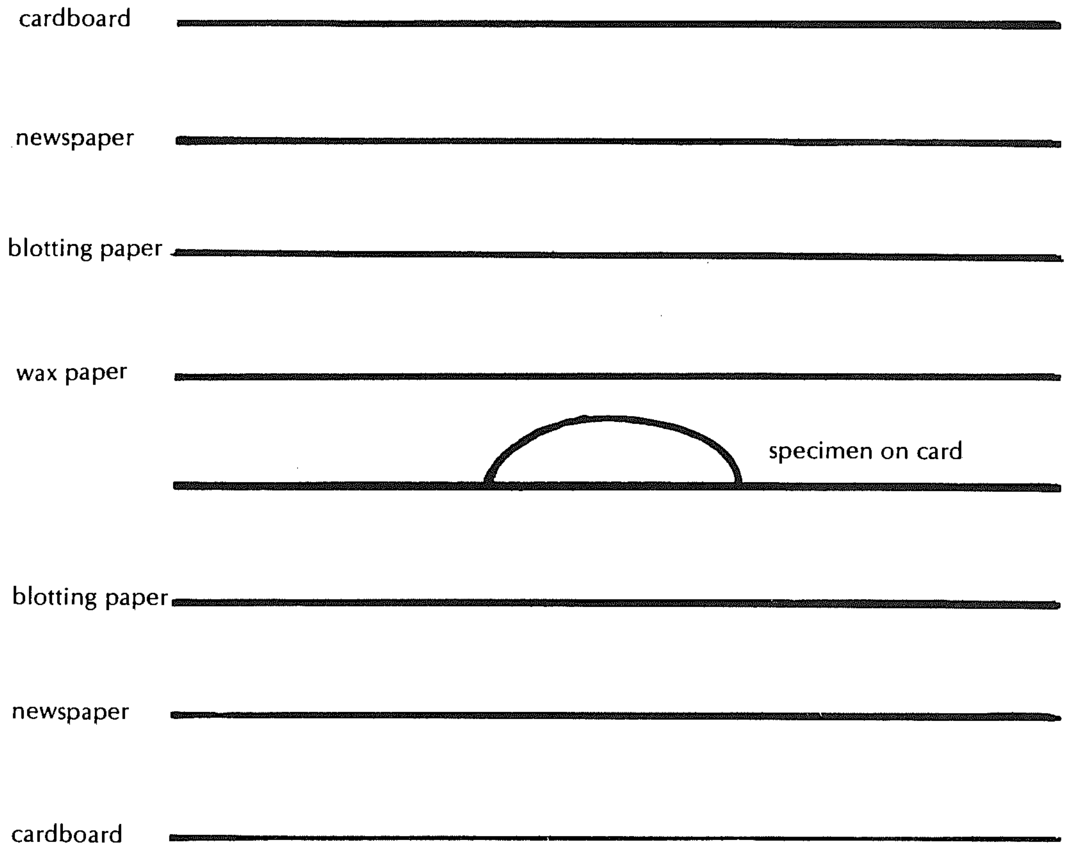
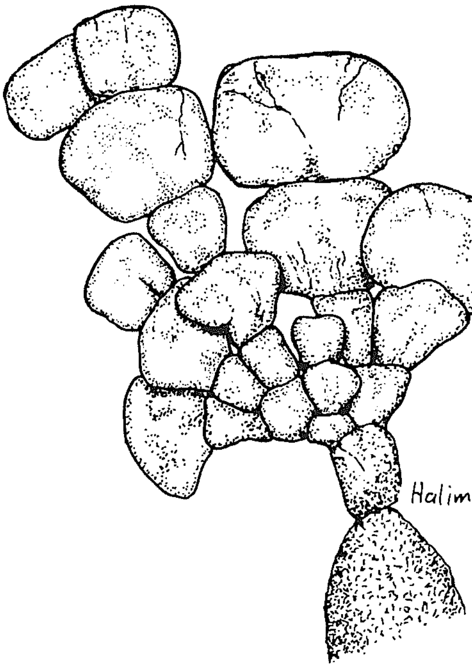
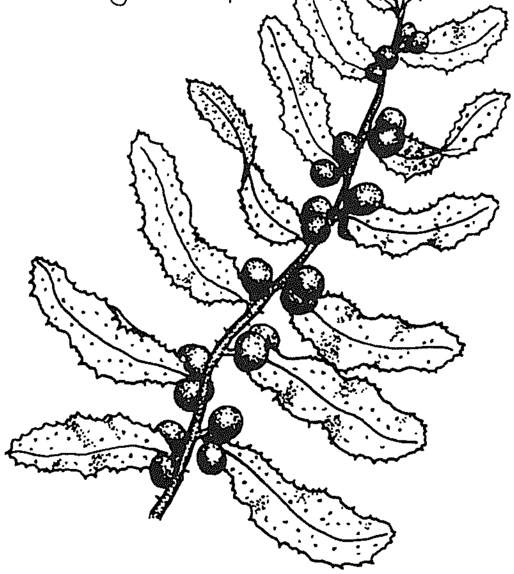


Fig. 29.1. *Arrangement of layers for pressing algae.*



Halimeda macroloba

Sargassum sp.



30. Algae are important 1 hr • •

Concepts
Algae
Species
Diversity
Photosynthesis
Zooxanthellae
Symbiosis
Grazing

Skills
Observing
Recording
Identifying

Attitudes
Confidence in own ability to observe
Interest in natural environment

Aim

- To investigate a number of algae species on the reef.

You will need

- Reef walking gear
- Reference material e.g. Cribb and Cribb (1985)

This activity needs to be conducted at low tide on the reef flat.

What to do

1. Walk out on to the reef flat towards the reef edge and see how many species of algae you can identify with the aid of reference material.
2. The "pink paint" that covers much of the rubble on the reef is, in fact, algae. How many different species can you find in a few square metres? Look carefully at the way the algae binds the coral rubble.

Consider now

3. What do you think is the role of the large algae growing on the reef in the general reef community? What would happen to this algae if the reef grazers were removed? Can you think of a way of testing your ideas?
4. What part do you think the "pink paint" algae play in reef construction?
5. Much of the algae on the reef is hidden within the tissues of the living coral polyps. Take a good look at the reef: if you think about this hidden algae, how does this change your opinions on what at first may look like a "consumer-dominated" community?

Ideas for further things to do

6. The algae within the tissues of the polyps are called zooxanthellae. You may like to find out more about these algae. For instance, of what benefit is it to the algae to live within the polyp? what is the benefit to the polyp? You may then be able to appreciate why luxuriant, hard coral growth is restricted to warm, clear, shallow waters.

Reading

Cribb, A.B., and Cribb, J.W. 1985. *Plant life of the Great Barrier Reef and adjacent shores.* St Lucia: Univ. Qld Press.

Talbot, F. ed. 1984. *Readers Digest book of the Great Barrier Reef.* Sydney: Reader's Digest.

31. Map an algae forest 1 hr • •

Concepts
Diversity
Distribution
Adaptations
Habitats
Producers
Photosynthesis
Substrata

Skills
Hypothesising
Observing
Measuring
Recording
Interpreting
Identifying
Mapping

Attitudes
Interest in natural environment
Persistence
Initiative
Enjoyment of outdoor experience

Aim

- To investigate the distribution of various types of algae in an area of the reef.

You will need

- Measuring tape or 1-metre length of string
- Markers, surveyors tape (coloured plastic tape)
- Graph paper
- Collecting permit and plastic bags (optional)

What to do

Part A

1. Select an area of the reef flat in shallow water at low tide where lots of different algae are visible.
2. Briefly describe the substrate(s), e.g. sand, coarse coral rubble, dead coral, live corals.
3. Using the tape, measure out an area 1-metre square as a quadrant. Define your square by tying coloured plastic tape to coral boulders or large clumps of algae at the corners. (You would need a permit to place pegs or poles into the sand or coral. Tie-on markers are less damaging.)
4. Looking down on the squre, accurately plot the location and cover of the main types of algae on graph paper. Use symbols for different types of algae. Identify algae types as you map. Give a temporary made-up name to any you can't identify. Make a sketch for later identification or take a sample back to base camp if you have a permit.
5. If one type of algae covers another, devise a method of showing this on the map.

Part B

6. What do the algae feel like to touch?
7. (a) What different colours are present? Which is the most common?
   (b) What different-shaped structures do these algae plants have? Make sketches of some shapes which interest you.
   (c) What different forms do the algae plants occur in (e.g. clumps, mats)?
   (d) What is the most common species of algae present?
8. Are the algae providing shelter for animals? If so, what types?
9. Is there any evidence that the algae are being grazed? What by?
10. What happens to the algae when the tide drops leaving it temporarily uncovered? What would happen if this drop were permanent?

Questions to consider

11. What do you think would happen if you put a net or cage over your area so that no animals could enter the area?
12. What are the functions of algae on a reef?
13. What similarities and differences are there between your algae forest and the forest on the island? Draw up an illustrated chart to show this. Display at your base camp.

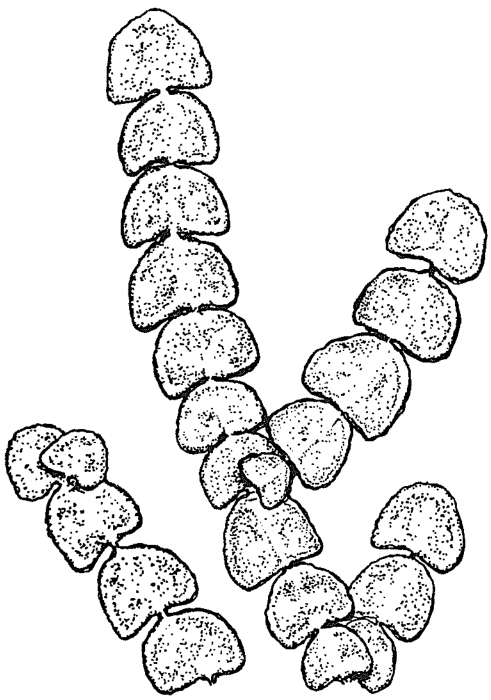
Ideas for further things to do

14. Compare algae maps from different areas on the reef flat or from different places, e.g. reef flat, reef crest, leeward side, windward side. What differences, if any, do you observe?
15. Do the variety and density of algae seem to change as you move across the reef flat towards the reef rim?

Readings

Mather, P., and Bennett, I. 1984. *A coral reef handbook.* Brisbane: Australian Coral Reef Society.

Cribb, A.B., and Cribb, J.W. 1985. *Plant life of the Great Barrier Reef and adjacent shores.* St Lucia: Univ. Qld Press.



Halimeda opuntia

32. Getting to know an active reef creature 2 hr •

Concepts
Ecosystems
Adaptation
Structure
Function
Behaviour
Environment
Habitat
Niche

Skills
Observing
Recording
Inferring

Attitudes
Appreciation of natural environment
Perseverence
Feeling of achievement

Aim

- To observe a living reef creature to find out how the animal is adapted to its environment through its structural, functional and behavioural characteristics.
- To describe in detail the particular habitat of the selected animal.

You will need

- Reef-walking gear and gloves
- Pencil and notebook

This activity should take place at low tide.

What to do

1. Decide on an animal you would like to find out more about. Choose a fairly slow-moving animal.
   Suggested animals: hermit crab; sea hare; sea-cucumber; blue sea star; cowry or other large mollusc.
2. Find it. Note its position exactly.
3. Roughly sketch its surroundings (to scale, if possible). On this sketch, mark its position and then map any movements throughout your observation time.
4. Describe the appearance of your animal. Use labelled sketches, note colours and make measurements. Take particular care to note all the structural features of the animal which you think are important adaptations.
5. Try to find out from your observations:
   (a) the particular habitat or micro-habitat your animal seems to prefer
   (b) how it feeds
   (c) how it moves and its rate of movement
   (d) what it reacts to and how it reacts. (As a last resort only, how it reacts to you, your shadow, your nearness, your touch.)
   (e) any camouflage or defence mechanisms the animal has
   (f) any predators it seems to have
   (g) any competitors it seems to have
   (h) whether it is solitary or whether it lives with others of its kind. How many?
6. Write up your results and display your maps and illustrations.
7. Discuss your results with reference to the needs of the animal and survival. What is your animal's niche?

Ideas for further things to do

8. Try to discover the range over which your animal moves in a specific time (hours, a day, a week).
9. You will need to put some thought into experimental design, e.g. how can you tag your animal? How will you map movements?
10. Design the perfect predator of your animal.
11. Find out more about your animal from books and other reference material.

33. Animal roll call 3 hr + • •

Concepts
Diversity
Classification
Phylum
Class
Species

Skills
Observing
Recording
Analysing data
Classifying

Attitudes
Interest in natural environments
Interest in processes of science

Aim

- To make a list of all the different types of animals you see on the reef flat.
- To classify these reef-flat animals into major groups.

You will need

- Reef-walking gear, including gloves
- Notebook and pencil
- Transparent viewer for looking underwater
- Polaroid camera (optional)
- Tape-recorder (optional)
- Small sheets of paper (a block of scribble paper)
- Pictures of common reef organisms on a sheet for use in the field (optional)

What to do

1. Throughout your visit, compile a list of all the different types of animals you see on the reef flat. Common names will do.
   If you don't know the name of an animal, observe it carefully, sketch it, or photograph it, or describe it into the tape-recorder. Do not collect animals.
2. Make a note of different types of habitats (living places) where you see each type of animal.
3. Put the information about each type of animal on a separate sheet of paper.
4. How many different types of animal did you see?
5. Now classify your animals into groups.
   (a) You might like to sort them into groups according to their phylum (and, if possible, class). To do this, you will have to read up on the distinguishing characters of phyla and classes and identify the phylum (and class) to which each animal belongs.
   (b) Alternatively, you might want to classify the animals according to some other system, e.g., according to whether mobile (or not); feeding habits; edibility; colour; living place; or any other characteristic.
6. Arrange your sheets of paper into a booklet or make a wall display showing the grouping you've chosen.

Ideas for further things to do

7. Use pictures in the literature to try to identify as many of the types of animals as possible. Try to apply a genus (and, if possible, species) name to each.
8. Carry out a similar roll call for the reef front (snorkelling), cay (walking) and reef crest (walking). Compare the number of types you record in these environments with the number seen on the reef flat. (If there are differences, how significant is this?) Are some animals found in several of those major reef environments?

Reference

Mather, P., and Bennett, I. 1984. *A coral reef handbook.* Brisbane: Australian Coral Reef Society.

34. Classifying can be fun — 2 hr + 1 hr

Concepts
Phylum
Class
Species
Classification
Identification
Biological key

Skills
Observing
Recording
Classifying
Using literature

Attitudes
Appreciation of natural environments
Interest in methods of science
Enjoyment of outdoor experience

Aim
- To classify common animals on the reef flat.
- To devise and use a simple biological key.

You will need
- A manipulative permit for *in situ* handling
- A notebook and pencil or portable tape-recorder
- Reef-walking gear
- Some friends to try out your key

This activity requires two hours in the field and about an hour at base camp.

What to do
Before your start, review safety precautions for studying reef biota.

1. Find about ten different common animals on the reef flat, e.g., sea-cucumber; clam; tube worm; sponge; fish, ascidian; crab; stromb shell; chiton; sea-urchin; coral.
2. As you find each animal, observe it carefully. Handle it gently. Do not remove from site.
3. Make a note of some easily observable characteristics which you think might be useful to define the group to which this animal belongs.
4. Replace each animal where you found it.
5. Now, with your partner, sort out your notes on these animals. Consider one characteristic at a time and divide the animals into groups on the basis of presence or absence of that characteristic. Do this until each animal has a place of its own in your system. This can be written down as a biological key such as the one below:

Example of a key

1.	(a)	legs	crab
	(b)	no legs	go to 2
2.	(a)	fins and scaly body	fish
	(b)	no fins or scaly body	go to 3
3.	(a)	body soft, no shell skeleton or outer casing	go to 4
	(b)	some hard parts, shell skeleton or outer casing	go to 6
4.	(a)	Elongate body with opening at other end; not attached	sea cucumber
	(b)	Body not elongate; attached	go to 5
5.	(a)	Small, translucent, jelly-like, with 1 or 2 body openings at top; living with others in colony	ascidian
	(b)	Body soft but not jelly-like; many openings in body	sponge
6.	Etc.		

6. Now, try out your key on some friends. Give them a copy of the key and an example of one of the types of animals you've used to make up the key. See whether they can use the key to identify the specimen. Amend your key if necessary. Trial it further to improve it.
7. Something to think about: Is the key you've made useful only for identifying exactly the same species as you used in constructing the key? Or is it useable with a wide range of species?

Ideas for further things to do

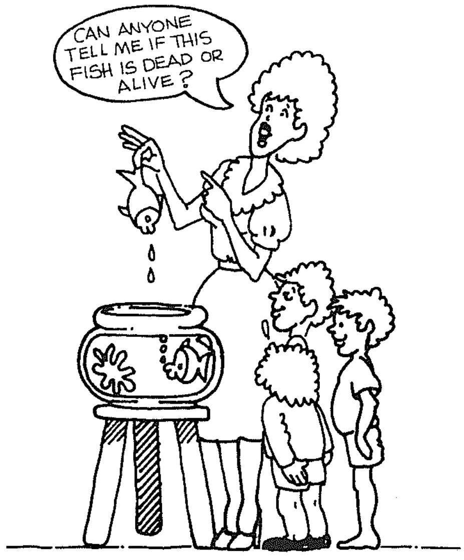
8. On the basis of your own observations and of your reading about invertebrate groups, try to make up a key which could be used to work out which phylum of invertebrates a particular specimen found on the reef flat belongs to. Make sure you refer only to easily observable characteristics. Try out your key on some friends.
9. As a result of reading and your own observations, produce a key to the classes of just one phylum. A good one to try would be phylum Echinodermata. Its classes include Asteroidea, Holothuria and Ophiuroidea. See whether the key can be used to identify some echinodern found on the reef.
10. Using members of just one class, produce a key to its species. You could try this for class Holothuria:

e.g.	red-bellied	Holothuria edulis
	black	Holothuria atra
	curry-coloured	Stichopus varegatus
	green	Stichopus chloronotus
	long, thin, striped	Synapta maculata

References

Rosen, G., and Kelly, N. 1981. *Focus on life*. Sydney: McGraw Hill.

Mather, P., and Bennett, I. 1984. *A coral reef handbook*. Brisbane: Australian Coral Reef Society.



35. Animal survival tricks 1½ hr + •

Concepts
Predation
Adaptation
Survival
Warning coloration
Camouflage
Counter-colouring
Behaviour
Symbiosis

Skills
Observing
Inferring
Recording
Discussing

Attitudes
Appreciation of natural environment
Confidence in own ability to make observations

Aim

- To find out by observations the methods (or adaptations) which a variety of different reef animals use to protect themselves from predators or to successfully "warn off" or "trick" their predators.

You will need

- Usual reef-walking and/or snorkelling gear
- Notebook or waterproofed field sheet attached to clipboard and pencil
- A partner

This activity could be spread out over your trip, so that you collect information on every reef walk or snorkel.

What to do

1. Think of all the different ways an animal might protect itself from predators or "warn off" or "trick" its predators. Make a list and try to find at least one animal which fits each category. You will probably find lots you hadn't thought of.
   Here are some common ones to start you off: stingray; blue *Linckia* sea star; brittle star; epaulet shark; turtleweed crab; gobies; nudibranch; hermit crab; cowry; flutemouth; threadfin butterfly fish.
2. Find an animal. Observe it in its environment. Watch its behaviour as well as its colour and shape. Add it to your list if you feel it's a good example.
3. Copy the field sheet example or invent your own if you prefer.

FIELD SHEET

35. Animal survival tricks

Adaptations which enable animals to avoid predation

Animal	Structural adaptation	Behavioural adaptation	How this adaptation helps the animal to avoid its predators

36. Colour in invertebrates 2 hr •

Concepts
Diversity
Zooxanthellae
Environment
Invertebrate
Habitat
Correlation
Random distribution

Skills
Observing
Recording
Mapping
Analysing
Hypothesising

Attitudes
Appreciation of beauty and diversity

Aim

- To survey the diversity of colour in a variety of invertebrates on the reef and to attempt to correlate colour differences with different reef environments.

You will need

- Notebook and pencil
- Map of reef-top
- Compass and measuring tape
- Usual reef-walking and/or snorkelling gear

This activity should be conducted at low tide.

What to do

1. Select an invertebrate species within which you have noticed colour variation.
2. Some suggested species: clam (*Tridacna maxima*), tube worm (*Spirobranchus giganteus*).
3. Select a segment of the reef-top to survey. This should start from the beach and end at the reef crest. You may decide to either count every animal on a line transect or sample over a broader area.
4. Survey your area. For each animal, record colour, position (distance from beach) and habitat.
5. Plot colours on a map and/or use a grid or scoring system to try to discover if colour seems to be related to habitat or distance from the reef crest or any other factor of the reef environment.
6. Can any conclusions be drawn? Can any correlations be made or is the distribution random so far as you have been able to find out?

Some questions to consider

7. What advantages might colour variation have?
8. Try to find out what causes the colour variation in your selected invertebrate species.

Ideas for further things to do

9. Survey other areas on different sides of the reef for comparison.
10. Is there a distinct difference between the results from the windward side of the island and those from the leeward side?

Readings

Grassle, J.F. 1973. Variety in coral reef communities. In *Biology and geology of coral reefs*, ed. O.A. Jones and R. Endean, vol. 2, pp. 247-70. New York: Academic Press.

McMichael, D.F. 1974. Growth rate, population size and mantle coloration in the small giant clam *Tridacna maxima* (Roding) at One Tree Island, Capricorn Group, Queensland. In *Proc. of the Second International Coral Reef Symposium*, pp. 241-54. Brisbane: Great Barrier Reef Committee.

37. Getting food 2 hr + •

Concepts
Diversity
Herbivore
Carnivore
Predator
Grazer

Skills
Observing
Recording
Analysing
Synthesising

Attitudes
Confidence in own powers of observation
Curiosity

Aim
- To observe a variety of invertebrates feeding on the reef flat so as to analyse the relationship between the environment, the animal's way of life and the food it eats.

You will need
- Reef-walking gear
- Snorkelling gear (optional)
- Transparent viewer for reef walks
- Field sheet and pencil
- Underwater slate (optional)
- Tape-recorder (optional)
- Camera (optional)

What to do
1. Throughout the time you are at the reef, make observations of reef invertebrates feeding (e.g. sea anemone, sea-cucumber, crab, gastropod, chiton, clam). Observe each animal carefully and make notes on the field sheet (or record into the tape-recorder) about:
   - its habitat (a brief description)
   - what it is eating
   - how it obtains the food
   - type of food
   - whether the animal is mobile or sessile (fixed)
   - if mobile, how the animal moves
   - if mobile, an estimate of its speed. (See if you can devise a good way of measuring speed so that comparisons between animals can be made.)
2. When you have built up a number of records, analyse the information. Can you place any of the organisms you've observed into feeding groups such as predator, grazer, filter feeder, scavenger. Can methods of food-getting be related to other aspects of an organism's way of life, especially such things as immobility and locomotion? Can methods of food-getting be related to an organism's habitat?

Ideas for further things to do
3. You might like to get from books some more information about feeding by animals you have seen in the field.

References
Talbot, F., ed. 1984. *Reader's Digest book of the Great Barrier Reef.* Sydney: Reader's Digest.
Bennett, I. 1981. *The Great Barrier Reef.* Sydney: Lansdowne.

FIELD SHEET

37. Getting food

Animal	*Habitat*	*Food*	*How obtained*	*Mobile or sessile (fixed)*	*Method of locomotion (if any)*	*Speed*

38. Foram studies 1 hr + 1½ hr • •

Concepts
Size
Protozoan
Test
Diversity
Benthos
Plankton
Habitat
Sediment

Skills
Observing using lens or microscope
Manipulation of small objects

Attitudes
Curiosity
Perserverence
Interest in natural environments
Interest in methods of science

Aim

- To become aware of common types of reef-top forams and to gain some insight into the contribution of these animals to reef-top sediment.

You will need

- Permit
- Sediment samples
- Hand lens
- Fine watercolour brush (00 sable)
- Stereomicroscope if possible (and light source if available)
- Petri dishes (optional)
- Matchboxes or special cardboard storage trays (optional)
- Rose Bengal solution (optional)
  This is a solution of alcohol (70%) and Rose Bengal stain (0.1%).

This activity requires up to an hour to collect samples plus another hour and a half to study them.

> *Common reef animals which often pass completely unnoticed by visitors are the foraminifera (called forams for short). These are small, single-celled organisms which, like their well-known relatives the amoebas, belong to phylum Protozoa, class Sarcodina. However, unlike the* Amoeba *we see moving in a drop of pond water, forams in the sea have hard shells. These shells (called tests) are usually made of calcium carbonate and they are often very complex in structure with ornate outer surfaces bearing spikes, knobs and ridges. Most forams are quite tiny — sizes usually are between 0.1 mm and 2 mm. However, in some tropical environments they grow to larger sizes and are often the same shape and size as coins. So-called star-sand, found in some reef areas, is made up almost entirely of star-like forams.*

What to do

1. (a) Collect a few samples of sediment from various places on the reef. Suggested locations: beach, reef flat, reef rim and, if possible, reef slope. About 50-100 cc for each sample will do.
   (b) Back at base, examine the sediment carefully using a microscope if possible. Pick out as many different kinds of foram shells as you can.
   (c) How many different types can you find? Can you identify any of them? (Use reference material such as Mather and Bennett 1984 or Maxwell 1968). Do the samples have different kinds of forams?

2. (a) When reef-walking, look for algae clumps to which living forams are attached. Turtle weed *(Chlorodesmis fastigiata)* and chain-weed *(Halimeda)* are two types worth inspecting. Collect pieces of the algae. Take back to base in sea water and examine.
   (b) Are different type of forams attached to different kinds of algae?
   (c) Try to identify the forams using reference material. Make sketches of shapes you see.
   (d) Can you distinguish living from dead forams? What colours do you see among the living ones?

3. When walking on the reef rim, look in small pools and on algae turf for confetti-like disc-shaped forams. They probably belong to the genus *Marginopora*. Take some back for a close look under a lens or microscope. Can you see structures in the interior of the test?

Ideas for further things to do

4. When walking on the beach look out for disc-shaped or star-shaped forams in the sand. In some parts of the world, disc forams are used to make necklaces.
5. Look carefully at a living disc-shaped foram. What colour is its protoplasm?
6. Why do you think it is an advantage for large forams which contain zooxanthellae to have a disc-like shape, rather than, say, a sphere or rod-like shape?
7. Read some published descriptions of reef sediment (e.g., Maxwell 1968, Hopley 1982). About what percentage of reef-top sediment is derived from forams?
8. Find out how abundant living forams are in different sediment samples by adding Rose Bengal solution. This stains the living forams red.
9. Find out something about the internal structure of a large foram by making a thin section of it (see instructions below). Which is the first-formed part of the shell? How are the other chambers arranged?
10. Read to find out how forams obtain their food, and what animals eat forams. Draw a food chain which include forams.
11. The forams which live on the reef itself are benthic types. Some shells of planktonic types of forams can also be found on reef-tops. They are much smaller (typically less than 0.5 mm in size) and thinner-walled than the benthic ones. Have you noticed any planktonic forams in your samples?
12. Make a reference collection of forams in a matchbox or special cardboard foram tray (see details below).

Notes on foram techniques

(a) Some large reef forams can be spotted easily with the naked eye. For smaller species or fine detail, a microscope is needed. The ideal is a stereomicroscope with a good light source and a magnification of 40 or more. If you don't have a microscope, a hand lens will help.

(b) To search through dry sediment for forams, you need to sprinkle the sediment thinly on something with a dark background. A petri dish resting on a black background will do.

(c) Pick out the forams with the moistened tip of a top-quality, very fine watercolour brush (00 sable) or the damp tip of a needle. It takes a bit of practice.

(d) A collection of forams can be mounted with glue on a cardboard tray. Paint the inside of a matchbox tray with a thin smear of glue such as gum arabic. Let the glue dry. When the forams are put on this with a moistened brush, they will become attached. Other glues and solvents can be used or even double-sided sticky tape. Special cardboard trays for holding forams are available commercially or can be homemade.

(e) Making a thin section of a foram shell:
- Choose a large foram.
- Attach it to a glass slide using a smear of a clear nail varnish.
- Under a stereomicroscope, grind away the top of the foram using a roughened glass slide. (This can be prepared by roughening up a glass slide with some fine carborundum grinding powder or sandpaper.)
- When the top of the foram has been ground away, use nail varnish remover to release the foram. Turn the foram over, carefully reattach and grind away the second side. Now you have a section which shows the internal structure of the foram shell.

Readings

Mather, P., and Bennett, I. 1984. *A coral reef handbook.* Brisbane: Australian Coral Reef Society. (Contains photographs of Great Barrier Reef forams.)

Maxwell, W.G.H. 1968. *Atlas of the Great Barrier Reef.* Amsterdam: Elsevier. pp. 172-76. (Contains lists and photographs of Great Barrier Reef forams.)

Further reading

Hedley, R.H., and Adams, C.G. 1974. *Foraminifera*, vol. 1. London: Academic Press.

Jell, J.S., Maxwell, W.G.H., and McKellar, R.G. 1965. The significance of large foraminifera in Heron Island reef sediments. *J. Palaeont.* 39: 273-79.

Murray, J.W. 1973. *Distribution and ecology of living benthic foraminifera.* London: Heinemann.

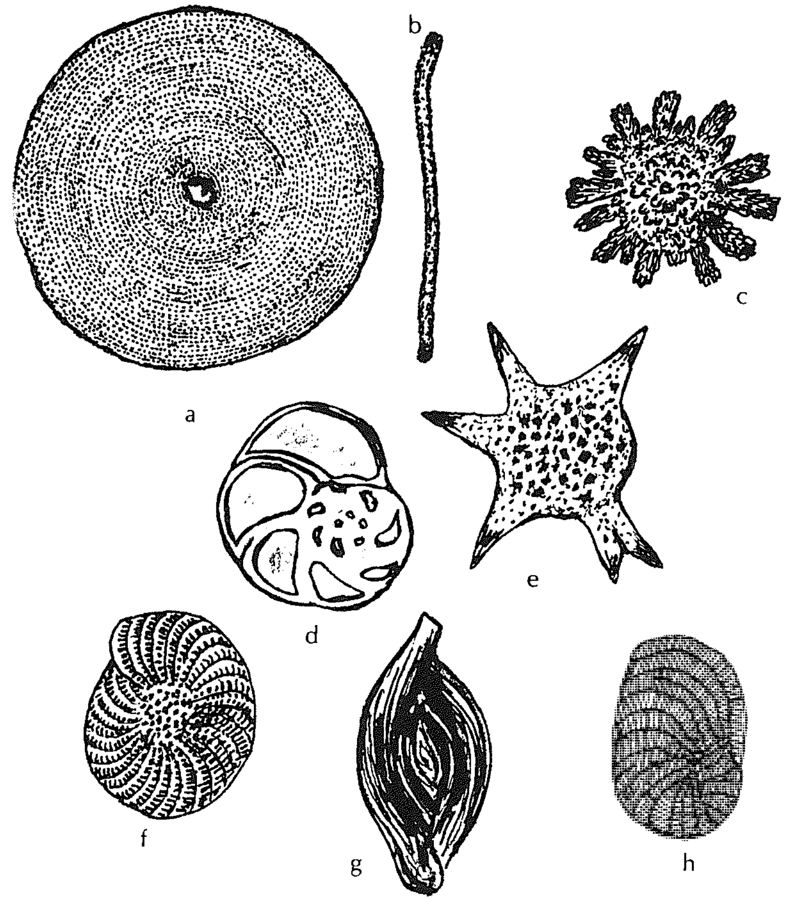


***Fig. 38.1* Common reef-top foraminifera**
a, b Marginopora sp (x6) c Calcarina sp (x10)
d Mississippina sp (x20) e Baculogypsina sp (x8)
f Elphidium sp (x20) g Spiroloculina sp (x30)
h Peneroplis sp (x12)

39. Drifters 2 hr + • •

Concepts
Identification
Producers
Consumers
Larval forms
Food chain
Adaptation

Skills
Observing
Recording data
Collecting specimens
Using equipment

Attitudes
Curiosity
Appreciation of interrelatedness of ecosystem components

Aim

- To identify some organisms that make up plankton ("drifters of the sea").
- To develop an understanding of the role of plankton in marine food webs and in life cycles of organisms, and of the part played by plankton in the distribution of marine plants and animals.

You will need

- Plankton net
- Boat (optional)
- Collecting jars(s)
- Formalin (3 %) (Warning: Formalin should be handled with care)
- Petri dish
- Hand lens (20x or greater)
- Stereomicroscope (if available)
- Collecting permit

What to do

1. Collect plankton from reef waters using a plankton net. This can be done by towing a net either by swimming or behind a boat for 5-10 minutes (boat speed, 1.5-2 knots).
2. It is possible for you to collect more than one sample, collect plankton at different times of the day from different areas of the reef, e.g. windward side, leeward side, lagoon.
3. Place each plankton sample in a labelled collecting bottle. Some material can be looked at when fresh (fascinating!) and some can be preserved for later study (use a 3 per cent solution of formalin and rinse off in sea water before observation).
4. Search through samples to find different forms of planktonic life. A hand lens can be used to begin the sorting out and identifying of various types of plankton in a petri dish. Further examination should be carried out using a microscope, if available.

Although plants are very abundant among plankton, they are extremely small. You may not be able to see them unless you are using a fairly powerful microscope.

5. Can you pick out any plants among the plankton? What helps you to recognise that these are plants?
6. In fresh plankton, what kinds of movements can you see?
7. Use the plankton identikit (p. 000) to identify as many different types of plankton as possible from your sample(s).

Questions to consider

8. What is the importance of plankton in ocean food chains? In particular, why are phytoplankton (plant plankton) important? What do zooplankton eat? What are some organisms which consume plankton? Make some diagrams showing ocean food chains or food webs which involve plankton.
9. How do the shapes, sizes and materials of planktonic organisms help them to live a floating lifestyle?
10. Many animal species have planktonic larval stages. What might be some of the benefits of having planktonic larvae?
11. How is the colour of ocean water related to plankton?

Ideas for further things to do

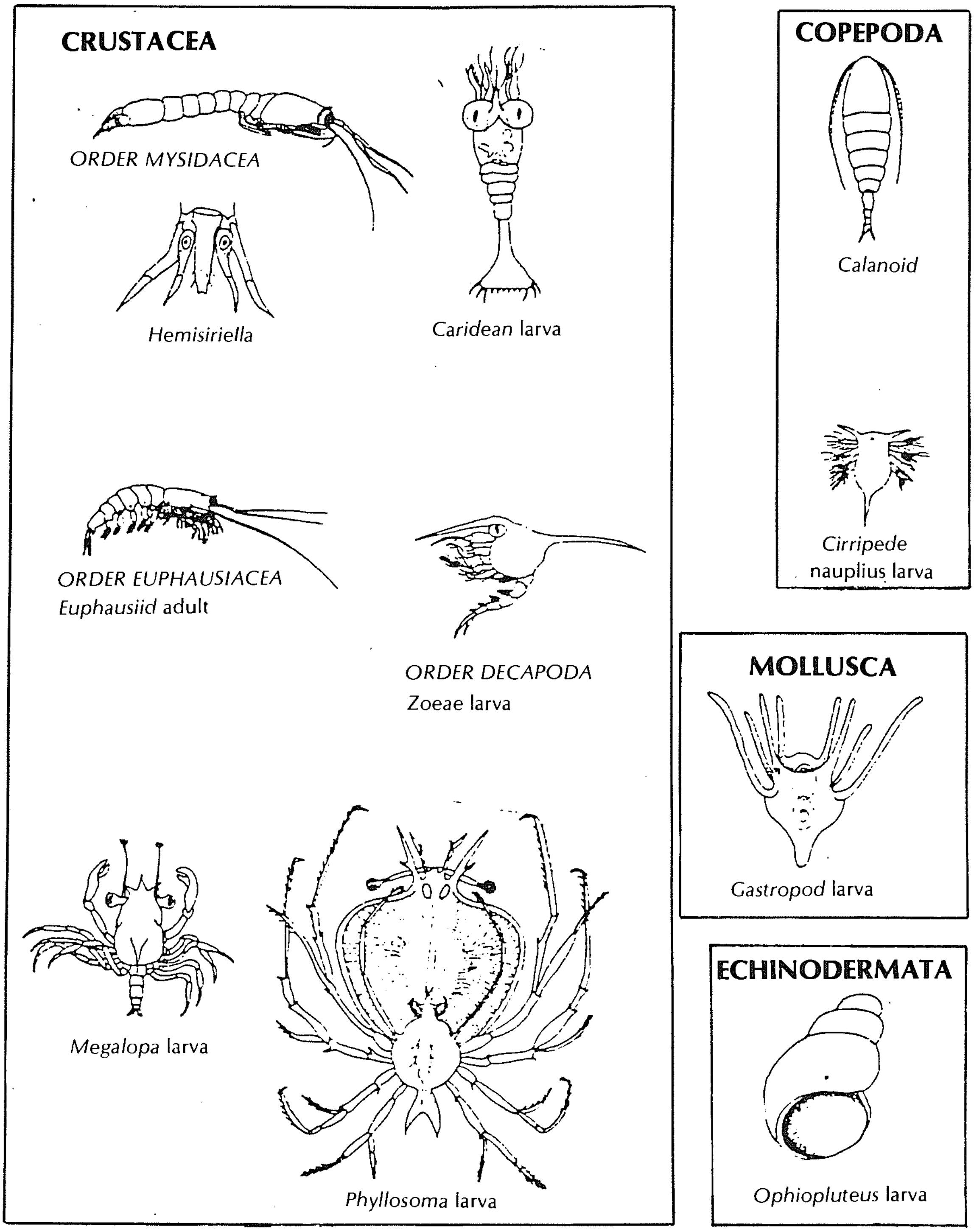
12. Find out how scientists are now able to map plankton movements from satellites. Why could this be important?
13. What would be the effect on the reef if all the plankton disappeared?
14. What could cause the death or disappearance of plankton in reef waters?

Readings

Newell, G.E., and Newell, R.C. 1977. *Marine plankton: a practical guide*. London: Hutchinson.

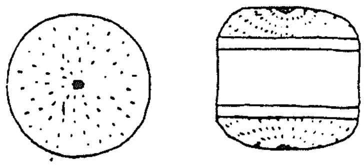
Wicksead, J.H. 1965. *An introduction to the study of tropical plankton*. London: Hutchinson Tropical Monographs.

39. Drifter's Identikit

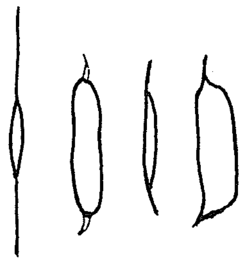


39. Drifters Identikit (cont.)

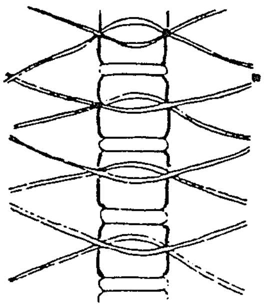
DIATOMS



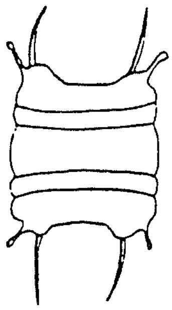
Coscinodiscus



Rhizosolenia



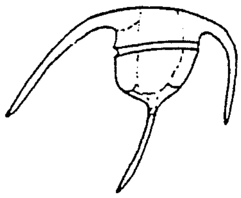
Chaetoceros



Biddulphia

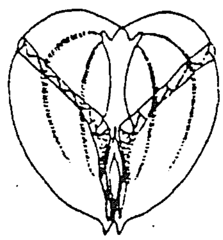
DINOFLAGELLATES

Noctiluca scintillans



Ceratium

CTENOPHORA

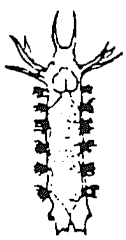


Pleurobrachia

CHAETOGNATHA

Sagitta enflata

ANNELIDA



Nereidae post trochophore larva

40. Luminous life — ¾ hr ● ●

Concepts
Bioluminescence
Plankton

Skills
Collecting
Observing
Recording
Experimenting
Identifying

Attitudes
Curiosity
Desire to question

Aim
- To examine and try to identify reef organisms which display bioluminescence.

You will need
- Plankton net
- Boat (optional)
- Collecting jar
- Hand lens
- Microscope
- Forceps
- Photographic paper
- Permit

What to do
1. Go for a walk at night where the water meets the coral cay sand. Movement over the sand can cause certain aquatic organisms at the water's edge to bioluminesce ("light up"). Try to sample these "lights" by picking them up with forceps from the sand and placing in a collecting bottle. (Alternatively, pick up a small patch of sand which contains a light. Place in a bottle and, back in the laboratory, try to isolate the organism which was lit up.) In the laboratory examine the bioluminescent organism and try to identify it, using reference material.
2. (a) Collect plankton from reef waters using a plankton net. (Refer to the technique in activity 39, "Drifters".)
   (b) Examine the plankton sample in the dark — either by collecting at night or using a dark room. If bioluminescence is not readily observed, shake the plankton in the bottle.
   (c) Try to identify what planktonic life bioluminesces. What phylum, class?
3. (a) Find out, by observation, something about the nature of the bioluminescence of the organisms you've collected:
   - Is it continuous or intermittant?
   - Is there a latency period, i.e., does the light go off for a period of time?
   - How long do flashes last?
   - Does the light affect photographic paper?
   - Is the light produced any differently when the bottle is shaken?
   - Does the light intensity always remain the same over a period of time? What experiment can you do to show this?

   (b) If a camera is available, try to photograph these flashes. (Don't use your camera flash.)

Ideas for further things to do and think about
4. Try to find out what bioluminescence is. What causes it?
5. How could bioluminescence be a survival advantage to reef organisms?

> *NOTE*
> *This activity cannot be carried out during some parts of the year. Bioluminescence is not predictable.*

41. Coral polyp – architect of the reef 2-3 hr •

Concepts
Polyp
Corallite
Colony
Nematocyst
Photosynthesis
Zooxanthellae
Symbiosis

Skills
Observing
Recording
Analysing
Using literature

Attitudes
Interest in natural environments

Aim

- To become familiar with the basic structure and function of polyps of a stony coral.
- To recognise similarities and differences between various polyp types.
- To gain some understanding of the way polyps contribute to building of a reef.

You will need

- Reef-walking gear
- Board, paper, pencil
- Hand lens
- Small plastic ruler
- Transparent viewing box (optional)
- Camera (optional)

The fieldwork in this activity should be done over two to three hours during one or several low-tide periods.

> *During the daytime, most coral polyps withdraw their tentacles and so cannot easily be seen. However, a few different types of reef-top coral polyps are extended during the daytime and can be used for this study. These are: daylight coral (*Goniopora*); organ-pipe coral (*Tubipora musica*); soft corals (*Sarcophyton *and* Xenia*). Mushroom corals (*Fungia*) also often extend their tentacles during the daytime.*

What to do

Polyp types (fieldwork)

1. On the reef flat, find a coral colony whose polyps have tentacles extended. (Initially, find a daylight coral, if possible. This can be recognised by its long, thin polyps which withdraw quickly when you touch them. If a daylight coral cannot be found, look for organ-pipe coral or one of the soft corals. Organ-pipe coral has a red skeleton and pale green polyps.)
   (a) Make simple sketches showing a plan of the polyp and a side view. Give a scale.
   (b) Make notes on other aspects of the polyp. How many tentacles are visible? What other structures can you see? What sort of skeleton (if any) does it have? How does the polyp behave? What is its relationship with other polyps?
2. Locate the other kinds of coral colonies listed above and make similar observations on their polyps.

Mushroom coral polyp (fieldwork)

3. On the reef flat, look out for a mushroom coral (*Fungia*). This is a solitary coral. How wide is the polyp? Where is the mouth? Is the coral attached to anything? Are the tentacles extended? What happens if a few grains of sand fall on it?

Ideas for further things to do

Coral skeletons (labwork)

4. Look at the skeletons of some dead stony coral colonies and try to identify the limestone cup (corallite) built up by each polyp in the colony. (Using a hand lens or microscope is worthwhile.) What colour is the skeleton? What shape is each coral cup? What internal structures can you see inside each corallite? What function do you think these might have? Where do you think the living polyp dwelt in each? Record your observations as labelled sketches.

Nematocysts (labwork)

5. In your laboratory at school, or in a reef research station, try to observe the discharge of stinging cells (nematocysts) from the tentacles of a sea-anemone. (A specific collecting permit is needed if a reef animal is used.)
   (a) Take a clean slide and lick it (the protein in your saliva will act as a stimulus).
   (b) Touch the slide to the tentacle of anemone or coral or, best of all, a hydroid (they have very large and beautiful nematocysts).
   (c) Add a drop of methylene blue (a biological stain that will help you see the structures of the nematocyst).
   (d) Wash off the methylene blue.
   (e) Place a cover slip on the slide.
   (f) View under high-powered microscope. Identify the following structures:
   - Nematocysts consist of a capsule containing a tightly coiled and folded thread.
   - Discharged nematocyst with the threads averting.
   - Discharged threads of varying length, diameter and structure. They commonly bear a formidable array of spines. Several different types of spines may be present on a thread of a single nematocyst type.

Further questions to consider

6. Table 41.1 shows a simple classification of phylum Cnidaria. The corals you observed in the field belong to class Anthozoa. Based on your observations, which belong to the *hexacoral* group and which belong to the *octocoral* group?

Table 41.1: Phylum Cnidaria (All have stinging cells-nematocysts)

Class *Hydrozoa*	*Class Scyphozoa*	*Class Anthozoa*	
In life history, usually an alternation between free-swimming medusoid stage "jelly-fish", and fixed polyp stage.	Usually there is only medusoid stage in life history, e.g. box jelly-fish.	No medusoid stage in life history — polyp only.	
		Zoantharia (hexacorals) Have 6 (or multiples of 6) tentacles.	*Alcyonaria* (octocorals) Have 8 branching tentacles.
		Includes groups such as sea-anemones (no skeletons) and scleractinian corals (stony corals). These corals have limestone skeletons and are major reef builders.	Mostly do not have hard limestone skeletons (and so are not major reef builders). Includes the soft corals and the sea whips, sea fans, sea-pens and other groups. (Two Great Barrier Reef species do have hard, coloured, limestone skeletons — blue in one case and red in the case of the organ-pipe coral, *Tubipora musica*.)

7. Read to find out more about stony corals (Scleractinia).
   (a) What are the most favourable conditions for the growth of reef-building corals?
   (b) Why are most corals found only in clear, shallow waters?
   (c) How do corals capture their food? What are nematocysts? What do they do?
   (d) What causes the colour of living stony corals? Why does the colour disappear when the coral dies?
   (e) What is the role of the minute algae, zooxanthellae, which live within the tissue of reef-building corals? How do the corals benefit from the presence of the zooxanthellae and how do the zooxanthellae benefit from being in the corals? Is this symbiosis?
   (f) How do corals produce their skeletons?
   (g) What are some natural agencies which destroy coral polyps? How can human activities contribute to coral damage?
   (h) How do corals reproduce? What kind of sexual and asexual processes are involved?

Readings

Deas, W., and Domm, S. 1976. *Corals of the Great Barrier Reef.* Sydney: Ure Smith.

Goreau, T.F., Goreau, N.I., and Goreau, T.J. 1979. Corals and coral reefs. *Scientific American*, August 1979.

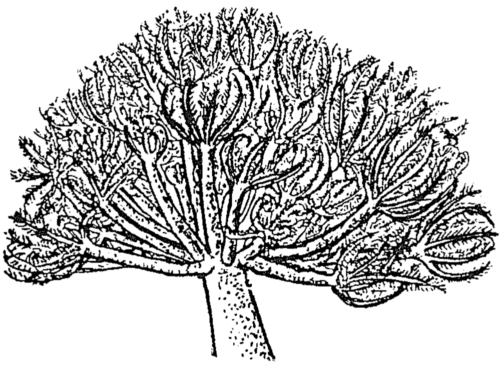
Great Barrier Reef Marine Park Authority, Reef Notes series: *The coral polyp; The soft touch; Coral spawning* event.

Jenkins, M. 1983. *Seashore studies.* London: Allen and Unwin.

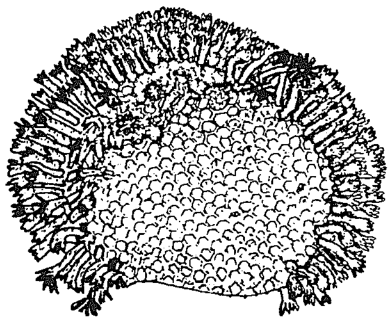
Mather, P., and Bennett, I. 1984. *A coral reef handbook.* Brisbane: Australian Coral Reef Society.

Sheppard, C.R. 1983. *A natural history of the coral reef.* Poole, Dorset: Blandford Press.

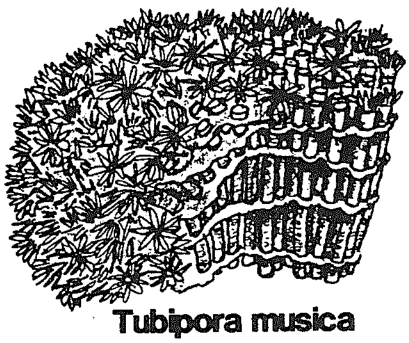
Talbot, F., ed. 1984. *Readers Digest book of the Great Barrier Reef.* Sydney: Readers Digest.



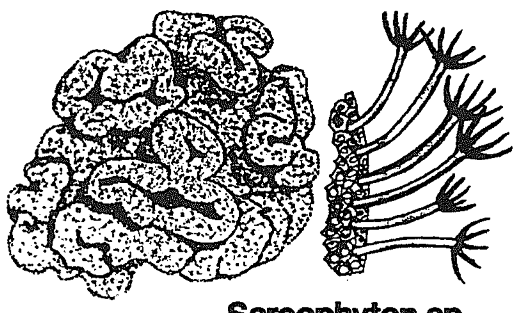
Xenia sp.



Goniopora sp.



Tubipora musica



Sarcophyton sp.

42. Love a coral clump 1½ hr •

Concepts
Structure
Characteristics
Community relationships

Skills
Observing
Measuring
Drawing
Recording
Using references in the field

Attitudes
Interest in natural environment
Enjoyment of outdoor experience

Aim

- To become acquainted with some coral and its associates.

You will need

- Reef-walking gear
- 1-metre rule or tape; clipboard and pen, or underwater slate and pencil
- Map of the island and/or its reef
- Pictures of common coral forms (for example, on GBRMPA leaflets)
- Snorkel and mask or glass-bottomed viewing box or tube (optional)

What to do

1. Select a small area or clump of coral in shallows which you can observe several times over a few days.
2. Mark its position on the island/reef map.
3. Draw your clump, looking down on it and then looking at its side view.
4. Measure your clump: width, height from its base on sand or rubble, and its circumference. Record these measurements.
5. Note your clump's shape, colour and feel. Using coral pictures, try to decide whether it is made up of hard or soft coral and what the coral's name is.
6. What happens to your clump at low tide — is it exposed? Does it have some dead bits?
7. Is your coral alone or is it surrounded by lots of relatives?
8. Who uses your coral? What is it being used for? Are algae growing on your clump? shells? worms? Are fish sheltering in your clump? Are there fish close by? Are some creatures merely moving around your clump or resting on, or in, it?
9. What happens to your clump when you touch it? Can you see its polyps? When?
10. After getting to know your clump, consider: what made you pick that particular clump? are you fond of it? Make a list of some further questions about it which you'd like to explore.

Ideas for further things to do

11. Attempt other activities in this handbook which involve coral and the creatures which live close to it.

Readings

Bennett, I. 1981. *The Great Barrier Reef.* Sydney: Lansdowne.

Mather, P., and Bennett, I. 1984. *A coral reef handbook.* Brisbane: Australian Coral Reef Society.

43. Coral colonies 1½–2 hr + ½–1 hr •

Concepts
Corallite
Colony
Growth form
Asexual reproduction
Diversity

Skills
Observing in field

Attitudes
Persistence
Interest in natural environments

Aim

- To become familiar with various shapes in which coral colonies grow.
- To become aware of various ways in which coral polyps are packed together within coral colonies.

You will need

- Reef-walking gear (part of activity could be done snorkelling)
- Board, field sheet, pencil
- Camera (optional)

This activity requires between 1½ and 2 hours at low tide for fieldwork which could be spread over several low-tide periods, plus ½ to 1 hour for a study of the literature.

> *Almost all stony corals are colonies of many polyps living together. Colonies differ in many ways: the overall shape (or growth form) of the colony; the size and shape of the corallites (limestone cups in which each polyp lives); the way these corallites are packed within the colony.*

What to do

1. Go walking on the reef-top; look into pools; snorkel over the reef edge, if possible. Which of the common colony types shown on the field sheet can you spot? Record your sightings on the field sheet.
2. Considering the various shapes in which coral colonies grow, what do you think might be the particular advantages and disadvantages of each shape for growth and survival? Think about: ability to get light (why is this important?); ability to fill space; ability to resist being broken.
3. If there are rubble piles of dead corals on beach, look at some of these coral colonies.
   (a) If you had no prior knowledge of corals, but were asked to classify these colonies into different groups, how would you go about the job in the field? How many different colony kinds can you find?
   (b) How are coral polyps packed together in each colony? For each colony, try to decide whether each surface pit was the home of one polyp or several. Is packing material developed between the walls of adjacent pits? How wide do you think each polyp was? Are there clear radiating partitions in each pit?

Further questions for you to consider

4. How could people's activities affect coral colonies? Which coral colony shapes do you think would be most easily damaged by people? Discuss ways in which this could be investigated by reef researchers.
5. How fast do coral colonies grow? How is coral growth investigated?
6. Do scientists consider that a particular coral species grows in only one colony shape or not?
7. Are all the polyps in a colony the same? Do different polyps in a colony function in different ways?
8. Is there any communication between the separate polyp members of a coral colony? If so, how?
9. Coral polyps can reproduce sexually, but they can also reproduce asexually by budding of polyps and fragmentation of colonies. Try to find out something about asexual reproduction in corals.

Idea for another investigation

10. The genus *Acropora* is one of the most abundant of coral groups. Using the literature, find out the distinguishing characteristics of the genus *Acropora*. Locate a specimen of branching *Acropora* in the field or in a laboratory collection. Try to understand how the branches grew and how new coral cups develop. What happens to the coral cup at the tip of each branch as the branch grows?

Related study

Activity 41, *"Coral polyp — architect of the reef"*, could be done before this activity.

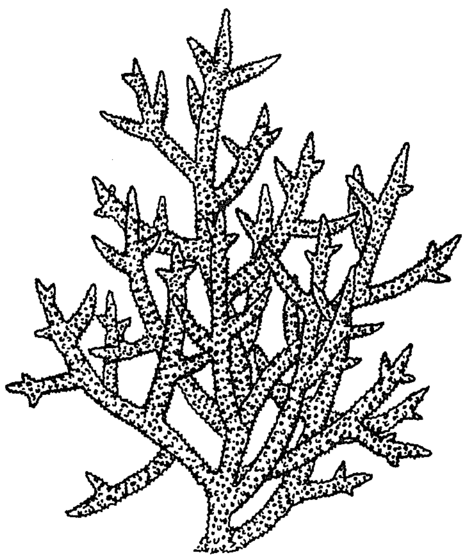
Readings

Deas, W., and Domm, S. 1976. *Corals of the Great Barrier Reef.* Sydney: Ure Smith.

Great Barrier Reef Marine Park Authority, Reef Notes series: *The coral polyp; The soft touch; Coral spawning event.*

Mather, P., and Bennett, I. 1984. *A coral reef handbook.* Brisbane: Australian Coral Reef Society.

Talbot, F., ed. 1984. *Readers Digest book of the Great Barrier Reef.* Sydney: Readers Digest.

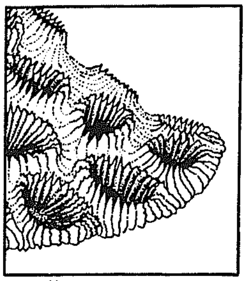


Acropora sp.

FIELD SHEET

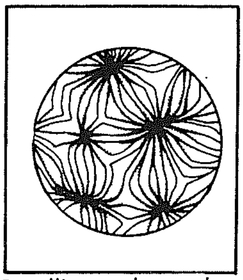
43. Coral colonies

Packing arrangements of polyps
Which of these can you spot?



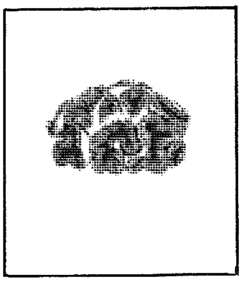
Corallites are rounded and do not have a common wall

☐ *A HONEYCOMB PATTERN*



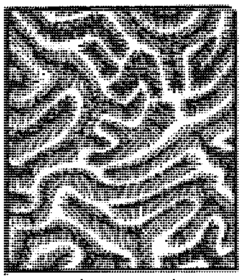
Corallites polygonal with common wall. Mouth can be seen here. Some less regular forms have several mouths in each depression.

☐ *A HONEYCOMB PATTERN*



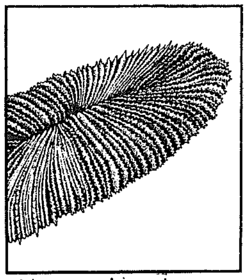
Irregular ridges and depressions. Each depression has several mouths.

☐ *A HONEYCOMB PATTERN*



Meandering ridges. Many mouths can be seen in pits.

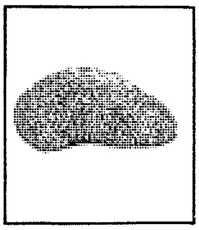
☐ *BRAIN PATTERN*



Not a colony but a single polyp.

☐ *MUSHROOM CORAL*

Colony shapes
Which of these can you spot?



Common reef flat.

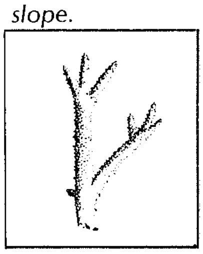
☐ *HEMISPHERE FORM*

Has stubby branches.

☐ *KNOBBLY FORM*

☐ *CLUB-LIKE FORM*
Common on reef flat.

☐ *STAGHORN FORM*
Common on reef slope.



44. Coral fingerprints 1-2 hr •

Concepts
Skeleton
Corallite
Species
Genus
Septum
Polyp
Diversity

Skills
Observing
Drawing
Comparing

Attitudes
Persistence
Interest in natural environments

Aim

- To learn more about the features of corals by comparing pictures of dead coral skeletons with living and dead coral specimens.

You will need

- Reference material Mather and Bennett (1984)
- Underwater board and pencil
- Reef-walking gear and/or snorkelling gear

This activity can be done at both high and low tide.

What to do

1. (a) When walking or snorkelling, try to locate examples of living corals which match the patterns of coral skeletons in Mather and Bennett. Note each pattern as it is recognised. Sketch the living coral. Note the colours.
   (b) If you're not sure about a match-up, put a question mark beside the picture. Why is it often difficult to match the living coral with the picture?
2. (a) On the beach or reef-top, or perhaps in a museum display, look out for skeletons of dead coral which match the pictures in your reference material. Once again make a note if you make a match.
   (b) Is it easier to match pictures with dead coral specimens than with live ones?
3. At your base camp, make a display of any sketches you've made.
4. Make a list of the pictures for which matches have been found on the reef you're visiting. Which species has been most commonly found?

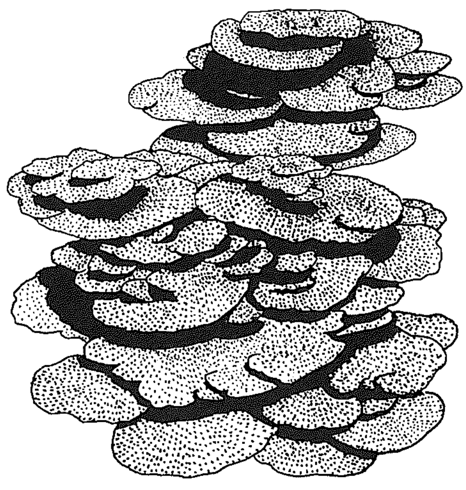
Ideas for further things to do

5. Find out the meaning of the following two words related to coral skeletons: *corallite, septum.* What function does the septum perform?
6. Whereabouts in the corallite does the coral polyp live?
7. Learn the distinguishing characters of four genera of corals.

Readings

Mather, P., and Bennett, I. 1984. *A coral reef handbook.* Brisbane: Australian Coral Reef Society.

Plate coral - *Acropora*



45. Microatolls — 2 hr ● ●

Concepts
Colony
Microatoll
Tide
Reef rim
Change

Skills
Observing
Measuring
Recording
Inferring
Predicting
Cooperating with others

Attitudes
Interest in natural environments
Interest in processes of scientific enquiry

Aim

- To study shapes and structures of reef-flat microatolls and to consider how these are related to environmental conditions on the reef flat.

You will need

- Reef-walking gear
- Paper and pencil
- Camera (optional)
- Measuring tape
- Measuring rod, 1 metre in length, marked into 2 cm lengths
- Watch

Early scientists gave the name microatoll to ring-shaped coral colonies they saw growing on some reef flats. The reefs on which microatolls form have a reef rim which acts like a "dam" at low tide: the "dam" holds back a shallow pool of water on the reef flat. This pool is sometimes called a "moat".

What to do

1. Find a microatoll on the inner reef flat.
   (a) Make a sketch of the microatoll. How wide is it? How high is it above the reef floor?
   (b) Which part of the microatoll consists of living coral? What do you think will happen to the microatoll as the coral grows?
   (c) Why do you think the top part of the microatoll is dead? Do you think the microatoll will grow any higher? If not, why? (Hint: Think about the effect of tides here.)
   (d) Is the centre part of the microatoll dead? If so, why?
   (e) Are there some younger microatolls forming in the centre of the main microatoll?
2. Find some other microatolls:
   (a) Are all the microatolls made of the same kind of coral? If not, how many types of corals are forming microatolls here? Make a simple description of each kind.
   (b) Make sketches (with a scale) of some different shapes and sizes of microatolls you see. Photograph them if you have a camera.
3. (a) Working with a group, close to anticipated low tide, keep a close watch on the height of water over a number of nearby microatolls as the tide falls on the reef top. Using a measuring stick, measure the distance between the water surface and the top of the living coral on the microatolls. (Everyone doing this should make the measurements at exactly the same times, agreed on beforehand. Measurements should be taken about fifteen minutes apart.)
   (b) At the lowest level reached by the water, is the water surface so low that the living coral is exposed? If not, how close does the falling water surface come to the living coral? If so, how much below the upper edge of the living coral does it fall?
   (c) At the microatoll you're observing, is the upper edge of the living coral all at the same level? How can you find out?

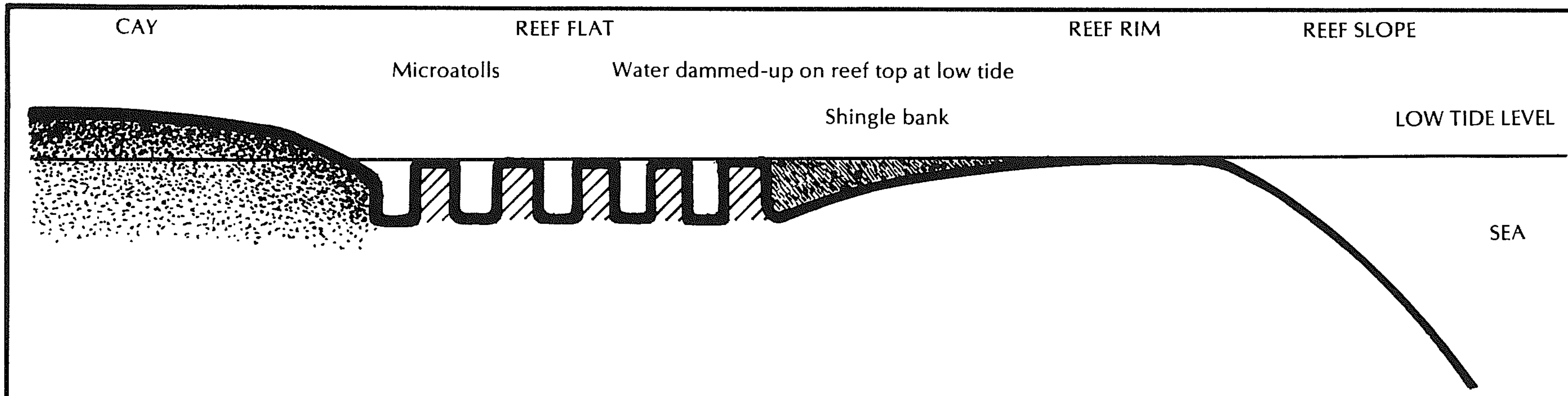


Fig. 45.1. Profile of reef-top showing microatolls (not to scale).

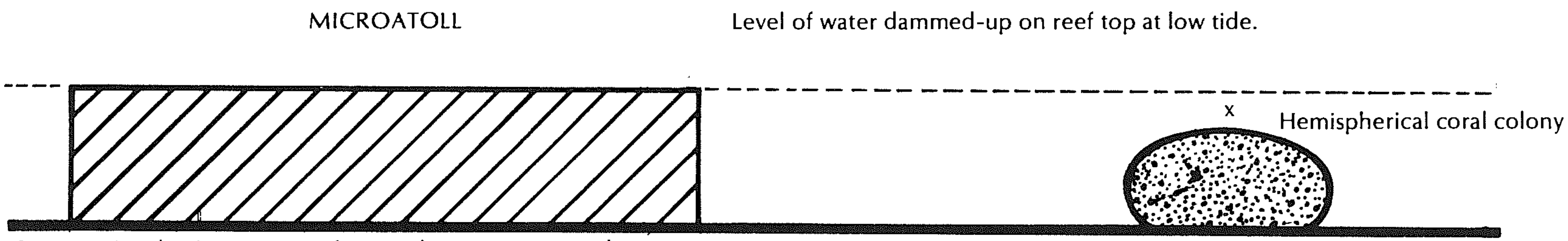


Fig. 45.2. Coral colonies on reef-top, side view (not to scale).

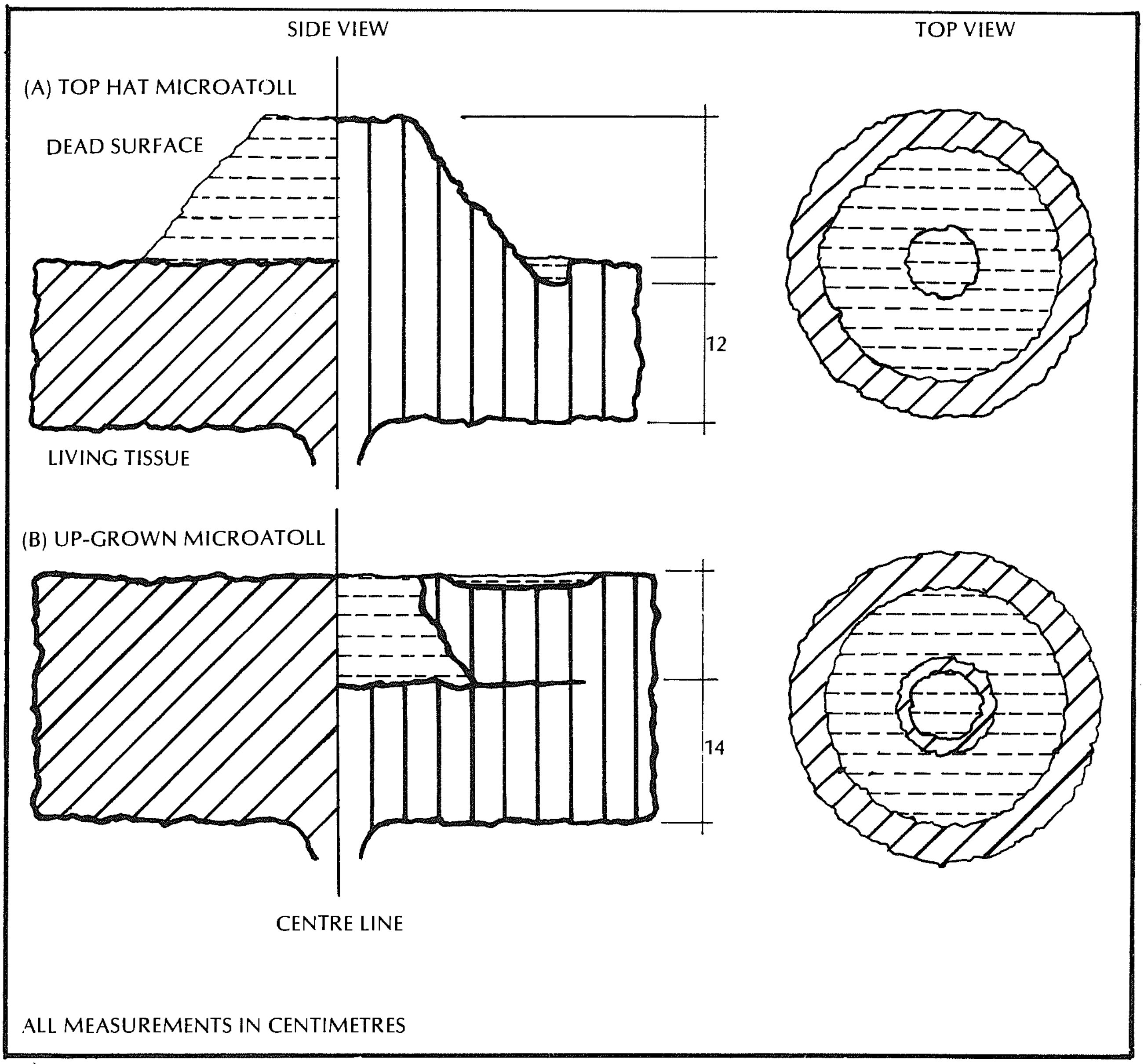


Fig. 45.3. *Unusual microatoll types.*

(d) Compare your results with those from other microatolls.
   - Is there a similarity between the results for all the microatolls?
   - If not, is there a similarity between the results for microatolls of one particular type of coral?
   - If several microatolls give similar results, does this mean that their tops are at the same level as one another?
   - If the tops of microatolls in your group measurements are at the same level as one another, what is the likely cause of this? How do you think microatoll height is connected with water level?

4. Make a diagramatic sketch to scale showing your results from 3(a)

Ideas for further things to do

6. Changes to the height of the "dam" around some reefs are thought to affect microatoll growth. Several types of unusual microatolls are illustrated in figure 45.3 and descriptions of their formation given (Hopley 1982).
   (a) In figure 45.3, match the description given to each diagram.
   Which of the two kinds of microatolls matches up with each of the descriptions on the next page:
   - If level of water "dammed-up" on a reef-top rises, then the living rim of the microatoll may begin to grow upwards and perhaps inwards.
   - If the level of water "dammed-up" on a reef-top falls then the upper part of the microatoll will die and further growth will be at a lower level.

   (b) Look around on your reef-top. Do either of these unusual microatoll types occur here?

7. At Heron Island some years ago, breaching of the reef rim to form a harbour led to a slight lowering of the level of dammed-up water on the reef flat at low tide. What effect do you think this might have had on reef-flat coral colonies? If you are visiting Heron Island, try to find out what happened.

Readings

Hopley, D. 1982. *The geomorphology of the Great Barrier Reef.* New York: John Wiley.

Jell, J.S., and Flood, P.G. 1977. Guide to the geology of reefs of the Capricorn and Bunker groups, Great Barrier Reef province, with special reference to Heron Reef. Dept. Geology, Univ. Qld, *Papers* 8(3).

Scoffin, T.P., and Stoddart, D.R. 1978. The nature and significance of microatolls. *Phil. Trans. R. Soc. Lond.*, B284: 99-112.

46. Corals in space — 2 hr ● ●

Concepts
Competition
Resource
Intraspecific
Interspecific
Interaction
Aggression

Skills
Observing
Comparing
Analysing

Attitudes
Interest in methods of science
Interest in natural world
Persistence

Aim

- To explore spatial relationships and interaction between coral colonies as they grow to occupy space on a reef.

You will need

- Reef-walking gear
- Camera (if possible)
- Plastic rule (approx. 30-40 cm)

This activity requires about two hours at low tide on the reef flat. Your observations could be continued on the reef slope by snorkelling or looking out from a coral-viewing boat.

> *When we see corals growing near one another on a reef top we can ask ourselves whether they are friendly neighbours or whether they are competing fiercely with one another? If they are competing, what resource are they competing for? Can we see signs of their competition? How do they compete? Who wins?*

What to do

1. Before you start your fieldwork, look at the list below of *some* conditions needed by corals to survive and grow. Why are each of these important to a coral?

- Supply of small animals
- Supply of dissolved oxygen
- Supply of light
- Water currents
- Space

> *Studies carried out on corals have shown that corals do compete with one another in seeking resources. Some have mechanisms which help them to prevent others taking over space on the reef and thus from getting exposure to water currents and needed resources such as light and food. Some hint of such struggles can be seen on the reef flat by looking at the spatial relationships of adjacent coral colonies.*

2. When walking on the reef top or when snorkelling on the reef slope, look carefully at places where coral colonies come close to one another or grow against or over one another.

   Look for the following kinds of relationships:

(a) *Encrusting:* one coral colony growing over and encrusting another.
(b) *Overtopping with deep shade:* one coral colony spreading out over another, strongly shading all, or part, of it.
(c) *Overtopping with light shade:* one coral colony filling in space over another, but without much shading.
(d) *Close approach:* two coral colonies coming very close to each other but "keeping their distance" so that there is a narrow gap of uniform width between the two.
(e) *Intergrowing:* the branches of one coral colony intergrowing with those of another.

Make some sketches or take some photos to illustrate each of these types of spatial relationships.

3. Consider the different kinds of spatial relationships you have observed. From these spatial relationships, what can you tentatively infer about ways in which the adjacent coral colonies might be possibly affecting each other in each case. Make a list of your ideas.

Ideas for further things to do

4. When any two particular kinds of corals are adjacent to each other, do they always display the same kind of spatial relationship? Does one of the two always seem to win against the other? Design (and if possible, try out) a field observation project which would help you to answer these questions.
5. By field observation, try to find out more about close-approach relationships. What kinds of corals participate in such relationships? Are the distances always the same? Does the distance depend on the types of corals involved?

Research studies by scientists have shown that corals can actively attack other corals using the stinging cells in their ordinary tentacles, strong stinging cells in long sweeper tentacles, digestive filaments which are sent out from one coral to digest the soft part of the other coral, or by use of poisons. Different types of corals tend to use different methods; a species strong in one method may be less strong using other methods. Scientists studying aggression among corals have recognised a sort of hierarchy or "pecking order", although factors affecting which coral wins are complex.

6. Find more about some of the *mechanisms* by which coral colonies compete with each other for space. Read Talbot (1984) pp. 95-132, Endean (1982) pp. 209-11, Sheppard (1983) pp. 73-76, and Done (1983) p. 136.
7. Carry out reading or field observation on the way other sessile (fixed) marine organisms, such as sponges, compete with each other for space.
8. What about fixed organisms which live on land? See if you can find out how some of these compete with each other for space.

Readings

Endean, R. 1982 *Australia's Great Barrier Reef.* St Lucia: Univ. Qld Press.

Done, T. 1983. Coral zonation: its nature and significance. In *Perspectives on coral reefs,* ed. D. J. Barnes. Canberra: Clouston/Aust. Inst. Marine Science.

Sheppard, C..R. 1983. *A natural history of the coral reef.* Poole, Dorset: Blandford Press.

Talbot, F., ed. 1984 *Reader's Digest book of the Great Barrier Reef.* Sydney: Reader's Digest.

Some further specialised readings

Connell, J.H. 1973. Population ecology of reef-building corals. In *Biology and geology of coral reefs,* ed. O. A. Jones and R. Endean, vol. 2, pp. 205-45. New York: Academic Press.

Lang, J. 1973. Interspecific aggression by scleractinian corals. Why the race is not only to the swift. *Bulletin of Marine Science* 23: 260-79.

Sheppard, C.R. 1979. Interspecific aggression between reef corals, with reference to their distribution. *Marine Ecology — Progress Series 1,* pp. 237-47.

Potts, D.C. 1976. Growth interactions among morphological variants of the coral *Acropora palifera.* In *Coelenterate ecology and behaviour,* ed. G. O. Mackie, pp. 79-88. New York: Plenum.

47. Growth forms – corals and algae 1-1¾ hr •

Concepts
Growth form
Species
Genus
Intraspecific variation
Interspecific variation
Algae
Coral
Colony

Skills
Observing
Comparing

Attitudes
Interest in natural environments
Curiosity

Aim

- To explore some ways in which the growth form of a plant or animal is affected by its environment.

You will need

- Pencil and recording sheet
- Reef-walking gear
- Snorkelling gear (optional)

For this activity, about 1½ hours on the reef at low tide is required, plus about ¼ hour on land.

We are all familiar with the idea that the form in which a particular type of plant grows is partly influenced by its environment. For example, if you take two garden shrubs of the same species and grow them in different places, they may end up looking quite different, depending on how much sunlight, wind or water they get and what sort of soil they are growing in. Not only may the overall size and shape of the shrubs differ, but the leaves may be of different size and the spacing of branches different. One shrub may, for example, end up looking compact, and the other may look quite straggly.

What to do

1. Look at some plants on the cay:
   (a) Can you find a case where, within an individual plant, there are two or more growth forms? (Look, for example, at a grass plant with long runners growing partly in shade and partly in the sun).
   (b) Can you find two plants which are of the same species but which have different growth forms?
   (c) Make some sketches of your observations.
2. Go walking on the reef flat. Look for plants of the alga sea grapes *(Caulerpa racemosa)* growing partly in sunlight and partly in deep shade (e.g. beneath a coral colony).
   (a) Find out whether the shaded parts of a plant have a different growth form from the parts of the plant growing in full sunlight. Follow the long runners from shady to sunlit areas.
   (b) Describe any variation you see within individual plants. Make sketches of your observations.
3. (a) Look at some large colonies of coral on the reef. Look both on the reef flat and the reef crest. Does the growth form of the coral appear to change *within* one colony? For example: Is one part of it flat and sheet like, whereas another part of it has branches? Does one part of it have a closely spaced, compact branching form, and another part straggly open branches? Make notes on your observations and draw some sketches.
   (b) You could also make similar observations while snorkelling or looking at the reef slope from a "submarine".

Questions to consider

4. If someone handed you several broken-up bits of a particular coral colony, or of a sea grapes plant, and if the pieces each displayed different growth forms, do you think you could be misled into thinking they came from different species of coral or algae?
5. Based on what you have seen in this study, do you think that growth form is a very reliable guide to deciding whether two different specimens of coral or sea grapes belong to the same species?

For many years, scientists have found it hard to decide which coral colonies belong to which species. They often have had difficulty deciding whether two corals with different growth forms belong to different species, or to the same species. Recent studies, however, indicate that one species of coral can grow in many different forms — depending on environmental conditions (see Talbot 1984, pp. 125, 127, 129).

Ideas for further things to think about

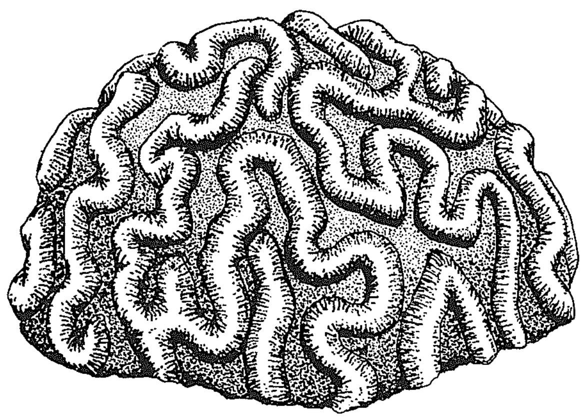
6. What is meant by the terms "intraspecific variation" and "interspecific variation"?
7. Think about the following aspects of intraspecific variation in humans. Which are influenced by environment, which by inheritance, which by both?
   skin colour; eye colour; body height; body weight.
8. Read literature to find out the types of coral features which are used to distinguish one genus and species from another.

Readings

Cribb, A.B., and Cribb, J.W. 1985. *Plant life of the Great Barrier Reef and adjacent shores.* St Lucia: Univ. Qld Press.

Mather, P., and Bennett, I. 1984. *A coral reef handbook.* Brisbane: Australian Coral Reef Society.

Talbot, F., ed. 1984. *Reader's Digest book of the Great Barrier Reef.* Sydney: Reader's Digest.



Brain Coral – Symphyllia radians

48. Coral-tree comparison 1½ hr •

Concepts
Habitat
Adaptation
Niche
Ecology
Photosynthesis
Zooxanthellae

Skills
Analysing
Comparing

Attitudes
Interest in diversity of living things

Aim

- To make some comparisons between the form, function and roles of corals and those of trees and other land plants.

You will need

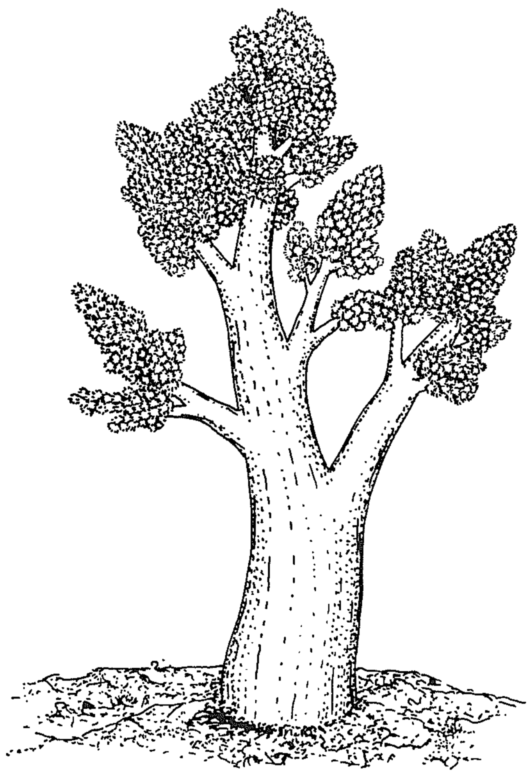
- Pen and paper
- Basic reference material on biology and reef life.

People who see the underwater scenery of the Great Barrier Reef are often reminded of beautiful gardens; many favourite reef snorkelling spots have been named "coral gardens". Whereas the main scenic features in the underwater "gardens" of the reef are corals, in land gardens it is often trees and shrubs which are the outstanding features. From a biological and aesthetic point of view, what similarities and differences exist between corals and trees?

What to do

Through discussion with others, by reading books and other literature and, if possible, by making your own observations of coral and trees, answer the questions below.

1. Corals and trees have many different growth forms. By looking at pictures or by looking at living trees or corals, make sketches of some different shapes in which corals and trees grow.
2. Try to find out by reading: About how high are the tallest trees? How fast do trees grow? What is the biggest coral colony you can find out about? How fast can the branch of a coral grow?
3. From each of the alternatives shown in the left-hand column of table 48.1 choose one which best fits a staghorn coral colony and a tree.



Soft Coral – Nepthea sp.

Table 48.1

	Staghorn coral colony	*Tree*
Animal/plant		
Fixed/mobile		
Single organism/ collection of many organisms		
Material in which it lives: air and soil/water		
Has a rigid skeleton of: calcium carbonate/wood and cellulose		
Animals which live in its branches: fishes/birds		
Animals which eat it: fishes/birds		

4. For both staghorn coral and a tree, answer the questions below:
   (a) Does it take in any material from the floor to which it is attached?
   (b) Does it capture other living things to eat?
   (c) Does it make all its own food?
5. Write a brief description of the following:
   - Coral polyp
   - Leaf
   - Photosynthesis
   - Nematocyst
   - Chlorophyll
6. Why do trees need light? Why do they tend to grow upwards and spread out?

Although the polyps of reef-building corals are animals, they harbour within their tissues many minute single-celled green plants called zooxanthellae. These algae carry out photosynthesis. The relationship between coral polyps and the algae is symbiosis. Both parties benefit from the relationship. The coral polyp, as well as capturing living things using the stinging cells on its tentacles, also derives some food material from the photosynthesis of the zooxanthellae. It is helped by the algae to grow its calcium carbonate skeleton at a rapid rate.

7. Reef-building corals grow only in well-lit areas of the sea. Based on the information given above, why do you think this is the case?
8. Make a sketch of a coral colony growth form which allows the colony to receive much light.

Ideas for further things to do and think about

9. Both trees and living corals are brightly coloured. Try to find out what causes the colouring in each.
10. In some species of corals, the way the colony grows is affected by *water movement*. Branches tend to grow aligned somewhat parallel to current or wave direction. Can you think of a way in which moving air *affects the growth of a tree?*
11. What destructive effects do storms have on trees and corals?
12. Many trees and corals are able to carry out *asexual* reproduction. Try to find out how this happens.
13. Both trees and coral colonies are hosts to many small invertebrate animals. What are some of these? How do they affect the hosts?
14. On some trees in rainforests, epiphytes such as staghorn ferns grow. Consider the relationship between a staghorn fern and the tree on which it grows. How does this compare with the relationship between coral polyps and zooxanthellae?
15. Scientists have found that some reef-building corals are able to grow well in lower light intensities than others. Think about a rainforest. Do all green plants require the same light intensity? What are some green plants which do well in low light intensities?
16. Coral colonies and trees can interfere with the growth of neighbouring corals or trees. Find out some methods by which this happens.

Readings

Talbot, F. 1984. *Reader's Digest book of the Great Barrier Reef.* Sydney: Reader's Digest.

Sheppard, C. R. 1983. *A natural history of the coral reef.* Poole, Dorset: Blandford Press.

Jones, O.A. and Endean, R. 1973-1977. *Biology and geology of coral reefs. Vols 1-4. New York: Academic Press.*

Goreau, T. F., Goreau, N.I., and Goreau, T.J. 1979. Corals and coral reefs. Scientific American, August 1979.

49. Worm watching

1 hr •

Concepts
Diversity
Adaptation
Habitat

Skills
Observing
Recording

Attitudes
Curiosity
Patience
Interest in natural environments

Aim

- To become aware of diversity among reef-top worms and to recognise some different adaptations possessed by worms.

You will need

- Underwater slate and pencil.
- Worm identikit
- Snorkelling gear (optional)
- Hand lens

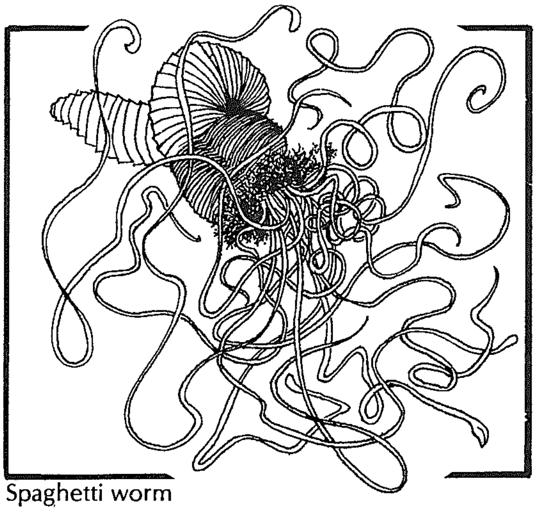
What to do

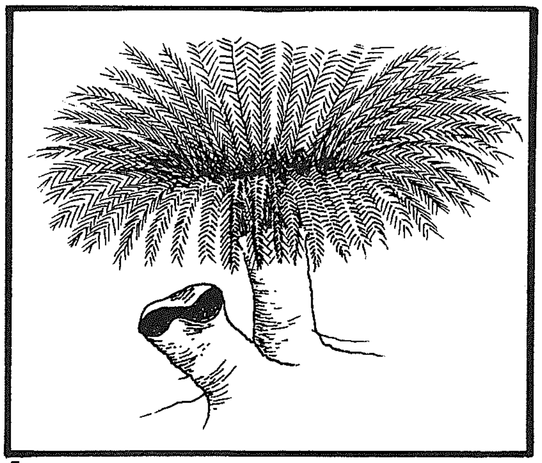
1. Start at the beach and walk slowly out through the inner sand zone to the reef crest looking carefully for worms along the way under boulders, in crevices, in algae clumps or in coral colonies. Be careful to return all boulders to their original position.
2. When you find a worm, look carefully at it for at least three minutes. Answer as many of the following questions as possible:
   (a) Where does the worm live?
   (b) Does the worm move about from place to place or is it more or less fixed in the one location?
   (c) Is the worm flat and leaf-like in shape without segments or does it have a long segmented body, or some other shape?
   (d) Does it have any bristles, legs, feathery gills or other appendages?
   (e) What sort of movement does it make?
   (f) How does it react to stimuli?
   (g) Can you see its head? What is the shape of the head? Where is the mouth?
   (h) How do you think it might get food and oxygen? What colour is it? Is the colour a means of camouflage?
3. Try to identify the worm using the identikit.
4. Now make a detailed sketch giving a scale.
5. Repeat your study and information collection for other worms.
6. Compile your information, read some literature on worms and write a short report on your observations.

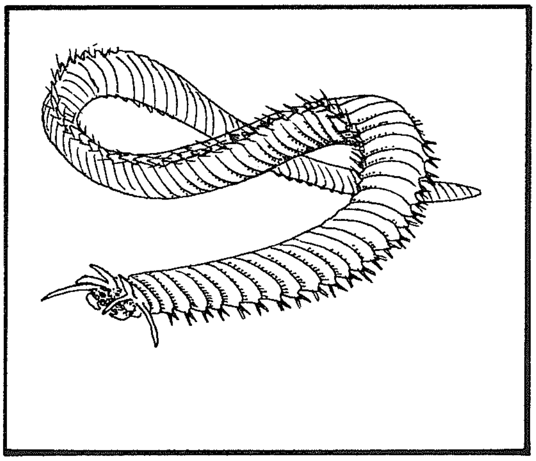
Warning
Some worms have bristles which are extremely irritating if handled. *Do not* pick up worms.

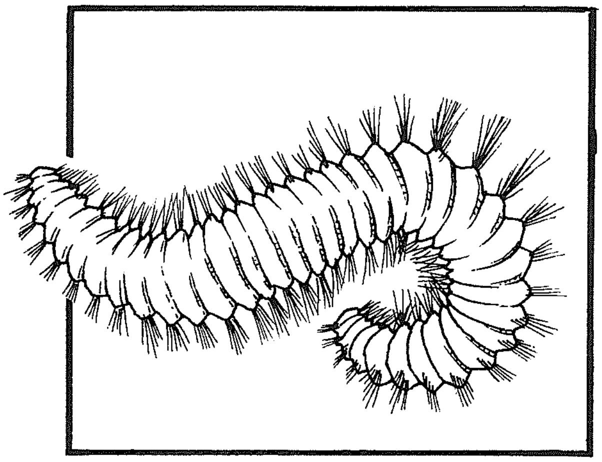
FIELD SHEET

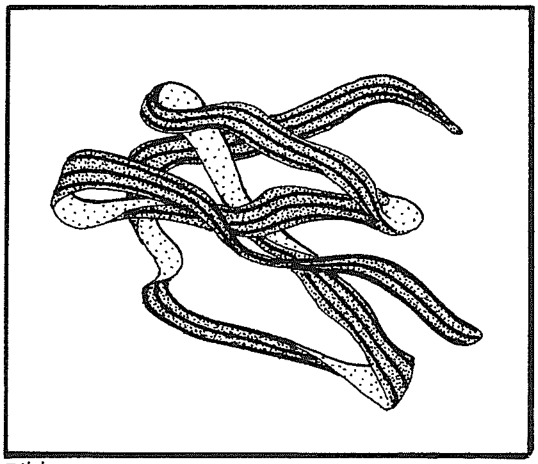
Worm identikit

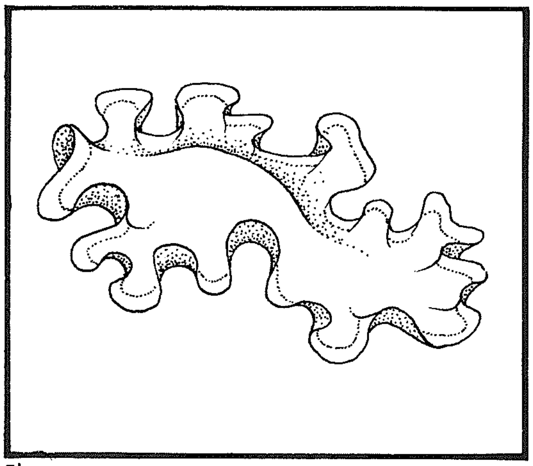

Spaghetti worm


Fan worm


Rag worm


Bristle worm


Ribbon worm


Flat worm

50. Clams big and beautiful 2 hr

Concepts
Diversity
Distribution
Adaptation

Skills
Hypothesising
Measuring
Identifying
Recording
Interpreting
Enquiring in a scientific manner

Attitudes
Persistence
Curiosity
Appreciation of qualities of natural environment

Aim

- To become familiar with some clam features.
- To record the distribution and variety of clams on a reef top.
- To explore possible reasons for clam distribution.

You will need

- Hand click counter or notebook
- Paper and pencil or portable tape-recorder
- Magnetic compass
- Plastic ruler
- Stopwatch
- 5 m length of rope

What to do

1. Select a distinctive landmark at the edge of the island and from this, walk out across the reef-top to the reef crest. Use a compass and walk on a constant compass bearing. Afterwards, plot the line of your traverse on a map.
2. As you walk out along the traverse, you will need to:
   (a) Keep a count of the distance you are from your cay landmark. (That's what the rope is for.)
   (b) Click or count the total number of clams.
   Record a clam if it is less than 1 metre from your transect line.
3. When you come to a clam stand back while you record its size, mantle colour, distance from shore and whether it is embedded in the coral or not. Then move so your body shadow falls across the clam. Time how long the clam takes to close. Are the shells still slightly apart? If so, measure distance apart. (Be careful!)
4. If you think there are several species of clam present, code your results with a different symbol for each.
5. Do a similar transect from another point on the island, i.e., one on the windward and one on the leeward side of the reef.
6. You could now use your data to estimate:
   (a) The average density of clams on the reef.
   (b) The ratios of different colours of clam.
   If you think there is more than one species present, you could do these calculations separately for each species.
7. From your results, can you see any regular patterns or trends in the distribution of clams on the reef-top, or in the distribution of particular colours of clams?
8. Can you put forward any hypotheses about why clams are distributed the way they are on the reef-top.

Ideas for further things to do

9. Try to find out what causes the colours in the clam mantles; how fast a clam grows; how clams reproduce.
10. Make a histogram showing frequency of sizes and classes of the clams you've seen.

Reading

McMichael, D.F. 1974. Growth rate, population size and mantle coloration in the small giant clam *Tridacna maxima* (Roding) at One Tree Island, Capricorn group, Queensland. In *Proc. of the Second International Coral Reef Symposium*, pp. 241-54. Brisbane: Great Barrier Reef Committee.

FIELD SHEET

50. Clams big and beautiful

Recorder: ______________________ Island: ______________________

Landmark on island: ______________________

Compass-bearing along transect: ______________ Weather: ______________

Distance from shore (m)	*Species code (optional)*	*Cumulative total*	*Colour*	*Size*	*Time taken to close*	*Distance between closed shells*

51. Homing chitons? 2 hr + •

Concepts
Herbivore
Consumer
Homing

Skills
Observing
Mapping
Recording
Designing experiments

Attitudes
Persistence
Curiosity
Desire to question

Aim

- To investigate behaviour of chitons on beach rock

You will need

- Tubes of artists acrylic paint
- Fine-hair paintbrush
- Magnetic compass
- Ruler
- Polaroid camera with flash unit (optional)
- Waterproof, coloured plastic tape
- Notebook or clipboard and sheet, and pencil
- Permit

This activity requires at least two hours in total, at various times during your trip. It is best done at low tide after nightfall.

What to do

1. Locate five chitons on the beach rock.
2. Identify each one by painting a very small dot on a shell segment. On the first chiton, paint the dot on the first segment; on the second chiton, put the dot on the second segment, and so on.
3. Make a precise record of the initial location of each specimen. Take compass bearings on obvious features to locate accurately where the chiton is, and map its position on a sketch or an instant photograph. Waterproof tape could be tied to the beach rock to further identify the site.
4. Record movements only of the marked chitons which take place while you watch.
5. Look at some chitons to find out:
   (a) how chitons move,
   (b) whether there are any signs of grazing off the algae which grows as a film on the rock,
   (c) what happens when water splashes on to a chiton,
   (d) whether you can easily move a chiton.
6. Return to the site after one or two hours and at the next low tide to find out what has happened to the marked chitons. Can you find five marked chitons? Is each one in the same place? Have any disappeared? How far did each move?
7. Return to the site for as many low tides as possible, noting differences, if any, in positions of marked chitons.

Questions to consider

8. Do chitons graze and move only at night?
9. Do you think each chiton has a "home base"? If so, does the chiton stay near its home base?

Some further things to do

10. Devise other experiments to find out more about chitons and their movements.

52. Looking at *Linckia* 2 hr + •

Concepts
Warning coloration
Tube feet
Adaptation
Habitat

Skills
Observing
Recording
Experimenting

Attitudes
Appreciation of natural environment
Curiosity

Aim

- To observe the large blue sea star *Linckia* and to develop an understanding of how this particular reef animal is adapted to its environment.

You will need

- A notebook or waterproof sheet attached to a clipboard; a pencil
- Ruler or tape
- Watch
- Sheet of clear perspex about 30 cm square
- Usual reef-walking gear

What to do

1. Find a blue sea star on the reef flat at low tide.
2. Observe carefully and sketch the animal.
3. Make some measurements, e.g., total diameter, length of longest arm.
4. Gently pick up the sea star. As you lift it, quickly check beneath to see if its stomach is everted. If so, take note of what the animal was feeding on.
5. Place the sea star on the perspex and splash it gently with sea water a couple of times.
6. When the animal has relaxed, look at it from underneath the perspex. Try to work out how the tube feet are operated and how they are rotated. How many tube feet does it have? Can you see its mouth? Put a small piece of bread, fish or algae under one arm. What happens?
7. Time how long your sea star takes to "walk off" the perspex. Can you work out its speed?
8. Gently turn the sea star on its back in water. Watch how it turns itself over. How does it do it? Time how long it takes. Be patient. Remember that the animal is extremely vulnerable in this position, so do not leave before it has turned itself right over.
9. Is *Linckia* easily seen on the reef? Why? How do you think this might help it to survive?
10. Describe the habitat of this animal.
11. Discuss what you consider to be this animal's major adaptations to enable it to survive in this part of the reef.

Ideas for further things to do

12. Consider populations — how many *Linckia* live on a particular section of the reef?
    Select a manageable study area. Decide whether to do a total count or whether to sample one area and estimate total numbers. Make a careful census of the population within an easily distinguished area. Your results can be compared with other people's results over time and we may be able to see whether the population is static, whether it changes seasonally, or whether it is decreasing or increasing.
13. Find out more about blue *Linckia* from books or other reference material.

53. Cucumbers are cute 1 hr + •

Concepts
Adaptation
Morphology
Habitat

Skills
Observing
Recording

Attitudes
Curiosity
Appreciation of natural environment

Aim

- To spend some time with a sea-cucumber so as to learn as much about its structure and behaviour as possible.
- To make observations concerning the habitat and population density of these kinds of animals.

What to do

1. Find somewhere comfortable in the water on the reef-top with a sea-cucumber.
2. Now make careful observations of your animal for at least 5-10 minutes. Try to discover:
   (a) its main external features — mouth, anus, tube feet, etc.
   (b) how it feeds
   (c) how it moves
   (d) what it reacts to and how it reacts
   (e) how it uses camouflage or defensive mechanisms
   (f) how it reacts to other sea-cucumbers around it
   (g) how it reacts to you.
3. Now look around you:
   (a) Are there other sea-cucumbers of this kind about?
   (b) Is there a particular habitat this type of sea-cucumber seems to prefer?
   (c) Make a rough estimate of the population density of this type of sea-cucumber: about how many are there per square metre?
4. From your observations, why do you think sea-cucumbers are called "vacuum cleaners of the reef"?
5. Read literature to find out more about the biology of holothurians (sea-cucumbers).
6. Make up a report on "My Experiences with a Sea-Cucumber" and give a three-minute talk based on it to members of your group.

sea cucumber

54. Cucumber count

2 hr +1 hr ● ●

Concepts
Population distribution
Abundance
Habitat
Adaptation
Competition
Niche
Sustainable yield

Skills
Observing
Collecting and recording data
Synthesising data
Hypothesising

Attitudes
Appreciation of natural environments
Confidence in making observations
Interest in methods of science

Aim

- To estimate the size and density of the sea-cucumber (holothurian) population of the reef-top.
- To gain an appreciation of the part sea-cucumbers play in the reef ecosystem.

You will need

- Reef-walking gear and possibly snorkelling gear
- Underwater board, waterproof field sheet and pencil
- Reference material
- Measuring tape or cord (20 m) (optional)
- 1-metre string, or metre stick
- Map or air photo of reef
- Ruler
- Transparent graph paper (optional)

This activity requires about two hours at low tide for fieldwork and about one hour for follow-up work.

> **PRECAUTIONS**
> *Avoid touching eyes after handling sea-cucumbers. Material from these animals may irritate the eyes.*

What to do

Gathering data (field work)

1. Divide into small groups (about four people per group). Each group is to make a transect at low tide across the reef-top from beach to reef crest, counting sea-cucumbers.
   (a) Each group should select a starting point which is recognisable on a map or air photo, take a compass bearing to the reef crest and walk along this bearing.
   (b) Use a knotted cord or measuring tape as the transect line, or measure the transect line using paces.
   (c) At sample points every 20 metres along the transect line, count all the sea cucumbers in a 4-square-metre area (you could conveniently do this by looking at a 2-square-metre area on either side of the transect line at each of your sample points). If you can, decide what species the sea-cucumbers belong to by referring to reference material.
   (d) Record the information on the field sheet.

Analysing data

2. Work out the *average number of sea-cucumbers* (all kinds) *per square metre* on the reef-top.
   One way this can be done is to combine the totals from each station on your transect and divide this by the total number of square metres sampled.
3. Make an estimate of the *total number* of sea-cucumbers on the reef flat and reef rim.
   (a) Use a map or air photo to work out the total area of the reef-top (not including lagoon, if present). (A grid such as transparent graph paper will help you do this.)
   (b) Use the value obtained in (2) for the average number of individuals per square metre. Multiply this by the total area of the reef-top (excluding lagoon).
4. Work out the *relative numbers* of the various species of sea-cucumber. (List the names of the species in order of abundance. Express the relative abundance as a ratio.)

Questions to consider

5. Do you think that the method used to calculate the average number of sea-cucumbers per square metre is valid? If not, how could the method have been improved?
6. (a) Look at your transect data. Does the population density of sea-cucumbers seem to be different in different zones of the reef-top (inner reef flat, outer reef flat, reef rim, etc.)? (You could make a graph showing the total numbers of sea-cucumbers obtained at each station along the transect.)
   (b) Look at the transect data obtained by other groups. Is there any difference between sea-cucumber population density on the windward and leeward sides of the reef?
   (c) If sea-cucumber population density is *not* the same on different sides of the reef or in different reef-top zones, what factors might contribute to this?
7. (a) Select two common sea-cucumber species, e.g. the "curry" cucumber *(Stichopus variegatus)* and the "knobbly" cucumber *(Stichopus chloronotus).*
   (b) Examine the distribution data for each.
   (c) In which zone of the reef-top is the population density of each species least? greatest?
8. According to research studies reported by Bakus (1973), an individual sea-cucumber might take in as much as 100 grams (estimate) of sediment each day. Let's assume an average intake rate per individual of 30 grams per day. How much sediment might be taken in annually by all the sea-cucumbers on this reef-top?
   Try to design an experiment to find out what sedimentary material they are taking in and what they are actually using from it?
9. What factors, natural and human-influenced, might cause a population of a species of sea-cucumber on a reef-top to fluctuate from time to time? How could this fluctuation be identified?

Sustainable use
When humans harvest living things, it is important to safeguard future production by ensuring that annual harvest size is not too great. The term "sustainable use" refers to the conservation practice of using a living resource at a level which allows the supply of the resource to be maintained indefinitely into the future.

10. In the past, fishing of some sea-cucumbers (called beche-de-mer or trepang) took place on many reefs in the Great Barrier Reef area. Suppose someone wanted to carry out beche-de-mer fishing now at a particular reef. Reef management authorities would have to decide whether this would be allowed. How do you think they could determine whether the proposed fishing activity would be detrimental to this reef and whether, and how, it could be carried out on a sustainable use basis? Are there other factors which you think should be taken into consideration in deciding whether the proposed fishing should be allowed to go ahead? What kind of information do you think the reef management authorities would ideally like to have available to them before they have to make a decision like this?

Other studies

Related studies which could be done before this are activity 32, *"Getting to know an active reef creature"*, or activity 53, *"Cucumbers are cute"*.

Readings

Bakus, Gerald. 1973. The biology and ecology of tropical holothurians. In *Biology and geology of coral reefs*, ed. O. A. Jones and R. Endean, vol. 2. New York: Academic Press

FIELD SHEET

54. Cucumber count

Station no.	Metres from shore	Zone of reef e.g. reef flat, reef rim	Total sea-cucumbers present	No. of each species, e.g. A = 24, C = 3	Station no.	Metres from shore	Zone of reef e.g. reef flat, reef rim	Total sea-cucumbers present	No. of each species, e.g. A = 24, C = 3
1					21				
2					22				
3					23				
4					24				
5					25				
6					26				
7					27				
8					28				
9					29				
10					30				
11					31				
12					32				
13					33				
14					34				
15					35				
16					36				

ISLAND/REEF: LOCATION OF TRAVERSE: Starting point: Bearing:	DATE: PEOPLE IN GROUP: (Initials)
CALCULATIONS: Total no. sea-cucumbers counted	Total area of reef-top (including lagoon) ....m^2
Total area of reef sampled on this traverse ....m^2	No. of sea-cucumbers on this reef-top (excluding lagoon) ....m^2
Average no. of sea-cucumbers per metre ^{2} on this traverse	If sediment consumption each day = 30g, total amount of sediment consumed yearly ....

55. Sea-cucumber habitats 2 hr •

Concepts
Habitat
Adaptation
Competition
Niche
Niche diversity

Skills
Observing
Collecting and recording data
Synthesising data
Hypothesising

Attitudes
Appreciation of natural environments
Confidence in making observations

Aim

- To find out where different types of sea-cucumber live on the reef-top.

You will need

- Reef-walking gear and possibly snorkelling gear
- Board, field sheet and pencil
- Reference material

At least two hours are required for fieldwork, mainly or entirely at low tide. The activity could be done piecemeal over several days.

> **PRECAUTIONS**
> *Avoid touching eyes after handling sea-cucumbers. Materials from these animals may irritate the eyes.*

What to do

Gathering data (fieldwork)

1. Walk or snorkel across the reef-top on one or more occasions. Explore living and dead coral clumps and look under boulders. Each time you find a sea-cucumber, note which species it is and the habitat in which it lives. Record on the field sheet provided.
2. During your fieldwork, think about the physical differences between the various habitats. Which seems to provide the most and least protection from light and desiccation? Which is best and least endowed with loose sediment particles? Which seems most exposed to wave action? Make a note of other ways in which the habitats might differ physically from one another.

Analysing data (back at base)

3. How many species did you find?
4. From the data recorded on your field sheet, what appears to be the habitat, or range of habitats, favoured by each species?
5. Is each habitat occupied by more than one species?

Questions to consider

Based on your fieldwork, literature study and discussion, answer the following:

6. Can you recognise any adaptation(s) which especially seem to fit each species for the habitat it occupies?
7. Where one or more species occupy the same habitat, to what extent do you think they might be competing with each other?
8. There is a tendency in reef areas for life roles of inhabitants to be very diverse, with available resources being finely divided up (i.e., partitioned) by reef inhabitants. This is called niche diversity. To what extent do studies of sea-cucumbers support the idea of niche diversity?

Reading

Bakus, Gerald. 1973. The biology and ecology of tropical holothurians. In *Biology and geology of coral reefs*, ed. O. A. Jones and R. Endean, vol. 2. New York: Academic Press.

FIELD SHEET

55. Sea-cucumber habitats

Reef:	*Date(s):*	*Observers:*

For each species make a tally in the spaces below as you go.

Species	*Reef flat*				*Reef crest*			
	Exposed on sandy areas	Under boulders or coral	Exposed on rubble	Other	Under boulders	Exposed on pavement	Exposed on rubble	Other
A								
B								
C								
D								
E								
F								
G								
H								

Calculations:

56. Ghost crabs ¾ hr •

Concepts
Structure
Function
Behaviour
Adaptation
Environment
Nocturnal environments

Skills
Observing
Discussing
Experimenting
Cooperating

Attitudes
Desire to question
Enjoyment of outdoor experience
Persistence

Aim

- To observe the behaviour, distribution and size variation of ghost crabs on the beach at night.

You will need

- A torch
- Companions
- A field notebook and pencil
- A watch with a second hand
- Some "crab food" (you decide what to try but make sure it is not left on the beach after your experiment)
- A permit

What to do

1. After dark, at low tide, walk around the island along the sandy beaches.
2. Spot some ghost crabs.
3. Observe one carefully, especially the shape of the carapace, the eye stalks and their position, the colour of the crab, the size of the pincers, number of legs, etc.
4. Try to catch one and check to see whether it is male or female. If female, does it have eggs? Note its size.
5. Chase a crab. What does it do? Do all the crabs react in the same way? Does size seem to influence the way they react?
6. When a crab stops, how long does it take to burrow? Does it burrow clockwise or anticlockwise? Does this vary with size.
7. How many species of ghost crab can you find?
8. Why do you think these crabs are nocturnal?
9. Try to find out what the crabs eat and how they feed. Put down some different foods, e.g. a chop bone, some bread, and see what happens. (Remove these when you leave.)
10. Either discuss your findings with other groups who have also looked at ghost crabs or write a brief report on your observations and conclusions about ghost crabs.

Ideas for further things to do

11. Do you think you could get a population density estimate of ghost crabs for the whole island? Work out your experimental design. You will probably need to mobilise your whole group to help. Try it on different nights and average your results. Does it make a difference if it is a clear night, a cloudy night or a full moon?
12. Find out minimum and maximum sizes of crabs on your island.

57. Hermit crabs 1 hr •

Concepts
Adaptation
Niche
Nocturnal
Behaviour
Population
Distribution
Habitat

Skills
Observation
Recording
Inferring
Experimenting

Attitudes
Appreciation of natural environment
Curiosity
Perseverence

Aim

- To observe the structural and behavioural adaptations of the large red land hermit crabs. (Lady Musgrave Island is a good place for this.)

You will need

- A torch
- A watch
- Companions
- Some "crab food" (you decide what crab food to use but make sure it is not left on the beach afterwards)
- Acrylic paint and a fine-hair paintbrush
- Permit, if animals are to be marked or tagged

What to do

1. Walk around the island along the beach after dark.
2. On the leeside of the island you may find some large red land hermit crabs on the beach.
3. Observe one animal carefully. Note size, colour, number of legs, shape and size of its eye stalks, what sort of shell it has, etc. Do they all have the same type and size of shell?
4. Watch how they move. Do they leave a track on the sand? How fast can they move? Design an experiment to work out their speed.
5. Observe the hermit crabs' way of perceiving and reacting to the environment. Experiment with sounds, light, vibration.
6. Observe their method of obtaining food and if they have food preferences. Put out your "crab food" and see which is preferred and how it is consumed.
7. Does a hermit crab have a particular range within which it stays? Work out a way of tagging or marking some animals. Observe crabs' undisturbed movements over time. Mark your observation spot. Go back to the same place the next night and see if you can find your marked animals. Are they in the same area? How far have they moved? (Acrylic paint dots might be used to mark individual crabs, but a *permit will be needed.*)
8. Discuss your observations and decide what you think are the most important adaptations this animal has which enables it to survive. Are they mainly behavioural or structural? Why do you think it is a nocturnal animal?

Ideas for further things to do

9. What is the population of red hermit crabs on this island? You may need to mobilise your whole group in order to monitor the entire island. If you divide the island into sections you may also be able to work out the preferred habitat for these crabs.
10. Discuss why they are not evenly distributed around the whole island.
11. Where do they go during the day?

58. Following a friendly fish 1 hr •

Concepts
Fish structure
Fish behaviour
Interrelationships
Adaptations

Skills
Observing
Recording underwater

Attitudes
Appreciation of natural environments
Confidence in making and recording observations

Aim

- To investigate the lifestyle of a single fish.

This activity consists of two parts — an introductory exercise and an in-depth exercise for those who wish to investigate their fish further.

You will need

- Snorkelling gear and appropriate protection from sun
- Underwater slate and pencil

What to do

Introductory activity

1. In a reef pool or harbour follow a particular fish quietly. (A sweetlip or bream is suggested.)
2. Observe its feeding behaviour. How much searching and "working" for food is performed?
3. What structural adaptations possessed by the fish help it to find and take its food?

In-depth activity — a single fish

4. Select one fish which you can observe carefully. (A parrotfish, butterfly fish or puffer fish is suggested.)
   (a) Observe and record its general structure. Note its size; sketch it, noting scale; record exact colour patterns, relative size and position of fins, size, shape and position of mouth.
   (b) Observe and record its
   - method of locomotion (note use of all fins, tail, etc.)
   - method of catching/obtaining food and ingesting — snorkel around with the fish to observe
   - method of perceiving and reacting to the environment
   - sense organs
   - response to changes (waves/depths/other fish/other groups/you)
   - special behaviour, e.g. territoriality, special relationships (symbiotic, commensal, parasitic).

Note: To get definitive data you will need to devise a record sheet which
- is easy to use and record on in the field,
- allows you to record factual data such as measurements, numbers.
- allows you to obtain statistically valid data, i.e., number of observations, to enable you to put forward an hypothesis on behaviour.

5. After your snorkel, identify your fish by reading.

Ideas for further things to do

6. Refer to the books listed below and compare the authors' notes with your own observations.
7. Check previous research findings on the species you've observed.

Reading

Carcasson, R.H. 1977. *A field guide to the reef fishes of tropical Australia and the Indo-Pacific region.* London: Collins.
Coleman, N. 1981. *Australian sea fishes north of 30°S.* Sydney: Doubleday.
Grant, E. 1978. *Guide to fishes.* Brisbane: Dept Primary Industry. (Waterproof version available.)

59. Pursuing a parrotfish — 2 hr •

Concepts
Fish structure
Fish behaviour
Interrelationship
Adaptation

Skills
Observing
Recording underwater

Attitudes
Appreciation
Perseverence
Enjoyment of outdoor experience

Aim
- To investigate the lifestyle of a parrotfish (family Scaridae).

You will need
- Snorkelling gear
- Underwater slate and pencil
- Reef-walking shoes

This activity requires one hour at high tide and one hour at low tide.

What to do
At high tide

1. Before going into the water, put a copy of the outline drawing of a parrotfish on your underwater slate.
2. Snorkel across the reef flat and find a school of parrotfish.
3. Lie very still in the water and listen. What do you hear?
4. Can you observe where these creatures have been feeding? As the school moves on, examine the coral more closely.
5. Follow the school and try to observe how many individuals are present. Are they all the same colour? Are they all the same species? Are they all the same size?
6. As you follow the school, try to observe what types of corals are grazed. Make as many observations as you can on behaviour and factors which you believe are important in the life of a parrotfish.

At low tide

7. Walk across the reef flat at low tide, leave your sandshoes on a conspicuous coral boulder and put on your fins and mask.
8. Find a school of parrotfish close to the reef edge. Repeat the observations you made at high tide. However, make comparisons between the behaviour of the school at low tide and at high tide. Do the fish appear to be as active? Are the schools larger or smaller? Is feeding activity as intense?
9. Consider the following questions in relation to your observations:
   (a) Do you believe parrotfish would have an effect on the growth rate of corals?
   (b) What would limit the distribution of parrotfish?
   (c) How would a Crown-of-Thorns starfish plague affect parrotfish populations on a coral reef? How would this affect the predators of parrotfish?

Ideas for further things to do
10. Distinguishing between parrotfish species can be difficult. You may like to consult the list of references given below. With the aid of these texts, carefully mark in your slate diagram distinguishing features of three different species. It will be quite a feat if you can go on to the reef and find these species. You may also like to research sexual dichromatism from the references given.

Readings

Coleman, N. 1981. *Australian sea fishes north of 30°S.* Sydney: Doubleday.

Carcasson, R.H. 1977. *A field guide to the reef fishes of tropical Australia and the Indo-Pacific region.* London: Collins.

Grant, E. 1978. *Guide to fishes.* Brisbane: Dept Primary Industry.

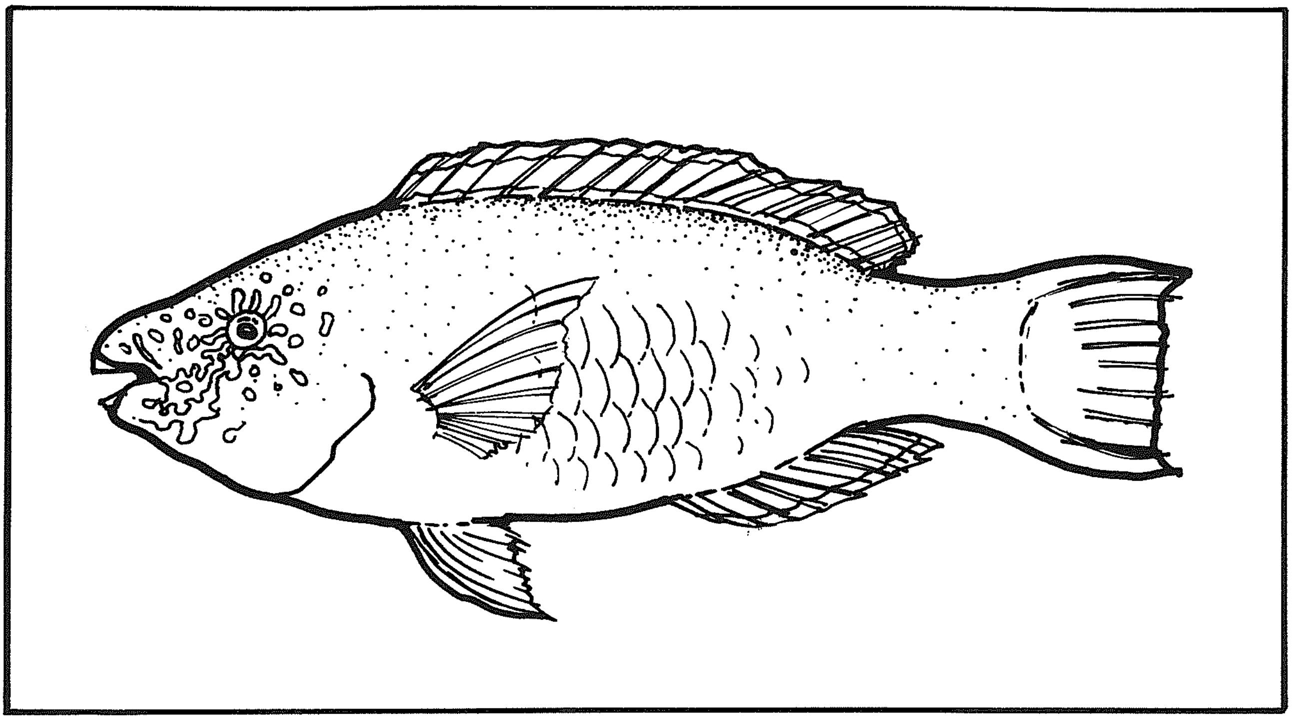


Fig. 59.1.

60. Super spotter ½ hr + ½ hr •

Concepts
Species identification

Skills
Observing underwater
Using reference materials
Comparing

Attitudes
Desire for achievement
Enjoyment of outdoor experience

Aim

- To become familiar with a number of fish species while having fun.

You will need

- Snorkelling gear
- Underwater slate and pencil
- A desire to test oneself in a competitive nature
- Fish identification guides such as books by Carcasson (1977) or Coleman (1981)
- An underwater watch between group members

This activity requires about half an hour snorkelling and a further half-hour on the beach.

What to do

Fieldwork

1. This is a fun project to test your powers of observation in spotting fish at a particular location. Take a slate with you and, at your favourite spot, make a labelled sketch and/or write a description in less than ten words of a particular species. Repeat this for as many species as you can find in half an hour.

Back on the beach

2. With the other members of your group, consult the reference material and see how many species you can identify from your descriptions.
   If you have identified more than 10 species you are an excellent spotter; 7-10, very good; 4-7, good; less than 4, suggest you take up golf!
   This project can be done at any bommie on any of the islands so long as there is an abundance of fish and your group has the suggested handbooks which contain fish identification information.

Ideas for further things to do

3. Test how good you are at identifying fish families. Over your stay, see if you can identify five species from each of the family forms you have memorised. At the end of your stay you should be able to take your friends on a snorkel and identify ten fish for them.

Consider now

4. When people first view the fishes of the reef, they are often overwhelmed by the incredible number of different species. After this exercise, do you now feel more confident in identifying individual species?

References

Carcasson, R.H. 1977. *A field guide to the reef fishes of tropical Australia and the Indo-Pacific region.* London: Collins.

Coleman, N. 1981. *Australian sea fishes north of 30°S.* Sydney: Doubleday.

61. Who's who in the fish families 1 hr •

Concepts
Fish
Families
Species

Skills
Observing
Recording underwater
Using reference books

Aim
- To be able to identify members of a few fish families at a glance.

You will need
- Reference book on coral reef fish, e.g. Carcasson (1977) or Coleman (1981)
- Snorkelling gear
- Underwater slate and pencil

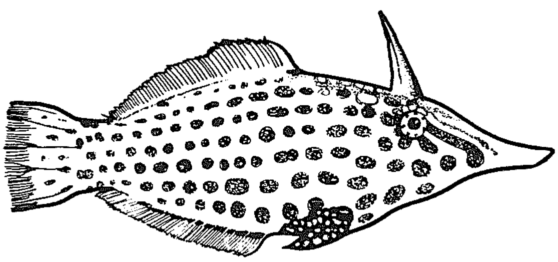
What to do
1. With your reference material, become familiar with the general form of the fish families: Scaridae (parrotfish); Labridae (wrasses); Serranidae (cods); Chaetodontidae (butterfly fish); and Pomacentridae (pullers, damsel fish).
2. Copy a generalised outline for each family on to an underwater slate before you go into the water.
3. Go snorkelling over the reef edge and try to pick out fish of a species from each of the above families. Observe their features and make notes about them on your slate — now go back to your reference book and track your fish down to a species name.

Ideas for further things to do
4. Test how good you are at identifying fish families. Over your stay, see if you can identify five species from each of the family forms you have memorised. At the end of your stay you should be able to take your friends on a snorkel and identify ten fish for them.

Consider now
5. When people first view the fishes of the reef, they are often overwhelmed by the incredible number of different species. After this exercise, have you gained a little more order in your ideas on fish on the reef?

Readings

Carcasson, R.H. 1977. *A field guide to the reef fishes of tropical Australia and the Indo-Pacific region.* London: Collins.
Coleman, N. 1981. *Australian sea fishes north of 30°S.* Sydney: Doubleday.
Grant, E. 1978. *Guide to fishes.* Brisbane: Dept. Primary Industry.



62. Colour patterns in reef fishes — 1 hr •

Concepts
Camouflage
Warning colour
Signal colours and patterns
Counter shading
Disruptive patterns
Diversity
Adaptation

Skills
Observing
Recording
Inferring
Comparing

Attitudes
Appreciation of natural environments
Confidence in own powers of observation

Aim
- To investigate the range of colours and colour patterns of reef fish.
- To develop observation skills in the field.

You will need
- Underwater slate and pencil
- A buddy

What to do
1. Before your fieldwork, draw a number of fish outlines on your slate.
2. Snorkel in a very safe area. Attempt to stay in one place, e.g. near a coral clump.
3. Concentrate on just one fish at a time. For your first fish, select one with a simple, definite pattern.
4. Don't try to identify the fish. Concentrate only on colour and pattern.
5. On the appropriate outline on your underwater slate, carefully record each new pattern.
6. Don't get too frustrated. Many fish will disappear just as you are halfway through your recording. You will get faster with practice. Record the most striking patterns first. Fill in the other details second.
7. After you leave the water, discuss:
   (a) What sort of pattern was most common?
   (b) What colours were most common?
   (c) Why do you think there are so many different patterns and colours?
   (d) Why do you think particular types of patterns are more common?
   (e) How do you think each pattern helps species survival?
   (f) Try to classify the patterns into groupings, e.g. camouflage, counter shading, disruptive colouring.

(**Note:** There is no simple "right" answer to any of these questions. **You** are the scientist who might come up with some original ideas by personal observations.)

8. (a) Write a brief report stating your findings and conclusions.
   (b) If you wish to make this into a major project, you will need to sample a variety of environments on the reef and make many more observations.

Ideas for further reading
9. Find out if reef fishes have colour vision.
10. Identify some of the fish you have observed.
11. Find out about the fish whose colour and patterns change radically as they mature. Think about how this may aid survival.
12. Find out about the nocturnal change patterns of fishes.
13. Find out about fishes which are dichromic.
14. Find out about fishes which change sex (e.g. wrasses and anemone fish). Do colour and pattern change too? Why or why not?

Readings
Ehrlich P. R. et al. 1977. The behaviour of Chaetodontid fishes with special reference to Lorenz's "poster coloration" hypothesis. *J. Zool Lond* 183, 213-28.
Endler, J. A. 1978. A predator's view of animal colour patterns. *Evol. Biol.* 11, 319-64.

63. Movement in fishes 1½ hr - 2 hr • •

Concepts
Adaptation
Locomotion
Habitat
Oscillation
Undulation
Propulsion

Skills
Observing
Snorkelling
Recording underwater
Analysing
Hypothesising

Attitudes
Enjoyment of outdoor experience
Willingness to suspend judgment

Aim

- To observe variety in the methods of locomotion among different fishes and to attempt to relate this to body shape and lifestyle.

You will need

- Snorkelling gear
- Underwater sheet and pencil

What to do

1. Before you go into the field, read the field sheet carefully; make sure you know the names of the fins on the fish; check up on what is meant by oscillation (back and forth movement) and undulation.
2. Go snorkelling and look for these three different fish types:
   - butterfly fish
   - parrotfish
   - trevally (or kingfish or dart)

   You might find a butterfly fish if you snorkel across the reef flat at high tide; a parrotfish might be found near the reef edge and a trevally over the reef slope. You could visit these localities when snorkelling at low tide.
   Don't approach the fish too closely. Lie still in the water and don't scare the fish with sudden movements.
3. For each fish, make observations as follows:
   (a) Where does it live (e.g. among coral, close to coral?)
   (b) What does it feed on (is it a herbivore? is it a predator?)
   (c) What is the main type of locomotion you observe (stationary, manoeuvring, cruising, fast swimming?)
   (d) For any of these types of movement you observe, write down which parts of the fish are involved, and whether you think the movement is oscillation or undulation.
4. Back at base camp, review your data
   (a) Of the three fishes, in which is depth-to-length ratio:
      - greatest?
      - least?

   (b) Which of the three fish appears to be a specialist for locomotion involving
      - maneouvring?
      - sprinting and accelerating?

   (c) How does the characteristic locomotion of the three fishes fit in with this
      - habitat?
      - food source?

   (d) Concerning the way manoeuvring is carried out, do body fins seem to be mainly involved or movements of tail fin and body? What about in fast swimming?
   Look at figure 63.1. Do your own observations fit in with the scheme suggested here. How do they differ?
   (e) Look at the shape of the tail fin. In which kind of fish is the tail most strongly forked?
5. Based on your observations, do you think that:
   (a) body shape and type of fins might be correlated with the main kind of locomotion carried out by a fish?
   (b) body shape might be able to be correlated with habitat and type of feeding?

Ideas for further things to do

6. Based on your guesses made in question 5, make one or two predictions or hypotheses. Carry out further fieldwork to test these.
7. Triggerfish and box fish have interesting means of locomotion. Look for these fish in the field and observe them.

Reference

Webb, P. W. 1984. Form and function in fish swimming. *Scientific American,* 251 (1), July 1984:58-68.

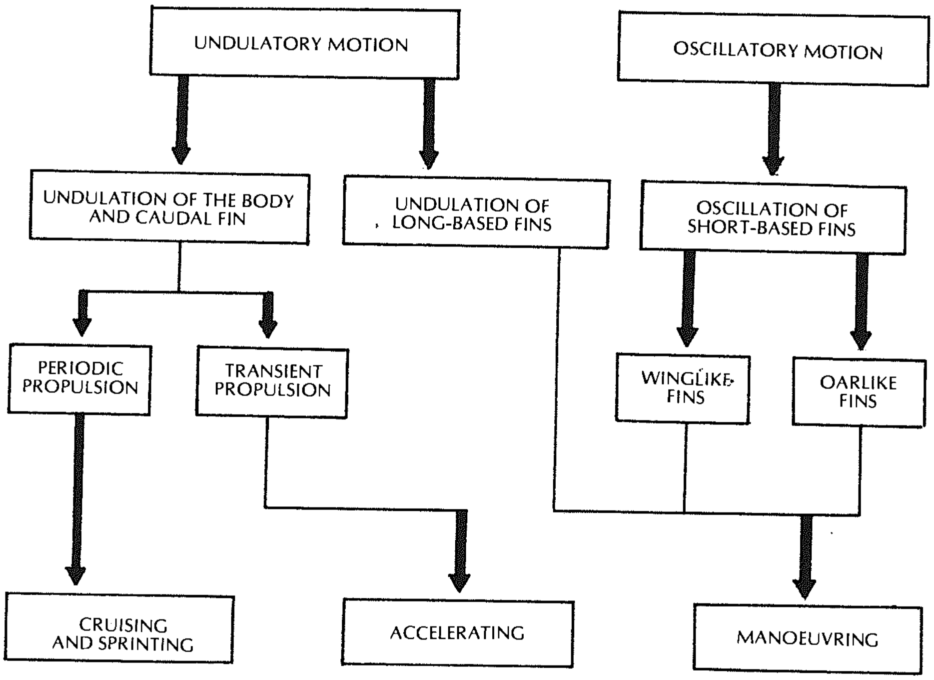


Fig. 63.1

FIELD SHEET

63. Movement in fishes

	Butterfly fish	Parrotfish	Trevally
Habitat (among coral, close to coral, open water, etc.)			
Feeding seen (if any)			
Type(s) of locomotion mostly observed (stationary, manoeuvring, cruising, fast swimming)			
When stationary Fins used			
Fin movement (oscillation or undulation)			
When manoeuvring Fins used			
Fin movement (oscillation or undulation)			
When cruising or fast swimming Is movement of tail fin and body or movement of other fins more important?			
Does the body and tail fin oscillate or undulate?			

64. Schooling of fishes ¾ hr • •

Concepts
Behaviour
Social organisation
Adaptation
School

Skills
Observing
Recording
Hypothesising

Attitudes
Interest in natural environments
Enjoyment of underwater experience

Aim

- To observe features of schools of fish and of behaviour of fish within schools.

You will need

- Notebook or underwater sheet; pencil
- Snorkelling gear, a visit to underwater observatory or trip in submarine viewer.

> *Many types of fish tend to go around in groups or schools. This provides tourists to the reef with spectacular underwater viewing. For commerical fishermen in reef zones where commercial fishing is allowed, it is a great convenience. Once a school has been located, many fish can be caught fairly readily.*

What to do

1. When looking underwater, locate a school of fish and make observations.
2. Answer these questions about the school:
   (a) Are all the fish of the same species?
   (b) Are all the fish the same size? If so, why might this be? (Think about the maximum swimming speeds of small and large fish.)
   (c) Approximately what shape is the school? For example, is it spherical, cylindrical, sheetlike? (Make some rough sketches to show what you think it would look like from above and from the side.)
   (d) Does it have many fish or only a few? (Make a rough estimate.)
   (e) Most of the time, are the fish swimming parallel to one another?
   (f) Is the spacing from fish to fish nearly uniform most of the time?
   (g) What happens to the acceleration of the fish when the school makes a sharp turn to left or right?
   (h) What happens to the spacing and acceleration of the fish if the school is startled?
   (i) Are there leaders? Do the fish travelling at the front of the school trade places with those behind?
   (j) Do fish schools "break up" if the fish start to feed?
   (k) Are there any signs of aggression within the school?
3. Make a list or sketches of some other species of fish which you also see in schools. Do these schools have different characteristics from the first school you looked at?
4. Compare your observations with those of others in your group.

Questions to think about

5. Why might fish form schools? It has been speculated that by swimming together, fish might create the illusion of a single huge animal moving through the water, and that this might help prevent attack by predators. Does this idea seem feasible? Can you think of some other possible advantages or disadvantages of schooling for fish? How could such ideas be investigated?

   Read Shaw (1962) and other literature for discussion of some suggestions.

> *Many questions about fish schooling and the possible advantages it has for fish are still to be answered by research.*

References

Shaw, E. 1962. Schooling of fishes. In Scientific American (1982), *Life in the Sea*. San Francisco: W. H. Freeman.

65. Fish distribution 1 hr + •

Concepts
Distribution
Schooling

Skills
Observing
Recording underwater

Attitudes
Confidence in making observations
Interest in natural world

Aim

- To investigate the distribution of different fish species around the reef you are visiting.

You will need

- Snorkelling gear
- Underwater slate and pencil

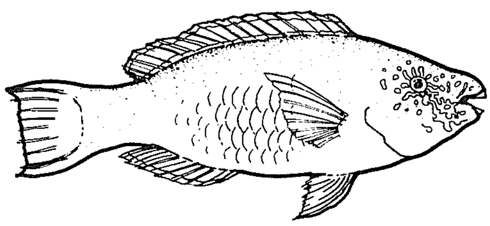
What to do

This project requires you to make general observations continually while snorkelling during your stay at the reef. At the end of your visit, you should be able to answer the following:

1. Where would you go to find rays on this reef? Why do you think they are there?
2. If some tourists wished to see large schools of fish, where would you direct them?
3. Where have you most often observed large coral trouts? Do the same fish appear to be in the same place day after day? If so, why do you think they inhabit a particular area?
4. List the places where you would find the following fish:
   (a) chaetodons
   (b) lion fish
   (c) parrotfish
5. In schools of fish, are the members of the school similar or different in size? Why do you think this is so?

Reading

Grant, E.M. 1985 *A guide to fishes.* Brisbane: Dept Harbours and Marine. (Waterproof edition).



66. Fish territoriality — 1 hr •

Concepts
Territoriality
Interrelationship
Interdependence

Skills
Observing
Recording underwater

Attitudes
Appreciation of natural environments
Confidence in making observations

Aim

- To investigate the territorial behaviour of species of damselfish.

You will need

- Snorkelling gear
- Underwater slate

What to do

1. Before entering the water become familiar with several species of damselfish (get to know their appearance from pictures and diagrams in the books).
2. Find an area of coral which in inhabitated by a species of territorial fish. Use the lagoon at high tide.
3. Draw the coral area as a rough outline map. Show the *size* of the coral area on your map. (Select an area no larger than 2 m across.)
4. Using reference material, identify the fish species.
5. Make a drawing of the fish species you are studying.
6. From your observations in the field, report on
   (a) the range of the fish (show this on your map)
   (b) behaviour towards members of the same species
   (c) behaviour towards members of other species
   (d) feeding habits
   (e) any other relevant behaviour shown.

Consider further

7. What would be the effect of removing your fish species from the small coral area you have been studying?
8. What are the advantages gained by these fish in being territorial?

Ideas for further things to do

9. Consult textbooks on fishes and find out which families have territorial species.

References

Risk, M.J., and Sammarco, P.W. 1982. Bioerosion of corals and the influence of damsel fish territoriality: Preliminary study. *Oecologia* 53, 376-80.

Carcasson, R.H. 1977. *Field guide to the reef fishes of tropical Australia and the Indo-Pacific region.* London: Collins.

67. Fish–bird comparison

½ hr • •

Concepts
Habitat
Adaptation
Niche
Ecology

Skills
Analysing
Comparing

Attitudes
Interest in relationships between organisms and environment

Aim

- To make some comparisons between the living places, body forms and lifestyles of birds and fishes.

You will need

- Pen
- Basic reference material on biology and reef life
- Worksheets

On a reef island, the birds are an eyecatching part of the scenery — moving about in the air, in trees or on the ground. When we go snorkelling, however, it is the fishes which catch our attention — a dazzling array of shapes, sizes and colours moving past our view in the water. What similarities and differences are there between the environments these two groups inhabit, and the adaptations they display? Within island bird communities and reef fish communities, what different kinds of roles are adopted by different species?

What to do

1. (a) Through discussion with others, by reading books and, if possible, by making your own observations of birds and fishes, fill in the spaces on worksheet A.
   (b) Discuss. How does the body form and function of each group fit it for life in the medium it inhabits?
2. (a) Can you recognise parallels in the lifestyles of some fishes and birds? Look at worksheet B and, by discussion, reading reference material or observation in the field, try to fill in as many spaces as possible.

Useful readings

Talbot, F., ed. 1984. *Reader's Digest book of the Great Barrier Reef.* Sydney: Readers Digest.
Morgan, D.S., ed. 1983 *Biological science - the web of life. Canberra: Aust. Academy of Science.*

WORKSHEET A

67. Fish-bird comparison

	Birds	*Fishes*
To what phylum do they belong?		
To what class do they belong?		
In what medium do they spend most of their lives?	Air	
Do they have fixed or mobile lifestyles?		
What organs do they use to obtain oxygen?		
What kind of locomotion do they carry out?		Swimming
What appendages do they use in locomotion?		
What name is given to a group of these creatuers?	Flock	
What kind of body covering(s) do they have?		
Are they warm-blooded (homoithermic) or cold-blooded (poikilothermic)?		
What are some sense organs which they use to find out about their environment?		
What kinds of materials do they eat?	Some eat plants, some eat animals, some eat both plant and animal matter	
What kind of fertilisation do they have — internal or external?		Most (but not all) have external fertilisation
Do their eggs have a hard external shell?		Most fish eggs do not have a hard external shell
Do they give parental care to their young?		

WORKSHEET B

67. Fish-bird comparison

	Great Barrier Reef bird example	*Great Barrier Reef fish example*
Has small body size		
Has large body size		
Moves rapidly		
Moves slowly		
Stays on or near the ground	Buff-banded land rail	
Moves about in a group		
Is territorial		
Catches and eats vertebrate animals		
Catches and eats invertebrate animals		
Is a herbivore		
Moves around among branches of another living thing	Silver-eye which moves about in branches of *Pisonia* tree	
Uses colour and shading as camouflage		
Has bright colouring		
Lives in a hole in the ground		
Has long, pointed mouth parts for selecting small food items		

68. Whale watch ½ hr + •

Concepts
Population dynamics
Extinction
Vulnerability
Endangered

Skills
Observing
Recording
Communicating

Attitudes
Caring for reef
Responsibility
Intellectual honesty

Aim

- To develop a feeling of responsibility for observations and to understand that everyone's observations are needed to contribute to scientific research in this immense, unpopulated reef region.

You will need

- Camera
- Field notebook and pencil

This activity requires at least half an hour spread over your trip, and maybe much more if you spot a whale.

This is an activity everyone can be involved in. Keep your eyes peeled all the time you are visiting the reef region especially in winter and spring. Make careful observations if you come across any of the following: whales, dolphins or dugong. These observations are vital to marine research, so the better your observations, the more you are contributing to the survival of these animals. Seeing a whale is not an everyday event in the reef area, nor easy. But, especially in September, as whales travel south from their breeding grounds, you may be lucky.

What to do

At sea

1. At sea, the whales you are most likely to see are the humpbacks. Sightings have also been recorded of the rare blue whale, southern right whale and the minke.
2. Observe the spout, the shape of the back and the method of diving.
3. Record date, time, place of sighting, identification, number, estimate of size, direction of travel and speed and whether there are any young.

Strandings

4. Report the finding immediately by radio or telephone to the Queensland National Parks and Wildlife Service or the Queensland Museum. (If alive, the animal may be able to be saved. If dead, it should be observed before it decomposes.)
5. Observe the animal carefully and fill in the stranding report sheet as accurately as possible.
   WRITE DOWN EVERYTHING — DO NOT RELY ON MEMORY
6. Take photographs or make sketches. These should show:
   (a) The side of the whole animal
   (b) Close-ups of the head, fins and flippers.
   (c) Close-ups of wounds or any unusual features.

Make sure you have something to show the scale, e.g. a person standing beside the specimen.

7. See notes about observations and strandings, and procedures to be followed, in the leaflet published by the Great Barrier Reef Marine Park Authority.

Readings

Great Barrier Reef Marine Park Authority. 1987. *Whales — Reef Notes.* Townsville.
Gould League of Victoria. 1979. *Whales — junior survival.* Prahran.

FIELD SHEET

68. Whale watch

Stranding report
Species: Date of stranding: Time of stranding: Locality: Number of individuals: Condition: Length (tip of upper jaw to tail notch): Sex: Number and longitudinal extent of throat grooves: Number of teeth each side of jaw: Colour description (plus photos and sketches): Remarks: Observer's name: Address:

69. Associations between species

Concepts
Association
Mutualism
Symbiosis
Commensalism
Adaptation

Skills
Observing
Snorkelling

Attitudes
Perseverence
Appreciation of natural environments

Aim

- To observe some distinctive associations between some unlike organisms which "live together".

You will need

- Usual reef-walking and/or snorkelling gear
- Underwater slate.

This activity requires several hours at various times during the fieldtrip.

What to do

1. On the reef, try to find examples of some of the interesting distinctive associations between unlike organisms. Good ones to look out for are: Goby and shrimp, needle coral and gall crab, turtleweed and crab, anemone and clownfish, cleaner wrasse and large fish.
2. Go on a shallow snorkel over the sandy flat at high tide. Look for holes in the sand with a sand-coloured goby standing guard. Hover nearby until the goby no longer notices you and you may find there is also a shrimp living in the hole and working industriously to clean it out. Observe them carefully and try to work out what sort of relationship is involved — who is helping whom?
3. On a reef walk, look for needle coral *(Seriatopora)* or the more club-like branching coral *Pocillopora*. In each clump look for a slightly expanded fan-shaped branch.

   A tiny female gall crab lives inside coral gall. What sort of relationship do you think this is?
4. Find some bright-green turtle weed. Gently run your fingers through the tuft. If you find a small lump in there, very gently tease it out. You will probably find it is a tiny, delicate, pale-green crab. What sort of relationship is this? (Make sure the crab gets back safely into its own tuft of turtle weed).
5. On the reef walk near the reef crest or when snorkelling, look for the large anemone with its attendant clownfish. How many clownfish are there? What sizes are they? Which is the dominant one? Look for other anemones and compare them.
6. When snorkelling, look for the small, slim, blue wrasse and see if you can find its cleaning station. You may find large fish of several different species lined up for cleaning just like cars at a car wash. What sort of relationship is this?
7. When snorkelling, if you are ever lucky enough to see a large manta ray look for the remora or sucker fish attached to it. (You may even find remoras following you around.) What sort of relationship is the one between a remora and a manta ray?
8. Make a table of all the relationships you find on the reef, heading your table as shown below.

Animal 1	Animal 2	Which animal benefits and how

70. The goby and shrimp ½ hr •

Concepts
Camouflage
Mutualism
Relationships

Skills
Observing underwater
Recording underwater

Attitudes
Perseverence
Fascination
Wonder

Aim

- To investigate the mutualistic relationship that exists between a goby and a shrimp.

(This project requires patience and careful observation while snorkelling in shallow water.)

You will need

- Snorkelling gear
- Underwater slate and pencil

What to do

1. At high tide, snorkel over the sandy patches in the lagoon (choose an area as close to the cay as possible). Focus your vision about 2-3 metres in front of you and directed down to the sand. Move slowly, making as little noise as possible. Keep your eyes open for a pale slim little fish with large eyes lying on the sand at the entrance to a hole.
2. Once you've found your fish, move in cautiously to about 2 metres distance. If the fish quickly retreats down the hole, move back slightly, remain very still, and wait for its reappearance.
3. Now, observe carefully, taking note of the following:
   (a) How would you describe the reappearance of the goby (bold, watchful)?
   (b) After the goby takes up station at the entrance to the hole, how long does it take for the shrimp to appear?
   (c) When the shrimp does appear, is it involved in any particular activity?
   (d) Does the goby appear to be involved in any activity besides observation?
   (e) Make a sudden movement towards the hole. What happens?
   (It would be a good idea to copy these questions on to your slate before you leave the beach).

Questions to consider

4. What appears to be the relationship between the goby and the shrimp?
5. Would survival be any more difficult for either the goby or shrimp if each lived a solitary life?
6. What particular adaptation does the shrimp have to fulfil its role in the relationship? What adaptations do you think the goby possesses to fulfil its role in the relationship?

71. Clownfish and anemone ½ hr + •

Concepts
Special association
Adaptation
Commensalism
Symbiosis

Skills
Observing
Recording
Hypothesing

Attitudes
Perseverence
Appreciation of natural environment
Confidence in making observations

Aim

- To investigate the association between anemones and clownfish.

You will need

- Snorkelling gear or reef-walking gear and transportable viewer
- Underwater slate or waterproof sheet; pencil

This activity can take from half an hour to many hours. It can be done in pools on the reef-top at low tide or on the reef front while snorkelling.

What to do

1. Visit a particular anemone while snorkelling on the reef front or while observing a reef-top pool.
   (a) Record the size of the anemone and sketch the species of fish associated with it for later identification.
   (b) Record the numbers of clownfish fish present. Is there a dominant member of the group?
   (c) Do the clownfish touch the anemone? If so, how do they move when doing this?
   (d) Do the clownfish appear to concentrate in any particular region of the anemone?
   (e) Does the anemone react to the movements of the fish?
   (f) What evidence, if any, do you see of either the clownfish or anemone feeding?
   (g) How far do the clownfish move from the anemone?
   (h) What do the clownfish do when away from the anemone?
   (i) What behaviour is displayed by the clownfish to other fish species?
   (j) How have the fish reacted to your presence and movements?
2. If possible, visit and observe other clownfish/anemone associations.
   (a) Are other species of clownfish present?
   (b) Are particular types of clownfish associated with particular types of anemones?
   (c) Can you recognise common patterns in the behaviour of the clownfish at the anemones you observe?

Questions for you to consider

3. Clownfish, unlike other fish, are not stung by nematocysts from the anemones they are associated with. Various reasons have been suggested for this. Try to find out about the research that has been undertaken on this.
4. In this association, who benefits, and how? Read literature discussing symbiosis and commensalism relationships. What kind of association is the clownfish/anemone partnership? How does the special association compare with other special associations you know of on the reef?

Ideas for further things to do

5. Investigate other special associations on the reef, e.g. crab/turtle weed.

Reading

Allen, G.R. 1975. Anemone fish and their amazing partnership. *Australian Natural History* 18(8).

72. Cleaner wrasse — 1 hr •

Concepts
Interrelationships
Symbiosis
Fish behaviour

Skills
Observing
Recording underwater

Attitudes
Confidence in making observations
Interest in natural environment and especially in interrelatedness of living things

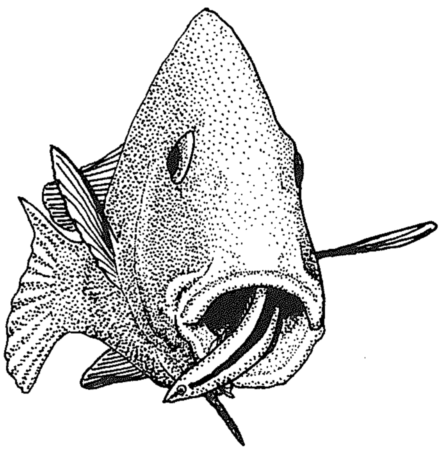
Aim
- To investigate a mutualistic relationship on the reef.

You will need
- Snorkelling gear
- Underwater slate and pencil

What to do
1. Snorkel along the reef edge until you find a cleaner station. Coral bommies are likely areas.
2. Observe a fish being cleaned. What parts of the fish are cleaned?
3. Study the behaviour of the wrasse inviting the fish to be cleaned and the behaviour of the fish receiving the cleaning.
   (a) Record the movements of the wrasse *before* cleaning begins.
   (b) Record the behaviour of the fish about to be cleaned.
   (c) Observe the range and territory of the wrasse.

Questions to think about back on the beach
4. Did different species show similar behaviour before cleaning commenced?
5. What factors might influence the size and position of a station?
6. Comment on the role of the wrasse in the coral reef community.

Ideas for further things to do
7. You can learn more about the cleaner wrasse by consulting the following reference:
   Behavioural ecology of cleaning fish. *Aust. Nat. Hist.* Sept. 1982: pp. 232-38.



Cleaner Wrasse & client - sweetlips
(Labroides dimidiatus & Gaterin pictus)

73. Reef-top transect 2 hr + 1 hr • •

Concepts
Distribution
Abundance
Transect
Sample
Zonation
Line intercept
Quadrat
Sediment
Sand
Gravel
Mud
Encrusting algae
Fleshy algae

Skills
Cooperating
Estimating
Recording
Hypothesising
Evaluating

Attitudes
Interest in methods of scientific enquiry
Willingness to suspend judgment
Willingness to work with others

Aim

- To investigate the pattern of distribution of reef-top organisms and sediment by gathering data along a transect from beach to reef edge.

Many reefs have a distinct natural zonation of reef-top sediments and living things, features near the reef edge different from those on inner parts of the reef-top.
Does the reef you are visiting have an obvious pattern of natural zones? If so, how is one zone different from another? Are there different zones on different sides of the reef? Why might the natural zonation pattern exist? You've probably already done some walking and looking about on the reef-top during your field trip, so you already may have some ideas about these questions. One purpose of this activity is to gather data in a systematic way to help test out any guesses you may have made.

You will need

(For each small working team)

- Reef-walking gear
- 20-metre-long rope or cord, knotted or marked at 1-metre intervals
- Clip board, pencil
- Field sheets on waterproof paper
- Viewing box with transparent bottom (optional)
- Magnetic compass
- Map or air photo of reef-top
- 1-metre-long plastic rod

This activity requires at least one low-tide period on the reef-top (about two hours), and about one hour at base camp plotting and discussing data.

What to do

Organising the fieldwork

1. With your group leader, study a map or air photo of the reef-top. Select a traverse line across the reef-top from beach to reef-edge. Mark the starting point on the map.
2. Using the map, work out how many stations there will be for collecting data along the transect. A convenient distance between stations is 20 metres.
3. Divide into small working teams of about four people. Each team is to collect data at a number of stations spaced out along the transect. Your group leader will allocate stations. Each team should have stations close to the beach, in the central part of the traverse, and near the reef edge.
4. Discuss the features you are going to record on the traverse.

In the field

5. Each team should walk out along the traverse line from the starting point on the beach. Use a compass and measured rope to help reach your stations.
6. At each station, study a 2-metre-square area along your traverse line from the station. Take a "birds-eye" view.
   Make estimates and record the following on field sheet A:
   (a) What percentage of the area of the "floor" of the strip is made of:
   - living coral
   - dead coral (still standing)
   - rocky pavement
   - loose sediment (sand)
   - loose sediment (mud)
   - loose sediment (fine gravel)
   - loose sediment (coarse gravel)

   (b) What percentage of the area is covered by marine plants?
   - green or brown fleshy algae
   - pink encrusting algae
   - other types of algae
   - sea grasses (if any)
   - no visible plants

   (c) How many different types of corals are present?
   (d) How many different types of algae are present?
   (e) Anything else?
7. Also at each station, make a quick sketch on field sheet B of the appearance of part of your area (a 1-metre-square area would be adequate). Put in features using symbols.

At base camp

8. Combine the data from all groups.
   (a) Make up *three* graphs: one for the coral and sediment distribution data, one for the algae data and one for the species diversity data. Use colours and shading decided upon by the whole group. Hang the graphs where everyone can look at them. (See the suggestions for presenting data at the end of this activity.)
   (b) Finalise the field sketches. Colour them using colours agreed upon by the whole group. Hang the pictures where everyone can look at them.
9. Discuss the results:
   (a) Along the traverse line, are there any systematic variations in the amount of live coral, dead coral, loose sediment, sand, gravel, algae, fleshy algae, etc?
   (b) Are distinct zones present? In what way is one different from another?
   (c) What are some factors which might cause variation along the traverse? In particular, think about the distribution of sand, coarse gravel, living coral and fleshy algae.
   (d) How could the possible influence of some factors on the distribution of biota and sediment be investigated?
10. What are some shortcomings and problems in the field method used?
    (a) Do you think that a good sample of the reef-top has been examined? How could it be improved?
    (b) Are there difficulties in splitting the job among different teams? How could this problem be overcome?

Ideas for further things to do

11. Carry out one or more transects on other parts of the reef-top. Compare data from the transects. Do different parts of the reef display different zonation patterns? Is there any obvious difference between windward and leeward sides? What might account for any differences you observe?
12. Compare data from your transect(s) with data (if available) from past transects made here. Have there been changes through time here? What might have caused these?
13. Prepare a group report of your transect so that future groups can compare their own observations with yours.

Ideas for alternative ways to organise this transect

14. Each small team could do an entire traverse on its own. Then all traverses made by different teams could be compared. Discuss the advantages and disadvantages of this method.
15. The sampling method used could be varied. The stations could be spaced further apart or closer, depending on time available. The quadrat area examined at each station could be enlarged or reduced. A circle could be examined instead of a rectangle. Discuss the advantages and disadvantages of this method.
16. A line intercept method could be used for gathering data instead of a quadrat method. Along the whole traverse, a record could be made of the length of the transect line which lies on, say, living coral, sand, dead coral, etc. Discuss the advantages and disadvantages of each method.

Some ideas for presenting data

There are some useful methods for presenting data obtained at transect stations:

- Bar graphs
  For each station draw a vertical bar divided into different sections of appropriate length for each component measured. Colour or shade each section of the bar in a distinctive way.
- Fence diagram
  Plan out a bar graph as above, but join up the data points from different stations. Colour or shade the whole graph area. This provides a good way of visualising change across the reef-top.
- Kite diagram
  Draw horizontal bars across the graph, each representing one component. The width of the bar represents the percentage of a component, or the number of species.

Specialist readings

On reef-top zonation

Done, T. 1983. Coral zonation: its nature and significance. In *Perspectives on coral reefs*, ed. D.J. Barnes, pp. 107-47. Canberra: Clouston/Aust. Inst. Marine Science.

Jell, J.S., and Flood, P.G. 1977. Guide to the geology of reefs of the Capricorn and Bunker groups, Great Barrier Reef province, with special reference to Heron Reef. Dept. Geology, Univ. Qld. *Papers* 8(3).

On reef fieldwork methodology

Loya, Y. 1978. Plotless and transect methods. In *Coral reefs — research methods*, ed. D. Stoddard and R. Johannes. Paris: UNESCO.

Stoddard, D. 1972. Field methods in the study of coral reefs. In *Proc. First Intern. Symp. on Corals and Coral Reefs*. Cochin: Marine Biological Association.

Stoddard, D. 1969. Biology and morphology of recent coral reefs. *Biol. Rev.* 44: 433-98.

FIELD SHEET A

73. Reef-top transect

Name of reef	*Date*	*Place where traverse starts*	*Bearing of traverse*	*Field team members*	*Time started*	*Time finished*

COMPONENTS	*STATIONS (metres from origin)*
Living coral	
Dead standing coral	
Rocky pavement	
Coarse gravel (1 cm)	
Fine gravel	
Sand (2 mm)	
Mud (if any)	
MARINE PLANT COVER	
Green/brown fleshy algae	
Pink encrusting algae	
Other types of algae	
Seagrasses (if any)	
No visible plants	
NO. OF SPECIES	
Coral	
Fleshy algae	

FIELD SHEET B

73. Reef top transect

Name of reef	*Date*	*Place where traverse starts*	*Bearing of traverse*	*Field team members*	*Time started*	*Time finished*

Scale 1:100

KEY

Live coral
Dead coral
Fleshy algae
Sand
Coarse gravel

Metres

Station
Metres

Station
Metres

74. Boulder communities — 2 hr • •

Concepts
Community
Producers
Consumers
Decomposers
Diversity
Food web

Attitudes
Awareness
Curiousity
Confidence in own powers of observation
Interest in natural environment

Aim

- To study organisms living on and under a reef-crest boulder and a reef-flat boulder and to develop an understanding of interrelationships between organisms and their environment.

You will need

- Reef-walking gear
- Notebook and pencil
- Board and field sheet
- Perspex viewing box (A4 size) (optional)
- Acetate sheets (OHP transparency sheets)
- Very fine waterproof OHP pens
- Tape-recorder (optional)

This activity should be done during one or two low-tide periods.

What to do

1. (a) Find an interesting boulder on the reef flat. Observe it through the viewer.
   (b) Draw its outline on an acetate sheet placed in the bottom of the box.
   (c) Identify anything growing on the upper side of the boulder. Add it to your drawing. Label it or use a symbol for it.
   (d) If the boulder is still underwater, observe any mobile animals in or around it. Add them to your sketch. When you finish, clip the drawing to a clipboard and start a new sheet.
   (e) Turn the boulder over carefully. Draw the outline on another acetate sheet. Try to identify as many living organisms as you can. Add them to your sketch.
   (f) Make sure you return the boulder carefully to its original position.
   (g) On the field sheet, list each organism. From your own observations, decide whether it is a producer, consumer or decomposer and how and what it eats. You may wish to make your observations on the tape-recorder and write them down later.
2. Do the same thing for a reef-crest boulder. You may have to do this at another low-tide period.
3. Compare the communities from the two boulders. Are they similar? If not, why do you think they are different?

Ideas for further things to do

4. For each boulder, draw up the relationships as you saw them. This may be part of a food web. You may wish to expand this and add mobile animals which would also be part of this web.
5. Would you describe your boulder communities as closed systems?
6. Is the top of each boulder dominated by producers or consumers? Is the bottom of each boulder dominated by producers or consumers? Suggest reasons for your answers.

NOTE
This activity can be followed without use of the perspex viewing box. Simply make sketches on a recording sheet held on a clipboard. A snorkel mask may be helpful in viewing the boulder.

FIELD SHEET

74. Boulder communities

Reef-flat boulder

Name of organism	Located on top or bottom or side of boulder?	Producer, consumer or decomposer	If a consumer: Fixed or mobile?	Grazer, predator, filter feeder or . . .?

Reef-crest boulder

Name of organism	Located on top or bottom or side of boulder?	Producer, consumer or decomposer	If a consumer: Fixed or mobile?	Grazer, predator, filter feeder or . . .?

75. Ecology of a reef pool 2 hr • •

Concepts
Ecology
Ecosystem
Habitat
Niche
Producer
Consumer
Community
Carnivore
Herbivore
Omnivore
Scavenger
Decomposer
Abiotic factor
Biotic factor

Skills
Observing
Recording
Mapping
Identifying
Cooperating
Using equipment

Attitudes
Interest in natural environment
Intellectual honesty
Self-reliance
Desire to question
Initiative

Aim

- To map a reef pool and to identify some of the common organisms that inhabit it.
- To observe interactions between the pool organisms and the environment.

You will need

- Underwater board or notebook; field sheets
- Reef-walking gear
- Compass
- Waterproof measuring tape or knotted string
- Measuring staff (1-2 metres) or plumb bob of length of knotted string 1-2 metres long with sinker on end
- Pictures of common reef-top organisms, e.g. from GBRMPA leafets (optional)
- Thermometer and water-test kit (optional)
- Camera (optional)

What to do

Map the pool — (field sheet A)

1. Choose a distinctive reef-top pool that is not too large. Pools near the reef rim are good for this activity.
2. Make measurements of the pool, using tape or knotted string. Select a scale and, using diagram 1 of field sheet A, carefully sketch the pool outline.
3. Roughly mark on, or shade in, areas of coral and sand.
4. On diagram 2, draw a cross-section of the pool. Use the measuring tape and a staff or plumb bob to make the measurements of the pool. Choose suitable horizontal and vertical scales.

Observe physical and chemical conditions in pool — field sheet B (optional)

5. On field sheet B, record answers to questions about physical and, if possible, chemical conditions of the pool. If possible, make one set of observations of temperature and wave conditions when you first arrive at the pool, and another set as you leave the pool.

Observe organisms

6. In notebook or on underwater board, make a list of the organisms you can see, where they are and what they are doing. (If you don't know what they are, give them names and identify them later from your notes and sketches.)

Questions to consider after the fieldwork

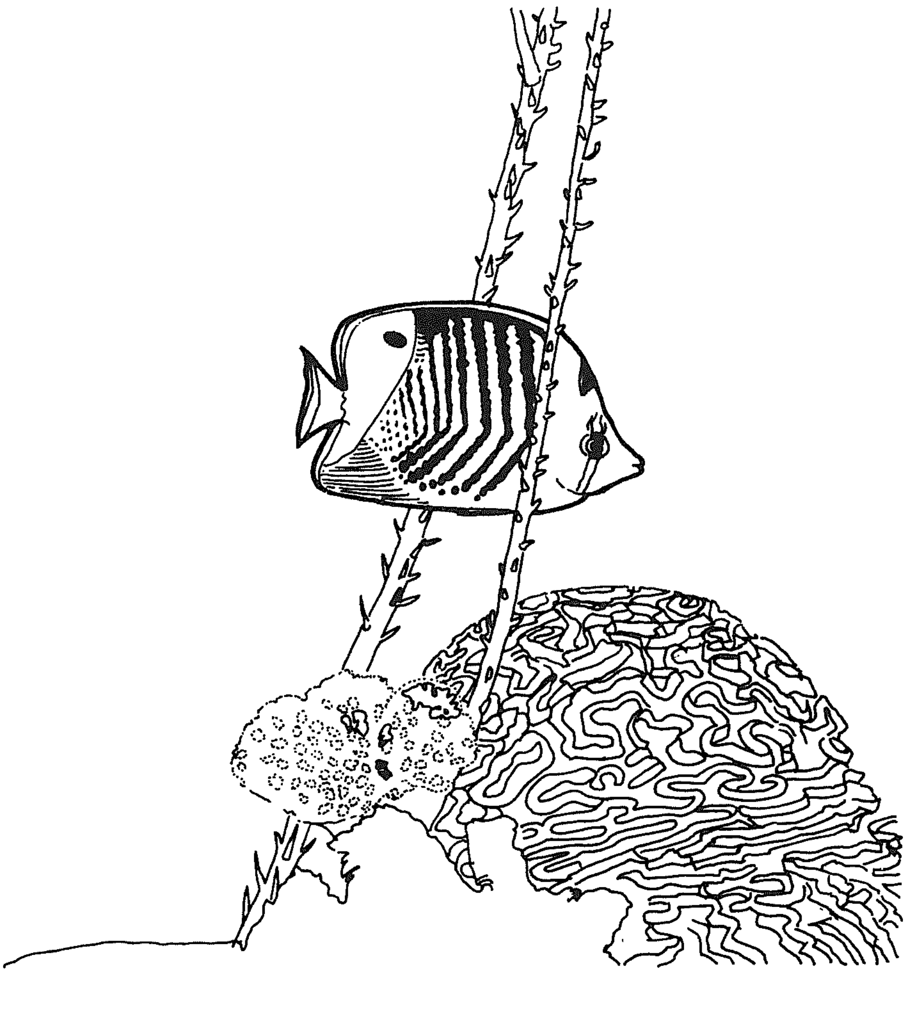
7. What are some ways in which organisms in the pool affect one another? Were you able to see any feeding relationships between organisms? Which organisms are the producers and which are the consumers? From your observations and reading, draw a food chain. Draw a part of a possible food web which involves the pool.
8. Suggest possible ways energy enters and leaves the pool.
9. How might physical and chemical conditions in the pool affect living things in the pool?
10. If you have measured physical and chemical conditions in water elsewhere on the reef, how do these differ from those in the pool?
11. Discuss the possible effects of tides, winds, currents, sediments, cyclones and people on the pool and its community.

Ideas for further things to do

12. Mark on the map and profile on field sheet A the organisms observed, using symbols.
13. Check out a different reef pool. How do conditions differ? Are the organisms different?

Reading

Bennett, I. 1982. *The Great Barrier Reef.* Sydney: Lansdowne.
Mather, P., and Bennett, I. 1984. *A coral reef handbook.* Brisbane: Aust. Coral Reef Society.
Talbot, F., ed. 1984. *Reader's Digest book of the Great Barrier Reef.* Sydney: Reader's Digest.



FIELD SHEET A

75. Ecology of a reef pool

Pool map and profile

Team no.__________ Date__________ Time__________ Tide__________

Group members ____________________

Location of pool ____________________

Indicate north, scale, boundaries, major features, wave zones and give directions to island features, so that the pool can be relocated at a later date.

Diagram 1: Map of aerial view of pool

Side X

Side Y

Scale: __________

Diagram 2: Pool profile

Investigate the depth of the pool along the transect line; take soundings at a number of positions along the transect line. Draw a depth profile of the pool. Indicate the types of substrate found along the transect line (coral, coral rubble, sand).

Side X

Side Y

Horizontal scale (use the same as in diagram 1) ____________________

Vertical scale: ____________________

FIELD SHEET B

75. Ecology of a reef pool

Abiotic conditions

Physical conditions in pool

Condition	*At beginning of activity (time)*	*At end of activity (time)*	*Has there been a change?*
What is the water temperature (°C)?			
Is new water coming into the pool?			
Are there waves on the pool?			
Can you see all the bottom of the pool?			
Are the tops of algae or coral growing in the pool exposed to the air?			
Is the tide rising or falling?			

Chemical conditions in the pool

Condition	*At beginning of activity (time)*	*At end of activity (time)*	*Has there been a change?*
Dissolved oxygen (p.p.m.)			
pH			
Salinity			

76. The inner coral zone by night — 1 hr •

Concepts
Nocturnal behaviour
Ecology

Skills
Observing
Communicating

Attitudes
Curiosity
Self-reliance
Enjoyment of outdoor experience
Appreciation of natural environment

Aim

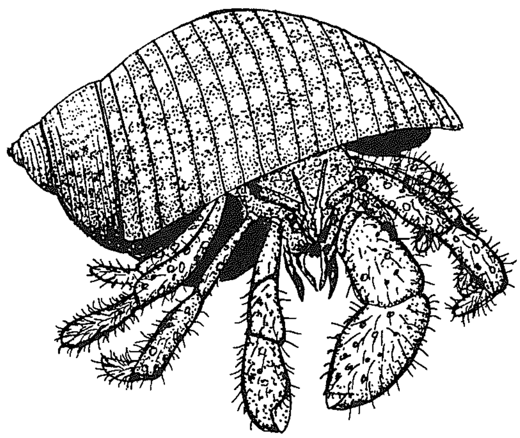
- To observe some life on the reef flat on a calm night, at low tide.
- To observe nocturnal behaviour of some animals in the inner coral zone.

You will need

- A torch (underwater torch, if possible)
- Protective reef-walking footwear (sandshoes or rubber booties)
- Other reef-walking gear, including windproof jacket

What to do

1. Assemble on the beach just after dark and select a buddy.
2. Discuss possible dangers of walking out onto the reef at night and precautions needed.
3. Walk out over the innermost coral zone, stopping at a number of places. Preferably choose an area where you have walked during the day. Walk only in very shallow water. Stay close to shore; keep with your group.
4. At each place:
   (a) Stand still for 30 seconds and listen carefully.
   (b) Discuss with your partner any sounds you hear.
   (c) Try to find out what it is that makes the sounds.
   (d) Shine your torch through the water and see what you can find.
5. Return to the shore and discuss the following:
   (a) Did you see a snapping shrimp?
   (b) Were the coral polyps really out?
   (c) Were any fish sleeping?
   (d) Who saw any crayfish?



Hermit Crab - Dardanus megistos

77. Map-a-bommie scuba project — 3 hr +

Concepts
Ecology
Distribution
Habitat
Population
Environment

Skills
Organisational skills
Orientation skills
Using compass
Observing and recording underwater
Mapping
Cooperation

Attitudes
Appreciation of natural environment
Perseverence
Enjoyment of outdoor experience

Aim

- To investigate the ecology of a submerged coral mass (bommie). This is a project requiring the use of scuba. It is recommended for a group of three or four divers.

You will need

- Diving gear (scuba)
- Underwater slate and pencil
- Underwater camera and torch (optional)
- Submersible compass

You will need to make three scuba dives at less than 10 metres.

What to do

1. To understand the ecology of a bommie, it is first necessary to analyse the physical features of the bommie and to assess the physical factors to which it is exposed. Choose a bommie which has appealed to you while snorkelling along the reef slope. Try to choose a bommie no larger than 5 m in diameter and no smaller than 2 m in diameter. Your bommie should also be in less than 10 m of water (to reduce your air consumption and avoid decompression problems).

First dive

2. (a) Record the position of your bommie on an outline map of the reef. You will need to take compass bearings from the bommie to prominent features of the island (end of vegetation, towers, etc.).
   (b) Record the size of your bommie.
3. Record the depth of the bommie at low tide. Hover above the bommie and make an outline sketch of the bommie on your slate. Now descend to the base of your bommie and make a sketch of its western side. Move through 90° (naturally, using your compass) and make a sketch of its northern side. Continue this procedure so that you obtain sketches of the eastern and southern aspects also. As you make these sketches, pencil in any prominent features, e.g. masses of brain coral, caves.
4. Make relevant notes on such things as currents in the area, slope of the bottom, proximity of other bommies and any other physical factors which you think may have an influence on your bommie.

Second dive

5. Slowly circle your bommie and, on the sketch you made on the first dive, record the locations of resident fish on your map (e.g., cod in caves, painted sweetlip, flutemouths under coral overhangs). Take particular note of territorial species such as moray eels, clownfish, etc. Try to find any cleaner stations. As you record the different fish species, jot down their approximate numbers as shown in the example in figure 77.1.

Third dive

6. Now move in close to your bommie and record the interesting and noticeable invertebrate life. By this time, you may have to use fresh outline drawings of your bommie. Try to find and mark on your map the location of nudibranchs, stinging hydroids, soft corals, etc. Look for sponges and ascidians under overhangs.
   What kind of hard corals are predominant on your bommie? (perhaps you can enlist the aid of students who have done activity 43, "Coral Colonies".) Make sketches of some of the corals so that you can identify them later.

Questions to consider

7. Over your three dives, did you have the feeling that your bommie retained a constancy in terms of the number and types of species present, or did you feel that the bommie was continually changing?
8. Were there any areas on your bommie where life appeared to be more concentrated? If so, why do you think more life was present in these areas?
9. How have your feelings changed towards coral bommies after this project? Is it possible to feel affection for a bommie?

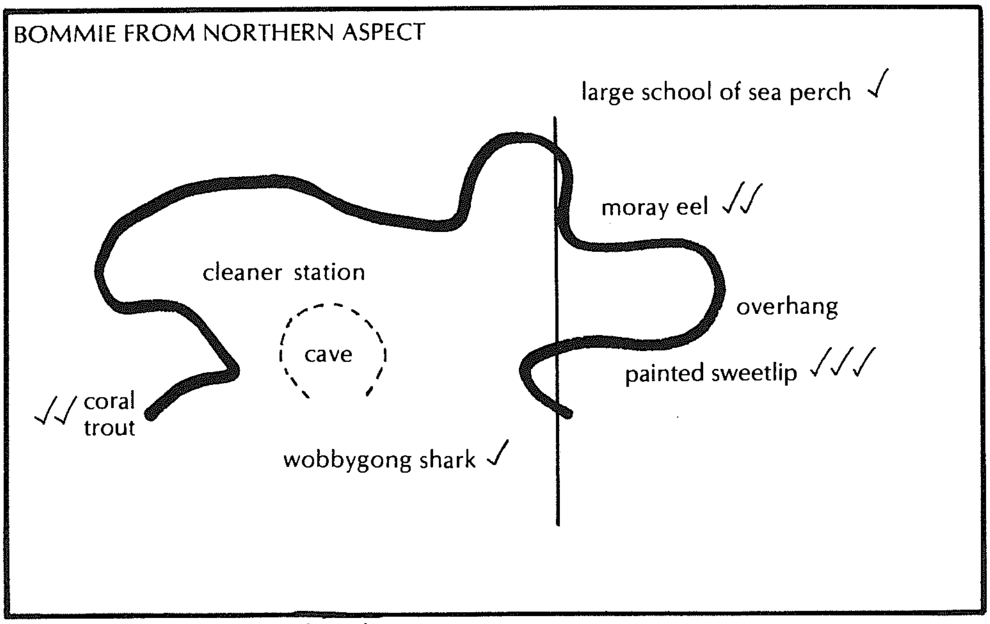


Fig. 77.1. Example of recording sheet.

78. Food web of a coral cay and reef 1½ hr • •

Concepts
Food web
Energy flow
Material cycle
Producer
Consumer
Interrelationships

Skills
Observing
Recording
Interpreting

Attitudes
Persistence
Appreciation of interrelatedness of living things

Aim

- To investigate the flow of energy and cycle of materials on a cay and reef. This activity is best done after a few days on the cay when you are familiar with a number of island and reef organisms.

You will need

- Pencil and recording sheet
- Large sheet of paper (approx. 2 m x 2 m) or blackboard

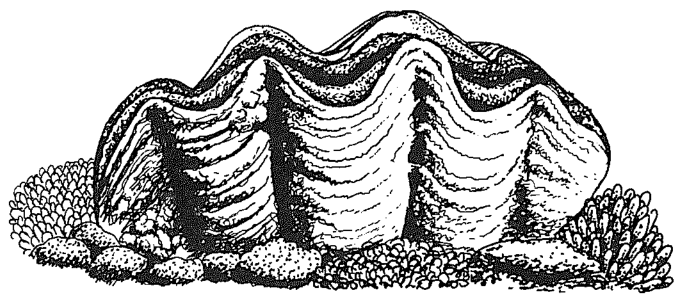
This activity will take a total of about 1½ hours spread over several days.

What to do

1. By now you should be able to list many of the life forms you have seen over the last few days under the headings of producer, consumer or decomposer (Don't forget zooxanthellae — the algae which live inside the tissue of coral polyps and many other reef animals).
2. On the same large piece of paper and side by side make up a food web for the reef and a food web for the cay.
3. Keep adding to this chart each day as you observe more organisms and discover their relationships to one another.
4. Use coloured arrows to show the flow of energy through the web you have drawn. How does energy enter and leave the system?
5. Use arrows of one or more other colours to show the transfer of one material (e.g. carbon, nitrogen) through the system. How does each material enter and leave the system?
6. Can you identify any links between the reef and the cay?
7. How are the trees of the cay dependent on the reef and the cay itself?

Further things to do

8. Consider other communities you have studied, e.g., desert, rainforest communities. Are there any principles which hold true for all communities?



Giant Clam - Tridacna gigas

79. What plant is that? 2 hr + • •

Concepts
Identification
Biological key
Classification

Skills
Observing
Recording
Using a biological key

Attitudes
Curiosity
Appreciation of natural environment

Aim

- To develop a simple key which others can use to identify trees, shrubs and other plants on a coral cay using simple external features.

You will need

- Notebook or waterproof sheet attached to a clipboard
- Biro/pencil
- Hand lens

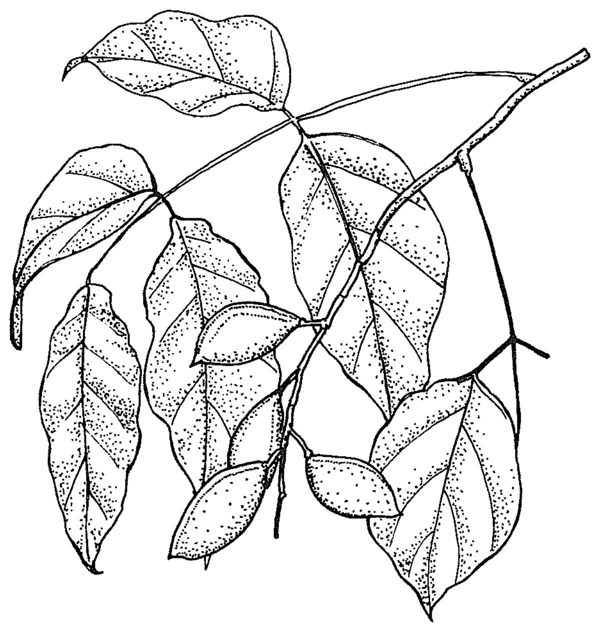
What to do

1. Walk around the coral cay and examine the leaves from the different types of trees and shrubs.
2. Find out the names of the trees and shrubs using Cribb and Cribb (1985).
3. To establish your key, use leaf characters such as leaf size, shape, hairs (presence/absence), colour, oil glands, simple or compound, entire or serrate, and the leaf arrangement (alternate or opposite).
4. Sort out the leaves on the basis of one characteristic at a time. You may want to start with simple or compound, alternate or opposite, or others suggested until each has a place of its own. Present the information as a biological key similar to the one in table 79.1.
5. You could use other features in your key such as the size of the plant, flowers (e.g. colour), root type (e.g. prop or buttressed) or fruit.
6. Make diagrams of your leaves and their arrangement, together with any other additional features (e.g. flower, fruit). You may wish to produce a key using illustrations of leaves or other features, rather than descriptions in words.
7. Repeat the above with herbs and vines as well as shrubs and trees.
8. Test your key with a friend.

Readings

Mather, P., and Bennett, I. 1984. *A coral reef handbook.* Brisbane: Australian Coral Reef Society.

Cribb, A. B., and Cribb, J. W. 1985. *Plant life of the Great Barrier Reef and adjacent shores.* St Lucia: Univ. Qld Press.

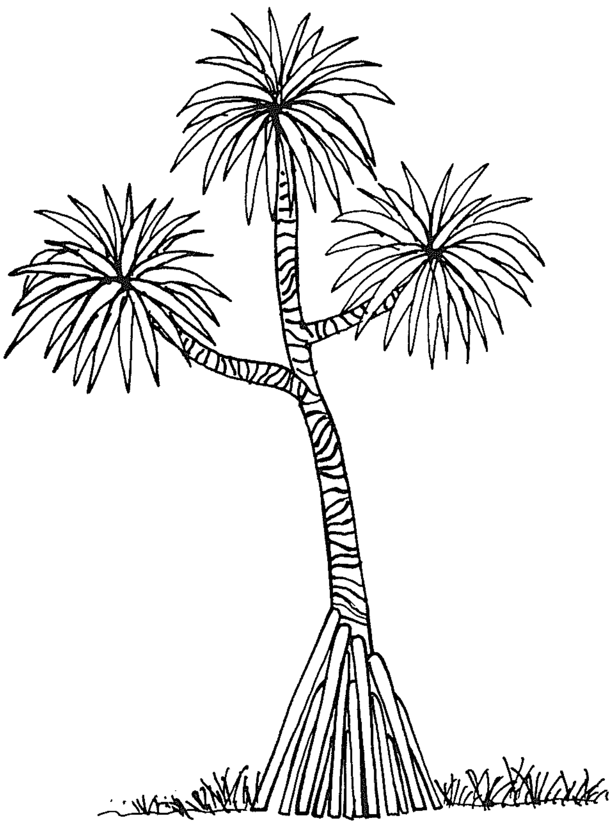


Pongamia pinnata.

Table 79.1: Example of key for some cay plants

(Main species: *Pisonia grandis; Casuarina equisetifolia; Argusia argentea; Scaevola sericea; Pandanus tectorius)*

1. (a)	Leaves reduced to tiny scales on needle branchlets	*Casuarina sp.*
(b)	Leaves not reduced	Go to 2
2. (a)	Leaves very large in dense clusters at top of tree like pineapple tops. Tree has prop roots.	*Pandanus sp.*
(b)	Leaves not as above. Trees do not have prop roots.	Go to 3
3. (a)	Broad oval-shaped pale-green leaves with prominent mid rib. Huge tree often with large buttress roots	*Pisonia sp.*
(b)	Not as above, smaller trees and shrubs.	Go to 4
4. (a)	Silvery, furry, elongated, oval-shaped leaves. Small-petalled, cream flowers.	*Argusia sp.*
(b)	Shiny dark-green leaves with rounded ends. Small tree or shrub	*Scaevola sp.*



80. She-oak study

½ hr •

Concepts
Adaptation
Nitrogen fixing
Cladode
Transpiration
Tap root
Bacteria
Symbiosis
Nitrogen cycle

Skills
Observing
Recording
Inferring

Attitudes
Interest in natural environments

Aim

- To consider ways in which coastal she-oaks are adapted for life on a coral cay and some ways in which they affect cay environments.

You will need

- Field sheet
- Pencil and notebook
- Hand lens

> *When a new cay is being progressively colonised by plants, coastal she-oaks (*Casuarina equisitifolia *variety* incarna*) are probably the first trees to become established. They can live in windy conditions and in porous soil with little water-holding capacity; they can grow in sand which is poor in nutrient substances such as nitrates.*

What to do

1. Walk around the edge of a cay and find some coastal she-oak trees.
2. Look for each of the features listed on the field sheet. On the field sheet, make a sketch of any feature you are able to see — give a scale for each.

Questions to consider

3. Think about the following questions. Discuss with others and write your answers in your notebook.
   (a) It is claimed that having reduced leaves helps the tree conserve its own moisture and survive when soil moisture is low. How could having reduced leaves be of benefit to the plant in this way? (Hint: Think about transpiration, stomata, surface area.)
   (b) How could the presence of nitrogen-fixing bacteria in the she-oak roots help the she-oak trees themselves to survive in cay conditons and be of benefit to other plant colonies of a cay?
   (c) Find out the names of some other plants which contain nitrogen-fixing bacteria.
   (d) Many she-oak trees have a long tap root. How could this help survival in a cay environment?
   (e) How could having winged seeds help she-oaks become established on a cay?
   (f) How does the profuse shedding of branchlets by the she-oak help other plants become established and survive on a cay?
   (g) How do she-oaks help a cay to become stabilised?
   (h) How do she-oaks provide protection for some other plants on the cay?

Ideas for further things to do

4. Read about the nitrogen cycle. Why are bacteria important in the nitrogen cycle? Why is the relationship between the she-oak and its nitrogen-fixing bacteria regarded as symbiosis?

Readings

Cribb, A. B., and Cribb, J. W. 1985. *Plant life of the Great Barrier Reef and adjacent shores.* St Lucia: Univ. Queensland Press.

Bronson, H. 1975. The coastal she-oak. *Beach conservation.* Brisbane: Beach Protection Authority of Queensland. (Leaflet).

FIELD SHEET

80. She-oak study

Where to look	*Feature*	*Sketch or notes*
Foliage of the tree	*Needle-like foliage. These are not leaves but branchlets with green stems which carry out photosynthesis. They are shed when they reach about 30 cm in length.*	
	Rings of tooth-like scales on the stems. These are the true leaves.	
Roots of the tree (if exposed)	*Branched root system.*	
	Lumps about the size of a fist on the roots. These contain bacteria which are able to take atmospheric nitrogen gas and convert it into substances such as nitrates which are used by the green plant.	
	Tap root (if partly exposed)	
Underneath the tree or in cones on the tree	*Winged seeds*	
Underneath the tree	*Layers of fallen needles under the tree*	
Anywhere in or near the tree	*Animals using the tree. Are there any?*	

81. Love a Tree — 1 hr •

Concepts
Biotic characteristics
Interrelationships
Forest
Perception

Skills
Using senses
Measuring and recording
Expressing and revising personal values

Attitudes
Willingness to investigate
Appreciation of natural environment

Aim

- To learn more about trees and to develop new feelings towards them.

You will need

- Tape measure, paper, crayon or heavy 4B pencil,
- 1 m rule, or a 2 m ranging rod or a clinometer (could be a protractor with a swinging weight)
- Reference book on trees

What to do

1. Select a tree that you like. Identify it, if possible, using the reference material.
2. Measure its girth (at chest height), and the extent of its canopy of leaves.
3. Estimate its height using several methods to cross-check. (See methods outlined below.)
4. Draw a leaf, noting its colour, feel, size and shape. Do a bark rubbing by placing the paper over the bark and rubbing the crayon or dark pencil over it to pick up the texture of the bark.
5. Can you see any flowers, pods or seeds?
6. Consider who uses your tree: are there birds resting in it, or nesting in it, or feeding from it? Are there any signs of other occupants or users?
7. Do these users appear to be affecting your tree?
8. How do you think your tree got to be at that place? Would its seeds have blown in, been brought in by birds, or washed ashore? If your tree had never arrived, what would the island be like now?
9. If someone arrived to cut down your tree, what would you do? How would you convince that person not to cut it down?
10. Is your tree alone, or does it have many relations? What if the relations were all removed?
11. Is your tree having an effect on the surrounding area? Does it drop leaves/bark on the ground nearby? What is the local soil like? Is there deep shade?
12. Make a badge to wear showing some of your feelings about your tree.

How to estimate a tree's height in metres

(a) *Without a clinometer*
Against the trunk of the tree place an object of known height (h): a metre rule or a ranging pole can be used, or even a person whose height is known. Move away from the tree. Hold up a pencil at arm's length and, sighting with one eye, cover the object against the tree with the pencil. Then move the pencil upwards. Count the number of pencil lengths needed to reach the top of the tree and multiply this by *h*. (see figure 81.1.)

(b) *Using a clinometer*
This must be done in pairs as one person must sight while the other watches the clinometer (or protractor and hanging weight).
Starting from a place considerably closer to the tree than the tree is high, move back until the clinometer registers 45^0 to the top of the tree. The height of the tree (H) is equal to the distance of the sighter from the tree *(x)* plus the height of the sighter to eye level *(y)*. (Note: With practice you can judge the 45^0 from your eyes to the top of the tree even without using a clinometer.)

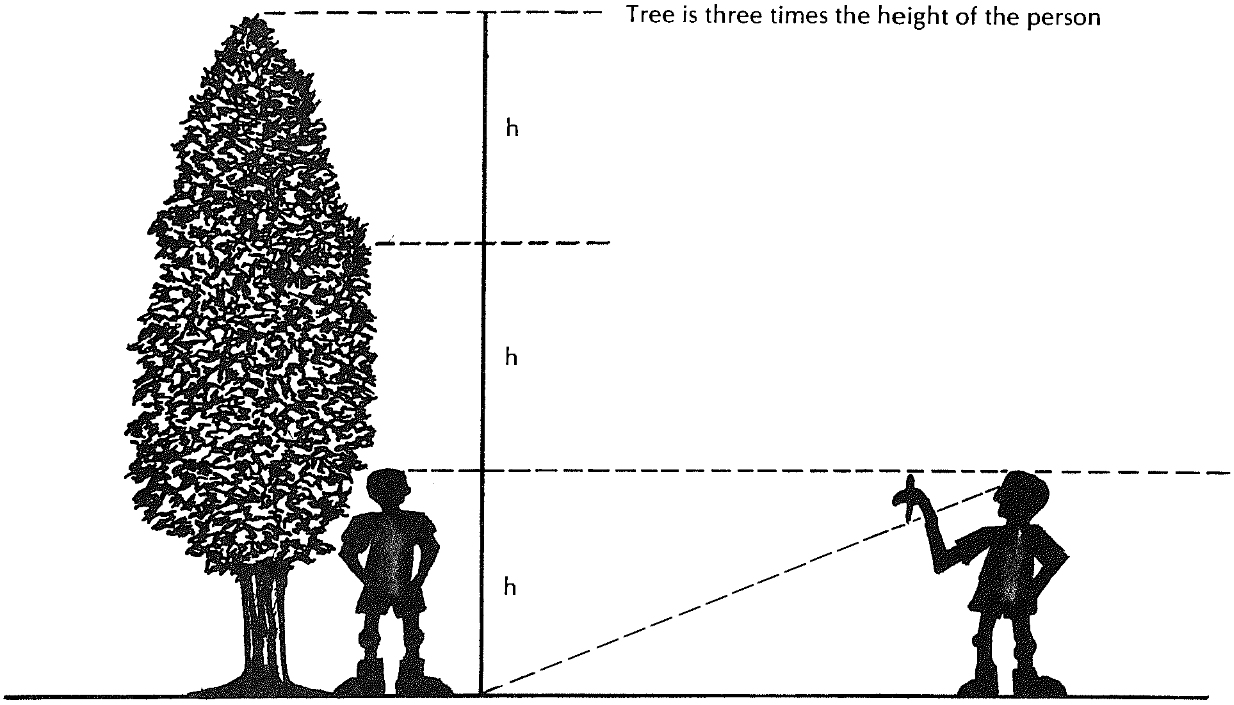


Fig. 81.1

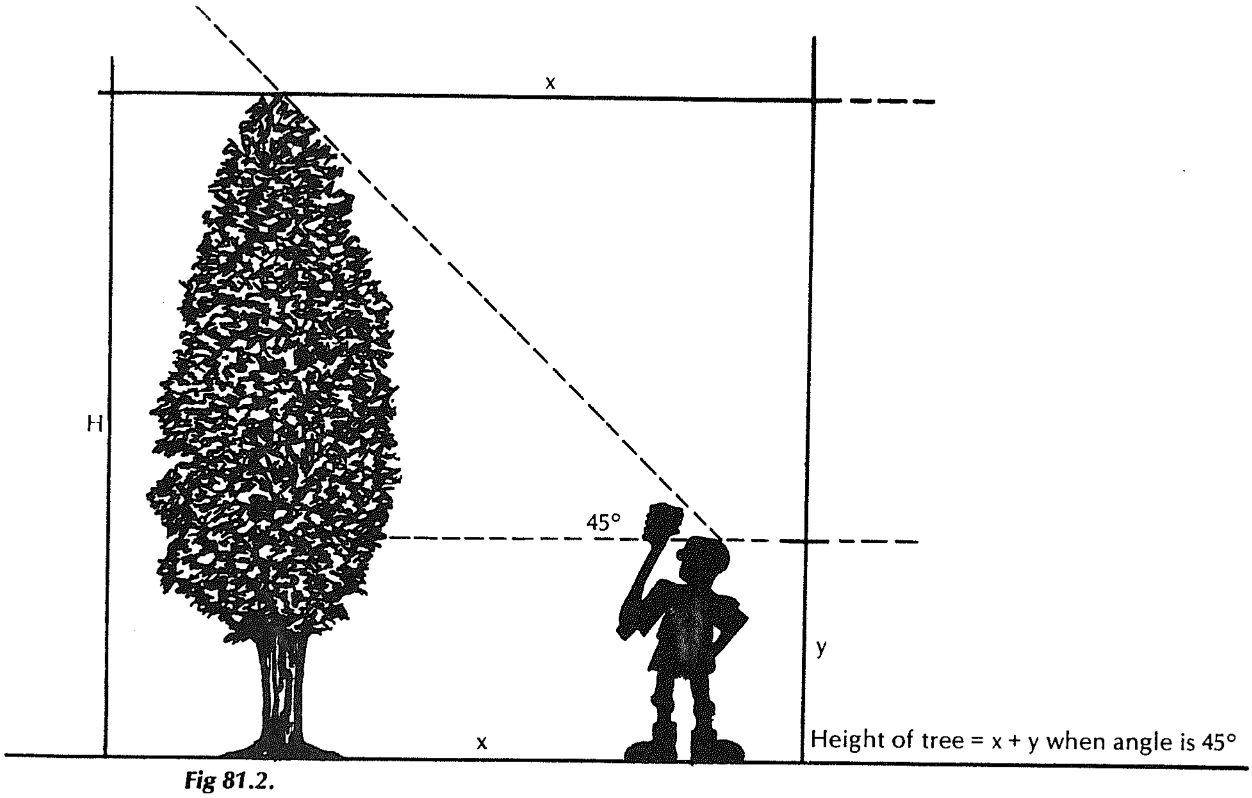


Fig 81.2.

82. Leaf varieties 1½ hr •

Concepts
Leaf distribution
Adaptation
Diversity

Skills
Observing
Drawing
Mapping
Imagining

Attitudes
Appreciation of natural environment

Aim

- To become more sensitive to plants on the cay and to develop an awareness of diversity in the cay environment.

You will need

- Field notebook
- Reference book
- Island map (optional)

What to do

1. Select a number of leaves that you consider fit the following descriptions. (It is not necessary to actually collect the leaves.)
   - a long thin leaf
   - a leaf larger than 5 cm^2
   - a leaf that feels waxy
   - a leaf that feels hairy
   - a leaf that is silvery
   - a leaf with points on it
   - a leaf smaller than 1 cm^2
   - a leaf being eaten by an insect
   - a type of leaf often covered in bird excreta
   - your favourite leaf
   - a leaf like a needle
   - a leaf coloured red
   - a leaf on a vine
   - a leaf growing in a clump/cluster
   - a leaf on a wood stem
   - a leaf with serrated edges
   - a leaf that squashes to produce a liquid
   - a blade leaf
   - a leaf which can cut you
2. When you have matched the description, draw or trace around the shape of the leaf; label each drawing. Use a reference book to identify the species, noting if the species is native or introduced. Where each of the leaves was found could be marked on an island map.

Ideas for further things to do

3. Give your list and drawings to someone else. See if they can find the same examples. Where were most of the examples found?
4. Discuss the island environment and how you think the leaves you've found are adapted to this environment.

Reading

Cribb, A.B., and Cribb, J.W. 1985. *Plant life on the Great Barrier Reef and adjacent shores.* St Lucia: Univ. Queensland Press.

83. On the lean – windshearing of *Pisonia* 1½ hr •

Concepts
Environment
Abiotic factor
Windshearing

Skills
Observing
Measuring
Compass reading

Attitudes
Curiosity
Interest in interrelatedness of organism and environment

Aim

- To study windshearing of *Pisonia grandis* trees on a coral cay.

You will need

- Map of the coral cay
- Magnetic compass and tape measure
- Clinometer

What to do

1. Select an area where there is an abundance of trees.
2. Using a tape measure and compass, mark on the map the position of *Pisonia* trees on a line transect from one side of the cay to the other.
3. Examine the trees for windshearing as you walk from one side of the cay to the other.
4. Rate the amount of windshearing you observe along different parts of the transect. You could use a three or four-point scale from "most obvious" to "least obvious". Place your ratings on the map using symbols or numbers.
5. Using a compass, note the direction in which the trees lean.
6. Measure the angle of lean of the main trunks of wind sheared *Pisonia grandis* trees.

Questions to consider

7. On which side of the island is windshearing in *Pisonia grandis* most obvious?
8. In what direction do the trees lean?
9. How does this relate to the direction of the prevailing wind?
10. What is the greatest angle of lean of the main trunks of windsheared *Pisonia grandis* trees?
11. How far back from the beach are the *Pisonia* trees more or less vertical?
12. Does the height of *Pisonia* trees vary with distance from the beach?
13. Could erosion of the beaches you are studying have brought some trees formerly protected from the main effects of wind close to the beach? If so, what evidence is there of this?

84. Seeds and fruits 1½ hr •

Concepts
Seed
Fruit
Dispersal
Adaptation

Skills
Observing
Recording
Drawing
Inferring

Attitudes
Interest in natural environment
Enjoyment of outdoor experience

Aim

- To explore ways in which plants travel to a cay.

You will need

- Notebook and pencil
- Hand lens (optional)

This activity will take a total of about 1½ hours at various times throughout your visit. (Note: Seasonal variation in fruiting times will affect this activity.)

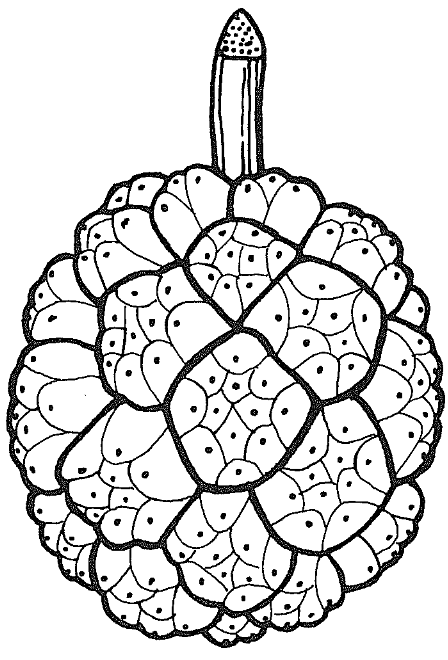
What to do

1. As you walk around the cay, look for fruits and seeds on plants; fruits and seeds associated with animals (e.g., in faeces or on feathers); and seeds being blown around.
2. Walk along the beach and see if there is any plant material along the shoreline. Are there any fruits or seeds which have been floating?
3. Make sketches of all the different types of seeds and fruits you see. Take note of any features that might have helped the species to which they belong to colonise an island, e.g., hooks, sticky coating, wings, buoyant structure.
4. Sum up your findings in a table using headings such as those below:

Brief description of seed or fruit	*Species or common name of plant*	*Feature of fruit or seed which helps it to travel to a cay*	*Means of travel to cay: water, wind, animal*

Reading

Cribb, A.B., and Cribb, J.W. 1985. *Plant life of the Great Barrier Reef and adjacent shores.* St Lucia: Univ. Queensland Press.



85. *Pisonia* and sex — 1½ hr • •

Concepts
Classification
Distribution
Plant reproduction
Dispersal

Skills
Observing
Recording
Identifying

Attitudes
Curiosity
Interest in natural environment
Interest in methods of science

Aim

- To distinguish between male and female *Pisonia grandis* trees.
- To study the distribution of the male and female trees in part of the cay.
- To discover whether individuals of one sex tend to be grouped together.

This activity can be done only at flowering time (spring/summer months).

You will need

- Diagrams of male and female *Pisonia grandis* flowers
- A notebook or paper attached to a clipboard
- Pencil
- Hand lens
- Forceps
- Measuring tape

What to do

1. Map out an area of *Pisonia grandis* forest 50 m x 50 m square.
2. Using symbols or numbers, make a simple map of the area showing the position of *Pisonia grandis* trees.
3. Examine each *Pisonia grandis* tree for flowers and distinguish its sex. Mark the sex of the tree on the map.

Questions to consider

4. Do the plants occur in single-sex groupings. If so, why?
5. What does this group tell you about the history of plant colonisation on the island?
6. What methods are used by *Pisonia grandis* to reproduce its own kind?
7. *Pisonia grandis* has very sticky fruits. What problems does this create for birds?

Reading

Cribb, A.B., and Cribb, J.W. 1985. *Plant life of the Great Barrier Reef and adjacent shores.* St Lucia: Univ. Queensland Press.

86. Island environmental stations 1-2 hr

Concepts
Habitat
Environment
Atmosphere
Emotion

Skills
Observing
Analysing
Recording
Expressing
Cooperating

Attitudes
Appreciation of environment

Aim

- To make detailed observations of a variety of island and seashore habitats.

You will need

- A sketch map and list showing environmental stations which have been marked on the island.
- Paper and pencil
- Thermometer
- Metre rule
- Height metre (optional)

> *Your leader has set up a number of observation stations along a route on the island. The sites are marked by coloured tape. There is a card of instructions at each site. The stations are in a variety of habitats, such as forest and beach edge. The stations may be linked together with string.*

What to do

1. Divide into a number of small groups.
2. Each group should go to one of the marked environmental stations.
3. At each station, read the card of instructions and questions. Carry out the instructions and record your observations on paper. Leave the card at the station.
4. After about 15 minutes, move on to the next station.
5. Continue until you have been to all the stations or until a signal is given to stop.
6. Return to base. Discuss and compare results. Display materials where appropriate.

Possible sites and examples of questions for cards

Site number A: Leaf litter area under trees
How much of the ground is covered by leaf litter? How deep is the litter? How much of it is: freshly fallen leaves; dry, fairly complete leaves; broken-down leaves? How does the leaf litter feel as you dig in it? Is it moist or dry? How does it smell? What are some animals you can find living in it? What effects can leaf litter have on the ground beneath? Can you think of some places on the island where there is more litter than here, or less litter than here?

Site number B: What happened here area
This is an unusual area on the island. There is evidence here of some kind of change not too long ago. Is the evidence of human origin, e.g., old pipeline, stone wall or building, ruin or wreck, rubbish heap, cut-down trees? Or is it of natural origin, e.g. blown-over tree? Using the evidence available and all your powers of observation and deduction, put forward some suggestions. What has happened in this area in the past?

Site number C: Shoreline area
At the high tide mark, observe flotsam and other debris. How much of the material has been made by people? What signs of life are there here? On the beach, do high tides reach much the same level every day?

Site number D: Dense tree area
What types of trees are here? Are the trees native trees or exotics? Are the trees evenly spread through the area or are they concentrated into clumps? What is the average density of trees in the area? What percentage of the sky is obscured by trees? In what condition are the trees? What animals and plants are using trees here?

Site number E: Bird area
This is a place where groups of birds congregate. Observe the types of birds; their size, shapes, distinctive colourings and features. Look for nesting sites. Make notes on their behaviour, including calls, when near their nests or when moving around the nesting area.

Site number F: Dreamtime area
This is a landscape where you can get a fairly long view into the distance. Sit, relax and "become" the scene you are in. Record your thoughts in short phrases or sketches. Allow the area to take you over.

Site number G: Littered area
This is a place where humans have littered. What is the dominant kind of litter? How does it affect the site — does it make it ugly, unsafe? Can you decide on the causes of the litter? Can you work out ways to prevent littering at this place?

Site number H: Clearing area
This is an open-space area among trees. Sit in the middle of the area and concentrate on using all your senses. Record your feelings about hotness, coldness, wind, shade, sounds and the life going on in the clearing. Is there much difference between the middle and the edges of the clearing?

Site number I: Shapes area
This is a place where there is a variety of shapes in vegetation, rocks and other things (including those made by people). Discover as many variations in shapes as possible. Which shape dominates? Comment on thinness and fatness, roundness and squareness. Make sketches showing the main shapes you see. Combine some of these and develop them into an idea for a design.

Site number J: Problem area
This is a place where a problem exists. Is the problem sand erosion, clearing of trees, undermining of vegetation by nesting turtles, dumping of rubbish, noisy machinery or other? Observe the problem — is it a short or long-term one? What are some causes of the problem? Is anything being done about the problem? What solution do you see as being feasible?

Site number K: Developed area
This is an area where people have developed part of a natural area so that they can make use of it. What signs of development are there? What is the purpose of the development? What aspects of the development do you think are most pleasing to the eye? What aspects are least pleasing to the eye? How do you think the development altered the natural environment? Has the development been beneficial in your opinion? Could the development have been carried out in an alternative way to serve the same purpose but to create less change to the previously existing environment?

87. Vegetation distribution on a cay 2 hr •

Concepts
Species distribution
Abiotic factors
Ecosystem

Skills
Mapping
Recording
Observing
Interpreting
Estimating

Attitudes
Initiative
Curiosity
Interest in natural environments

Aim

- To map out the distribution of five major species of trees and shrubs on a cay and relate their distribution to environmental conditions.

You will need

- Outline map of the island you are visiting
- Pencil and paper
- Magnetic compass

What to do

1. Become familiar with the trees and shrubs *Pisonia grandis, Pandanus, Casuarina, Argusia, Cordia.*
2. Obtain or make a copy of an outline drawing of the cay. Decide upon a key to represent the five plant species. Indicate north on your map.
3. Walk *around* the island and map the distribution of these plants along the edge of the vegetated part of the cay. (Estimate average heights.) Now walk *through* the island along several lines and around patches of vegetation. Once again map the distribution of these trees and shrubs.

Questions to think about

4. Can you see any relationship between tree distribution and the direction of prevailing winds?
5. Why do you think that *Pisonia* are not generally found around the periphery of the cay?
6. How does the height of the *Pisonia* trees vary as you approach the centre of the cay? How do you account for this?

Reading

Cribb, A.B., and Cribb, J.W. 1985 *Plant life of the Great Barrier Reef and adjacent shores.* St Lucia: Univ. Queensland Press.

Argusia argentea

88. Cay bird life

3 hr • | • •

Concepts
Identification
Diversity
Habitat
Feeding
Populations
Behaviour

Skills
Observing
Recording
Identifying
Innovating

Attitudes
Perseverence
Appreciation of natural environments
Interest in methods of science

Aim

- To get to know at least *five* common types of birds, to observe their behaviours and to estimate populations.

You will need

- Bird field guide
- Binoculars, if possible
- Field notebook and pencil
- Tape-recorder (optional)
- Outline map of the cay

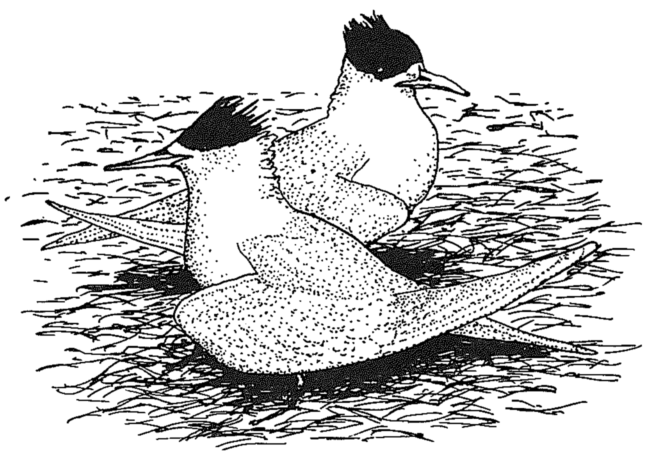
This activity requires at least 3 hours, spread over several days.

What to do

1. Common species
   (a) Early morning is a good time to start. Walk slowly around the cay. Look at the different birds. Try to pick out the main differences.
   (b) Choose one obvious bird. Note its size; colour; markings; length and colour of legs; shape and size and colour of beak; the length of its neck; where it spends most of its time, e.g. soaring , wading, running on sand.
   (c) Identify it from the field guide.
   (d) Repeat until you know five birds. Continue to walk around the cay. Test yourself.
   (e) Try to learn a new bird each day.

Ideas for further things to do

2. Populations
   (a) Choose one species. How could you find out the population of this species on the cay?
   (b) Work out a method of estimating the population. Discuss with your leader, stating the difficulties and reasons for possible inaccuracies. Modify if necessary.
   (c) Apply your method.
3. Behaviour
   (a) Observe one species closely.
   (b) On a map of the cay, show where this species congregates (you may need different maps for different times of the day).
   (c) Choose one, a pair, or a small group of birds. Observe and record behaviour over time.



Crested Tern

Some suggestions on method:

- During your initial observation, record all behaviours noticed in words, on tape or by diagram, e.g., noddy lands on branch, foot looking, moves towards nest, avoids looking at bird on nest, foot looking.
- Devise a record sheet based on these initial observations so you can record the frequency of different behaviours, or devise a code.

Things to look for:

- — different types of call
- — different postures (aggressive, courting, reply to courting, acceptance, rejection, greeting, submission, food begging)
- — different types of flight
- — nesting behaviour
- — feeding behaviour (adults, chicks)

- Make frequent observations throughout one day.
- Draw up a 24-hour timetable for your bird.

4. Colour phases in reef herons
   Reef herons *(Egretta sacra)* may be grey or white. What proportion of the heron population is grey? You will need to plan a method of how to count, when to count, how often, where. Observe herons, their habitat and behaviour. Discuss which colour phase has most survival value in different conditions. What do you think are the advantages of this polymorphism?

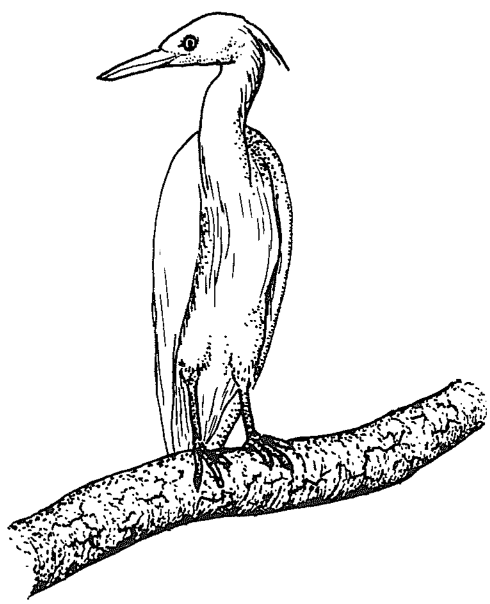
Readings

Frith, H.J., ed. 1976. *Complete book of Australian birds.* Sydney: Reader's Digest.

Serventy, D.L., V. Serventy and J. Warham. 1971. *The handbook of Australian sea-birds.* Sydney: Reed.

Slater, P., Slater, P., and Slater, R. 1986. *The Slater field guide to Australian birds.* Dee Why: Rigby.

Pizzey, G., and Doyle, R. 1980. *A field guide to the birds of Australia.* Sydney: Collins.



Reef Heron

89. Bird behaviour 3 hr ● ●

Concepts
Behaviour
Courting
Territory
Submission
Aggression

Skills
Observing
Recording

Attitudes
Curiosity
Interest in methods of science

Aim

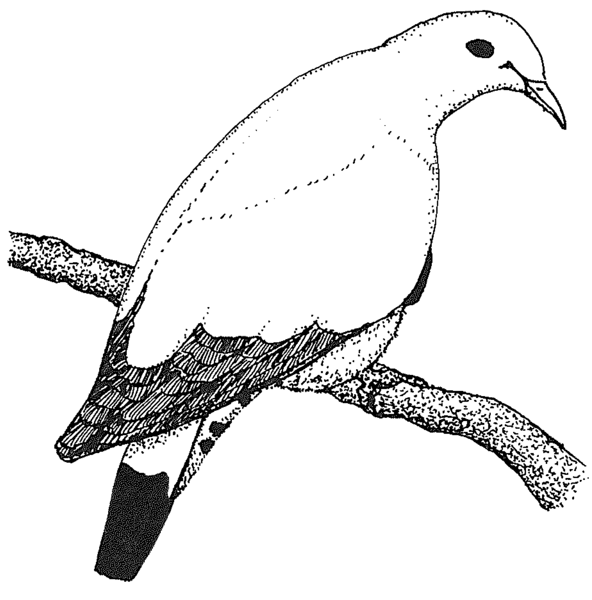
- To study the behaviour patterns of a selected bird species (individual, pairs or group) associated with a coral cay.

You will need

- Binoculars
- Notebook or paper attached to a clipboard
- Pencil
- Recording sheets
- Tape-recorder (optional)
- Camera (optional)

What to do

1. Select a site to observe birds of a particular species with the minimum disturbance.
2. On the first day, make a list of behaviour patterns exhibited, or record descriptions into a tape-recorder. These could include the different types of calls, flight patterns and postures. Note any distinctly different behaviour types you see. You may be able to label some of these, for example, aggression, courting, response to courting, acceptance, rejection, greeting, submission, nesting, feeding adults, feeding chicks, adults with chicks.
3. Devise a record sheet (based on your initial observations) on which to make detailed descriptions of the behaviour patterns, using words and diagrams (see table 89.1 for an example). Make another sheet for recording the frequency of different behaviours for a number of minutes (e.g. every 5, 10, 15 minutes, see table 89.2).
4. On the second day fill in both sheets, recording the different types of behaviour patterns and their frequencies. Try to make observation at different times of the day to help build up a 24-hour timetable for this species.
5. After several days of observations, what can you conclude from your notes about behavioural adaptations for survival?
6. If possible, take photos of distinctive behaviours and set up a display for other students. Caption each photo with information you have gained from your observations.



Torres Strait Pigeon

Table 89.1: Reef bird behaviour patterns (example only)

Date:______ Species:____________

Pattern no	*Description of observed pattern*	*Diagram*	*Name for behaviour pattern (if any)*
1.			*Call (types)*
2.			*Aggression*
3.			*Courting*
4.			*Courting reply*
5.			*Acceptance*
6.			*Rejection*
7.			*Greeting*
8.			*Submission*
9.			*Food begging*
10.			*Feeding*
11.			*Nesting*
12.			*Flight (types)*

Table 89.2: Behaviour pattern frequencies of a reef bird (example only)

Time of commencement:______ Date:______ Species:____________

Pattern No	*Behaviour patterns*	*Frequency* (record at 5 minute intervals) 0 5 10 15 20 25 30 35 40 45 50 55 60
1.	Call (types)	
2.	Aggression	
3.	Courting	
4.	Courting reply	
5.	Acceptance	
6.	Rejection	
7.	Greeting	

90. Bird feeding techniques 1½ hr •

Concepts
Identification
Ecological niche
Food web
Adaptation

Skills
Observing
Recording

Attitudes
Perseverence
Curiosity
Interest in natural world

Aim

- To observe the feeding habits of different birds found on a reef and cay.

You will need

- Binoculars
- Field sheet
- Pencil
- Map of island
- Camera (optional)
- Tape-recorder (optional)

What to do

1. Walk around a coral island. Walk across the reef flat if possible. Make observations at various times of day.
2. Observe the feeding habits of as many different species of birds as possible.
3. Record observations on a field sheet. (Use the headings shown below.) Leave blanks where you don't have complete information.
4. Summarise the general feeding techniques and food required for the survival of birds on a coral island.
5. Is there any recognisable relationship between beak form and feeding habit? Is there any recognisable relationship between diet and habitat?

FIELD SHEET

90. Bird feeding techniques

Bird	*Site*	*Time*	*Food Type*	*Capturing method*	*Beak form (draw)*	*Eating method*

91. Wrong song – bird calls 1½ hr •

Concepts
Aggression
Territoriality
Courting behaviour

Skills
Recording
Communicating

Attitudes
Curiosity
Perseverence
Willingness to innovate
Interest in natural world

Aim

- To become aware of the diversity of bird calls, to record calls, and to identify bird species by their calls.
- To develop an understanding of the different functions of different calls by the same species.

You will need

- Binoculars
- Notebook
- Bird field guide
- Tape-recorder (optional)
- Meter for recording sounds (optional)
- Camera (optional)

What to do

1. Focus on one species of bird to start with. Good examples are the black noddy or mutton bird.
2. (a) Listen carefully to all the sounds your bird makes.
   (b) Record these sounds either with a tape-recorder or by code. Figure 91.1 shows one way of coding sounds. Devise your own code.
   (c) If using a tape-recorder, watch the sound-level monitor and become familiar with the pattern for a particular call.
   (d) If you have a meter which can trace a graph of a sound pattern, use this to distinguish calls.
3. Once you have distinguished different types of calls, observe the bird's behaviour at the same time. Can you find the reason behind the call type? For example, is the bird courting, feeding its mate, signalling territory limits, being submissive to another bird?
4. Repeat these techniques for various bird species and present your results on a chart for the information of others.

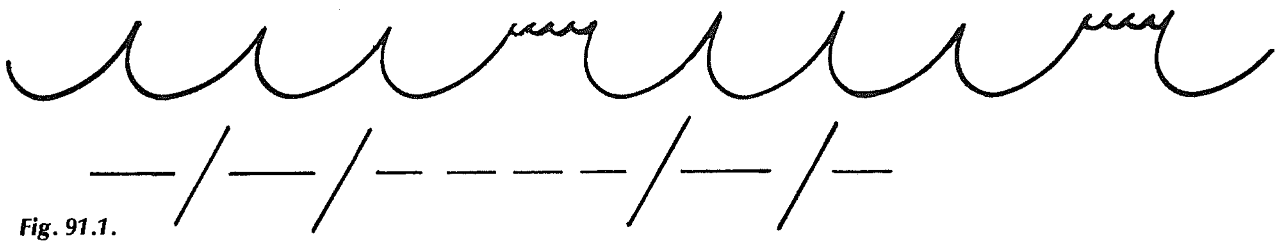


Fig. 91.1.

Ideas for further things to do

5. You may wish to produce a slide/tape presentation of your work.
6. Test bird reactions when you play a tape-recording of calls back to them. How do they react when you play the "wrong song", e.g., a territory call to courting birds. Do not persist with this activity if it disturbs the birds.

Readings

Pizzey, G., and Doyle, R. 1980. *A field guide to the birds of Australia*. Sydney: Collins.
Slater, P., Slater, P., and Slater, R. 1986. *The Slater field guide to Australian birds.* Dee Why: Rigby.
Serventy, D.L., Serventy, V., and Warham, J. 1971. *The handbook of Australian seabirds.* Sydney: Reed.
Frith, H.J., ed 1976 *Complete book of Australian birds.* Sydney: Reader's Digest.

92. Flight patterns 1½ hr •

Concepts
Bird flight
Bird calls
Diversity

Skills
Observing
Recording

Attitudes
Curiosity
Perseverence
Willingness to innovate
Interest in natural world

Aim

- To observe and record flight patterns of reef birds.
- To use these records to identify birds in flight.

You will need

- Binoculars (optional)
- Field notebook and pencil
- Bird field guide

What to do

1. Observe birds flying and notice their different flight patterns.
2. Start with a slow flyer, watch carefully how the bird uses its wings, and try to record this flight pattern. This is one way:

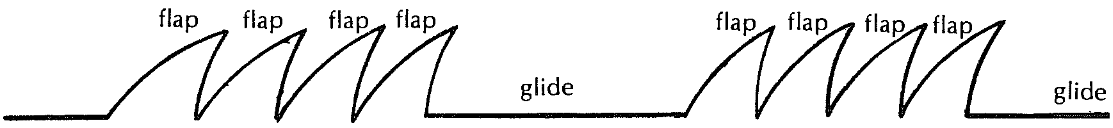


Fig. 92.1.

3. Record several birds of each species and see how the patterns relate.
4. Build up your records for at least five different species.

Questions to consider

5. Is the flight pattern related to wing shape, wing size?
6. Does each species of bird have its own flight pattern?

References

Slater, P., Slater, P., and Slater, R. 1986. *The Slater field guide to Australian birds.* Dee Why: Rigby.

Pizzey, G., and Doyle, R. *A field guide to the birds of Australia.* Sydney: Collins.

Serventy, D.L., Serventy, V., and Warham, J. 1971. *The handbook of Australian seabirds.* Sydney: Reed.

93. Bird nests 1½ hr •

Concepts
Bird behaviour
Nests
Population
Adaptations

Skills
Observing
Recording
Measuring

Attitudes
Persistence
Interest in methods of scientific enquiry
Appreciation of natural environments

Aim

- To learn more about the nests and nesting habitats of birds of the Capricorn Group.

You will need

- Binoculars
- Notebook or clipboard
- Pencil
- Map of island
- Camera (optional)

This activity is best done between September and March.

What to do

1. Find the nests of a few different bird species. Some good examples are:
   - black noddy
   - wedge-tailed shearwater
   - silver eye
   - bridled tern
   - sea eagle
   - reef egret (heron)

   Take care not to disturb the colony or pair, or to touch the nest. (Herons and land rails are particularly sensitive.)
2. Mark the location of each nest on the island map.
3. Describe the site (on ground, in tree, type of tree, shaded, in open, etc.).
4. Describe the nest (shape, size and material).
5. Find out what materials are used for the nest.
6. Find out what is in the nest. If there are eggs or chicks, how many and describe them.
7. Observe the nest to find out if it is being regularly attended.
8. If parent birds are present, describe their alarm calls.
9. Describe whether your nest is alone or part of a colony. If in a colony, how many nests are there at one site? Are most nests at the same stage, e.g., all with a chick or all with birds sitting on eggs.
10. Observe the nest at various times of the day, if this can be done without disturbing the birds. Note the activity of the birds and how local weather conditions affect them. What happens at night?
11. Tabulate your observations using headings such as location, site, nest design, eggs (size, number, colour), chicks, activities.
12. Compare your data for the four nests. Which birds accepted you best?
13. Discuss the birds and their nesting adaptations to the reef cay environment.

94. Those magnificent birds in their flying machines 1 hr •

Concepts
Nesting behaviour
Bird movement
Interrelationships

Skills
Observing
Measuring and recording
Testing hypotheses
Recording bird sounds

Attitudes
Persistence
Interest in bird life

Aim

- To learn more about mutton-birds, their nesting habits, and landing and take-off behaviour.

You will need

- Pen, notebook; tape-recorder
- Map of the island

Time needed

- About 2 hours in daylight during the nesting season, from mid-October to mid-April, for base data collection, and some observation time at night (about 30 minutes at 7.00 p.m. and about 30 minutes at 4.30 a.m.).

What to do

1. Select an area where burrows are present. (Be careful in site selection. Avoid using an area of collapsing burrows. Take great care to avoid burying birds in burrows as you move about.)
   Record the general appearance of burrows. How can you tell if burrows are occupied? (Footmarks? Debris at mouth of burrow? Noise?) Note and record the site of the burrows, e.g., near a building, near a tree, shaded or not shaded. Make a sketch of the sample area indicating these features.
2. When you have completed your observations, it might be possible to put forward some hypotheses about mutton-bird nests. Examples might include such statements as the following:
   - Most burrows occur in *Pisonia* forests.
   - Mutton-bird burrows occur beneath the nests of other bird species.
   - Mutton-bird nests occur in clusters.
   - Most used burrows are in shade.
   - Most occupied burrows are on the northern side of the island.
3. Make further observations. Do these support your hypotheses?
4. In the early evening, observe some mutton-bird burrows in which chicks are present. Watch carefully. At what times do the returning adults arrive at the burrow? How close to the burrows do they land? Do all adults arrive together? What happens when an adult approaches a burrow? What noises are made by the adult, the chick, and the adult which stayed at home? Did one of the adults stay at home? (When the chick is partially grown, both adults fly to sea to feed and collect food for the chick.) Make notes of your observations.
5. Using a tape-recorder, record the sound the adult makes at the burrow. What happens if you play the sound back to it? What happens if you play the sound at another burrow? Record what happens.
6. Early in the morning, about 4.30, the adults fly back to sea, taking off in certain areas often called runways. Locate one of these in daylight (identifiable usually as a path leading to the beach) and observe quietly what happens when the adults take off. How do they lift off? What happens when they are airborne? Where do they go? Are they together? Return to some burrows. Is it all peace and quiet? Are chicks sitting outside burrows?

95. There came a big spider . . . 1½ hr • •

Concepts
Behaviour
Colour patterns
Habitat
Interrelationships
Distribution

Skills
Observing
Recording
Interpreting

Attitudes
Curiousity
Persistence

Aim

- To investigate the species of insects and spiders on the cay, and to develop an understanding of these with their habitats.

You will need

- Permit to collect insects and spiders
- Field notebook, table, pencil
- Butterfly net
- Small collecting jars, or plastic bags
- Identification books (e.g. Mather and Bennett 1984)

What to do

1. Read the summary of insects and spiders in Mather and Bennett and check any reference books for identikits.
2. Draw up a table on paper or field slate, using headings such as these:
   Date
   Side of cay
   Site description
   Habitat (under bark, in trees, on rock, under earth, in air, in web or hole, in or on leaf, etc.)
   Description of species
   Action while observed
   How gets food
   Identification — name
3. According to Mather and Bennett, recordings of insects and spiders on most of the cays are both spasmodic and incomplete. Therefore, any details you obtain of these species will be useful to the Queensland National Parks and Wildlife Service. Keep your data carefully and be prepared to give it to the Authority's database.
4. Select a suitable area for investigation of habitats of insects and spiders and examine it carefully. Make recordings of what you see and hear (and feel?). If necessary, collect your spider/insect in a jar/net/bag, and examine it closely. Attempt to return it alive to its own habitat area.
5. Make notes as to where you find the insects and spiders, their actions at the time of your observation, and how they are collecting food. What are they eating? What eats them?
6. You could also note their methods of home-making, locomotion, eating, defence, etc.
7. Attempt positive identification of some of your spiders/insects.
8. Are there any places on the cay where insects and spiders are found in great abundance, or not found at all? Can you suggest why?
9. Apart from birds, insects and spiders, what are the main non-marine animals on the cays. If you had no other food, would you be able to eat them? How would you find out if they were safe to eat?

Reading

Mather, P., and Bennett, I. 1984. *A coral reef handbook* (2nd ed.). Brisbane: Aust. Coral Reef Society.

96. Turtle watching 3 hr •

Concepts
Life history
Population dynamics
Population monitoring
Wildlife research
Behaviour
Survival strategies

Skills
Observing
Recording

Attitudes
Perseverance
Willingness to communicate
Curiosity
Interest in natural environment
Interest in methods of science

Aim

- To carry out a census of laying turtles and/or turtle hatchlings.
- To discover as much as possible about turtle behaviour.

You will need

- To have read information on turtles and know how not to disturb them
- Torch or caving helmet light
- Notebook and pencil
- Measuring tape
- Outline map of island
- To be prepared to share your knowledge with tourists

This activity should be carried out for at least 3 hours over several different nights between November and March.

What to do

At some reef islands during November-January, turtles will be laying. In December-March, young turtles will be hatching.

1. Contact staff of the National Parks and Wildlife Service at the island you are visiting. If they are carrying out turtle studies on the island, it may be possible to assist them with their work. If not, get permission to do your own studies.
2. Each night, walk around the island. Count the female turtles laying. Work out a system so you don't count a turtle twice. If the turtle is already laying and won't be disturbed, note the tag number if tagged, measure across the curve of the carapace, and note any damage to flippers, occurrence of barnacles on shell, and date and time of nesting.
3. Plot nesting sites accurately on an outline map of the island. What patterns can you see? Can you explain them?
4. For several turtles each night, try to count the number of eggs and time taken to lay.
5. Describe how the turtle digs the egg chamber and how she fills it in. Time different actions.
6. Graph the number of turtles nesting each night for each species.
7. What is the proportion of tagged to untagged females?
8. What is the proportion of green turtles to loggerheads or other species?

Ideas for further things to do

9. If there have been no National Parks rangers on the island, your records will be valuable. Write up your results and send them to the Queensland National Parks and Wildlife Service.

Follow-up reading

10. Find out more about what species are known to lay on your island. Which species are most likely to be disturbed? What influence does the date of laying have on the proportion of male to female young? Try to find out the most recent information on:
    (a) Where turtles go between hatching and maturity.
    (b) At what age a turtle reaches sexual maturity.
    (c) Whether turtles return to the same beach to lay each time.
    (d) Whether female turtles lay each year, or every two, three or four years.
    (e) Whether turtles return to lay on the same beach where they were born.
    (f) What each species feeds on.
11. Find out which species of turtles are considered endangered in Australian waters and worldwide.
12. Propose conservation measures and write these up in a list which the National Parks and Wildlife Service could pin up on notice boards.
13. Write an information leaflet on nesting turtles for tourists.

Readings

Bustard, H. Robert. 1972. *Sea turtles: natural history and conservation.* London: Collins.

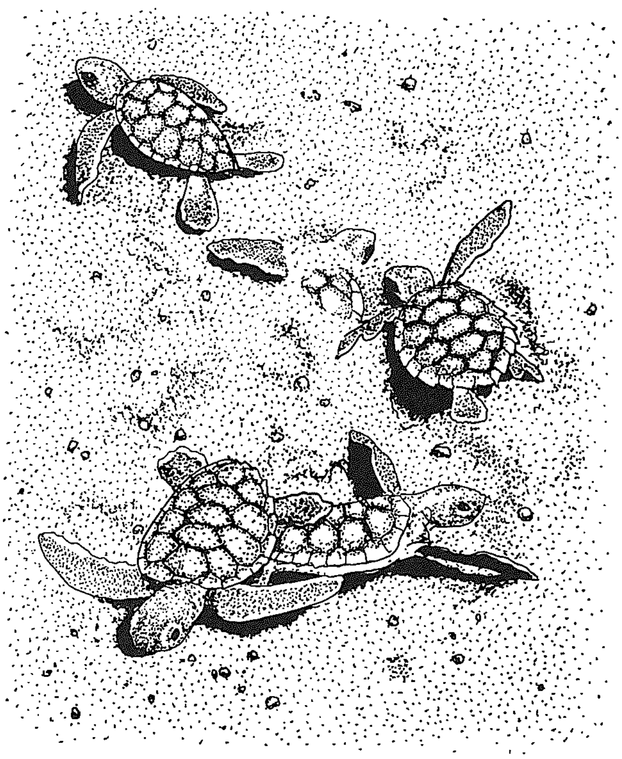
Bustard, H. Robert. 1974. Barrier Reef sea turtle populations. *Proceedings 2nd International Coral Reef Symposium,* vol. 1, pp. 227-34.

Bustard, H. Robert. 1976. Turtles of coral reefs and coral islands. In *Biology and geology of coral reefs,* ed. O. A. Jones and R. Endean, New York: Academic Press.

Limpus, C., Fleay, A., and Guinea, M. 1984. In *The Capricornia section of the Great Barrier Reef — past, present and future,* ed. W. T. Ward and P. Saenger. Brisbane: Royal Society of Queensland and Australian Coral Reef Society. pp. 61-78.

Seal, Vicki. 1981. The talk is all turtles, *Australian Natural History* 20 (5).

Serventy, V., and Raymond, R. 1975. Marine turtle research. *Australian Wildlife Heritage* 6 (80): 2536-41.



Turtles hatching

THE HUMAN DIMENSION

The reef as human resource

97. Why people go where on holiday

Concepts
Perceptions
Choice
Individual attractions
Differences
Wants

Skills
Relating to others
Communicating
Interviewing
Analysing data

Attitudes
Curiosity
Interest in others
Appreciation of methods of scientific enquiry

Aim

- To assess visitor perceptions of the factors important to making a good holiday at the reef.

You will need

- Recording sheet and pen

What to do

1. Talk to 10 to 20 different visitors to find out what is important to them on a holiday. Ask each person to number the holidays listed on the fieldsheet in order of importance to him or her. (Put a number 1 in the box alongside their first choice, a number 2 alongside their second choice, etc., down to number 14 alongside their last choice.)
2. Analyse your results. Did you expect these results? How do the visitors' ideas compare with your own?
3. Was there a difference between the answers of males and females?
4. Was there a difference between age groups?
5. Would the facilities and features of the island provide for the visitors' wants? (For example, good shops, nice scenery?) If not, what do you think should be done?

Further things to do

6. You may be able to complete the more detailed "Tourist survey" in activity 98 to get more opinions.
7. Contact the Queensland Tourist and Travel Corporation for their recent surveys and reports.

FIELD SHEET

97. Why people go where on holiday

Recording sheet

Holiday attraction	*Person no., sex and approximate age group*					
	No.: 1 (example) Sex: Male Age: 25-34	No.: Sex: Age:	No.: Sex: Age:	No.: Sex: Age:	No.: Sex: Age:	No.: Sex: Age:
Good food	12					
Accommodation	14					
Shows/entertainment	13					
Nice scenery	6					
New places	7					
Learning new things	11					
Good weather	4					
Sea bathing/snorkelling	1					
Making new friends	5					
Sun bathing	10					
The beach	3					
Shopping	9					
Fishing	8					
The reef	2					

Age groups: 15 yrs and under, 16-24, 25-34, 35-44, 45-54, 55-64, 65 and over

98. Tourist Survey

Concepts
Perception
Management
Tourism

Skills
Data collecting
Evaluating
Communicating

Attitudes
Tolerance and respect for others

Aim

- To interview tourists about their impressions and perceptions of an island to find out whether their expectations of the island were met during a visit.

You will need

- Duplicated copies of survey form
- Pen
- If appropriate, permission from the resort manager or other tourist operator to interview visitors

This activity will take about 15 minutes for each survey.

What to do

1. Before the trip, draw up a list of questions you would like to ask visitors, or use the survey sheets as a guide.
2. Before starting your survey, your leader should obtain the tourist operator's permission. You should discuss how the interviews are to be carried out. Decide how to select and approach visitors, how to explain the purpose of the survey, and how to avoid infringement of privacy.
3. After obtaining the data, you should attempt some correlation, e.g.
   - Do overseas visitors expect different scenery from Australians?
   - Do older people undertake activities different from younger groups?
   - What percentage of visitors knew who managed the Marine Park on a day-to-day basis?
4. As a result of your data, do you want to recommend some action? To whom?

Ideas for further things to do

5. Try these activities:
   - "Why people go where on holiday" (activity 97)
   - "Perception of place" (activity 134)
   - "Showing off" (activity 147)

Tourist survey

1. Your usual place of residence is — Australia ________ Overseas ________
2. In which country do you normally live? ________
3. What is the nature of your visit to the Great Barrier Reef?
   - Brief holiday ________
   - Part of extended holiday ________
   - Mainly a business trip ________
   - Business plus sight-seeing ________
   - Working holiday ________
   - Study/research ________
   - Other (please describe) ________
4. How many people are included in your group including yourself?

	Number of persons Male	Female
• 15 years and under		
• 16-24		
• 25-34		
• 35-44		
• 45-54		
• 55-64		
• 65 and over		

5. What are the main occupations of the people in your group? (List)

   ____

6. How long are you staying at this island? ________ nights
7. Why did you decide to visit this island?
   - Heard of it from friends/relatives ________
   - Visited it before ________
   - Travel agent/tourist bureau recommended it ________
   - Other (please specify) ________
8. How was your accommodation reserved?
   - By the Queensland Tourist Bureau ________
   - By airline/shipping/coach line ________
   - Direct with the management ________
   - Other (please specify) ________
9. What type of accommodation are you using?
   - Resort self-contained units ________
   - Resort share facilities ________
   - Research station dormitories ________
   - Tent ________
10. Have you visited this island before? YES/NO
11. How did you travel from the mainland?
    - Launch ________
    - Barge ________
    - Helicopter/plane ________
    - Private boat ________

12. Have you ever visited other parts of the Great Barrier Reef? YES/NO

If yes, when ____________________

and where ____________________

13. Would you recommend that your friends visit this island and spend more or less time than you have?
- Will suggest longer stay ________
- Will suggest shorter stay ________
- Will not recommend visit ________
- Don't know ________

Would you like to give your reasons for answering this question as you have?

____

14. What natural features did you expect to find on this island (e.g. palm trees, a lagoon, forest)?

____

15. What facilities did you expect to find on this island (e.g. tennis courts, shopping facilities)?

____

16. What have you been doing on the island during your stay?
- Eating ________
- Swimming ________
- Other sports ________
- Walking on the island ________
- Coral walking/viewing ________
- Fishing ________
- Trips to other areas ________
- Scuba/snorkel diving ________
- Other (please specify) ____________________

17. What other activities would you have expected to do (but did not have the opportunity to do) on the island?

____

18. Is this island a national park? YES/NO

19. Did you know that the waters and reefs in the Great Barrier Reef area are part of a marine park? YES/NO

Who controls this marine park? ________
- The resorts ________
- University of Queensland ________
- Commonwealth Government ________
- Queensland National Parks and Wildlife Service ________
- Great Barrier Reef Marine Park Authority ________
- Queensland government ________
- Don't know ________

20. Who is responsible for the day-to-day management of the Great Barrier Reef Marine Park?

21. What are some restrictions which apply under the terms of the Great Barrier Reef Marine Park?

22. Do you think oil drilling should be permitted on the Great Barrier Reef? YES/NO

23. Do you think scientific research on the Great Barrier Reef should continue? YES/NO

24. Some researchers have recommended that reef walking should be banned because of the damage to the coral. Do you agree?

If staying at a resort

25. How do you find the resort meets with your expectations in terms of the following?
    - Accommodation/food
    - Facilities (pool, courts, etc)
    - Recreational opportunities
    - Educational programs
    - Organisation/management
    - Suggestions for changes:

26. On this island, do you expect to use or participate in the following?
    - Walks on the reef
    - Educational programs (guided)
    - Displays/museum
    - National park ranger
    - Interpretive centre
    - Poster, card, information books
    - Tours to other islands/reefs
    - Organised night entertainment
    - Fishing trips
    - Shopping facilities
    - Televisions
    - Baby sitting
    - Other (please specify)

27. Do you like having landscaped areas around the resort YES/NO

28. Do you consider that water pollution would be a problem on the islands? Why?

29. Do you feel land/soil pollution is a problem? YES/NO

    Why?

30. Did your visit meet your expectations? In what ways?

31. What changes, if any, would you recommend for this island?

Thank you for your assistance.

99. Recreational fishing ● ●

Concepts
Fisheries
Management
Conservation

Skills
Catching, preparing and cooking fish
Using literature

Attitudes
Fishing ethics
Self-reliance

Aim

- To develop skills in interpreting the Great Barrier Reef Marine Park Authority regulations on recreational fishing.
- To follow the motto "Enough Fish for One Meal" while fishing.

You will need

- Boat and outboard motor complete with safety gear
- Fishing gear (hand lines, sinkers, hooks, bait)
- Bait net (check if permit required)
- Great Barrier Reef Marine Park zoning information
- Fish identikit or field guide
- A licenced boat driver
- Correct anchoring gear, e.g., reef pick

What to do

1. Discuss how many fish you will need for one meal.
2. Find out about recreational fishing regulations at the reef you are visiting and read carefully the zoning information.
3. Check weather, tide, boat, gear and equipment.

SAFETY RULES

- *Do not go offshore further than 50 metres.*
- *Do not go out in one boat alone.*
- *Do not gut fish near snorkelling or swimming areas.*
- *Do not keep fish that are unsafe to eat or that are the wrong size.*
- *Do not stay out too long — 2 hours must be considered a maximum.*

4. In choosing your spot, stay clear of areas prohibited for fishing and stay away from popular snorkelling areas.
5. Tell someone where you are going and when you will be back. Watch the tides. Wear suitable clothing.
6. Go out and catch the number of fish you need. (If you catch a fish which is protected or undersize, return it quickly.)
7. Clean and prepare your fish by gutting and filleting it.
8. Either pan fry or cook in alfoil.

Ideas for further things to do

9. Discuss the zoning strategy for the reef you are visiting. Does it have a reef appreciation area? Does it have a seasonal closure area? If so, why do you think it has these? Why are some parts of the Great Barrier Reef Marine Park set aside as "replenishment areas"?
10. Locate information about coral trout. Draw a diagram of a coral trout and make notes on the habitat of coral trout. Seek information on coral trout surveys carried out under the auspices of GBRMPA. Why are the surveys done and what have been their findings and significance? Try to find out how many coral trout are caught at the reef you are visiting. What about catches during previous trips by members of your group?
11. With other members of your group discuss and make a list of some reasons for and against going fishing at the Reef. How important are each of these reasons in your view?

12. Do you think that the principle of catching only "enough fish for one meal" is a worthwhile one? Why?
13. In some parts of Australia, there are legal limits, called bag limits, on how many fish can be caught by a recreational fisherman in any one day. Do you think that such bag limits should also apply in the Great Barrier Reef area? Why?

Readings

Grant, E. M. 1982. *Guide to fishes.* Brisbane: Department of Harbours and Marine (Use waterproof edition)

Russell, B. C. 1983. *Annotated checklist of the coral reef fishes in the Capricorn-Bunker Group, Australia.* Townsville: GBRMPA.

100. Your trip by sea

Concepts
Distance
Direction
Hull
Charter
Safety
Life rafts
Weather
Swell
Sea
Navigation

Skills
Observing
Communicating

Attitudes
Enjoyment of outdoor experience
Interest in interrelatedness of people and environment
Appreciation of importance of safety procedures

Aim

- To record some of the main features of the boat you travel on, the conditions you experience and the things you see on your trip.

You will need

- Pencil and notebook

This activity will require a total of about ¾ of an hour at various times during your trip.

What to do

Your trip

1. (a) What is your destination?
   (b) What is the date today?
   (c) How far is your destination from the mainland port?
   (d) In what direction is your destination from the port?
   (e) How long is your trip expected to take?

Finding out about the boat

2. Find out the main features of the boat you are travelling on by talking with your group leader and/or the boat's skipper or crew.
   (a) What is the boat's name?
   (b) What are the main materials of which it is built?
   (c) How long is it (metres)?
   (d) How many hulls does it have: one, two?
   (e) What is the maximum speed it can travel (in knots)? How fast is one knot?
   (f) Is it designed for skimming over the water (planing) or travelling through the water (displacement)?
3. (a) Has your group chartered the boat or is this a regular service?
   (b) How many passengers is this boat allowed to carry out to sea?
   (c) What sort of work does this boat usually do?
4. Make a very rough plan showing a bird's-eye view of the boat. Label the following and mark anything else you think is interesting: bow (front end of boat); stern (back end of boat); starboard (boat's right-hand side); port (boat's left-hand side); wheelhouse; cabin entrance (s).
5. Where is the engine located? You might be able to indicate this on your sketch.

Safety on board

6. How many life rafts does the boat have? Mark their locations on your sketches.
7. Find out where the lifejackets are kept on the boat.
8. What are some safety precautions you have been asked to observe while on board?
9. What are some procedures you have been asked to follow if there is an emergency?

The boat's equipment

10. If possible, visit the wheelhouse of the boat:
    (a) What is the skipper's name?
    (b) How many items of the following navigation and safety equipment can you see?
    chart; radar; magnetic compass; echo sounder; pelorus; sextant; radio transmitter; computer.

(c) Which of the above is used to do each of the following jobs?

- Measure the depth of the sea floor beneath the boat by using sound waves?
- Show the boat's heading or directional orientation relative to magnetic north?
- Enable a navigator to check distances from nearby land, and to "see" such things as other ships at night and approaching rainsqualls in a radius of about 25 km.
- Provide a map which shows land and sea areas, depths to sea floor, and location of reefs, shoals, buoys and lights?

Weather and waves

11. What weather has been forecast for winds and the state of the sea on the day you are travelling?
12. When you are away from the mainland, look at the surface of the sea and try to distinguish between swell and sea waves, using the following information.

The waves you see when you look at the surface of the ocean may be of two kinds: sea waves and swell waves.
Sea waves are being produced in the local area you are in. They move in the same direction as the wind you can feel blowing around you. They often have a rather irregular appearance.
Swell waves have been generated elsewhere and have travelled out of the area in which they were produced. They have a more regular appearance than sea waves. They travel in regular succession and in a well-defined direction with rounded crests. They are not travelling in the same direction as the local wind.

13. (a) Look at the swell waves. Try to estimate approximately how often a swell wave passes you and about how high the swell waves are.
    (b) Look at table 100.1. Based on your observations, how would you classify the swell your boat is experiencing? Ask others what they think.
14. Look at the sea waves and at table 100.2
    (a) About how high do you estimate the waves are? What is their general appearance? Into what classification on table 100.2 would you place them?
    (b) Based on the appearance of these sea waves, what description would you apply to the wind?
    (c) What number on the Beaufort Wind Scale would you apply to the wind which is blowing?
    (d) According to the table, what is the maximum wind speed in knots?

Traffic

15. When you are 20 minutes away from the mainland, start making a log of any boats or aircraft which you see. Record the time you first spot it, and the direction of its travel (towards or away from mainland). What kind of boat or aircraft does it appear to be? What kind of job does it seem to be doing? Do you observe anyone aboard? If so, how many?

Wildlife

16. When you have left the harbour, make a log of any wildlife you see on or in the ocean.

Ideas for further things to do

17. Write something on the following, and compare notes with your friends.
    (a) Most enjoyable things about the trip.
    (b) Worst things about the trip.
    (c) Most interesting things about the trip.

Table 100.1: State of swell

Period of swell wave (seconds)	*Swell wave length (metres)*	*Probable height of swell waves (metres)*	*Classification*
Less than 11	0-200	0-2	Low swell of short or average length
Greater than 11	over 200	0-2	Long low swell
Less than 8	0-100	2-4	Short swell of moderate height
Greater than 8 Less than 11	100-200	2-4	Average swell of moderate height
Greater than 11	over 200	2-4	Long swell of moderate height
Less than 8	0-100	over 4	Short heavy swell
Greater than 8 Less than 11	100-200	over 4	Average length heavy swell
Greater than 11	over 200	over 4	Long heavy swell

Source: From *Observing the Weather,* p. 14.

References

Australia. Bureau of Meteorology. 1984. *Observing the weather.* Canberra: AGPS.
Queensland Dept of Harbours and Marine, *Official tide tables — coast of Queensland,* and *notes on boating.*

Table 100.2: Beaufort wind scale and sea disturbance.

Sea criterion	*Probable mean height of waves (metres) in offshore waves*	*Descriptive terms (sea)*	*Descriptive terms (wind)*	*Wind force (Beaufort)*	*Limits of speed in knots*
Sea like a mirror.		Calm (glassy)	Calm	0	Less than 1
Ripples with the appearance of scales are formed but without foam crests.	0.1	Calm (glassy)	Light air	1	1-3
Small wavelets, still short but more pronounced; crests have a glassy appearance and do not break.	0.2	Calm (rippled)	Light breeze	2	4-6
Large wavelets. Crests begin to break. Foam of glassy appearance. Perhaps scattered white horses.	0.6	Smooth (wavelets)	Gentle breeze	3	7-10
Small waves, becoming longer; fairly frequent white horses.	1.1	Slight	Moderate breeze	4	11-16
Moderate waves, taking a more pronounced long form; many white horses are formed. (Chance of some spray.)	1.8	Moderate	Fresh breeze	5	17-21
Large waves begin to form; the white foam crests are more extensive everywhere. (Probably some spray.)	2.9	Rough	Strong breeze	6	22-27
Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind.	4.1	Very rough	Near gale	7	28-33
Moderately high waves of greater length; edges of crests begin to break into spin-drift. The foam is blown in well-marked streaks along the direction of the wind.	5.5	High	Gale	8	34-40
High waves. Dense streaks of foam along the direction of the wind. Crests of waves begin to topple, tumble and roll over. Spray may affect visibility.	7.0	Very high	Strong gale	9	41-47
Very high waves with long overhanging crests. The resulting foam in great patches is blown in dense white streaks along the direction of the wind. On the whole the surface of the sea takes a white appearance. The tumbling of the sea becomes heavy and shocklike. Visibility is affected.	8.8	Phenomenal sea	Storm	10	48-55
Exceptionally high waves. (Small and medium-sized ships might for a time be lost to view behind the waves.) The sea is completely covered with long white patches of foam lying along the direction of the wind. Everywhere the edges of the wave crests are blown into froth. Visibility is affected.	11.3	Phenomenal sea	Violent storm	11	56-63
The air is filled with foam and spray. Sea completely white with driving spray; visibility is very seriously affected.	13.7	Phenomenal sea	Hurricane	12	64-71

Source: From *Official Tide Tables*, p. 86.

101. Reef quiz ¾ hr • •

Concepts
Recall
Identification
Self-assessment

Skills
Identifying
Communicating

Attitudes
Interest in reef environments
Desire to achieve

Aim

- To test your recall of reef features on facts about the reef.

You will need to do this activity near the end of your trip. A wet day or evening is a good time for this. Specimens may need to be collected beforehand.

You will need

- One or more collecting permits (QNPWS, GBRMPA)
- Specimens, objects and pictures to make up exhibits for a quiz (Note: Specimens from reef or island should be collected only with permission of your leader and strictly in accordance with park collecting permits.)
- White cards or sheets of paper for presenting quiz questions
- Pencil and paper for writing answers

What to do

Beforehand

1. Divide into pairs. Each pair is to devise two items for a quiz. Each item should be based on an exhibit of a specimen, object or picture of something you should all have seen during your trip. After deciding what you want to do, consult with your leader to avoid duplication and to make sure that you plan to collect only in accordance with your group's collecting permit.
2. Collect the needed specimens or select the required pictures for your exhibits. Use a separate white card for each exhibit. On the front of the card print clearly one or more very simple questions about the exhibit, e.g. "What is this?" or "Where would you find this?" On the back of the card write the answer(s).
3. Lay out the exhibits in a sequence at your base camp. Assign numbers to the exhibits. Make sure that living specimens are kept in appropriate containers and conditions, e.g. plenty of water.

Running the quiz

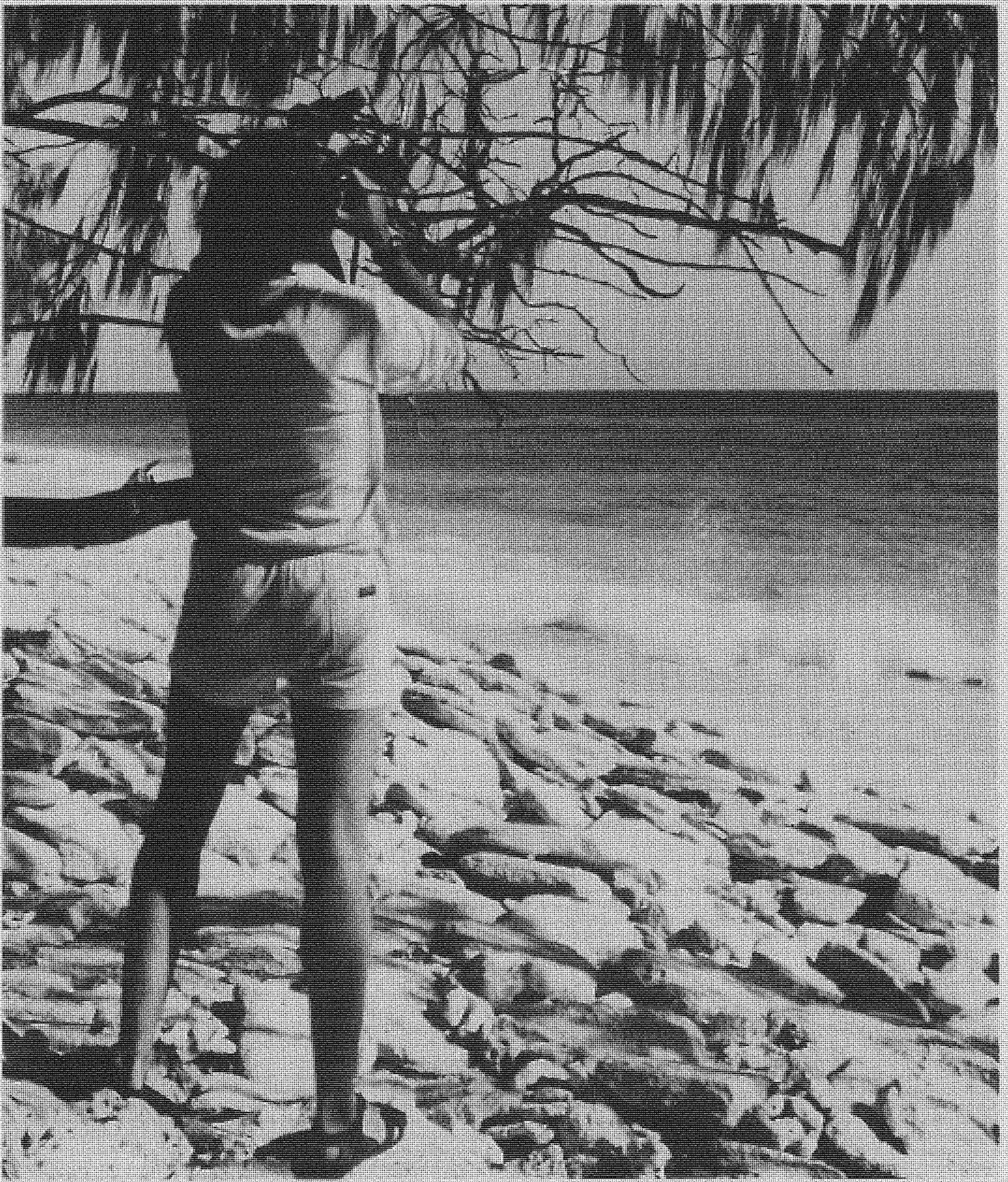
4. All participants should walk past the exhibits, writing down answers to questions.
5. When everyone has answered the questions, turn the cards over so that the answers are visible. Now check your answers. How well did you score? Make a tally of the total class scores on the board.
6. Turn the cards over again. Repeat the process of writing answers and checking them. Has your personal score improved? Has the class score improved?
7. If you want to, continue until total mastery by your whole group is achieved. You could make a graph showing the improvement.
8. Make sure all specimens are returned as quickly as possible to the reef or island in accordance with your permit.

Ideas for further things to do

9. Make up a set of reef question cards suitable for playing the game Trivial Pursuit.
10. Conduct a quiz based on 35 mm slides. The questions can be read out as the slides are projected.
11. Make up a quiz based on touch rather than sight.

Some suggested items for quiz

- Corals: dead skeletons, e.g. staghorn, mushroom, organpipe, knobbly.
- Algae: common species of both live and dead (from flotsam).
- Sea stars: e.g. live specimens of blue *Linckia*.
- Holothurians: e.g. live specimens of at least two species.
- Sand pellets: cast by holothurians.
- Beach rock: small piece that has broken naturally off the outcrop.
- Mollusc: live specimen of red-lipped stromb. Pictures of chiton and clam.
- Crabs: piece of dead crab skeleton; live specimen of other crab.
- Landplants: e.g. *Pisonia* leaf; *Casuarina* foliage; fruit or seeds of *Pisonia*.
- Birds: feathers, pictures of common species.
- Turtles: pictures of turtles or their trails.



102. Effects of humans

Concepts
Pollution
Environment
Human impact
Change
Conservation

Skills
Observing
Recording

Attitudes
Perseverence
Concern for changes made by humans to their environment

Aim

- To assess the influence of humans on a reef area.

You will need

- Recording materials

This activity will require at least 1½ hours at various times during your visit.

What to do

Keep the following questions in mind all the time you are at the reef. Make notes of any evidence you observe yourself. Ask questions of other visitors or long-term residents. Read literature concerning the effects of human activities at this reef.

1. People activities
   (a) Make a list of five human activities which occur here.
   (b) For each of these, suggest two or three possible effects on the island or reef environment. Are these effects detrimental or beneficial to the environment?
2. Pollution
   (a) What forms of pollution occur here?
   (b) What evidence is there of pollution?
   (c) What human activities cause pollution here?
   (d) Do you observe any measures designed to control or minimise pollution?
   (e) How could pollution be further controlled here?
   (f) Is one part of the island (or reef) more polluted (e.g. by litter) than another?
   (g) Summarise your findings using a map to show polluted areas and perhaps a graph to show frequency of pollution over time (e.g. noise pollution by generators or oil discharge from boats) or by common items (e.g. cans or cigarette butts on beach).
3. Other effects of humans
   Discuss these questions:
   (a) How might the following aspects of the island and reef have been changed by people?
   - flora and fauna of the island
   - life form of the reef
   - shape of the island and reef

   (b) What evidence can you see of such changes?

103. Litter on the island

Concepts
Distribution
Association
Environment
Planning

Skills
Observation
Recording

Attitudes
Concern for the environment
Acceptance that personal action can be effective

Aim

- To find the most littered sites on the island and draw up a plan to reduce these.

You will need

- Measuring tape or rule; paper for recording
- Map of the island
- Observation time of about 5 minutes for each site

What to do

1. Find the places on the island which have the most use at, say, three set times a day — you could try 9 a.m., noon, and 5 or 6 p.m.
2. Mark out a circle at each spot of, say, 20 metres.
3. At each site, count and record the amount and types of litter in the circle at each of the three times in a day.
4. Repeat the counting and recording over several days.
5. Now summarise your results: Which is the most littered site? At which time is most litter found? What is the main type of litter? Does one particular group of people litter?
6. Think about what you could do about this litter. Would you recommend to island authorities that more litter bins be provided? or that certain items be restricted in the shops? or that regular clean-ups of certain areas should be undertaken? or that litter fines be imposed? (Most of these types of actions are available to owners or lessees of islands, and apply in any national park.)
7. On the other hand, do you think little can be done and that your findings would be disregarded?

Ideas for further things to do

8. Attempt some of the activities concerned with other aspects of human impact on reef areas, e.g. "Waste disposal from a cay", activity 104.

104. Waste disposal from a cay — 2 hr • •

Concepts
Waste disposal
Biodegradibility

Skills
Data collection
Evaluation

Attitudes
Perseverence
Curiosity
Concern for changes made by humans to their environment

Aim

- To investigate methods of disposing of waste from a cay.

You will need

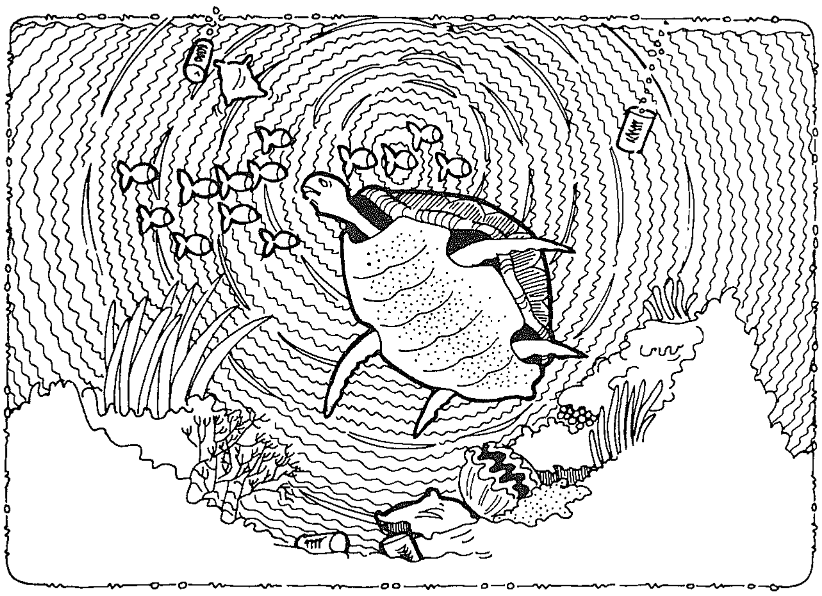
- Recording sheet and pen
- Camera (if available)

What to do

1. Observe and record methods of disposal of solid wastes, e.g. food, tins, greases, plastic, drums, old machinery, roofing iron, bottles, paper.
2. Observe and record methods of disposal of human wastes, e.g. septic tanks, deep sinkers (i.e., pit toilets).
3. Observe the discharges from the desalination plants in resorts.
4. Assess the biodegradibility of materials released into the environment.
5. What improvements could be made to this waste disposal?

Ideas for further things to do

6. Try activities 103, "Litter on the island", 102 "Effects of humans", 152 "Do the right thing".
7. Find out the regulations which apply to waste disposal in the Great Barrier Reef Marine Park.



105. Trampling effects on a reef flat — 2 hr •

Concepts
Environmental impact
Controlled experiment
Coral growth form

Skills
Observing
Interpreting
Designing experiment
Thinking critically

Attitudes
Concern for natural environment

Aim

- To observe some of the damage done by humans as they walk across a reef flat.

You will need

- Reef-walking gear
- Recording sheet and pencil
- A few metres of coloured plastic tape
- Outline sketch map of reef-top (or air photo)
- Magnetic compass and measuring cord or tape

What to do

1. In a part of the reef-top popular with reef walkers, select three study areas about 5 metres square on the outer reef flat. If possible, mark out the areas by tying small lengths of plastic tape to pieces of coral at each corner. Mark the location of your study areas on the map. (Obtaining bearings with a magnetic compass could help you to identify the location of your study plots.)
2. Make a map of each plot showing the areas covered by dead coral, live coral and sand. Use symbols to indicate the growth form of corals. Record signs of damage using symbols. Look for broken-off fragments, unhealed fractures, overturned colonies, ditches through strands of branching coral.
3. Visit the plots on subsequent days after reef walkers have visited the area. Are there any signs of change? Plot fresh damage, if any, using symbols.
4. If evidence of damage is present in these study plots, can you be sure that reef walkers caused it?
5. How could an experiment be designed to explore reef-walking damage to plots?
6. The next time you go walking on the reef, walk very carefully, and observe the results. Despite your care, were any colonies broken?
7. Consider your observations. Do some parts of the reef-top seem to be more vulnerable to damage than others? Are some coral growth forms more vulnerable than others to breakage?
8. Discuss with members of your class: How can damage from trampling be minimised?

Ideas for further things to do

9. Find answers to the following: Is breakage of coral always detrimental? In what way might breakage be of assistance to a coral species?
10. Read research publications on the effects of trampling on corals and on reef-walking management.

Reading

Kay, A. M., and Liddle, M. J. 1985. *Manual for assessment location and design of reef-walking activities.* Technical report of the Great Barrier Reef Marine Park Authority.

106. Effects of building projects

½ day •

Concepts
Human impact
Management
Resources development

Skills
Observing
Recording

Attitudes
Concern for maintenance and improvement of environmental quality

Aim

- To observe and assess the effects of construction works taking place on an island.

You will need

- Recording materials
- Camera (optional)

What to do

1. You may see engineering and building projects going on around you. Consider the following questions and make some detailed notes.
   (a) Where is the project?
   (b) What is its purpose?
   (c) Who is responsible for it?
   (d) How many workers are involved?
   (e) What happens to material removed from the site?
   (f) What appear to be the environment changes occuring?
   (g) Are flora and fauna being removed or damaged?
   (h) Does the final project meet requirements of the island management plan?
   (i) Is everything possible being done to minimise the effect of the project on the environment of the island?
   (j) What recommendations would you make about safeguarding the environment in the area where the project is taking place?
2. Compare your findings with others. Do you all agree?

107. Are you a perfect camper? 2 hr •

Concepts
Environment
Human impact
Experiment
Control

Skills
Observing
Measuring
Experimenting

Attitudes
Interest in scientific enquiry
Concern for changes made by humans to their environment

Aim

- To study the effects of camping damage on a coral island.

You will need

- 8-10 metres of string or cotton
- A camera
- Recording materials

What to do

1. Set up your campsite.
2. Accurately measure your camping area with string, i.e., the tent, your cooking area, the spot where your sink is, your personal space.
3. Using the string, mark out a control area of approximately the same size in a location adjacent to your camp site.
4. Mark this second area carefully with a sign:

   EXPERIMENT CONTROL AREA
   PLEASE DO NOT ENTER

5. Photograph the two sites at the beginning of the camp. At the end of the camp, when you have cleaned up your site, photograph both sites again.
6. Make a list of any changes which have occurred in each site. What changes has camping caused?
7. Make a list or take photographs of other camping damage, and make a photographic report on camping damage when you return home.
8. How could you have prevented this damage?

Ideas for further things to do

9. Try to find out how many people camp at this island each year. Are limits placed on the numbers of people who are allowed to camp here? Is it necessary to obtain a permit to camp here? What restrictions are applied?

108. Effects of boating — 2 hr •

Concepts
Management

Skills
Observing

Attitudes
Concern for maintenance and improvement of environmental quality

Aim

- To study the effects of boating damage on a coral reef.

You will need

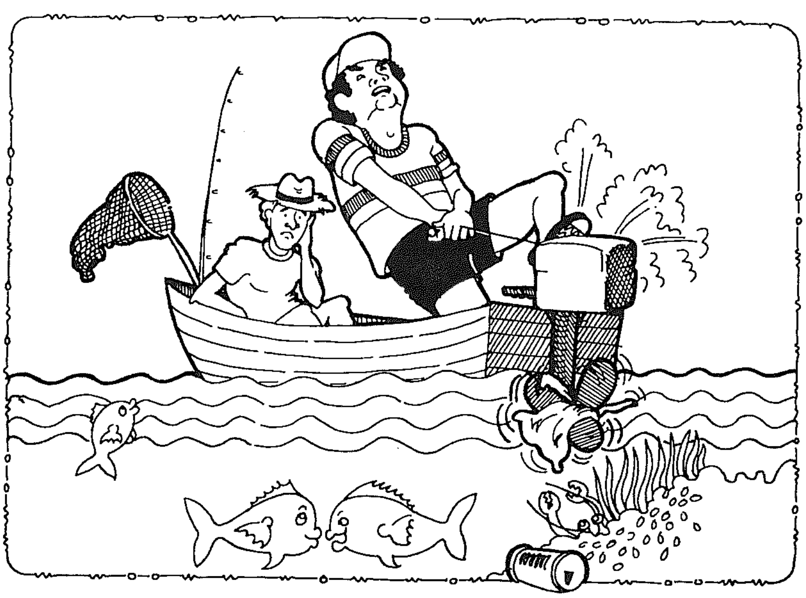
- Snorkelling equipment
- Underwater camera (optional)
- Underwater slate and pencil

What to do

1. Select a study site and snorkel over the area looking for damage caused by boats.
2. You will need to look carefully for the effects of:
   - boat hulls hitting the reef
   - boat propellers
   - reef anchors and chains
   - fishing lines
   - sinkers
   - rubbish — cans, glass, etc.
3. If you can, take photographs or make descriptions of the area damaged.
4. Assemble all your evidence (photographs and/or sketches) and make a report of the effects you have noticed. Your report should include:
   - description of the damage
   - notes on how the damage seems to be caused
   - your ideas on how such damage can be prevented.

Ideas for further things to do

5. Find out about new ideas for mooring which are now being developed for use in reef areas.



109. Wrecks 2 hr • •

Concepts
Environmental impact
Ecology
Archives

Skills
Snorkelling
Observing
Recording
Analysing
Scientific enquiry

Attitudes
Intellectual honesty
Self-reliance
Willingness to be convinced by evidence

Aim

- To examine the wrecks near cays and to assess the impact of these on their surroundings.

Several shipwrecks are visible near some of the islands of the Great Barrier Reef. Lady Elliott Island has three on the shore, and Heron Island has one big ship at the entrance to the harbour. This was deliberately sunk to provide shelter for small ships. All the wrecks provide interesting study sites.

When to do

At low tide when the wrecks are exposed. If investigating the old ship at Heron Island, avoid the turn of the tide as currents there can be dangerous.

You will need

- Underwater slate and pencil
- Snorkelling gear (if wreck is in deep water)
- Small inflatable boat or raft to hold gear
- Flow meters (optional)
- Floats or oranges
- Thermometers (in shielding)
- Camera (optional)

What to do

1. If you are at Lady Elliott Island, walk to the wrecks exposed at low tide, or snorkel to the ones on the edge of the reef. (Detailed maps of wreck location are available on the island.) If you are at Heron Island, snorkel to the wreck, and tie the boat or raft to the wreck to store equipment. For each of the wrecks investigated, record your impressions:
   (a) What living things are attached to the wreck (e.g. algae, coral, molluscs)?
   (b) What is resting on it or living in it?
   (c) How are birds using it? Are there any nests? What species of birds appear to rest there constantly? Do you see these birds on the island itself?
   (d) What is inside the wreck? (Look carefully through the holes.)
   (e) What shelters in it, or near it?
   (f) How much of the original ship remains?
2. Look at the water flow around the wreck — release oranges or other floats in the water at one end of the wreck, and watch what happens to them. Retrieve them later. If you have a flow meter, you may be able to measure the flow of water underneath the surface and compare the observations. Does the wreck seem to affect water flow?
3. Use a thermometer to measure the water temperature. Is one side of the wreck warmer? Does more coral grow on the seabed on one side than on the other? (You might have to wait for low tide to observe this.) Is there a sand build-up? Where?
4. Sum up this activity: What seem to be the main effects of the wreck on the reef flat/lagoon/harbour of the island? Illustrate with photos and/or sketches.
5. Is the wreck in one place, or are parts of it and its engine, anchor, beams, etc. scattered over the reef? Where? Do these pieces provide shelter or homes for marine life and birds?

Ideas for further things to do

6. Go back to the wreck when tide conditions are different. Check conditions around the wreck. Are there differences between your observations at high and low tide?
7. Research the history of the wreck. How old is it? What caused the shipwreck? Where did the ship come from? What should have been its destination?
8. Have there been attempts to preserve the wreck? Why do you think the Australian government has now passed a law protecting all wrecks?

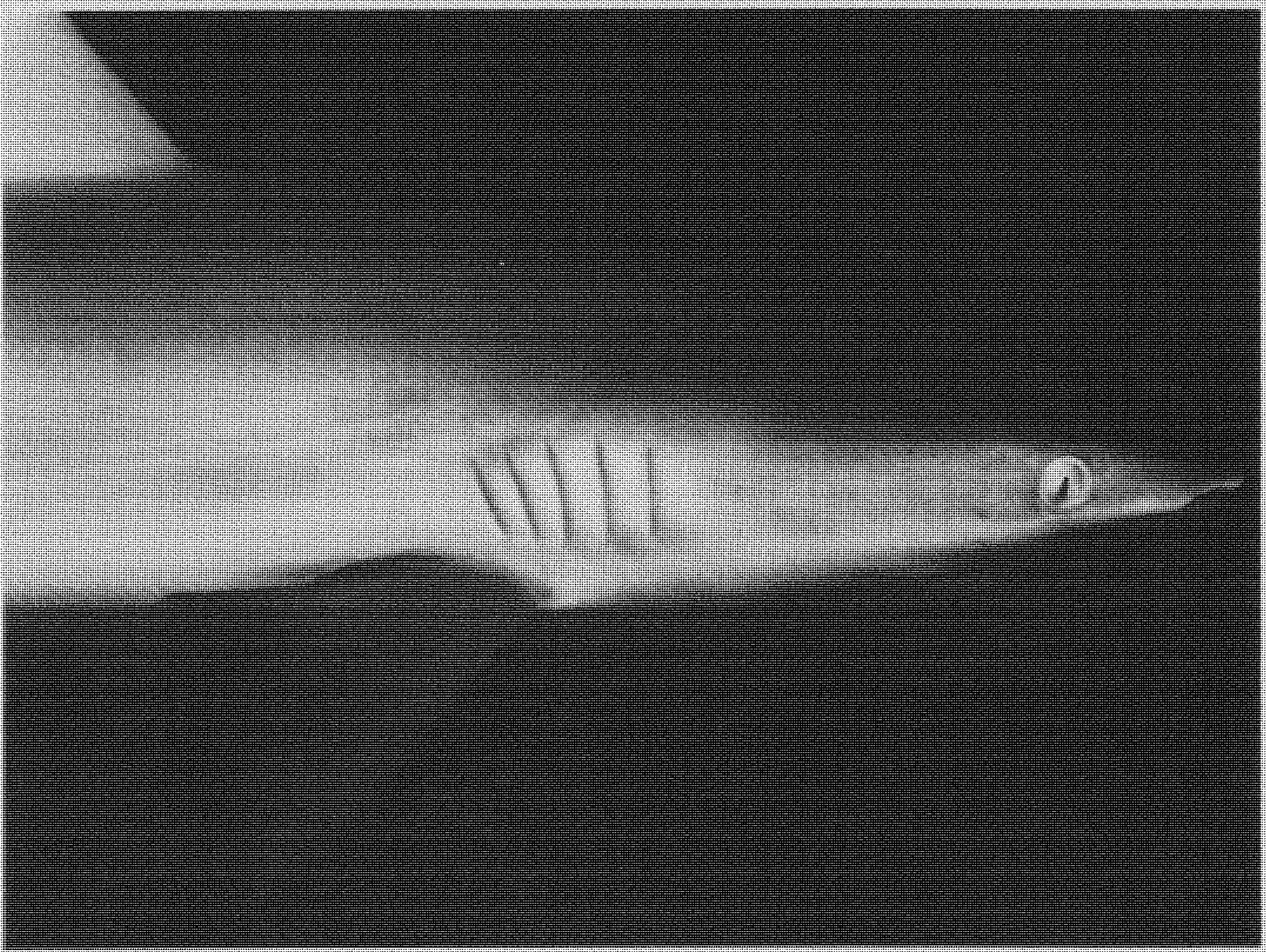
Further research

9. There are investigations of various wrecks going on all round Australia. The Great Barrier Reef Marine Park Authority publishes a Reef Note on wrecks. Wrecks can be investigated by referring to the readings or by research in your local library or museum.
10. Make observations of the materials and construction methods used in building the ship. What evidence is there of corrosion?

Readings

Bateson, C. 1972. *Australian shipwrecks,* vol. 1, 1622-1850. Sydney: Reed.
Loney, J. 1980. *Australian shipwrecks,* vol. 2, 1851-1871. Sydney: Reed.

Human well-being



110. Keep cooking 2+ hr • •

Concepts
Hygiene
Planning
Nutrition

Skills
Organising

Attitudes
Willingness to cooperate
Tolerance and respect for others

Aim

- To cooperate as a group in organising the meals for your trip.

You will need

- Writing materials
- Information from the field-trip organiser about facilities which will be available for cooking at the island and about arrangements already made (if any) for food supplies.

What to do

1. Discuss the roles each of you wishes to play in cooking, depending upon what facilities you will have. This will depend on which island you are visiting.
2. Make a list of jobs.
3. Plan what food and equipment to take. How is the food going to be purchased? You may need to get a list of food prices before you can make your plan.
4. Decide how you are going to transport food and equipment.
5. Decide how you are going to store food and equipment.
6. Submit a complete organisation plan for your group based on the following:
   - Food list (includes breakfast, dinner, lunch and snacks)
   - Cooking facilities required (gas, billy, water container, etc.)
   - Cooking roster (includes days, and names of those doing the preparing and washing up, as well as those who will be cooking)
   - List of responsibilities (includes who buys food, who will supply particular items).

111. Safety on the reef ½ hr •

Concepts
Safety

Skills
Decision making
Cooperating
Communicating

Attitudes
Appreciation of importance of health and safety procedures

Aim

- To become aware of the need for safety on the reef.

You will need

- To work in a group
- Paper and pencil
- Blackboard

What to do

1. Brainstorm in your group (maximum of six people) a list of unsafe situations for your forthcoming trip. Appoint a leader and scribe. (5 minutes)
2. Reduce your list to the six most dangerous situations or places. Remember the rules for brainstorming. (5 minutes)
3. Each group leader reports back to the class on the six most dangerous situations or places. (5 minutes)
4. The class then decides what the six most dangerous situations or places are and why they are dangerous. (Class discussion)
5. Prepare an individual report on the need for safety on the reef.

RULES FOR BRAINSTORMING

- *No criticism of other people's ideas.*
- *All ideas are written down, irrespective of whether you agree or not.*
- ***After** brainstorming, criticism begins.*

112. Dangerous reef creatures — 1 hr •

Concepts
Toxin
Venom
Polyp
Stinging cell
Hydroid
Safety

Skills
Observing
Using literature

Aim

- To become more aware of some dangerous animals which can be met during reef walks and snorkelling activities.

You will need

- Coloured pencils
- Reference books or slides on dangerous marine animals

What to do

1. For each dangerous creature shown on worksheet A, select a name from the list given and write the names in the spaces underneath the pictures. Use reference material to help you make your choices, and/or discuss with your teacher.
2. Using reference books or slides on marine organisms, colour the main areas of each picture lightly so that its distinctive colour features are shown.
3. Answer each of the questions shown on worksheet B, using information given.
4. Why do some reef animals produce toxic material and develop the ability to inject it?
5. How can visitors avoid injury from these creatures?
6. What are the dangerous effects of these creatures? What are the main first-aid treatments for these?

Readings

Covacevich, J., Davie, P., and Pearn, J., eds. 1987. *Toxic plants and animals: a guide for Australia.* Brisbane: Qld Museum.

Edmonds, C. 1975. *Dangerous marine animals of the Indo-Pacific region.* Melbourne: Wedneil Publications.

Edmonds, C. 1984. *Marine animal injuries to man.* Sydney: Wedneil Publications.

Marsh, L., and Slack-Smith, S. 1986. *Sea stingers.* Perth: W. A. Museum.

Saenger, P. 1977. *The diver's guide.* Brisbane: AUF.

INFORMATION SHEET A

112. Dangerous reef creatures

Crown-of-thorns starfish *(Acanthaster planci)*
Colour: Blue-grey arms often with reddish-orange tips
Location:
Description: Up to 60 cm in diameter and up to 16 arms covered with short, sharp spines. Spines can penetrate human skin. Venom may be injected. Slime on the starfish can irritate human skin.

Sea-urchins with long spines (e.g. *Diadema setosum*, described below)
Colour: Black
Location: On sandy bottoms or under rocks in reef-top pools or on reef slope.
Description: Have very slender needle-like spines about 25 cm long. The spines are very brittle and sharp. They can easily penetrate and break off in human skin.

Sea-cucumber (e.g. *Holothuria leucospilota*)
Colour: Various colours, according to species
Location: Sandy bottoms.
Description: Sausage-shaped bodies. When disturbed, many species produce sticky white threads from arms. Material from these may cause inflammation of human eyes or skin.

Stonefish (e.g. *Synanceia horrida*, described below)
Colour: Brownish; mottled
Location: Buried in mud, coral or rocks in shallow water.
Description: About 30 cm long. Lies quietly concealed on bottom. Strong spines along the back pierce human body if trodden on or touched. Venom is discharged into wound.

Bristle worm (e.g. *Eurythoe complanata*, described below)
Colour: Salmon pink
Location: Under boulders or in weed mats on reefs.
Description: Body up to 14 cm long with a pair of short hollow bristles on each segment. The bristles contain venom which causes painful injury if touched.

Butterfly cod *(Pterois volitans)*
Colour: Red and white striped
Location: In reef-top lagoons and reef slope habitats. often under ledges or in caves.
Description: Up to 35 cm long. Brightly coloured. Have long spines along the back and in the anal and pelvic areas. The spines can pierce human flesh and venom passes along the spine into the wound.

112. Dangerous reef creatures

Fire coral *(Millepora)* (sometimes called **stinging hydroids**)
Colour: Light brown with smooth, yellowish branch tips
Location: On outer reef flat and upper parts of reef slope.
Description: Has a hard limey skeleton with smooth stumpy branches. Looks like a true coral but is a member of a related group, the hydrozoans. Has minute stinging polyps in its branches.

Cone shells (e.g. textile cone, *Conus textile*)
Colour: Often have striking patterns of various kinds. The textile cone pattern is one example.
Location: On bottom of reef flat and elsewhere. Often buried or hidden.
Description: Usually, but not always, cone shaped. Inject venom using a harpool in their mobile proboscis. Easily confused with harmless types of shells, such as the red-lipped stromb. Beware!

Stingrays (e.g. blue-spotted ray, *Taeniura lymma,* described below)
Colour: Bright blue spots
Location: In shallow waters of reef-top. May shelter under ledges during day. May be partly buried on bottom.
Description: Flat disc-like body about 37 cm in diameter. Long whip-like tail may inflict wound and discharge venom.

Box jellyfish *(Chironex fleckeri)* (sometimes called **sea wasp**)
Colour: Translucent; almost colourless
Location: Often in shallow water in muddy inshore areas but can also be found in many other kinds of locations.
Description: Consists of round-topped, box-like bell (often 10-17 cm) attached to many tentacles up to 2 metres long. Stinging cells occur on tentacles.

Stinging hydroid — "white" *(Lytocarpus phillipinus)*
Colour: White
Location: In deeper water than fireweed. Look out for this when snorkelling over the outerslope of a reef.
Description: This is a more delicate hydroid than fireweed. It has a feathery appearance; stems are brown; polyps are white.

Fireweed *(Aglaeophenia cupressina)*
Colour: Khaki
Location: Reef flat, among coral in pools.
Description: This looks like a clump of small brown fern but is actually a colony of small animals — hydroids. In each "frond" there is a central stalk and side branches along which small stinging polyps occur.

WORKSHEET A

112. Dangerous reef creatures

- Write the names of the pictured animals in the spaces provided.

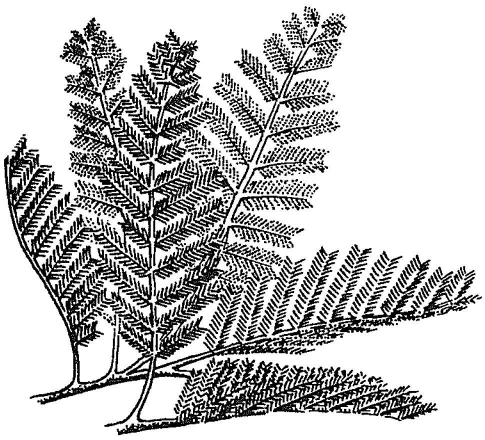


Fig. 112.1

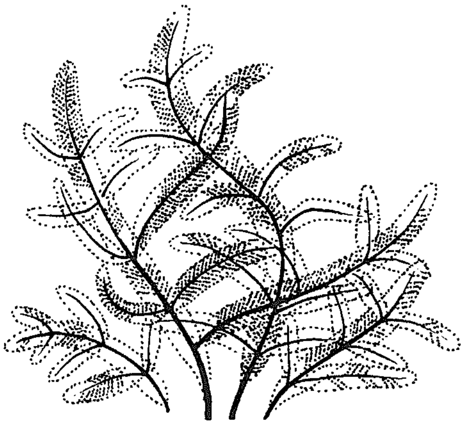


Fig. 112.2

(a) _ _ _ _ _ _ _ _ _

(b) _ _ _ _ _ _ _ _ / _ _ _ _ _ _ _ _

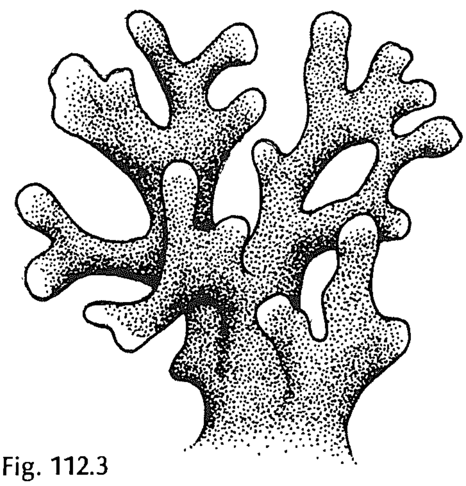


Fig. 112.3

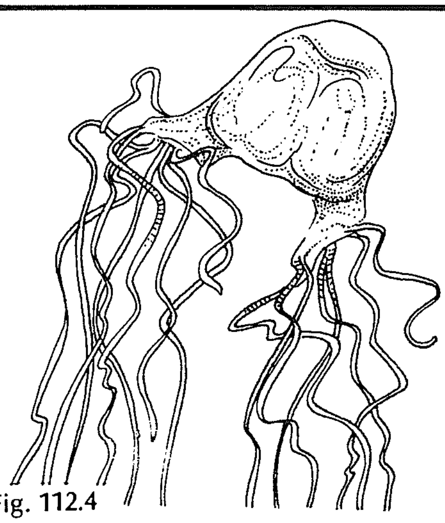


Fig. 112.4

(c) _ _ _ _ / _ _ _ _ _ _

(d) _ _ _ / _ _ _ _ _ _ _ _ _ _

WORKSHEET A (cont.)

112. Dangerous reef creatures

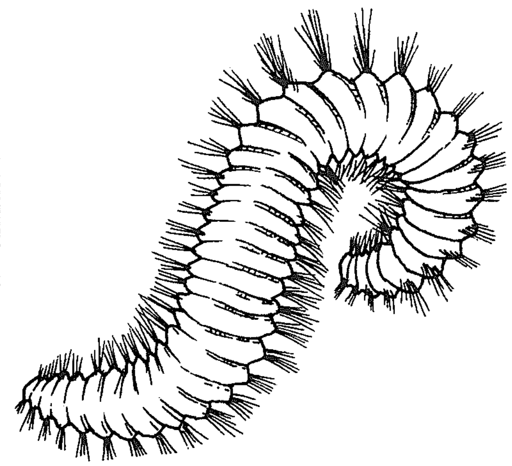


Fig. 112.5

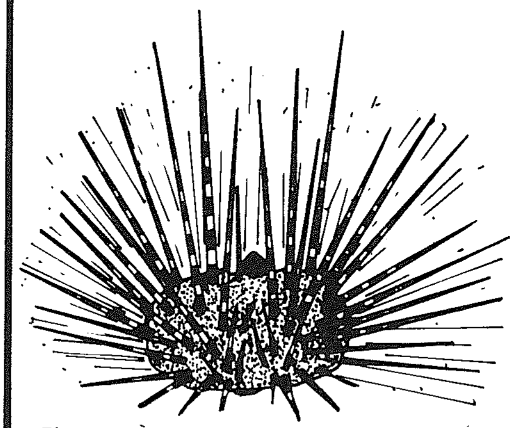


Fig. 112.6

(e) _ _ _ _ _ _ _/_ _ _ _

(f) _ _ _/_ _ _ _ _ _ _

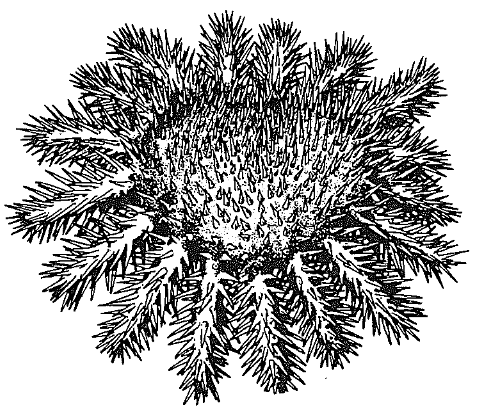


Fig. 112.7

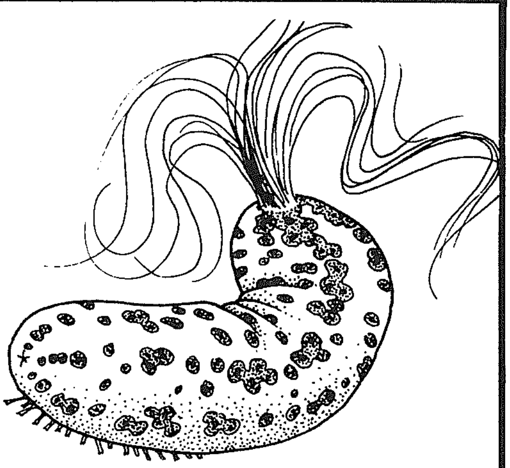


Fig. 112.8

(g) _ _ _ _ _/_ _/_ _ _ _ _ _/_ _ _ _ _ _ _ _

(h) _ _ _/_ _ _ _ _ _ _ _

WORKSHEET A (cont.)

112. Dangerous reef creatures

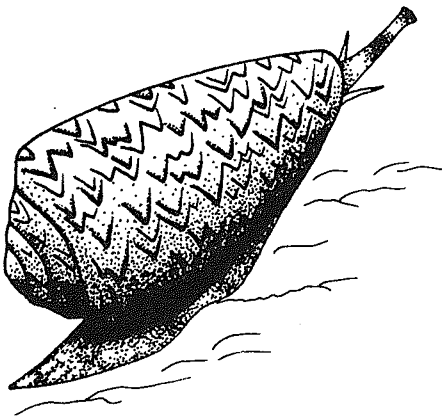


Fig. 112.9

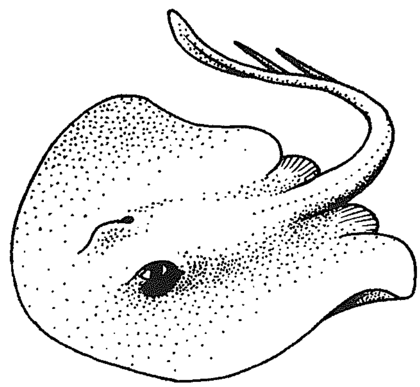


Fig. 112.10

(i) ----/-----

(j) --------

Fig. 112.11

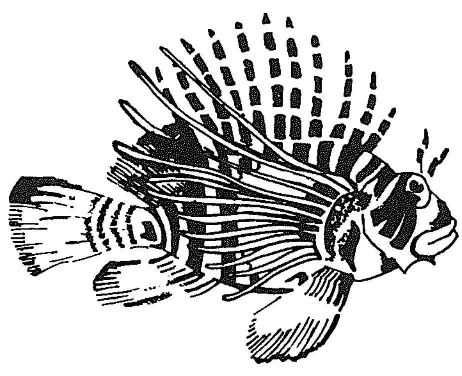


Fig. 112.12

(k) ---------

(l) ---------/---

WORKSHEET B

112. Dangerous reef creatures

- In each of the spaces below write an appropriate name from the range of animals illustrated on worksheet A.

(a) Molluscs which inject venom using a harpoon ----/------

(b) Red-and-white fish which sting using venomous spines ---------/---

(c) Feathery white animals whose polyps contain stinging cells --------/--------

(d) Hard brown-coloured colonies with yellow, smooth tips ----/-----

(e) Bottom-dwelling fish with venomous barbs on whip-like tail ---------

(f) Plagues of these echinoderms have occurred at some reefs -----/--/------/--------

(g) Animals which dwell on the surface of the sea and which are hazardous in northern parts of the Great Barrier Reef area in summer months ---/---------

(h) Material from the slimy outside of these animals must not be allowed to get into your eyes ---/---------

(i) These dull-coloured fish are well camouflaged. Wear stout shoes when reef-walking. ---------

(j) Khaki animal colonies which look like brown clumps of fern --------

Answers to worksheet A
(a) Fireweed, (b) Stinging hydroid, (c) Fire coral, (d) Box jellyfish, (e) Bristle worm, (f) Sea-urchin, (g) Crown-of-thorns starfish, (h) Sea-cucumber, (i) Cone shell, (j) Stingray, (k) Stonefish, (l) Butterfly cod

Answers to worksheet B
(a) Cone shells, (b) Butterfly cod, (c) Stinging hydroids, (d) Fire coral, (e) Stingrays, (f) Crown-of-thorns starfish, (g) Box jellyfish, (h) Sea-cucumbers, (i) Stonefish, (j) Fireweed

113. First aid at the reef

¾ hr • •

Concepts
First aid
Safety

Skills
Using reference materials

Attitudes
Self-reliance
Responsibility

Aim

- To become more acquainted with some first aid procedures on the reef.
- To become familiar with the contents of the first aid kit being taken to the reef.

When

After your group leader has talked with your class about first aid and dangerous marine creatures on the reef.

You will need

- A first aid book or booklet
- Some reference books (see below)

What to do

1. Complete the first aid table using the information available in the reference books.
2. Make sure you have your table checked by your group leader for accuracy.
3. Check the first aid kit list and decide whether the proposed kit would be sufficiently stocked and complete to handle the injuries and complaints listed in the table. What changes if any do you suggest?

Ideas for further things to do

4. Look through an actual first aid kit so that you become familiar with the contents and arrangement of the kit.

References

Thomas, R., and McKenzie, B. *The divers' medical companion.* Diving Medical Centre Monograph, repr. 1986.

Dunleavy, M. 1981. *Stay alive.* Canberra: AGPS.

Edmonds, C. 1975. *Dangerous marine animals of the Indo-Pacific region.* Melbourne: Wedneil Publications.

Edmonds, C. 1984. *Marine animal injuries to man.* Sydney: Wedneil Publications.

Saenger, P. 1977. *The divers guide.* Brisbane: AUF.

St John's Ambulance Brigade *First aid manual.*

First aid table

Injury or complaint	*Marine creature involved (if any)*	*First aid*
Severe sunburn		
Coral cut to the ankle		
Jellyfish sting to arm		
Puncture wound from stonefish		
Boiling water burn		
Bite from a centipede		
Bite from a wobbygong shark		
Sea-sickness		
Stepping on glass		
Cramp while snorkelling		
Asthma		
Sore ears		
Ulcers in the mouth		
Diarrhoea		
Broken ankle		
Severe headache		
Cone shell sting		
Cut from a rusty peg in the ground		

114. Survival from trees 1½ hr •

Concepts
Photosynthesis
Transpiration

Skills
Observing
Recording
Measuring

Attitudes
Self-confidence
Tree-appreciation
Self-reliance

Aim
- To acquaint students with survival techniques using trees.

You will need
- 5-6 clear plastic bags
- Shoe lace
- String or rubber band
- Measuring cup

You will need a total of about 1½ hours spread over half a day.

What to do
1. Select a variety of trees — *Argusia, Pisonia,* she oak.
2. Carefully place a plastic bag over some leaves and seal the end.
3. Observe what happens over the next hour.
4. After 3-4 hours, collect the water and measure the volume.
5. How much water collected in each bag?
6. How many bags would you need to survive off each kind of tree?

Permit required - one group only to do this per trip.
7. Before your trip, write for a permit to collect 50 *Pisonia* shoots.
8. If you received the permit, collect 50 fresh young *Pisonia* shoots. Wash them. Lightly cook in 50/50 salt/fresh water and serve with freshly cooked fish. Yum!

Reference
Cribb, A. B., and Cribb, J. W. 1976. *Wild food in Australia.* Melbourne: Collins.

115. What would you do if . . .? ¾ hr •

Concepts
Hazard
Cyclone
Survival

Skills
Discussing
Planning
Decision-making
Clarifying values

Attitudes
Willingness to cooperate
Initiative
Appreciation of importance of health and safety procedures

Aim
- To discuss what you would do if you had bad weather whilst on your reef trip.

You will need
- An example of a cyclone warning pamphlet

What to do
1. With other members of your group discuss what you would do if:
   - a cyclone warning was given two days before your trip.
   - a cyclone watch was given two days before your trip.
   - it rained continually for the whole trip.
   - strong winds and rain occurred for the whole of your trip.
   - a cyclone struck the island and you were unable to be evacuated.
   - you were delayed by two days on the island owing to high seas.
   - transport fails to arrive and you have two extra unplanned-for days on the island.
2. Find out what the emergency procedures are for your area.
3. Devise a plan among your group to prepare for each of these situations.

116. Human comfort on a cay

Concepts
Climate
Weather
Microclimate
Comfort
Perception
Relative humidity

Skills
Measuring
Evaluating

Attitudes
Interest in interrelationship between humans and their environment

Aim

- To collect data about the weather conditions at various places during your visit to a cay and to use this to decide on the most comfortable spots on the island.

You will need

- A map of the island
- Weather instruments: cup anemometer, ventimeter or other wind gauge, compass, whirling psychrometer (wet and dry bulb thermometer)
- 30-metre tape
- Coloured tape to mark sites
- Recording sheet
- Watch
- Pencil
- Bureau of Meteorology records for your island or a nearby island (optional)

This activity will take 5 minutes at each site selected around the island on several days.

What to do

1. Select at least six monitoring sites on the island. Some should include the beach front. Mark each site on the map. Identify the site with a piece of coloured tape with the site number marked on it. Visit each site on a rotational basis. If there are enough instruments, simultaneous readings at, say, six sites could be recorded at one time.
2. Record wet and dry bulb temperatures using the whirling psychrometer. Record wind speed and direction. Repeat just above ground level. Record the cloud cover, time and general conditions. Then move to next site and repeat.
3. Record data on sheets.
4. Graph the results for each site.
5. Evaluate the data you have collected, and work out how the microclimate on one part of the island differs from that on another part. Decide on:
   - the warmest place on the island.
   - the most sheltered place if SE winds or NE winds are blowing.
   - the coolest place (if it is mid-summer).

   Make a map showing these areas.
6. Advise other people of the spot(s) on the island where you think conditions are:
   - most favourable for sunbathing.
   - most likely to be cooler.
7. Discuss with others in your group: What weather factors affect out comfort? Is any one factor more important than another?
8. Is it possible to predict how comfortable we feel from measured data on temperature, humidity, wind, etc.?
9. Devise a method to find out how people's feelings compare with the measurements made using instruments.

Reference

Australia. Bureau of Meteorology. 1984. *Observing the weather.* Canberra: AGPS.

Weather recording sheet

Date and time	Site	Temperature				Surface wind			Cloud % cover	Present weather
		Upper		Ground		Dir-ection	Upper Km/h	Lower Km/h		Remarks
		Dry bulb	Wet bulb	Dry bulb	Wet bulb					

117. Castaways on the reef — 1½ hr • •

Concepts
Survival
Decision making
Values clarification

Skills
Working in a group
Decision making
Analysing and evaluating

Attitudes
Cooperation

Aim

- To make group decisions for effective survival on a reef island.

What to do

1. Form into groups of eight. Read the situation below and follow the procedures.
2. Swap decisions with other groups.
3. Discuss your decision-making process. Was everyone's opinion taken into account? Did you consider all the possibilities in making the decisions?
4. Would your decisions about the importance of the salvaged items have been different if you had been considering their usefulness to a group staying on the island? How?

Situation

You are one of eight members of a school group on a field trip to study a cay on the reef. It is the last week in January. You are 8 hours out of port when, at 10.40 a.m., your launch is overturned by a humpback whale and sinks. The driver and the teachers of the group are drowned. The rest of you are relatively uninjured. You all swim to a nearby cay and land safely on the beach.

You know that the mainland is approximately 70 kilometres west of where you are. When your launch does not report to its base that evening you will be missed. It is known generally where you are, but because of the nature of your outing people will not be able to pinpoint your exact whereabouts, and it may take at least three or four days before a launch or plane spots you.

The island is rather barren and very dry. You heard from a weather report before you left that the temperature would reach 35 degrees, making the surface temperature 45°C on the beach. You are all dressed in lightweight, summer clothing and sandshoes. Before your launch sank, you were able to salvage the following items.

> Magnetic compass; large, light-blue canvas; book, *Marine Animals of the Reef*; 1 hand mirror; 1 flashlight; flask of rum; 1 pocket knife; 1 cigarette lighter; 1 packet of sandwiches in a plastic bag; accurate chart of the sea, sealed with rubber band; 1 20 m length of rope; 1 litre bottle of vinegar; 4 canteens, each containing 3 litres of water; 4 hats; 3 pairs of sunglasses; 2 pairs of fins; 1 dozen oranges; 1 packet of bread in a plastic bag; Zodiac inflatable raft (not a life raft).

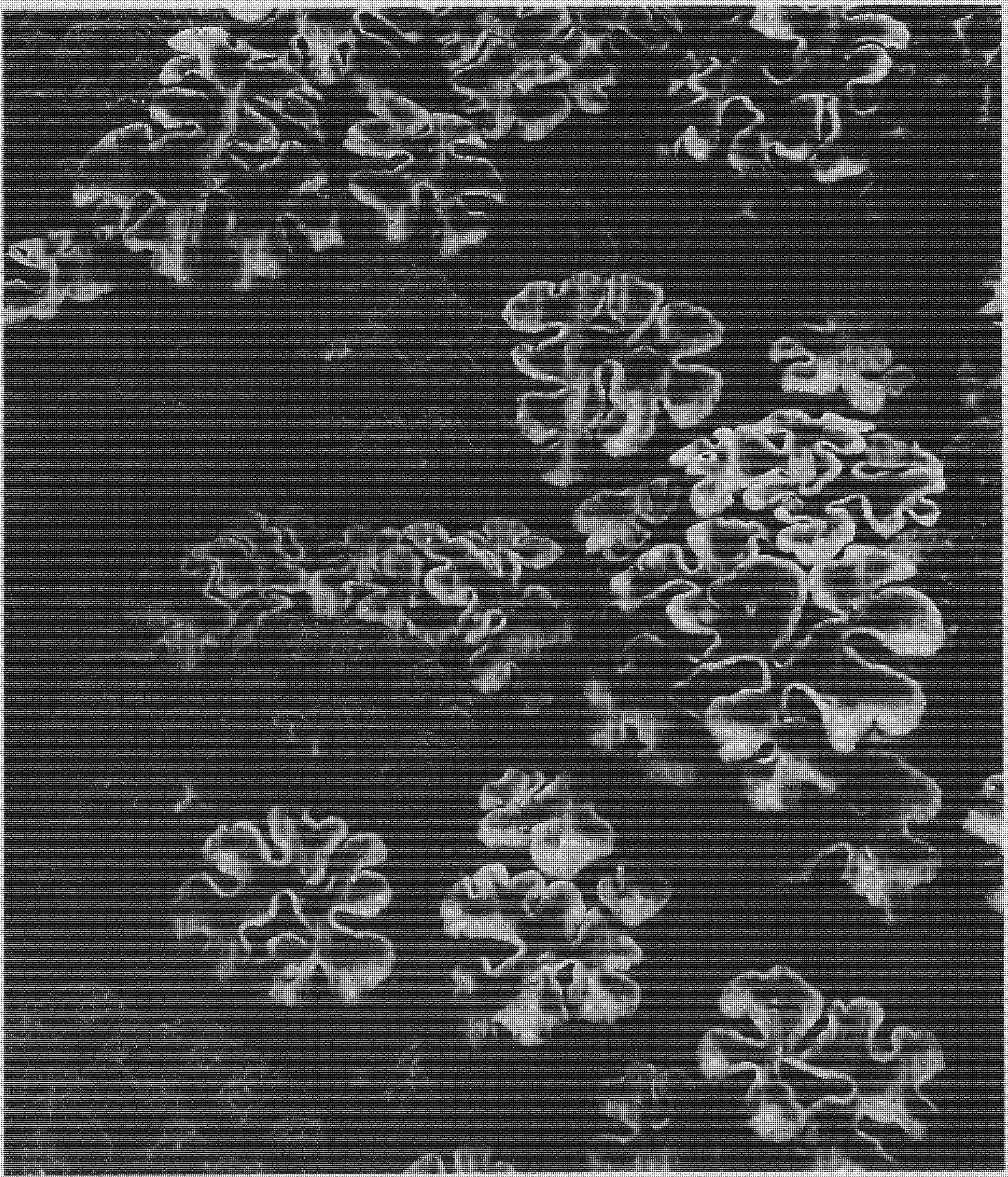
Decisions to be made

The group ultimately needs to decide whether to stay on the island or to try to boat out.

But before making that decision, try to rank the salvaged items in order of their importance to your future if you do decide to sail out. (Some items may have to be left behind!) Each of you should, first of all, individually list the items according to their importance for survival in a boat: no discussion allowed! Then the whole group should discuss this and re-rank. Remember to use the ideas from all the group. Continue the process until you are all in fundamental agreement about the value of the salvaged items.

Now, try to reach a consensus about your future actions. Decide if the whole group should try to boat out using a makeshift sail, or remain on the island and survive on what you have and can find. Or should the group split up and, if so, how should the salvaged items be allocated?

Creative response



118. Reef orchestra

Concepts
Sound
Tone
Rhythm

Skills
Interpreting musical score
Musical performance
Expressing

Attitudes
Willingness to interact and cooperate with others in a group
Enjoyment

Aim

- To present a musical interpretation of the Great Barrier Reef using reef-inspired instruments.

You will need

- Some copies of the "music" in figure 118.1 (optional)
- Instruments such as:
  - Large *Pisonia* leaf (a permit may be required to pick leaves)
  - Bottles with sand and small pieces of dead coral in them
  - Straw, basin of water
  - Small water containers
  - Small branch
  - Sticks and some pieces of beach rock
  - Some old coral pieces
  - Pieces of dead coral or shells hung from sticks

What to do

1. Select your instrument and agree on the score.
2. (a) One person conducts each group of instruments.
   (b) Perform your piece, allowing individuals to express their feelings without worrying too much about the music.

Note: If you are in a national park, the "natural" component must be returned to the site of collection afterwards.

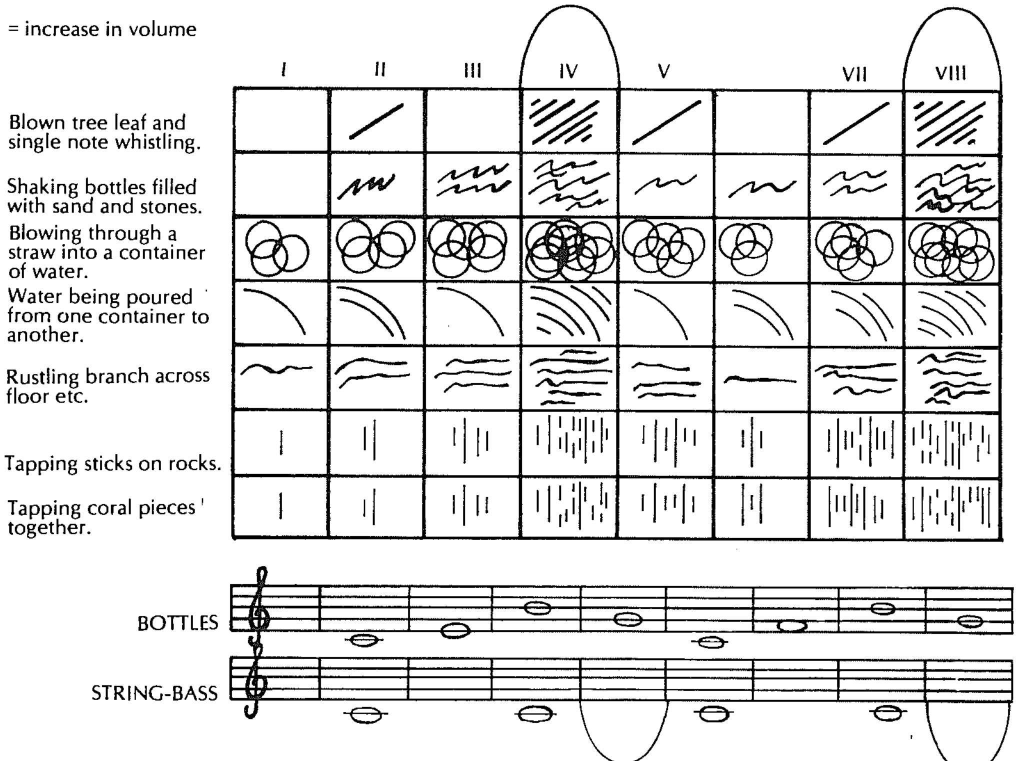


Fig. 118.1.

119. Art and the reef

Concepts
Environment
Creativity
Perception

Skills
Expressing
Craftwork
Modelling

Attitudes
Appreciating aesthetic qualities
Perseverence

Aim

- To represent your impressions of the Great Barrier Reef in an artistic way.

You will need

- Pencils, charcoal, crayons, paper
- Coloured or black paper
- Cellophane
- Glue
- Origami paper
- Cotton gauze
- Light card in several colours
- 3 kg plaster of Paris
- A basin
- A book on origami
- Roll of self-adhesive Contact
- Fabric paint in red/black
- Stanley knife or razor blade
- Permit (where appropriate)

What to do

Select from these suggestions to express your feelings:

(a) Using paint, charcoal, pencil or other medium, depict the same scene at sunrise, noon and sunset.
(b) Do reverse pictures (black/white) of trees, shells, coral, etc.
(c) Select a small portion of a large object or scene and draw the detail in a "blow-up", using black or colour.
(d) Try drawing an enlargement of a grass seed, the stamen of a flower, the opening of a shell, the junction of a twig with a branch.
(e) Using coloured or black paper, create a mosaic or picture or silhouette on white paper to show some aspect of the reef.
(f) Using scraps of coloured paper and a large sheet of butcher's paper, make a collage inspired by a reef cross-section or a reef food web.
(g) Make origami (paper folding) fish and suspend on a mobile.
(h) Make a fish mobile, using fish shapes cut from paper or card, suspended by cotton or fishing line, to be hung in the classroom. These can also be made from coloured cellophane or coloured tissue paper, with fine wire supports (florist's wire) to permit light to show through shapes.
(i) Make 3D replicas of fish, shells, sea stars or any other suitable living or dead reef organism using plaster of Paris, plasticine or clay (permit needed). If you use plaster of Paris, you need about 1 kg of plaster in a basin with fresh water to mix to a paste. Press the animal briefly into damp sand to form a mould. Return it to its original site. Then pour freshly mixed plaster into the mould, and wait till it is set. Dispose of waste plaster carefully.
(j) Design a logo suitable for using on the proposed field trip to the reef. It should be suitable for black and white reproduction.
(k) Design a poster showing dangerous marine organisms of the Capricornia group area. (This should preferably be in colour and have some type of scale.) This could be prepared beforehand and displayed on the field trip.
(l) Do spray painting of leaf shapes using a piece of gauze wire, toothbrush and water/plastic paint (can be used for species identification).
(m) Make a "bark" painting on a card (postcard size).
(n) Make a design on a T-shirt by making a stencil from a piece of self-adhesive Contact and painting fabric paint over it with a brush. The design could be a reef shape or symbol. Cut the design as an aperture in the plastic with a razor blade or Stanley knife. Place a wad of newspaper inside the T-shirt. Strip the backing paper off the plastic, press the plastic on to the T-shirt and then paint on the colour. Leave the shirt to dry. Iron the shirt before washing to set the paint.

120. Kite making ½ hr • •

Concepts
Wind currents

Skills
Making a kite
Using wind
Observing
Comparing

Attitudes
Initiative
Appreciation of qualities of natural environment

Aim

- To make and fly a kite on the reef in order to develop an understanding of wind currents over an island.

You will need

- Large, green plastic garbage bag
- 2 thin pieces of dowel
- Masking tape
- String
- Fishing line
- Scissors

What to do

1. Cut the bag to the pattern shown in figure 120.1
2. Place the dowel pieces parallel to each other as illustrated. Make 2 holes no bigger than 10 cm in diameter as shown.
3. Reinforce the corners of the kite with tape.
4. Join the edges with string, as shown.
5. Tie at least 30 m of fishing line to the centre of the string and fly the kite from the beach.
6. Use your kite to develop an understanding of wind currents over the island. Fly your kite at different times of the day. Do wind currents change? Can you explain why? Make diagrams to show most common flight patterns.

Ideas for further things to do

7. Fly the same kite at home. What differences are there?
8. Make a traditional kite and compare the efficiency.

CONSERVATION
Retrieve your kite no matter where it lands.

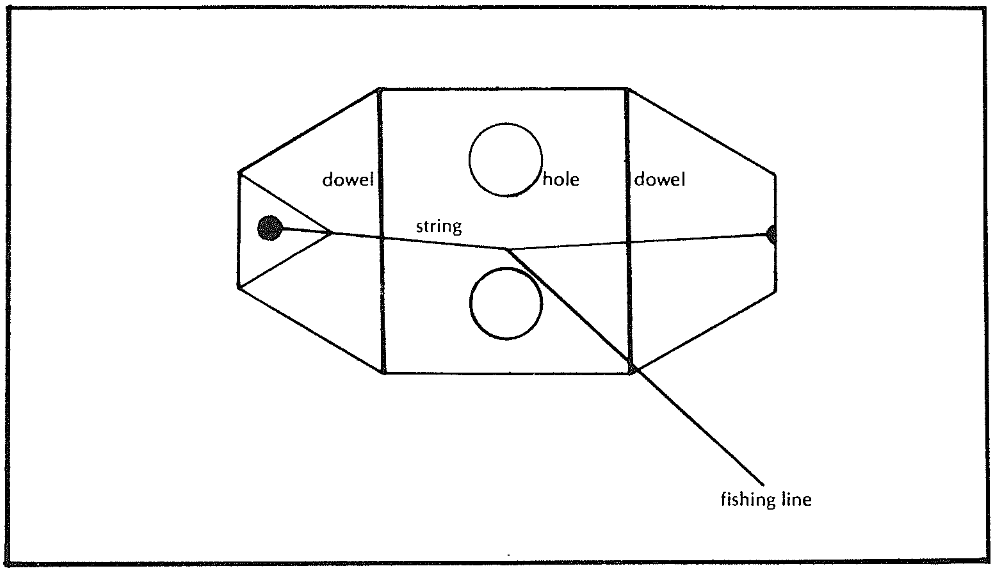


Fig. 120.1.

121. Projection art — 1 hr • •

Concepts
Creativity
Individuality
Image
Silhouette
Transparent
Opaque
Projection
Scale

Skills
Manipulating small objects
Clarifying visual concepts
Expressing
Communicating
Designing

Attitudes
Appreciation of aesthetic qualities of natural environments

Aim

- To make and show some mini works of art which reflect feelings about reef environments.

You will need

- Scissors
- Thin acetate sheeting
- Mounts for making 35 mm projection slides
- Small quantity of PVC glue (optional)
- Some of the following:
  - tiny reef objects (permit needed)
  - very fine overhead transparency marker pens
  - small pieces of coloured transparent plastic or cellophane

What to do

1. Obtain cardboard or plastic mounts of the kind used in making 35 mm photographic projection slides. (Boxes of these mounts can be purchased from photographic suppliers. Plastic ones, e.g. AGFA brand, are better.)
2. Cut two matching rectangles in the thin acetate sheeting. These should be just a little larger than the rectanglar openings in the slide mount.
3. Now, on one of the acetate sheets, make up a mini work of art which reflects some of your impressions of, or feelings about, the Great Barrier Reef. This work should be just the right size to be framed by the edge of the opening in the slide mount. Examples of things you could do are:
   - make a collage on the acetate sheet of some tiny natural objects (permit needed). The objects should be transparent or translucent or have interesting silhouettes, for example: fragments or dried seaweed or leaf skeleton, pieces of feather, dried leg of tiny shrimp.
   - use small pieces of coloured cellophane or transparent plastic in a collage.
   - write or draw on the acetate sheet using very fine overhead transparency marker pens — preferably permanent. (Plan this out on paper first.)
   - a combination of all of the above.
4. After you have finished your work, if it is a collage, place the second acetate sheet over the objects to hold them in place. Make a sandwich by securing the edges of the sheeting with a little sticky tape. (As a precaution, a tiny speck of PVC glue may be used to hold the collage pieces in place.)
5. Put the acetate into the slide mount and seal the mount. Make sure the whole thing is about the same thickness as a regular 35 mm slide.
6. Now project your slide for all to see!

Ideas for further things to do

7. A group could make a sequence of these slides to make an integrated showing, perhaps on a theme. You could make an audiotape to go with your slides.

122. Art and photography • •

Concepts
Environment
Sensory awareness
Aesthetics

Skills
Planning
Photographing
Displaying
Cooperating

Attitudes
Appreciation of aesthetic qualities of reef environment
Concern for the reef

Aim

- To convey impressions of your visit using photography and other visual media.

You will need

- Camera and film
- Underwater paper and pencil
- Plastic bag to keep camera in
- Reef-walking gear

This activity will need to be done at various times during the trip.

What to do

1. Select one or more of these ideas, and plan and take photographs to suit.
   (a) Study elements within the environment that show harmony or arrangement or balance or emphasis or contrast or colour or unity.
   (b) Try to convey the "feel" of corals.
   (c) Do a series of shots on one subject only; e.g., leaf patterns or leaf colours from one site or a bird and its activities or a nest in a tree over a period of time.

   Unless you are using a polaroid camera, you will need to assemble your developed photographs after you return to fit your selected topic.
2. People sometimes make "bark" rubbings of trees. With your underwater paper and pencil, make an underwater rubbing of a marine organism.

123. Film makers

Concepts
Landscape
Visual impact
Visual evaluation
Sensory awareness

Skills
Photography
Scripting
Production
Planning
Editing

Attitudes
Appreciation of landscape

Aim

- To plan, produce, film and edit a video film, or sequence of photography, on part of the reef.

You will need

- VHS camera and film
- Porta-pak
- Spare batteries
- Tripod
- Writing materials
- Small blackboard
- Battery charger (if electricity available)
- Carry pack
- Polaroid or underwater cameras

What to do

1. After some initial activities on the island and reef have been followed, "brainstorm" ideas about what you would like to put on film as a record of your visit.
2. Do you want to film specific places, or events, or a specific species in its habitat? What is your audience? What is the purpose of filming? Some suggested topics are:
   - Recreation on the Great Barrier Reef
   - Life on the Reef Flat
   - Transit across Island and Flat to Rim
   - A Ranger's Life
   - Human Use and Impact on the Reef
   - Sea-cucumbers/Sea stars/Molluscs
   - Vegetation Variations
   - Legs and Arms
   - Sounds and Scenes
3. Set up a production team; select suitable sites; write a script; work out shots (long shots, panning, close-ups, high or low angles; back or side lit — especially for still camera shots). Editing is time-consuming so you may have to reshoot scenes which have notable blunders. On video, sound can be dubbed in later, but try to include some sounds of the reef at the time of filming. Musical scores can be taped and used to back up a slide or photograph show. Practice first, especially if you are using voiceovers or interviews. Viewing professional videos on the reef should help you to know what is effective.
4. After your trip, edit your work and have a film show or slide display.

124. Graffiti wall

Concepts
Environment
Feelings
Individual differences

Skills
Expressing
Drawing
Evaluating
Creating

Attitudes
Tolerance
Concern for reef

Aim

- To express your feelings about your reef visit.

You will need

- Large white plastic garbage bags
- Masking tape
- Large felt-tipped pens (black and/or coloured)
- Space to hang bags

This activity can take place over the entire trip

What to do

1. Split open the bags and stick them on to a convenient wall. Use pens to draw pictures, cartoons, brief statements, comments on your observations, activities and feelings about your visit. Allow others to add to your graffiti display.
2. Use this graffiti wall to evaluate your trip and your group's feelings about the reef environment.

Human perceptions and perspectives

125.	How do I feel?	Base camp
126.	Reefscape aesthetics	Island
127.	Arousal evaluation	Base camp
128.	Perspectives	Island
129.	Be a detective!	Island
130.	Guess the texture	Island
131.	Blindfold walk	Island
132.	A sound map	Island
133.	Can we map it?	Base camp
134.	Perception of place	Base camp
135.	The best place and the worst place	Base camp
136.	Me and the reef	Base camp
137.	I want to preserve my personal space!	Base camp
138.	Imagine	Island
139.	How are we satisfied?	Base camp
140.	Shell jewellery	Island
141.	Decisions! Decisions!	Base camp

125. How do I feel? 20 min •

Concepts
Environment
Individual differences
Perception

Skills
Communicating

Attitudes
Appreciation of environment

Aim

- To increase your awareness of your own feelings about reef landscapes.

You will need

- Pencil

What to do

1. Study the list of paired words and tick the dash which you feel matches your response to Reef scenery and happenings. For example, if you feel that the Reef is very complex, you would tick the dash nearest to the right on the first line. If you have mixed feelings about a landscape, or no opinion, tick the dash in the middle of the line between the two words.

Simple	— — — — —	Complex
Bright	— — — — —	Dull
Impressive	— — — — —	Unimpressive
Obvious	— — — — —	Mysterious
Colourful	— — — — —	Colourless
Distant views	— — — — —	Limited views
Pleasant	— — — — —	Unpleasant
Flat	— — — — —	Hilly
Frightening	— — — — —	Secure
Known	— — — — —	Unknown
Orderly	— — — — —	Chaotic
Varied	— — — — —	Monotonous
Artificial	— — — — —	Natural
Diverse vegetation	— — — — —	Uniform vegetation
Idyllic	— — — — —	Degraded

2. After you have placed a tick on each line, discuss your responses with several people.
3. Compile the results of the entire group. Discuss.

126. Reefscape aesthetics

Concepts
Perception
Scenic values
Conservation
Aesthetics

Skills
Evaluating landscape
Decision making

Attitudes
Appreciation of aesthetic qualities of reef environments

Aim

- To establish the scenic quality of a reef landscape using a rating scale.

You will need

- The word scale
- Pen

What to do

1. Sit down outside and look at the reefscape in front of you.
2. Use the word scale on and tick the space which you think is appropriate.
3. Now read the information and the MAST analysis given below, and rate the reefscape.

Components of landscape
M = Majesty — the relative relief of the land system and the visibility or distance of view.
A = Artistic quality — the colour properties of the scenery, its shapes and its forms.
S = Serendipity — the ruggedness of the scenery and the element of surprise. Do you know what is around the corner?
T = Total atmosphere — lack of spoliation of the landscape.

4. Each of these factors has a total value of 5 points. Rate your landscape and total the points for each factor. The total is the MAST value.
5. Compare your value for this landscape with other students. View other landscapes and compare the scenic beauty of those.
6. Finally, consider this question:
   - If a reefscape has a high MAST value of, say, 18 out of 20, does this automatically demand a high priority for conservation of that landscape?

(This activity was adapted from the work of Robin Simson, Queensland, and is used with permission.)

126. Reefscape aesthetics

Word scale for landscape analysis

Majesty

	(5)	(4)	(3)	(2)	(1)	
Mountainous	–	–	–	–	–	Flat
Spectacular	–	–	–	–	–	Unspectacular
Great	–	–	–	–	–	Small
Impressive	–	–	–	–	–	Unimpressive
Distant views	–	–	–	–	–	No views

Serendipity

	(5)	(4)	(3)	(2)	(1)	
Complex	–	–	–	–	–	Simple
Varied	–	–	–	–	–	Monotonous
Mysterious	–	–	–	–	–	Obvious
Rugged	–	–	–	–	–	Smooth
Diverse vegetative cover	–	–	–	–	–	Uniform vegetative cover

Artistic quality

	(5)	(4)	(3)	(2)	(1)	
Bright	–	–	–	–	–	Dull
Vivid	–	–	–	–	–	Drab
Orderly	–	–	–	–	–	Chaotic
Colourful	–	–	–	–	–	Colourless
Attractive forms	–	–	–	–	–	Unattractive forms

Atmosphere

	(5)	(4)	(3)	(2)	(1)	
Pleasant	–	–	–	–	–	Unpleasant
Tranquil	–	–	–	–	–	Disturbed
Natural	–	–	–	–	–	Artificial
Idyllic	–	–	–	–	–	Degraded
Clean	–	–	–	–	–	Polluted

127. Arousal evaluation 15 min •

Concepts
Perception
Individual differences
Self-awareness

Skills
Evaluating
Graphing
Interpreting

Attitudes
Intellectual honesty
Appreciation of environment

Aim

- To provide an estimate of individual reactions to Reef experiences.

You will need

- The word scales provided (worksheet A)
- Pen and grid

What to do

1. Read the discussion on worksheet A.
2. Complete the word scale for one activity, ticking how you feel next to each pair of words.
3. Repeat for another activity.
4. Compile the data from all members of your group for two pairs of words (e.g. excited/bored and secure/insecure) for each activity. Plot this on the grid provided on worksheet B using a different symbol for each activity.
5. Discuss your findings with the group. Is there much variation of response within your group?
6. Overall, which of all the activities you were involved in at the reef gave you the greatest emotional experience, i.e., caused the greatest feelings of emotion in you?

WORKSHEET A

127. Arousal evaluation

Organisations responsible for the management of the Great Barrier Reef are carrying out programs of research into tourist attitudes. Visiting the Reef is centrally concerned with providing a rich and diverse range of experiences for people. Various activities for tourists appear to be different in the kind of emotional experience provided.

Some of the activities you have carried out at the reef are also used by tourists. It would be interesting to explore your own response to these activities, and to compare your own response with those of other groups who have been to the reef.

Consider activities based on both the water and the island. Choose one water-based activity (e.g. snorkelling, chasing fish, reef-walking) and one land-based activity (e.g. island walk, bird study). Write the activity at the top of the groups of word scales and assess your feelings for those activities in the three dimensions of Pleasure, Arousal and Dominance. For each pair of words, tick the space which best matches your response.

Activity 1

Pleasure

Happy	_ _ _ _ _	Unhappy
Satisfied	_ _ _ _ _	Unsatisfied
Hopeful	_ _ _ _ _	Unhopeful
Pleased	_ _ _ _ _	Annoyed
Contented	_ _ _ _ _	Discontented

Arousal

Stimulated	_ _ _ _ _	Depressed
Wideawake	_ _ _ _ _	Sleepy
Aroused	_ _ _ _ _	Sluggish
Excited	_ _ _ _ _	Bored
Frenzied	_ _ _ _ _	Calm

Dominance

Controlling	_ _ _ _ _	Being controlled
Influential	_ _ _ _ _	Insignificant
Important	_ _ _ _ _	Feeling submissive
Being dominant	_ _ _ _ _	Being awed
Secure	_ _ _ _ _	Insecure

Activity 2

Pleasure

Happy	_ _ _ _ _	Unhappy
Satisfied	_ _ _ _ _	Unsatisfied
Hopeful	_ _ _ _ _	Unhopeful
Pleased	_ _ _ _ _	Annoyed
Contented	_ _ _ _ _	Discontented

Arousal

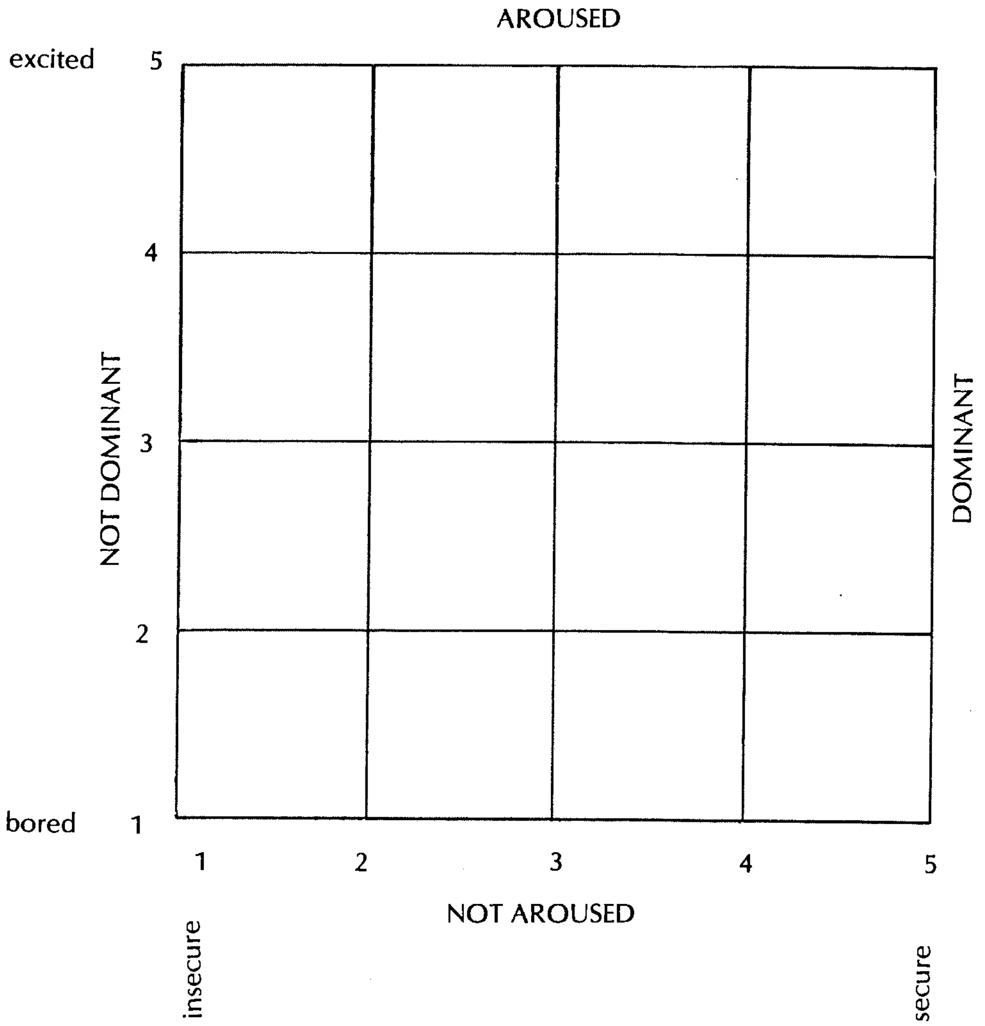
Stimulated	_ _ _ _ _	Depressed
Wideawake	_ _ _ _ _	Sleepy
Aroused	_ _ _ _ _	Sluggish
Excited	_ _ _ _ _	Bored
Frenzied	_ _ _ _ _	Calm

Dominance

Controlling	_ _ _ _ _	Being controlled
Influential	_ _ _ _ _	Insignificant
Important	_ _ _ _ _	Feeling submissive
Being dominant	_ _ _ _ _	Being awed
Secure	_ _ _ _ _	Insecure

WORKSHEET B

127. Arousal evaluation



For one of the activities considered on Worksheet A, score the response to two pairs of words, "bored-excited" and "insecure-secure", on a rating scale of 1-5. Now work out an average value for the response of your group to this activity and plot this as a point on the grid above. Repeat for other activities, using a different symbol for each activity.

128. Perspectives ½ hr •

Concepts
Poetry
Individual differences
Perception

Skills
Analysing
Evaluation

Attitudes
Empathy
Appreciation of environment

Aim

- To compare your views with other people's, especially those of poets.

What to do

1. In a quiet place on the reef, read the poetry extracts provided. Do you think the poets are describing something they have seen? Do your own feelings and opinions match those of the poet? Why or why not?
2. Consider: If these poets had been given the responsibility for making up laws and regulations concerning the Great Barrier Reef, what kinds of laws and regulations do you think they would have wanted? Would their laws and regulations be like the ones which now affect the Great Barrier Reef?

Poetry Extracts

(a) **The Pairing of Terns — Mark O'Connor**

Human lovers know it only in dreams
the wild mating flight of the terns:
riding the weird and ungessable surf of the air
though flung round the compass they hold as one pair.
Firm as if interlocked by invisible steel
rigid and taut as their back-swept wings
like the sharp stretched skin of a pterodactyl.
Now criss-crossing moon-high in an evening sky
now outskimming the wind on the waves of a twilit bay
now rising, now falling tumultuous heights
and cackling their random delirious laughter . . .

. . . Their love is everything for which we have only metaphors,
peaks and abysses, stallings and dizzying speeds
wild oceans of distance, and fethertip closenesses,
and wingbeats that answer so swiftly none knows
which struck first, which called and which answered . . .

(b) **The Killer — Mark O'Connor**

Master of two elements, the invulnerable gannet
swivels his inquisitorial beak on high
studying the rocks and shoals below.

He can see all, clear as the murderous pilot
hefting his cargo of deth views the pattern
seated aloft, of ricefields and towns.

The wonder is the bird can make choice
among such richness of life below,
but he does, and then
suddenly plu-
mmets, never
failing to
kill.

(c) **I am the Island — Jan Chee (unpub.)**

Surrounded by *sea*
and *currents* in sinuous motion
and *ponds* alive yet secretive.
Surrounded, by the *coral*
home of the *fish,* the *algae,* the *shells.*
Fringed by *sand*
clothed with trees
sanctuary of the *birds.*
And the *wind* moves continuously
and the *sun* beats down.
Then in walk the *people*
with *machines*
and *feet* tramp coral
and *bodies* drift in water, head down in awe.
I am the island.

Reference

O'Connor, Mark. 1976 *Reef poems.* St Lucia: University of Queensland Press. By permission.

129. Be a detective! 20 min •

Concepts
Environment
Ecosystem
Perception
Individual differences

Skills
Collecting data

Attitudes
Curiosity
Appreciation of qualities of island environment

Aim
- To find examples of flora to match perceptions and descriptions.

You will need
- Pencil

What to do
1. Move around the island, shoreline and reef flat to locate an example that you can list next to each of the descriptions below.
2. What problems are there in answering these questions?
3. Compare your list with those of other group members.

Observation list
- A living thing that makes its own food
- An animal that can't move from place to place
- A frightening thing
- Something that is living on something else
- Something beautiful
- Something which can be removed without damage to the environment
- Something that can't be touched
- Something that's impossible to count
- Something that can't be photographed
- Something that has undergone change
- Something that appears similar to something else
- Something that was once alive

130. Guess the texture ½ hr •

Concepts
Perception
Sensory awareness
Distribution
Texture
Individual differences

Skills
Observing
Drawing
Interviewing
Recording

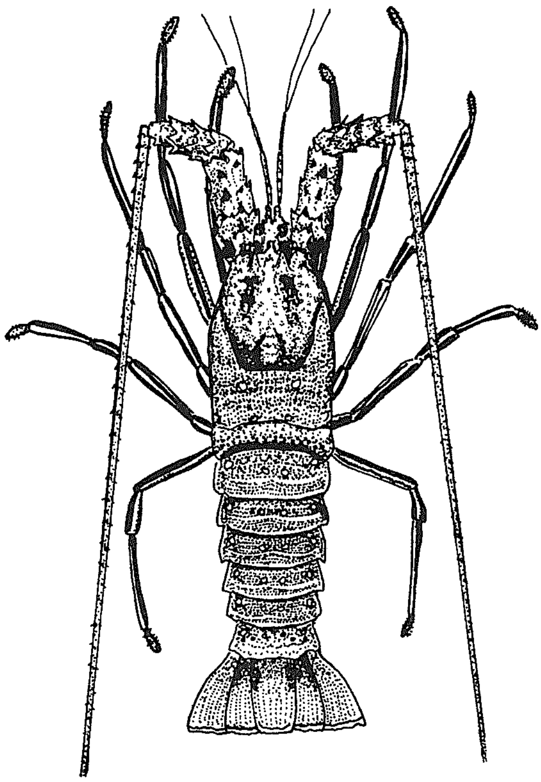
Attitudes
Appreciation of aesthetic qualities

Aim
- To examine varieties of textures found around the reef

You will need
- Paper, drawing materials, e.g. Pentel crayons and butcher paper

What to do
1. Take a piece of paper about 10 centimetres square and make a small hole in it. Use the hole as a peephole through which to view textures of, say, trees, beach rock, the ground, building materials.
2. Find one texture you like and draw it as realistically as possible.
3. Ask five people to guess where the texture you drew came from. Record their responses.

Ideas for further things to do
4. Do "bark" rubbings of some of the textures and display for identification.



CRAYFISH

131. Blindfold walk ½ hr •

Concepts
Sensory awareness
Environmental stimuli

Skills
Collecting data
Walking blind
Recognising dangers

Attitudes
Curiosity
Appreciation of sight
Empathy

Aim

- To use various senses (other than sight) to learn about the environment.
- To develop trust in others.

You will need

- A blindfold made from an old sheet or scarf
- A partner with a recording sheet
- Pen
- Portable tape-recorder (optional)

What to do

1. One partner wears a blindfold. The "sighted" person leads the other along a track or suitable level area where the blindfolded person uses the other senses, i.e., feeling both with hands and feet; smell; hearing; taste. As the couple proceed, the blindfolded person comments on what he or she feels, smells, etc., and the sighted person records these comments on paper or tape.

   Note: Watch safety — overhangs, slippery areas, traffic (people), and don't give your partner dangerous things to handle or taste. (But there's nothing wrong with mud, sand, bark, leaves, feathers, etc.)
2. After a while, swap places; choose another path so that the experiences are different.
3. Consider what you both learned.

Idea for further things to do

4. Try expressing your feelings through an art and craft activity or prepare a "Sound Map".

132. A sound map 2 hr • •

Concepts
Environment
Human impact

Skills
Data collection
Data presentation

Attitudes
Appreciation of environmental qualities

Aim
- To record and evaluate the sounds of a reef island.

You will need
- A tape-recorder and tape
- Map of island
- Pen
- Paper

What to do
1. Using a tape-recorder, record the sounds of the island at several sites. You could record at the same site at sunrise, noon and sunset. If you have a decibel or volume needle on the recorder, record the maximum level of noise.
2. Play back your tape and evaluate your sounds.
   (a) At any particular site, are there different sounds at different times of the day?
   (b) What are the varieties of sounds which are heard on the island?
   (c) Do human-made sounds dominate?
3. Show your findings on a map.

133. Can we map it? ½ hr •

Concepts
Area
Location
Aerial distribution
Distance
Scale

Skills
Mapping

Attitudes
Curiosity
Interest in interaction between people and their environment

Aim

- To recall routes frequently travelled on an island and to map them.

You will need

- Piece of paper (e.g. butcher's paper) for each person.
- Drawing materials
- List of mapping symbols
- Compass

This activity should take place at least three days after the trip commences.

What to do

1. Your group should stay at base camp for this activity. Each student should attempt to map from memory one commonly used route from the base camp to a major feature in another place. You should use correct mapping symbols, with a key, a compass direction and a scale.
2. Display your maps. How accurate are they?

134. Perception of place ½ hr •

Concepts
Perception
Landscape
Location

Skills
Drawing and mapping from memory
Expressing

Attitudes
Appreciation of the Reef's character
Interest in others
Interest in interaction between people and their environment

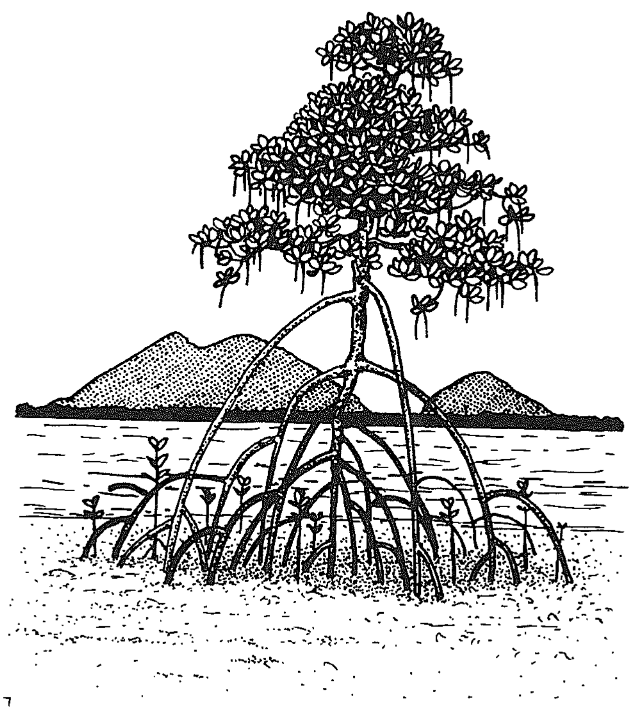
Aim
- To put your mental map of an island on to paper.

You will need
- A group of people with a piece of paper (e.g. butcher's) each and a crayon, felt pen or pencil each

You should attempt this activity after you have spent at least a day on the island.

What to do
1. Have each person map the island using the images they have formed. Don't feel that everyone has to show the same things on each "map" — just put down what is important to you.
2. Now print the word "Fear" on the map at the spot where you feel most frightened, and the word "Awe" at the place where you feel overwhelmed by the beauty, the colour, the grandeur of it all.
3. (a) When everyone has finished, pin or tape the maps on to a wall as a display.
   (b) Can you see similarities or differences between each map?
   (c) Did everyone draw the island from an overhead view or from side-on?
   (d) Was the whole island and reef shown or just a part of it?
   (e) Were natural and artificial features shown? Were some left out?
   (f) Were the "fearful" places in the water? Were the "awesome" places near coral or sand or water?

Ideas for further things to do
4. Compare the maps with the actual map of the island. Note the differences.
5. Express your feelings in other ways — painting, making up a poem, making up a song, a collage.



Rhizophora stylosa

135. The best place and the worst place ½ hr •

Concepts
Perception
Personal geography
Problem solving

Skills
Observing
Communicating

Attitudes
Appreciation of environment
Tolerance

Aim
- To evaluate places using your own opinions.

You will need
- Pictures or photographs, postcards or actual visits to various places on a coral island

What to do
1. (a) Select the scene you like best.
   (b) Explain to someone else why you like that place best.
   (c) Do other people also select your place as their best place?
   (d) If other people do not like your place, how would you change their views?
2. (a) Repeat this activity for the place you hate or dislike the most.
   (b) How did you decide on that least-liked place?
   (c) What would make your disliked place a more liked place? Could you do something about this?

Ideas for further things to do
3. Try activity 134 "Perception of place"
4. Carry out a variety of field activities on the island and in the sea. These will give you an opportunity to see places and form opinions about them.
5. Take photographs or draw scenes of the reef

136. Me and the reef — 10-60 min •

Concepts
Individuality
Personal preferences
Self-image

Skills
Expressing
Communicating
Empathising

Attitudes
Appreciation of individuality
Tolerance
Interest in others

Aim

- To introduce group members to each other and provide opportunities for self-expression of one's position.

You will need

- Butcher's paper rectangles at least 30 cm x 20 cm
- Crayons or felt pens

This activity should be undertaken at the beginning of the visit.

What to do

1. Draw the way you see yourself now in relation to the reef. What do you expect to be, or how do you imagine you will change, as a result of visiting the reef?
2. Fix your papers to the wall. When all are ready, explain your drawings to the group, and how you expect to benefit (or not) from your visit.

Ideas for further things to do

3. Try some other activities, such as no. 125, "How do I feel?" and no. 139, "How are we satisfied?"

137. I want to preserve my personal space! ½ hr •

Concepts
Individuality
Personal space
Resources

Skills
Observing
Gathering data
Recording

Attitudes
Appreciation of need for privacy
Tolerance

Aim

- To assess how much room individuals feel the need for.

You will need

- Recording sheet and pen

What to do

1. Visit and observe the accommodation you are using. Note how each student uses the space around his or her bed/sleeping bag.
   - How far do his or her belongings intrude into the space of others?
   - Are they neatly arranged?
   - On a surprise visit to the dormitory or tent, note if each student is sitting on his or her own bed, or in the middle of the room, or on someone else's bed.
   - At meal times, watch where students sit. Do they sit close to one another, or do they try to keep as large a personal space as possible around themselves?
2. Devise a method of showing the results of your observations.
3. Discuss the results with your group. Can you suggest ways to help people obtain privacy on camps?

Ideas for further things to do

4. Repeat your survey at the end of the trip. Do you think that people's personal space requirements have altered?

138. Imagine

½ hr + •

Concepts
Self-awareness
Perception
Values

Skills
Empathising
Predicting
Evaluating

Attitudes
Curiosity
Tolerance

Aim

- To put yourself in the island's place.

You will need

- Writing materials

What to do

1. Sit quietly somewhere on the island and imagine you *are* the island.
2. Consider these questions:
   (a) How do you feel about people walking over you?
   (b) How do you feel about people digging into you . . . or burning you . . . or putting pipes into you? How do you feel about birds making burrows in you?
   (c) How do you want people's actions altered?
   (d) Would these changes be good for you . . . and for people? How?

139. How are we satisfied? ½ hr •

Concepts
Human needs
Recreation
Lifestyles
Perception

Skills
Analysing
Evaluating
Hypothesising

Attitudes
Appreciation of natural environment

Aim

- To evaluate perceptions of human needs on a reef island.

You will need

- Writing materials

What to do

1. Examine and discuss the basic human needs — food, water, shelter, leisure, etc. How are these satisfied on the island?
2. If the supply boat did not arrive with the food, what foods could be obtained from the island and reef?
3. Do the clothes that tourists wear on the island differ from clothes they wear at home? In what ways? Why are they different?
4. Do people behave differently in places like the reef than they do at home? How? Why?
5. In what ways might visitors' lifestyles be changed while they are staying on an island?
6. Why are people prepared to live differently when they are on a holiday island?

140. Shell jewellery ½ hr •

Concepts
Aesthetics
Harvesting
Equity
Conservation
Economics
Development
Ethics
Values

Skills
Observing
Discussing
Evaluating
Clarifying values

Attitudes
Empathy with others
Interest in conservation

Aim

- To explore feelings about jewellery and ornaments made from sea life.

You will need

- Notebook and pencil
- Copy of the Great Barrier Reef Marine Park Authority regulations or pamphlets describing activities permitted in the Marine Park.

What to do

1. Visit a shop in the area where souvenirs are sold.
2. Are any of the things on sale made from coral, shells or other marine materials? What types of animals have produced the materials? What parts of the animals have been used? Have you seen animals like these on the Great Barrier Reef? Does the material on sale come from Australia or an overseas country?
3. Would you like to buy any of these souvenirs for yourself or for someone else? Which, if any, of the items do you find appealing or unappealing? Why? Make some sketches.
4. Would you be interested in trying your hand at making ornaments or jewellery from shells or other materials from the sea? What would you like to make? Where would you be able to get the materials?
5. Find out about regulations concerning collecting of shells, coral and similar material from the Great Barrier Reef Marine Park. Do you think it's a good idea that collecting should be restricted? Why or why not? Should the existing rules be changes?

Some people think that all collecting of shells and live corals on the Great Barrier Reef should stop. Others think that people should be given more opportunity to collect. Some people think that the sale of ornaments and jewellery containing marine materials should be discouraged in the reef area. Other people think it is all right providing the materials are not collected from the Great Barrier Reef.

6. The following statements (a) to (g) relate to issues about the collecting and selling of shells and similar products. Read the statements and decide whether you agree or disagree with each. Take a group vote on each.
   (a) All collecting of shells and coral should be banned in the Marine Park. AGREE/DISAGREE
   (b) Collecting in the Park should be restricted, as at present. AGREE/DISAGREE
   (c) Restrictions on collecting in the Park should be relaxed so that tourists and commercial collectors can collect more freely. AGREE/DISAGREE
   (d) Selling and buying jewellery and ornaments made from marine products is all right provided the material does not come from the Great Barrier Reef. AGREE/DISAGREE
   (e) It's all right to buy and sell these things, no matter where the material comes from, provided it has been legally collected. AGREE/DISAGREE
   (f) Once the creatures are already dead, it hardly matters what happens to them. So we might as well let these things be bought and sold freely. AGREE/DISAGREE
   (g) Sale of all these things should be discouraged, whether this material comes from Australia or overseas. AGREE/DISAGREE

7. The following statements (a) to (l) are some facts and opinions related to the issues you have been considering. In small groups discuss each of these statements and think about their implications for the questions you have just voted on in question 6.

Facts

(a) Unrestricted shell collecting occurred on many reefs in the Great Barrier Reef area in the past. This collecting was very detrimental and its effects can still be seen today in the limited variety and small size of molluscs in places visited by many tourists at areas like Green Island and Heron Island.

(b) Much of the coral, shell and other marine material used in souvenirs sold in the Great Barrier Reef area comes from overseas, much of it being collected in reef areas in the Philippines. For many people in the Philippines, collecting and processing such material is a major source of income. Many reefs in the Philippines, unprotected by conservation laws, are being badly damaged by this harvesting.

(c) The industry which collects Great Barrier Reef shells and coral and makes it into ornaments and souvenirs provides employment and income for some people in Queensland.

(d) The sale of jewellery and ornaments made from overseas marine products provides some income for Australian retailers.

Opinions

(e) For many people, part of their enjoyment of a reef visit is to take home a reef souvenir.

(f) Any sale of shells and marine products as ornaments and jewellery in Australia might create a fashion which results in people wanting to collect more from the Great Barrier Reef.

(g) Banning the sale of overseas shells, etc. here might deprive some people in developing countries of their livelihood.

(h) Banning the sale of overseas shells, etc. here might help reefs be conserved in other parts of the world.

(i) Australians should not exploit people of third world countries by encouraging them to sell us their shells and despoil their environment when we have been able to protect our own reefs with conservation laws.

(j) If shell jewellery and coral is available for sale in souvenir shops in the Great Barrier Reef area, it might stop people wanting to collect their own shells from the reef.

(k) People who visit the reef should be encouraged to "Look, don't touch".

(l) Encouraging people to take an interest in shell collecting might help reef conservation by making the public more interested in marine environments.

8. Vote again on the seven statements in question 6. Has the voting changed?
9. What actions can be taken to help solve some of the problems raised in this activity?

Ideas for further things to do

10. Find out what actions have been taken in the United States concerning the import of kangaroo products into that country. What do you think of these actions? Are they relevant to issues you have been considering in this activity?
11. How do you feel about killing reef wildlife? Consider these two acts:
    (a) Legally catching a reef fish to eat.
    (b) Legally killing a mollusc to make an ornament.

Are either or both of these actions right or wrong in your opinion. Why?

141. Decisions! Decisions! 1 hr •

Concepts
Individual differences
Perception
Values
Conservation
Self-awareness

Skills
Analysing data
Clarifying values

Attitudes
Empathy
Curiosity
Interest in social and environmental issues

Aim

- To clarify your own ideas about the reef and to compare them with those of other people.

What to do

1. (a) At the beginning of your trip, read the following statements carefully and then decide whether you strongly agree, mildly agree, midly disagree, strongly disagree, or have no opinion at all on each. Tick the appropriate column.
   (b) When you have finished, arrange for all the results of your group to be summarised.
2. Repeat this at the end of your trip.
3. Discuss the results and their significance.

Statements	Strongly agree	Mildly agree	No opinion	Mildly disagree	Strongly disagree
1. *Access to the Great Barrier Reef should be restricted to those who have an interest in studying some aspect of it.*					
2. *If scientists find a chemical in a rare form of coral which can cure cancer, they should not make any attempt to extract the chemical for use by cancer patients.*					
3. *If I study a good book about the Reef I can learn more than when I go to the Reef, because at the Reef I am unlikely to see all of the living organisms which I can see and read about in the book.*					
4. *I would like to return to this part of the Great Barrier Reef after this trip.*					
5. *Reef-walking should be banned, since it does such damage to coral.*					
6. *Even if I could write down all of the facts which I am learning from this field study, it would not describe what I feel I am gaining from the study.*					
7. *Field studies such as this take a lot of time, money and effort. Equivalent or better results can be achieved more efficiently by staying at home and spending some of the money on having good quality films and using these as a basis for discussion.*					
8. *The Great Barrier Reef provides a magnificent resource through which we can come to a better understanding of the living world.*					
9. *I feel that I have a responsibility to do something to help conserve the reef.*					
10. *If world oil supplies run short it would be worthwhile exploring for petroleum in the Great Barrier Reef area.*					
11. *New tourist resorts should be established on the Reef to give as many people as possible a chance to enjoy the Reef.*					
12. *In areas where fishing is allowed on the Reef, people fishing for recreation should be allowed to catch as many fish as they can.*					

Management and conservation

142. Compatible uses

½ hr • •

Concepts
Interaction
Environmental impact
Compatibility
Zonation

Skills
Communicating
Observing
Analysing

Attitudes
Interest in interrelatedness of people and their environment

Aim

- To consider how various human uses of reef environments affect one another.

You will need

- Pictures or slides of people using reef environments (optional)
- Grid sheet (see below)
- Pencil and writing paper

What to do

1. Look at some pictures which include people using the reef or effects of human activity in the reef area (optional).
2. Through group discussion, build up a list of up to twenty different ways in which people use the Great Barrier Reef.
3. If you are visiting the reef, be sure to include the major reef-using activities which occur at the place you're visiting.
4. Draw up a grid and write in the names of the activities or other uses along both the horizontal and vertical axes, as shown in table 142.1.
5. In small groups, talk about ways in which these uses interact with one another. If one type of activity takes place in an area, does it interfere with (i.e., is it incompatible with) another type of activity?
6. Use the symbols provided to show on the grid whether the activities may interfere with one another: *only slightly (or not at all); moderately* or *strongly.*
7. If some reef activities are incompatible with others, what can authorities responsible for managing the reef do? What are some choices available? Should the activities be banned . . . separated . . . ?
8. For comparison, think about the situation in a school. What are two school activities which would be incompatible with each other if carried out at the same time in the same place in the school? How is this sort of interference prevented?
9. Look at a Great Barrier Reef Marine Park Zoning Plan. Why is the Great Barrier Reef Marine Park called a multiple-use park? How does the plan attempt to prevent uses interfering with one another? From your experience or understanding of the Great Barrier Reef, do you think the plan is successful as a way of preventing uses interfering with one another?
10. Find out about the way in which the locations of activities and developments in your home area are controlled by your local municipal or shire council. Are there different zones for different purposes in your area? In what kind of zone is your home? Are there limits on the kinds of buildings or activities which can occur in this zone?

Table 142.1: Compatible uses

Human activities in reef area	1. Reef walking	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
1. Reef walking																				
2.																				
3.																				
4.																				
5.																				
6.																				
7.																				
8.																				
9.																				
10.																				
11.																				
12.																				
13.																				
14.																				
15.																				
16.																				
17.																				
18.																				
19.																				
20.																				

O Interfere only slightly or not at all
X Interfere slightly
XX Interfere strongly

143. User roles and zoning game

2 + 2 hr • •

Concepts
Resource use
Management
Planning
Role play
Zone
Individual differences
Perception

Skills
Communicating
Decision making
Adopting a role
Empathising
Resolving conflict

Attitudes
Tolerance
Willingness to work in a group
Willingness to compromise

Aim

- To play the roles of people attending a public meeting on zoning a reef area.

You will need

- The role cards for the groups
- Map of imaginary marine park area (see figure 143.1)
- OHP sheet of map and pens
- Large sheets of paper (attached to wall)
- Felt pens
- Some copies of existing Great Barrier Reef Marine Park zoning plans for reference and Great Barrier Reef Marine Park Authority leaflets on zoning.
- Basic reference books on the reef

This activity will require 2 hours one morning to set up the game and for role groups to plan; 2 hours one evening for the presentation and decision making; a short debriefing session.

The Great Barrier Reef is a multiple-use park. To stop one type of use interfering with another, different kinds of zones, for different purposes, are established within the park. The ideas and views of members of the public help in the making of decisions about where zones will be. Different people have different points of view about the way the park should be zoned.

This game investigates how people might put their points of view about park zoning.

What to do

1. Your leader will decide how many students will be in each role-play group and prepare the role cards. You will draw your role card and group from a random selection in a hat.
2. Each group then meets and decides on strategy, using the role cards and reference materials. You could also decide what dress will be appropriate for the presentation.
3. The chairperson, following the role card, notifies your group of the order of presentation, the place and time. Each member may be given a limited time in which to speak, or one speaker may present the group decisions.
4. When the meeting is convened, each group, dressed according to their roles, presents their case about the zoning, referring either to the projected map or to a copy on paper. The secretary can record your points on large wall sheets of paper or on a blackboard. The chairperson can allow heckling, be prepared for a noisy session!
5. The Park Authority group will make a decision about the zoning and announce it at the end of the presentation, or the following day, whichever is possible. The reasoning behind the decision will be stated.
6. In your debriefing session discuss:
   (a) Your views on the zoning plan decided upon by the Authority group.
   (b) How you feel the zoning procedures were influenced by the presentations.
   (c) The actual role-play game.

Suggested group numbers for roles for 30 students

The Park Authority Group:		**Members of the public:**	
Chairperson	1	Conservationists	4
Secretary	1	Professional fishermen	4
Artist	1	Recreational fishermen	3
		Scientists	4
		Indigenous people	3
		Tourist developers	3
		Alternative life-stylers	4
		Reporters	1-2

Types of zones in a marine park

Zone	*What is allowed*	*What is prohibited*
General Use "A" Zone	Trawling, trolling, line fishing, netting, boating, general recreational activities, non-manipulative research	General prohibitions apply: Mining, oil drilling, commercial spearfishing and spearfishing with scuba gear
General Use "B" Zone	As for General Use "A", except for trawling, general commercial shipping and research	General prohibitions, plus trawling and general commercial shipping
Marine National Park "A" Zone	Holidaying, reef-walking, swimming, diving and limited recreational fishing	General prohibitions, plus collecting and commercial fishing
Marine National Park "B" Zone	"Looking but not taking"; reef-walking, swimming, diving and photography	General prohibitions, plus collecting, and all fishing, tourist and educational facilities
Scientific Research Zone	Research — only under permit	General prohibitions, plus all non-research activities (including fishing and diving)
Preservation Zone	Research only under special permit	All other activities

(This activity is derived from material prepared by Brian Armour and others for the GBRMPA/TCAE kit "Encounters with the Reef")

1. **Conservationist Group**

Your overall aim is to prevent damage to the natural environment and to reef life by human activities. So you want to see a *large PRESERVATION ZONE* established.

You realise, however, that people should be allowed to experience the beauty and wonder of the reef world but you emphasise that they must do this in such a way that they do not destroy plants and animals and their habitats as they do so. You are willing, therefore to support *limited areas for recreational uses.*

To prevent visitors from taking large numbers of fish and other animals like shellfish and corals you want REEF APPRECIATION AREAS set up.

You agree with scientists that research into reef life is important if we are going to find out how to protect and conserve reef life. You wish to support scientists in the setting up of useful SCIENTIFIC RESEARCH ZONES (at least for non-manipulative research which does not lead to destruction of any reef life.)

You do not believe that setting up a tourist resort is in the interests of conservation of the area since the buildings for hotels, accommodation units, water storage, and the need to dispose of human wastes will destroy plant life and animal habitats. You only support day-trips by tourists who return to the mainland at night. You are not willing therefore, to see areas around islands included in GENERAL USE "A" AND "B" ZONES or MARINE NATIONAL PARK "A" ZONE because this may allow tourist facilities to be built in the future.

You are not convinced that professional fishermen need access to Marine Park (Middle Section) because there are fishing grounds elsewhere that they can use. You would be unhappy to see a large GENERAL USE "A" ZONE.

The use of reef resources by the indigenous people or alternative life-stylers does not worry you because they have both been using them for many years without destroying them.

2. **Professional fishermen**

You argue that your livelihood depends on access to the rich resources of Marine Park (Middle Section) which is a valuable source of reef fish. A *large GENERAL USE "A" ZONE* would suit you well.

In general, you believe that no special laws are needed to make you conserve fish stocks, because you only do yourself harm by overfishing.

You know, however, that fish stocks can run low after a lot of fishing in limited areas; so you are willing to support establishment of *REPLENISHMENT AREAS* especially where heavy fishing has already occurred. Sharkfin Shoals and Hoof Reef have been heavily fished because they are so close to the port of Newhaven.

You fear that setting up a tourist resort will bring more recreational fishermen. You therefore support the conservationists in opposing the inclusion of areas around an island in any of the GENERAL USE "A" and "B" ZONES and the MARINE NATIONAL PARK "A" ZONE.

You do not object to the indigenous people or hippies being given special rights to catch fish and other animals for their own food; but you would object to their using these rights to set up a profit-making fishing industry.

You know that outsiders often object to you fishing the Reef, so you will try to avoid antagonising other user groups; you also know that the Authority has, in the past, given you a good deal.

3. Recreational fishermen

In general, you are not willing to let governments and their organisations tell you where you can and cannot fish. Setting up of large zones which restrict your freedom to fish where you want to is opposed by your group. Your interests are best served by a *large GENERAL USE "B" ZONE* since you would be allowed to fish with rods, handlines, and spearguns and you would not have to compete with trawlers.

You point out that Marine Park (Middle Section) has, for a long time, been a favourite haunt of recreational fishermen. Your members have invested in motorboats that are large enough and powerful enough to get to the reefs of this section from Newhaven Port. They are not really big enough to go further afield. Nor do you have much time during weekends and holidays to travel far to fishing grounds. You point out that professional fishermen have more time and usually have boats that can go much further than those of recreational fishermen.

You object to most restrictions on the areas, and to the use of various reefs by conservationists, "alternative life-stylers" and indigenous people.

4. Scientists

In the parts of Marine Park (Middle Section) which are furthest from Newhaven, there are still areas that have not been affected very much by human activities. You would like to see *PRESERVATION ZONES and SCIENTIFIC RESEARCH ZONES* set up in these areas.

Studies carried out by scientists have shown that large vessels (over 500 tonnes) using the Qld Shipping Lane have affected reefs and islands on both sides of the lane mainly through oil spillage from their bilge pumps and from washing out their holds. *You maintain that the Qld Shipping Lane should be placed in at least a GENERAL USE "B" ZONE to prevent such shipping.*

Your research shows that

(a) Muttonbird Island is an important nesting site for seabirds which lay eggs around October and have chicks in the nest until March.

(b) Turtle Islands are the only islands in Marine Park (Middle Section) where turtles come to nest in large numbers from October to February. The young turtles are all hatched by March.

You argue that it is important to protect these islands by making them *CLOSURE AREAS.*

You have also found that the lagoon between Glory Islands and Three-tree Island is a calm stretch of water where turtles mate in season. You would like to see this become a *SEASONAL CLOSURE AREA*, too. At least you would be unhappy to see a tourist resort built on either Glory Island or Three-tree Island as consequent boating and sea-plane movements would endanger the turtles.

The anthropologists among you support the indigenous people in seeking a *PRESERVATION ZONE* at the south-western end of Three-tree Island.

5. Indigenous people

Your home islands are just to the south of Marine Park (Middle Section).

You have for centuries travelled by canoe among the islands and reefs of Marine Park (Middle Section) gathering eggs and catching birds, fish and turtles. These are still the main sources for your diet.

You point out that a special state law allows your people to continue gathering and hunting anywhere in marine parks to provide food for their own needs. You wish to take this opportunity to remind the public that the zoning system cannot legally take away that special right.

Centuries ago, your people had used fish traps at the south-western end of Three-tree Island. This is a site of particular historical value to you; so you wish to see a *PRESERVATION ZONE* set up there. You point out that anthropologists also need this site preserved in order to study the traditional fishing methods of your people.

In general, you feel that both professional fishermen and recreational fishermen are a threat to your traditional food supplies. *You do not favour large areas being made into GENERAL USE "A" and "B" ZONES or a MARINE NATIONAL PARK "A" ZONE* unless there are plenty of *Replenishment Areas* or *Seasonal Closure Areas* set up in these zones.

6. Tourist resort developers

Your case rests on two major arguments:

(a) You wish to develop a tourist industry which will attract many tourists from other states and from overseas. Thus you are bringing wealth to the region.

(b) You are making it possible for many people to come and enjoy the glory of the Great Barrier Reef without too much discomfort.

You argue that the international tourist, especially, is used to excellent facilities for accommodation, eating, drinking and travel. These needs can be met only by building a first-class resort on an island that is not far from Newhaven (which has an international airport). It must have calm, deep water close at hand for a boat harbour and also for a sea-plane landing area. Glory Islands seem to meet all these requirements.

You want access to some of the outer Reefs to take your visitors on snorkel trips or to moor landing platforms.

You would not be happy to have professional fishermen, spear fishermen, and shell collectors taking away the animals that make the area around your resort so attractive to tourists.

All your needs seem to be satisfied by having the reefs around the Glory Islands as part of a *MARINE NATIONAL PARK "A" ZONE.*

If, however, these reefs are in one of the *GENERAL USE ZONES,* you want *REEF APPRECIATION AREAS* to be established on them.

7. Alternative life-stylers

Your group lives on the mainland close to the area to be zoned; you sometimes take small boats out to the islands closest to the shore and fish, collect anything you think is artistic or useful from the flotsom washed up on the sand, and go swimming. You cannot abide anything which restricts your freedom . . . after all, you have set up your commune to escape from the regulations imposed by city and state governments further south.

Your interest would be best served by a large GENERAL USE "B" ZONE as you would then be able to continue fishing with rods, handlines (but you don't need or want spearguns), and you would not have to compete with trawlers or commercial fishermen — which you don't like. However, if the "B" zone is set up, you know you will have lots of tourists and other people coming into the area and ruining your favourite places. So you point out that you want restrictions close in to shore, perhaps leaving the outer reefs and areas for people with bigger boats, or who are organised by tourist operators. You rather approve of the scientific zones, as it restricts people, and some of you are ex-scientists anyway. Your group thus has an awkward decision — do you want to keep the area restricted to scientists and conservationists, or allow the free-for-all in a General use "B" Zone?

8. Chairperson of the meeting

You are a representative of the Park Authority which controls the Reef. You are to run this meeting and, with others from the Authority, make a decision about the zoning at the end of the meeting.

In general, you should:

- Have firm control of the meeting.
- Be seen as fair to all sides yet firm when you have made a decision.
- Be quick-witted to act decisively before problems get out of control.
- Be clear in your own mind (or have it written down before the meeting begins) how the meeting should proceed.
- Listen carefully to each case being put and ask questions to clear up details that were not fully explained by any spokesperson.
- Guide your Authority group to make the zoning decision.

Start the meeting by saying something like this: "I declare the meeting open. The purpose of this public meeting is to listen to the points of view of groups interested in the zoning of Marine Park (Middle Section). The Authority will consider these viewpoints when drawing up a proposed zoning plan and will then invite further comment."

Then remind each group of the order of presentation. (Decide for yourself the full order before the meeting and inform the groups.)

When the turn of each group arrives call out the name of that group and invite their spokesperson/s to come forward to present the case.

After all cases have been presented and spokespeople questioned, close the meeting by saying, "I thank all those who have put their case today and the audience, too, for their orderly behaviour. A public announcement will be made when the proposed zoning plan is ready for your examination."

Your Authority Group may then make its announcement, or wait until the following day, and then explain your decisions.

9. Secretary to the meeting

You are a representative of the Marine Park Authority at this meeting. Your job is to make sure that the main points of each interested group or person are recorded for consideration by the Authority Group.

To help you do this you could:

(a) Ask each spokesperson to provide a summary of main points for your use.

(b) Add to this any further point you consider important or which comes out in the questioning session following each speech.

(c) Record all speeches via a microphone on to a cassette tape. To help the various groups, record the points on the chalkboard or an overhead transparency as the speech proceeds. The groups can then revise the main points using your record, when the speakers are finished.

If any point is not clear, or you want more details, ask the speaker (through the chairperson) further questions.

Your record of the main points will be required when the Authority Group draws up a zoning plan.

You will be contributing to the Authority's decisions with your chairperson.

10. Graphic artist of the Authority Group

You have four main responsibilities:

1. Drawing up a poster to announce the public meeting.
2. Sketching various zoning ideas on the map of Marine Park (Middle Section) at the meeting.
3. Helping other members of the Authority Group to decide on zoning of the area.
4. Drawing up a map after the meeting showing the zones decided upon by the Authority Group.

The poster should give the following information:

NOTICE OF PUBLIC MEETING

The Marine Park Authority invites members of the public to present submissions and information relevant to the zoning of Marine Park (Middle Section). A PUBLIC MEETING will be held for this purpose at the TOWN HALL OF NEWHAVEN PORT on ..... (date) ..... beginning at ..... (time) .....

In zoning Marine Park (Middle Section) the Authority will be guided by its aims as stated in the Great Barrier Reef Marine Park Act of 1975: "The regulation of the use of the marine park so as to protect the Great Barrier Reef while allowing the reasonable use of the Great Barrier Reef Region."

11. Reporters (Radio and TV)

You are interested in reporting:

(a) The purpose of the meeting.
(b) The general attitude of each group.
(c) Only one or two of their main points.
(d) Any interesting events at the public meeting.
(e) Any clash of interests among groups.
(f) What the "Authority" plans to do next.

You may "broadcast" your report "live" from somewhere outside the classroom or you may tape it for playback later, and/or record the meeting on a video camera.

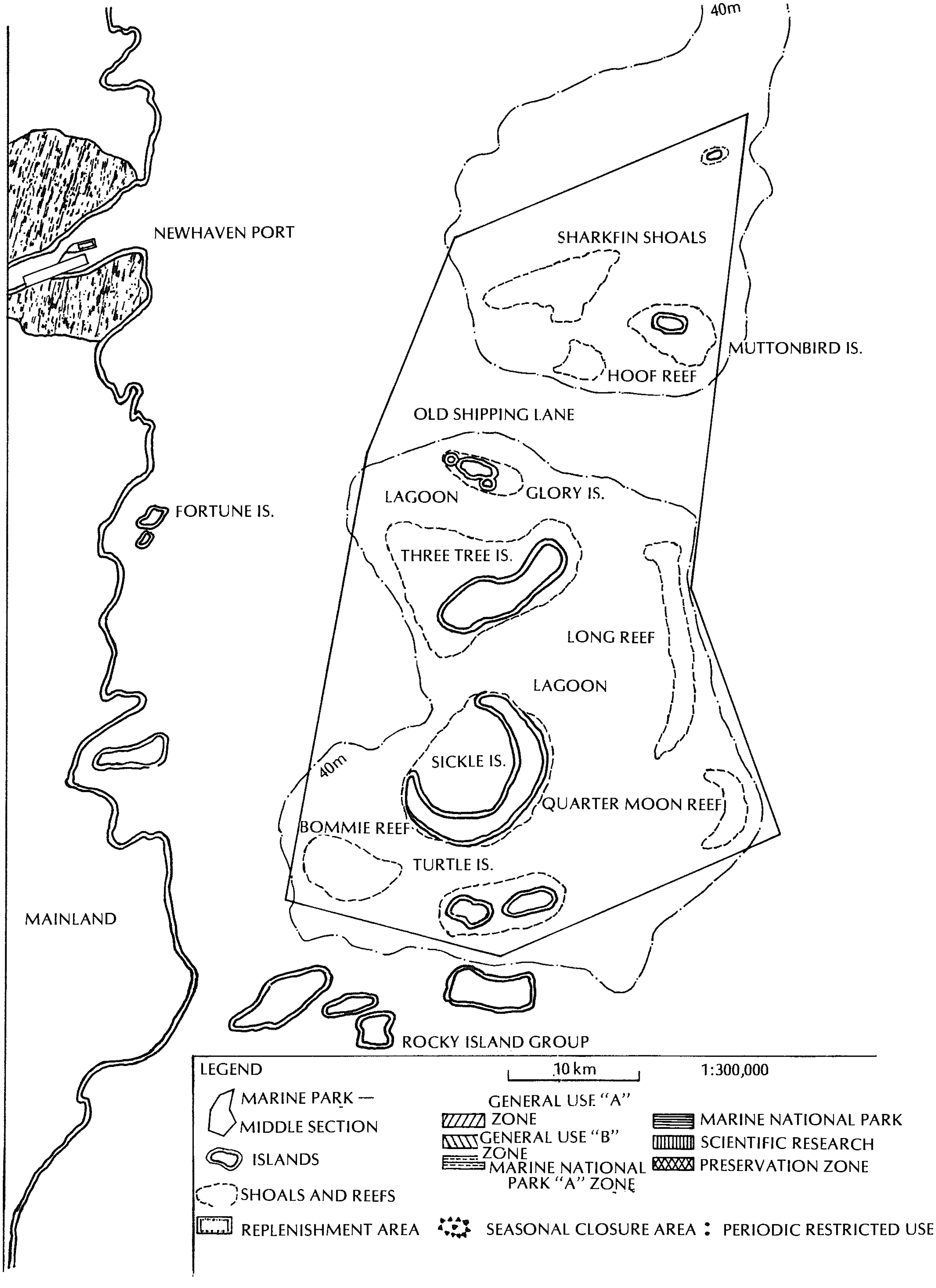
Your report will be made more interesting if you can capture short interviews with several of the leading figures at the meeting.

Learn how to use the tape-recorder and camera before you attempt to record your news broadcast. You should choose a recorder that has a *Pause button* and on which you can adjust the recording level by turning the *volume* control. Start each section of your broadcast with the volume on zero. Then release *pause*, fade up the volume to the required level, and record the section. After recording the section, fade volume to zero quickly, then press *pause*. Repeat this procedure for each section. In this way you will avoid annoying clicks and groans between sections.

Have someone else introduce your broadcast by saying: "This is (choose a suitable station name) News. We are now crossing to Newhaven Port for a report by our roving reporter (your name)."

You could present a newspaper report after the meeting reporting on the main decisions. Display it on the wall.

Fig. 143.1. *Map of Marine Park Section to be zoned.*



ZONES: (TO BE PLACED ON THE MAP BY THE "AUTHORITY")

144. Develop the island! 1-2 hr

Concepts
Evaluation
Development
Relationships
Environment
Planning
Simulation

Skills
Mapping
Expressing
Decision making

Aim

- To participate in an evaluation of resort proposals for an island within the Great Barrier Reef Marine Park.

You will need

- A copy of the news report for each student
- Copies of brochures from tourist authorities on Central Queensland resorts
- General resources on the Great Barrier Reef, including Reefnotes: Fringing Reefs (optional)
- Pen and paper

What to do

Various islands along the Great Barrier Reef under the planning control of the Great Barrier Reef Marine Park Authority may be released for resort development leases. One such island is "South Island". The two proposals are outlined in a news report from a local paper. Your task is to decide which of the proposals you would support. You will need to do some research into the facilities provided by various tourist resorts, and the effects those resorts have on the marine environment. Then you will have the opportunity of presenting your views.

There are three methods of using this simulation:

(a) Working as individuals, research the two proposals for the island development and reach a conclusion based on available evidence. Then cast a vote in a secret ballot as to the "best" development. The majority decision can then be discussed in the classroom.

(b) Working as individuals, prepare and write two "Letters to the Editor" expressing different views about the two proposals for developing a resort. The letters should include sufficient detail to provide logical support for your views. The letters can then be displayed in the classroom to act as a focus for class discussion.

(c) Groups of students can be allocated roles of various members of the public interested in the development of the proposed resort. Work in groups to draw up a case which can be presented to a panel in an open hearing. The class can then vote (in their roles) as to which proposal is preferred. Suggested roles include:

- The director of the Safari Resort Company
- The director of the Reef Hotel Pty Ltd
- The director of the Wildlife Preservation Society
- A representative of the local Parents and Friends Association; the Commercial Fishermen's Association; the Retail and Associated Trades Union; the local diving school; the Whitsunday Golf Club; Whitsunday Tourist Association; Outward Bound Association of Australia
- A representative from the following businesses: the local builder, a charter boat company, a nursery supplying plants, a charter sailing boat company, a helicopter company
- A representative from a local school using the island for hiking
- An officer from the Queensland National Parks and Wildlife Service; and from the Marine Park Authority
- The planning officer of the local shire council
- The scientific officer from the Australian Institute of Marine Science
- Local individuals (such as an artist, a potter, shopkeepers, waitresses, tourists, "hippies").

NEWS REPORT
Extract from the Whitsunday Bulletin, 10 December 1987
NEW RESORT PROPOSED FOR SOUTH ISLAND
by our Staff Reporter

It was announced today that two proposals for developing South Island are being considered by the Shire Council. Shire Chairman, Alderman Brown, said that Reef Hotel Pty Ltd wanted to build a three-star hotel, with eight lodges, accommodating over two hundred guests and employing about one hundred and fifty staff, near the site of the old jetty in Bauer Bay.

A spokesperson for the Safari Resort told our correspondent that his company wanted to put in twenty permanent tents with a central kitchen, dining and bar area at Camp Bay. "We will cause far less damage to the fragile fringing reefs and forests of the island than a large hotel," he said. "Where will a big resort get its water from? How is it going to stop the reef from being destroyed? If what we hear is true, they propose to transport their guests from the mainland in big helicopters, doing the locals out of their charter boat businesses. We are not into the big-time resort image."

The secretary of the local branch of the Preservation Society has strongly protested at the idea of a large land. "There are far too few good islands left in the Whitsunday Island Group," said Mrs Lucy Teague. "Why can't we have some natural spots of reef left for all of us to use?"

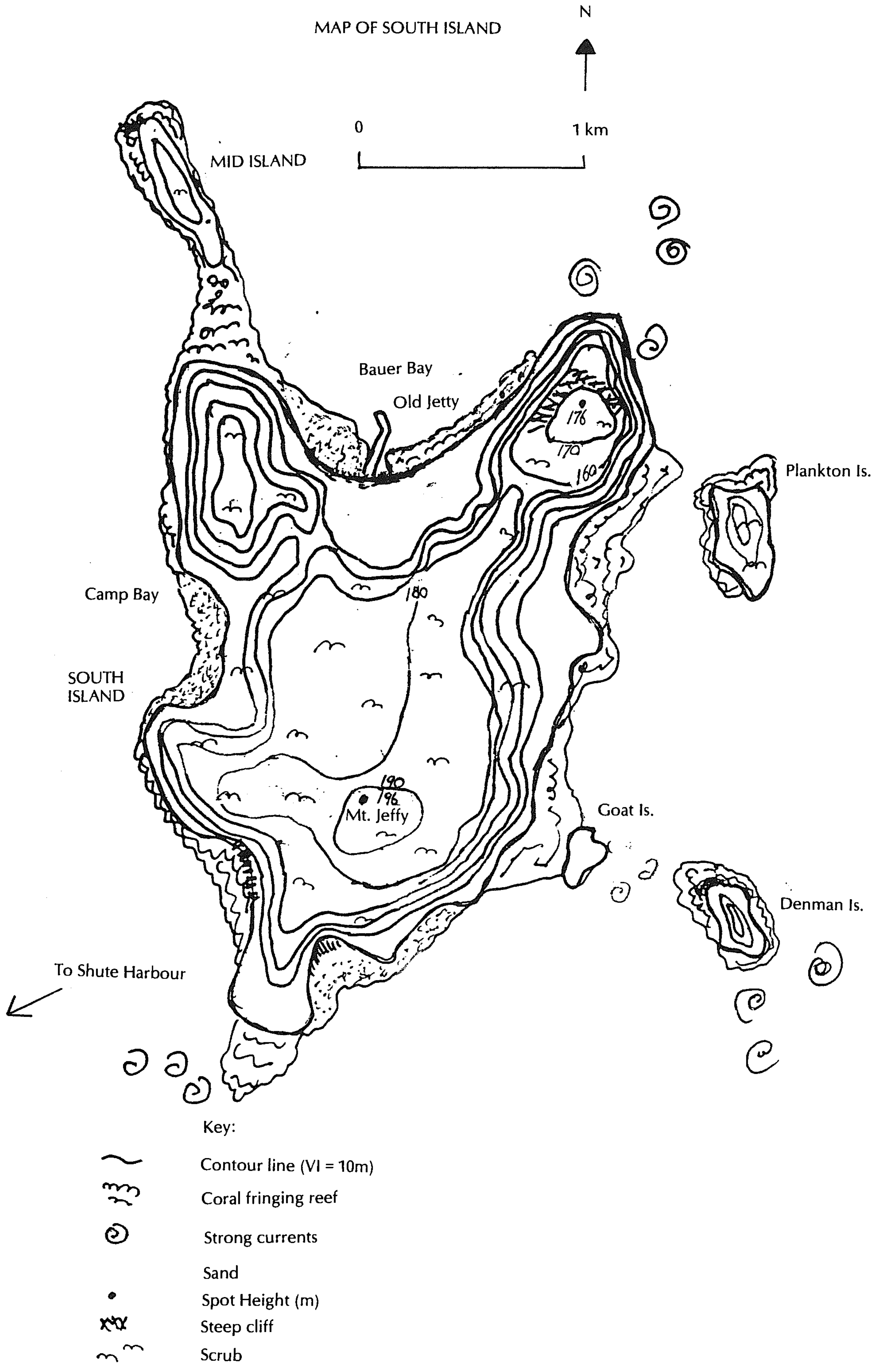
Paul Smith, secretary of the RSL, said from his office in Shute Harbour that his organisation was not prepared to see any development by any company with foreign interests, but he declined to answer any further questions put to him by our reporter.

The proposals are sure to create a lot of interest as South Island has not had any permanent settlement on it since 1960 when the fishing huts burnt down in a spectacular fire on Christmas Day.

Ideas for further things to do

If you want to find out more about what really occurred on this island, you can read the real name below. You could use the appropriate tourist brochures to see what the resort is like.

The island is really South Molle Island off Shute Harbour in the Whitsundays. It does have a large resort in Bauer Bay, a golf course, helicopter pad, and numerous walking tracks through a national park.


MAP OF SOUTH ISLAND
N
0
1 km
MID ISLAND
Bauer Bay
Old Jetty
176
170
160
180
Plankton Is.
Camp Bay
SOUTH ISLAND
190
196
Mt. Jeffy
Goat Is.
Denman Is.
To Shute Harbour
Key:
Contour line (VI = 10m)
Coral fringing reef
Strong currents
Sand
Spot Height (m)
Steep cliff
Scrub

145. Under the influence ¾ hr •

Concepts
Values
Decision making
Self-awareness
Empathising
Issue

Skills
Communicating
Cooperating

Attitudes
Interest in others
Interest in interactions between people and their environment

Aim

- To clarify your stance on an environmental issue.
- To explore the ways in which people try to influence decision making of others.

You will need

- Self-adhesive labels (stickers)
- Pens
- Large sheet of paper or blackboard

What to do

1. Identify two contrasting positions about a reef issue (e.g., should a new resort be established; should commercial fishing be banned).
2. Establish and record a basic list of factors for and against.
3. Place yourself (either by choice or chance) into a "pro" or "con" group. Wear a sticker designating your allegiance.
4. Each pro or con group has a set time (say, 15 minutes) to influence as many as possible of the other side to change sides (and stickers).
5. Discuss with the group the methods which were used to persuade or coerce people to change sides.
6. Do you know of instances when these methods have been used in real life? List some of these.

146. Am I willing to be committed? ½ hr ● ●

Concepts
Environment
Interaction
Human impact
Choice
Values

Skills
Decision making

Attitudes
Willingness to consider own point of view and evaluate alternatives

Aim

- To test your willingness to hold a particular point of view in a controversial issue related to the reef area you are visiting.

You will need

- Writing materials
- Reference materials if available

What to do

1. Think about some controversial environmental issues related to the reef area you are visiting. Some examples of issues you might think about are whether or not there should be:
    - A ban introduced on an island of sale of items likely to cause litter, e.g. cans, ice-creams on sticks.
    - A restriction placed on all island camping during the bird nesting season.
    - Expansion and upgrading of an existing island resort.
    - A ban on greater numbers of day trippers visiting an island and reef.
    - A ban introduced on all recreational fishing in the Marine Park.
    - Introduction of a fee for tourists using the Marine Park.
    - A limit introduced to the number of fish each recreational fisherman can catch each day.
    - Lifting of bans on shell collecting by reef tourists.
    - Restrictions of tourist visits to an island where turtles are nesting.
    - Building of floating hotels on the outer reefs.
    - Greater restriction of visits by snorkelling groups to Reef areas.
    - Encouragement of big game fishing in the northern reef area.
    - Continuation of the ban on spear fishing with scuba.
    - Development of a bêche-de-mer industry in the reef area.
    - Further restriction of reef-walking by tourists.
    - Progressive introduction of a ban on deliberate killing of reef creatures.
    - Reintroduction of petroleum industry exploration in the Great Barrier Reef region.
    - Bans on all collecting of live specimens by student groups.
    - Bans placed on development of all new tourist resorts on islands in the Reef region.
    - Catching in reef waters of whales and dolphins for dolphinariums.
    - Continuation of use (by large ships) of shipping channels between the Great Barrier Reef and the mainland.
    - Government controls on the activities of professional fishermen.
    - Payment of a fee to the government by anyone who wants to run an industry in reef waters.
    - Research and management of the Reef area.

2. Write a brief statement of one of these, or another issue which interests you. Make a note of where you stand on the issue.
3. Work through the following seven points to test how committed you are, and how strongly you really feel about the issue:
   (a) Have you made your choice freely, without help from others?
   (b) Have you considered alternative possibilities before deciding on your present viewpoint? What is good about the choice you have made?
   (c) Have you thought over the consequences of adopting this view? Who will benefit if the alternative you favour is adopted?
   (d) Does it personally matter to you? Are you proud of your decision?
   (e) Can you speak openly of your choice? Does your group agree .... or even know about it?
   (f) How far are you willing to go? Can you do something about your viewpoint? Are you considering joining others similarly inclined?
   (g) Do you consider your decision is consistent with your behaviour and lifestyle? Or is this a whole new area to you?

(This activity is freely adapted from *Values Clarification — A Handbook of Practical Strategies for Teachers and Students* by S. B. Simon (New York: A. & W. Publishers, 1978).

147. Showing off — 1-2 hr • •

Concepts
Programming
Tourist attitudes
Decision making
Heritage

Skills
Mapping
Planning
Evaluating

Attitudes
Appreciation of reef qualities
Tolerance
Empathy

Aim

- To select sites and activities on the Reef which could assist visitors to appreciate the worth of the Reef and the Marine Park.

You will need

- A map of the island and reef
- Paper and pen

This activity can be done at night or as a quiet activity after lunch.

> *The Great Barrier Reef Marine Park is unique in the world. It is the largest marine park in the world, and is the largest park situated within one country. It has an immense variety of plants and animals.*

What to do

1. You are required to convince a group of visitors, e.g. Japanese, that the area visited
   (a) is worthwhile keeping as a World Heritage area,
   (b) is contributing to the uniqueness of the Great Barrier Reef Marine Park.
2. Select at least three sites on and around the island you are visiting. You have to plan for a two-day visit by ten overseas visitors, only five of whom speak good English. Decide on the experiences you would provide for them. Would you need to do any activities with them?
3. Write out your program, using a format similar to the one below:

	High tide	Place	Activities
Day 1:	9.00 a.m.		
Day 2:	10.00 a.m.		

4. How could you find out what the visitors thought? Are their reactions likely to be different from those of Australian visitors?

148. Selecting a reef-walking area

Concepts
Environmental management
Criterion
Evaluation
Weighting

Skills
Evaluating
Communicating

Attitudes
Concern for maintenance of environmental quality

Aim

- To consider ways in which areas for reef-walking can be selected.

You will need

- Reef-walking gear
- Waterproof recording sheet
- Pencil and paper
- Ruler
- A map and/or aerial photograph of the reef-top you are visiting.

For this activity you will need one or two low-tide periods on the reef-top, plus one hour for follow-up.

Reef-walking is a popular activity in many parts of the Great Barrier Reef. Tourists and students go reef-walking in groups of about 10-30 under the guidance of a tour operator or teacher. But reef-walking areas need to be chosen carefully.
Everyone who goes reef-walking knows how easy it is to trample and break corals. The Great Barrier Reef is such a vast structure that human trampling does not pose a major threat to its survival. But in small areas visited by many people, the natural appearance of a reef-top can be spoiled very easily. Because of this, park management authorities recommend that people who plan reef-walks should follow certain guidelines to avoid too much reef damage.

What to do

1. Read the list below of reasons given for going reef-walking. Decide which of the reasons seems important and rank the others in order of importance to you. Compare your ratings with those of another person.
   A. Learning about reef environment.
   B. Appreciating the beauty of corals and other life forms.
   C. Communing with nature in an unusual setting.
   D. Carrying out research on reef environments.
2. (a) Obtain a map or aerial photo of the reef you are visiting. Visit two areas of the reef-top which you think might be suitable for reef-walking.
   (b) Suppose you were a tourist activity officer trying to decide which of these two areas would be better for tourists to visit. Compare the areas using the following yardsticks:
   - How accessible is the area?
   - How many people are already using it?
   - How easy it it to walk around?
   - What attractions does it contain that will satisfy the needs of reef-walkers?
   - How damaged is it at present?

   (c) Work with another member of your group to write a short report on each area, answering each of the above questions.
   (d) Mark the location of each area roughly on a map. Give each a mark out of 5 using the scale below:

Accessibility	Good 5	Poor 1
Numbers of people now using	Many 5	Few 1
Ease of walking in it	Easy 5	Hard 1
Attractions for visitors	Many 5	Few 1
Present damage	Great 5	Slight 1

   (e) Decide which area you think is most suitable for a new reef-walk.
   (f) Have a group meeting. Choose someone to act as a chairperson, and try to decide as a group which will be the new reef-walking area. Take a vote.

(g) As you do this, consider the following questions:
- Is each factor as important as the others? Do you think that some factors are more important? Which? Should the marking scheme be altered?
- Do you think that factors should be used other than the ones already considered? Should, for example, the age and physical ability of people be a factor?
- Do you think that more information about the areas is needed to make a choice? If so, what kind of information would you like to have?

Ideas for further things to do

3. For more information on a proposed reef-walking area, carry out a quick-look survey described in the activity no. 149, "A quick look reef-top survey".

Reading

Kay, A., and Liddle, M.T. 1985. Manual for assessment, location and design of reef-walking activities. *Technical Report of GBRMPA.*

149. A quick-look reef-top survey 2 hr •

Concepts
Survey
Management
Evaluation
Criteria

Skills
Observing
Recording
Evaluating

Attitudes
Appreciation of need for wise management of natural resources

Aim

- To carry out a quick-look survey of a reef-top area to help decide whether it is suitable as a place for reef-walking.

You will need

- Reef-walking gear
- Field sheet and pencil

You will need to do this activity at one low-tide period.

> *Imagine you are teachers or marine park rangers who want to find out about various reef-top areas to try to decide which are good places to take students or tourists for reef walks. How can you collect some information to help you make your decision?*

What to do

1. In small groups, carry out a quick-look survey of one or more areas on the reef-top, using the following method:
   Walk across the length and breadth of the proposed area at least once and record the following on the field sheet provided:
   (a) How many people seem to use the area?
   (b) What portion of the walk was:
   - difficult to negotiate
   - spent on corals (and/or other surfaces) that broke underfoot?

   (c) What proportion of the area do you estimate to be:
   - bare sand
   - sand dotted with isolated outcrops of living and dead coral and/or boulders
   - patchwork of sand pools, channels and expanses of coral
   - scattered coral rubble, shingle and boulders
   - a solid level surface with or without corals
   - continuous dead/live corals with/without sand pools?

   (d) What kinds of coral growth forms are mainly present (staghorn, plates, encrusting, hemispheres, microatolls).
   (e) What interesting mobile animals (seastars, fish, eels, crabs, etc.) did you see and how abundant were they (rare, common, etc.)?
   (f) If boulders were present, were there colourful or interesting animals underneath them?
   (g) Were live corals rare, average, abundant?
   (h) What proportion of corals were brightly coloured?
   (i) Did you see any signs of recent physical damage such as newly broken branches on colonies, live broken-off coral fragments or overturned colonies?
   (j) Using a rough sketch map of the reef-top, show areas where you see interesting features such as pools surrounded by branching coral, dense cover of finger-like corals and a flat pavement, extensive thickets of coral, etc.
2. Do you think the area is suitable as a reef-walking site for your groups? Why?
3. Compare your data with the data from other groups who have surveyed other areas. How are the areas different? Which of the areas seems the most suitable? What criteria should you use to help you decide?

FIELD SHEET

149. A quick-look reef-top survey

Site: ______________________________

(a) Number of people in sight: ______________________________

(b) Approximate proportion of walk
- difficult to negotiate: ______________________________
- breaking coral or other surfaces: ______________________________

(c) Approximate proportion of area (give %)
- bare sand: ______________________________
- sand and coral clumps: ______________________________
- patchwork coral/sand: ______________________________
- rubble and boulders: ______________________________
- pavement: ______________________________
- dead and live coral: ______________________________

(d) Coral growth forms: ______________________________

____

(e) Mobile animals: ______________________________

____

(f) Underboulder communities: ______________________________

____

(g) Live corals: ______________________________

____

(h) Proportion of colourful corals: ______________________________

____

(i) Recent physical damage: ______________________________

____

(j) Rough sketch map:

150. Getting permits — 1 hr • •

Concepts
Zoning
Permit
Criteria
Evaluation
Decision making
Resource management

Skills
Analysing data

Attitudes
Appreciation of need for wise management of natural resources

Aim

- To explore the permit system used in the Great Barrier Reef Marine Park.
- To consider how park management authorities decide whether or not to grant a permit to allow a particular activity to take place.

You will need

- Information provided
- Notebook and pen
- Copy of a Marine Park Zoning Plan
- Copy of Marine Park permit application form

Most human activities which are reasonable are allowed to take place in the Great Barrier Reef Marine Park. However, zoning plans for the Park mean that certain activities can take place only in particular areas. In the case of some kinds of activities, it is necessary to apply to park management authorities for a permit. Did you know that anyone organising an educational field trip has to get a permit?
To obtain a permit, you must provide information about your proposed activity to the Great Barrier Reef Marine Park Authority. You must abide by any special conditions laid down for your activity, and provide park management authorities with a written report about the activity afterwards.

What to do

1. Read the information on the zoning plan for a section of the Great Barrier Reef Marine Park. According to the zoning plan, what kinds of activities require a permit in this section of the Marine Park?
2. Imagine you are planning to organise an educational program in this section of the Great Barrier Reef Marine Park. Use a copy of the permit application form to show how you would make an application for your permit.

When a permit application is made, officers of the Great Barrier Reef Marine Park Authority take into account certain criteria in deciding whether to grant the permit. These criteria are listed in information sheet A.

3. How does the permit application you have written measure up against each of the criteria given in information sheet A? Exchange permit applications with another member of your group. Read the application as if you were a member of the park authority staff trying to decide whether to grant the permit. Write a list of brief comments about the application using the criteria in information sheet A as headings. Decide whether to grant the permit. Do you feel you need more information? If you grant the permit, do you wish to apply any conditions to it?
4. How do you think that having a permit system might help the Great Barrier Reef Marine Park Authority to conserve the Reef? Discuss with some other members of your group. Compare your ideas with the statements made by the Authority (information sheet B).
5. Do you think that having a permit system in the Marine Park is a good idea? Are there any disadvantages in such a system? Can you think of an alternative system?

Ideas for further things to do

6. Find out about regulations which cover a land-based national park near your home. Does a permit system apply? Would a permit system be useful there?
7. Look at a copy of a permit application form provided by the Great Barrier Reef Marine Park Authority. Is it clear? Do you think any questions should be added?
8. Obtain a copy of the report form which has to be filled out by people granted a permit to carry out an educational activity. How do you think the information gathered here might help the Marine Park Authority?
9. Because a number of government authorities work together in controlling the Great Barrier Reef area, it may be necessary to get more than one permit to conduct an activity there. Find out which authority is responsible for granting a permit to carry out the following:
   - Camping on an island national park in the Great Barrier Reef area.
   - Taking a party of students reef-walking and snorkelling in waters of the Great Barrier Reef Marine Park.
   - Carrying out research in the waters of the Great Barrier Reef Marine Park.
   - Conducting a research project on birds in an island national park.

INFORMATION SHEET A

150. Getting permits

Criteria for assessing applications for permits to use or enter the Great Barrier Reef Marine Park

When an application for a permit is made, park authorities, in trying to decide whether to grant the permit, ask how the proposed activity fits with each of the following:

(a)	The objectives of the zone to be used or entered.
(b)	The orderly and proper management of the zone to be used or entered.
(c)	The conservation of the natural resources of the Marine Park.
(d)	The existing use and amenity, and the future or desirable use and amenity, of the area and adjacent areas.
(e)	The size, extent and location of the proposed use in relation to any nearby use.
(f)	The likely effects of the proposed use on adjoining and adjacent areas and any possible effects of the proposed use or entry on the environment.
(g)	The proposed means of access to, and egress from, any use and the adequacy of provisions for aircraft or vessel mooring, landing, parking, loading and unloading.
(h)	Where the purpose for which the permit is required is research in a Scientific Research Zone: (i) the environmental impact of the research; (ii) the need for long-term conservation of the Great Barrier Reef; and (iii) the needs of other researchers.
(i)	Where the purpose for use and entry is traditional hunting or fishing — special criteria, which are indicated in the park regulations.

INFORMATION SHEET B

150. GETTING PERMITS

Statement from the Great Barrier Reef Marine Park Authority on the reasons for the use of permits
The Great Barrier Reef Marine Park Act 1975 provides for the establishment, control, care and development of a marine park in the Great Barrier Reef region. This is achieved by a number of methods including zoning regulation, and the use of permits. The use of permits will help the Great Barrier Reef Marine Park Authority to ensure the conservation of the Great Barrier Reef. The permit system allows the Authority to:

- collect data on activities which may become damaging to the Reef;
- impose, where necessary, limits on time and areas in which such activities may occur;
- separate potentially conflicting activities; and
- encourage responsible behaviour in all Reef users.

AUSTRALIA

GREAT BARRIER REEF MARINE PARK REGULATIONS

PERMIT

PERMIT NO. G86/148

Permission(s) is/are granted for the use and entry of zones in the Great Barrier Reef Marine Park in the following sections:

CAPRICORNIA SECTION

This/these permission(s) remains in force, unless sooner revoked, for the period:

19-SEP-86 to 27-SEP-86

in accordance with the details set out in Part A, and subject to conditions set out in Part B. (See reverse side)

Name: Mrs Janet OLIVER
St. Aidans School

Address: P.O. Box 46
CORINDA QLD
AUSTRALIA 4075

Signature: [signature]
Delegate of the Great Barrier Reef Marine Park Authority

Date of Issue: 2/8/86

PART A:

- Zones and locations to which the permission(s) apply/applies:
  MARINE NATIONAL PARK 'A' ZONE - Heron Island Reef
  MARINE NATIONAL PARK 'A' ZONE - Wistari Reef

- Purposes of use and entry authorised by permission(s):
  Conduct of an educational program - Senior environmental education camp at Heron Island Research Station

151. Following the rules 1½ hr

Concepts
Evaluation
Environment
Preservation
Management

Skills
Observing
Evaluating

Attitudes
Responsibility for conservation
Appreciation of need for wise management of natural resources

Aim

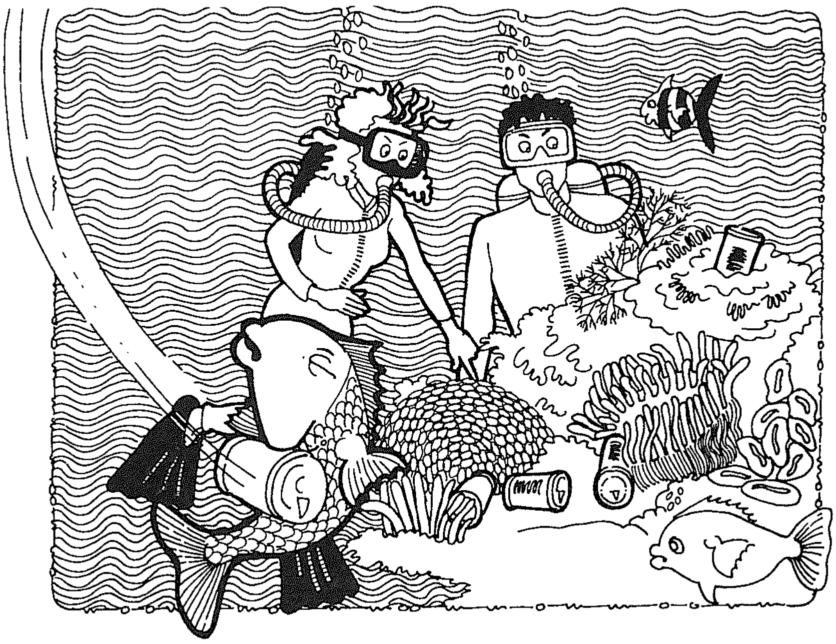
- To evaluate attempts by users of the Great Barrier Reef to minimise their impact by following Great Barrier Reef Marine Park and National Park regulations.

You will need

- Park regulations for the reef and island you are visiting

What to do

1. Review and make a list of regulations designed to contribute to the conservation of the Great Barrier Reef and its islands, e.g.,
   - no collection of species from land and water
   - no removal of vegetation
   - no discharge of rubbish or effluent
   - walking paths to be followed
   - no interference with biota
   - no litter dumping
   - no fires
   - no exotic animals or plants to be introduced
2. As you move around the island and reef, note whether visitors are following these regulations.
3. Discuss as a group what you should do if you see visitors breaking one of the regulations. What will you do about it? What if nobody else (e.g. a ranger, tourist operator or research personnel) is doing anything about this type of situation?



152. Do the right thing ½ hr •

Concepts
Human impact
Commitment
Values
Conservation

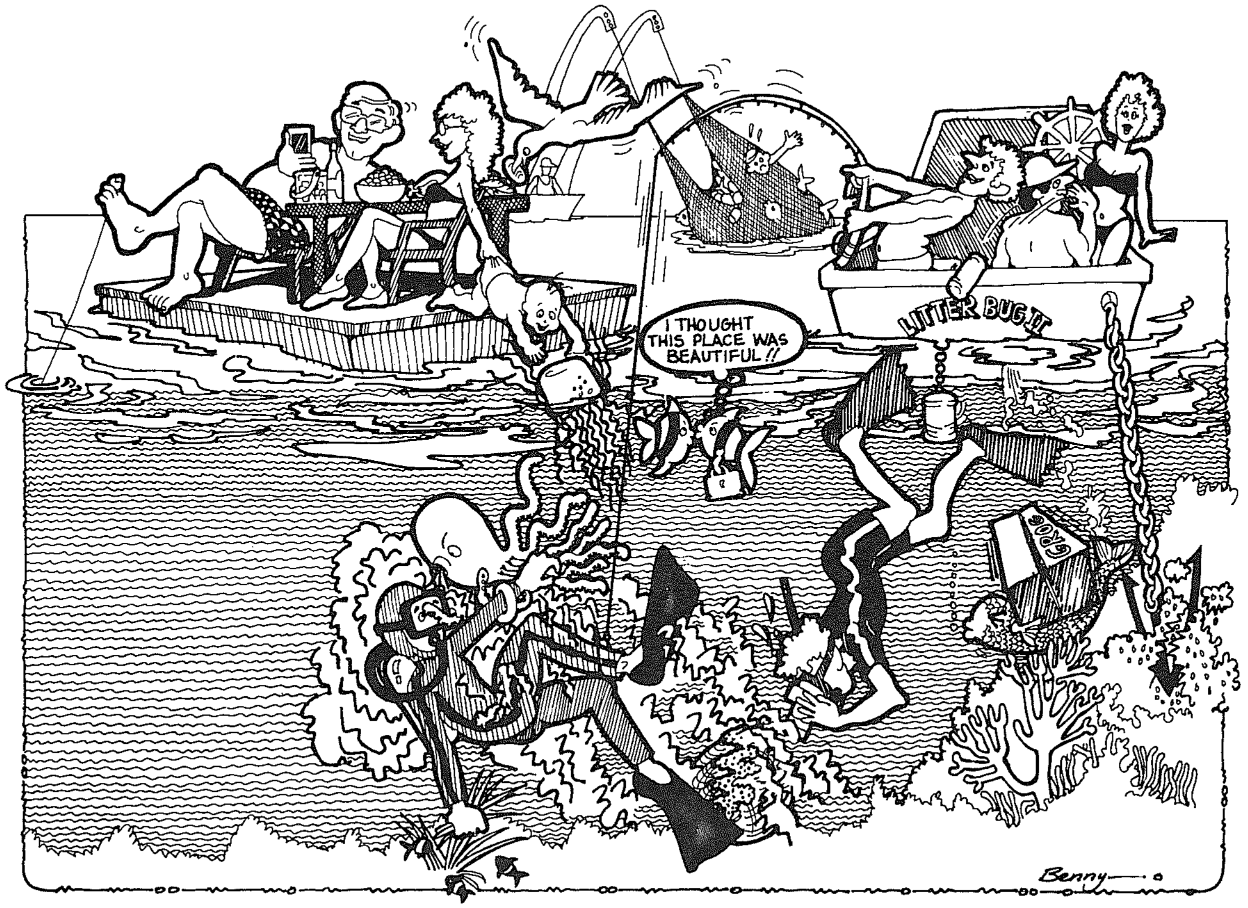
Skills
Interpreting
Applying
Valuing

Attitudes
Perseverence
Intellectual honesty
Appreciation of environmental qualities

Aim
- To consider one's commitment to conservation of the reef environments.

You will need
- Pencil and paper

What to do
1. Make up a set of guidelines for behaviour which you think all visitors (tourists and students) should be given on arrival at a cay. The guidelines could relate to the reef, the water, the island and the air above it. (An example of a possible rule: Don't use torches on beach at night in summer.)
2. List the reasons for each of the guidelines put forward (e.g. lights at night disturb nesting turtles).
3. Consider which of the guidelines should be compulsory for all to obey (i.e., rules), and which should merely be suggestions.
4. Which of the guidelines are you prepared to enter into a contract about? (Try the contract out for at least a day; amend if necessary.)
5. Think about the difficulties you encountered in adhering to the "rules" put forward (e.g. On a dark night, it's hard for visitors to find their way along the beach.)
6. Rank the "rules" in order of importance to you. Which ones would be hardest to obey if the "rules" become law?
7. Should visitor behaviour be monitored at the Reef? If so, how? Should your "rules" be enforced?



153. Ranger's work — 1 day •

Concepts
Management
Efficiency

Skills
Observing
Interviewing
Recording
Evaluating

Attitudes
Tolerance
Appreciation of need for wise management of natural resources

Aim
- To observe day-to-day management activities carried out by the Marine Park rangers.
- To consider how these contribute to the aims of the Great Barrier Reef Marine Park.

You will need
- Fieldsheet
- Pencil

Many of the coral cays found within the outer boundaries of the Great Barrier Reef Marine Park are Queensland island national parks. The waters and reefs surrounding the islands up to low-water mark are part of the Great Barrier Reef Marine Park. Marine Park rangers employed by the Queensland National Parks and Wildlife Service carry out the day-to-day management of the Great Barrier Reef Marine Park and the island national parks. Their activities include issuing permits for various activities, monitoring natural resources and human activities, and assisting people who visit the reefs and islands.

What to do
1. While you are visiting the island and reef, note the activities you see these rangers and officers undertaking. It may be possible for you to arrange to "follow a ranger" for a morning. Record your observations on the sheet provided:
2. Consider what you have recorded. What did you most frequently observe? Check with the rangers themselves — is this pattern normal? Does it vary at different times of the year? Do the rangers feel they should be doing something else or are they satisfied with their activities?

Ideas for further things to do
3. Read information leaflets on the Great Barrier Reef Marine Park and island national parks. Are the observed ranger activities matching the stated aims of the Great Barrier Reef Marine Park and of Queensland National Parks? Is the time of rangers well spent, in your opinion? Compare notes with other students to see what they think.

FIELD SHEET

153. Rangers' work

Complete the table as you observe a ranger at work.

Activity examples	*Number of rangers involved*	*Place*	*Day and time*
Providing leaflets, etc.			
Talking to the public			
Issuing permits			
Checking permits			
Giving slide shows			
Leading guided walks			
Replanting trees			
Taking people on boats			
Aerial reconnaissance			
Building paths, etc.			
Clearing up rubbish			
Looking after sick birds, etc			
Doing research, e.g. tagging fish			
Eradication of noxious plants, e.g. prickly pear			
Eradication of feral animals, e.g. cats, goats, rats			
Repairing equipment			

154. An island management plan 1½ hr • •

Concepts
Management
Environmental conservation
Resource management

Skills
Observing
Recording
Analysing

Attitudes
Interest in conservation

Aim

- If at Heron Island, to assess how a management plan for the island is working, or if at another island, to develop some ideas for future management of that island.

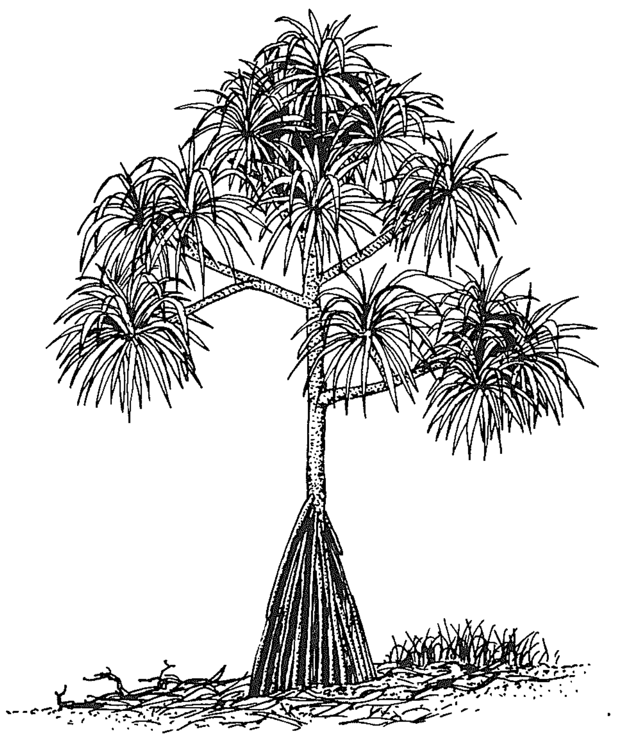
You will need

- Field sheets
- Pencil

What to do

In 1983, the various organisations with an interest in Heron Island met together and drew up a management plan to provide guidelines for management of the island. Joint committees were later set up to implement the plan and to coordinate the use and conservation of the island. Some of the guidelines and policies included in the Heron Island Management Plan are listed on the fieldsheets.

1. Read the list of guidelines and policies on the fieldsheets.
2. As you walk around the island during your field trip, keep your eyes open for anything relevant to the list. If you are not at Heron Island, decide which of the suggestions listed on the fieldsheets could be applied to the island you are visiting.
3. Which of the suggestions are actually being followed here? Which are being violated or ignored? Evaluate what you see.
4. If you are staying at Heron Island, decide how the management plan could be improved for Heron Island. Discuss with others.
5. If you are staying at another island, decide on some guidelines and policies which ought to be in a management plan for that island. Discuss with others.



Pandanus tectorius

FIELD SHEET

154. An island management plan

Standards for development on Heron Island

Design, landscaping and construction	*Could this suggestion be applied to the island you are visiting?*	*Being done?*	*Not being done?*	*Notes*
A. Designs and styles (a) Materials and styles to be aesthetically attractive in the island landscape. (b) Buildings to have external faces, finishes, shape and colours designed to visually break up massive features. (c) With the exception of the navigation-communication tower, all built structures to be of lower overall height than the tree canopy. (d) In consultation with Q.NPWS, designs to be modified wherever feasible to ensure minimum effects on the natural environment or wildlife. (e) All lamps to be installed with care, to ensure minimal scatter of light. (f) All lamps, other than those essential to navigation, to be fitted with time switches or screened completely to prevent illumination of the tree canopy and the foreshore or beach. B. Landscape and land use (a) All structural development be restricted to Development Zone areas as identified in the land-use zoning plan. (b) All new and replacement buildings to be hidden to viewing from the beach and reef flat. (c) All new and replacement buildings to be 30 metres inland from the mean high-water mark. (d) All construction proposals to incorporate specifications for surrounding landscaping and restoration works to be carried out. (e) Aerials and external antennae to be unobtrusive wherever possible. (f) Cable and pipe-runs between buildings to be buried by soil to a minimum depth of 60 cm below local ground levels. (g) New and replacement in-ground water tanks to be buried by soil apart from surface service manholes, to a minimum depth of 60 cm below local ground level. (h) The "alienated" or "sterile" surround to a building to be kept to a minimum, consistent with pathways and hard-standng areas.				

FIELD SHEET

154. An island management plan (cont.)

Standards for development on Heron Island

Design, landscaping and construction	*Could this suggestion be applied to the island you are visiting?*	*Being done?*	*Not being done?*	*Notes*
C. Construction work (a) No work involving potential interference with bird nesting or turtle nesting to take place between 1 October to 30 April. (b) All site work to be conducted with full consideration to minimising interference to the island's wildlife. Contractors to be fully briefed, verbally and in writing, of the various safeguards to be applied. (c) Site works to include restoration and landscaping of the surrounds to a natural uncompacted and vegetated state with delimited pathways and open-ground areas, damaged soil rejuvenated and indigenous shrubs or trees planted. D. Restoration — landscaping program (a) Demarcate tractor ways, footpaths, storage areas. (b) Remove all waste materials from Natural and Buffer Zone areas, including where necessary all items of buried junk, and return these materials to the mainland for disposal. (c) Clear all materials or equipment to appropriate areas. (d) Pull down the bull-dozed piles of *Pisonia* logs and use in C (c), D (a) and (f). (e) Construct suitable island-to-beach access paths. (f) Block off to traffic all excess pathways, turning spaces and storage areas. (g) Clean and dig over damaged soil areas. (h) Establish a nursery area of indigenous tree and shrub cuttings and seedlings. Plant trees and shrubs in restoration areas following D (b) and (c). Monitor changes in vegetation cover. Grass cuttings only allowed in the Development Zone (Resort). Leaf litter to be removed from buildings, pathways and hard standing areas only around resort.				

Reference

Queensland National Parks and Wildlife Service. 1983. *Heron Island management plan. Brisbane, September.*

155. Environmental impact statements 1½ hr • •

Concepts
Environmental impact
Environmental impact statement
Decision making
Development
Public participation
Matrix

Skills
Analysing data
Applying data
Evaluating

Attitudes
Appreciation of need for wise management of natural resources
Interest in social and environmental issues

Aim

- To consider some strengths and weaknesses in the way we use environmental impact statements to help maintain the quality of our environment.
- To explore the part which environmental impact statements can play in environmental decision making.

You will need

- Information sheets A and B
- Any published environmental impact statement (optional)
- Pencil

Suppose a new development is proposed in a sensitive area such as the Great Barrier Reef. If it seems likely to have significant (or controversial) effects on the environment, a government authority may rule that a Public Environmental Review (P.E.R.) or an Environmental Impact Statement (EIS) must be prepared. This can help in making a decision about whether the project should be allowed to go ahead or not.

An EIS is a report which consists basically of three parts: a description of the existing environment; an analysis of the proposed development; and an analysis of environmental impacts the proposed development will cause. The government authority which has to decide whether to allow a proposed project to go ahead is known as the determining authority. Its decision is made both by weighing up the material in an EIS and by taking other factors into account. Encouraging public participation in planning may be an important purpose of an EIS. Members of the public are usually given the opportunity to comment on the contents of an EIS. The federal government and the governments of various states have laws which allow environmental impact statements to be requested for some development proposals.

The Great Barrier Reef Marine Park is under the control of the federal government. The law which gives this government the power to request an EIS for new developments in the Great Barrier Reef Marine Park is the Environment Protection (Impact of Proposals) Act 1974. (Amended in 1987).

***(Note:** In most cases, this law does not apply to development proposals for islands in the Great Barrier Reef area because most of these islands are under the control of the Government of Queensland.)*

What to do

1. Read information sheet A and answer the following questions:

(a) What was the proposed new **development** mentioned in this newspaper advertisement, and where was it located?
(b) What do you think was the main **purpose** of the advertisement?
(c) Which government authority had responsibility for **determining** whether the proposed project would go ahead?
(d) How could members of the **public** get more information about the proposed project and make their views about the project known?
(e) Think about, and discuss with others, possible reef development proposals like the one mentioned in information sheet A. Make a list of some possible consequences (benefits and/or problems) which you think this kind of development might produce:
- possible social/economic benefits for community
- possible social/economic problems for community
- possible problems for natural environment
- possible benefits for natural environment

2. Use information sheet B to help you answer the following questions about Environmental Impact Statements produced for consideration by federal bodies such as the Great Barrier Reef Marine Park Authority.

(a) Federal authorities can request preparation of an EIS only for a proposal which involves the Australian government in some way. A list of the main types of developments which concern the Australian government are listed in paragraph 5 of information sheet B.

- Of which type is the Great Barrier Reef tourist industry development mentioned in the advertisement in information sheet A?
- Why do you think that the construction of new buildings on most resort islands in the Great Barrier Reef area does not require preparation of an EIS for federal authorities?

(b) Some people are surprised (or outraged!) to find that it is the person who proposes a new project who is responsible for preparing an environmental impact statement for consideration by a government authority.

- What are possible advantages and disadvantages of making the proponent responsible for preparing the EIS?
- Can you see any alternative ways is which an EIS might be prepared?

(c) In some places overseas, an EIS is prepared after plans for a new development are completed. Under the system used in Australia, an EIS is usually prepared while the plans for the new development are being formulated. Which of these two systems seem better to you? Why?

(d) The law which covers the preparation of environmental impact statements for the Australian government states that an EIS may be required in cases where a proposed development is thought likely to have a significant effect on the environment. The use of the word "significant" is regarded by many people as a major weakness of the law. Why do you think this word might pose problems?

3. Read paragraph 2 of information sheet B. (Any EIS related to the Great Barrier Reef Marine Park must cover all the areas mentioned in this paragraph.)

(a) Under the heading "Description of Existing Environment", what kinds of features do you think ought to be described in the EIS? Make a list of some general subheadings which the writers of an EIS could use under this main heading.

(b) How could the writers of an EIS get information for writing this section? What kinds of problems can you envisage in getting the necessary information?

(c) The EIS is meant to deal with the expected effects (or impacts) on the existing environment of the proposed development. Yet experts claim that such predictions are difficult to make in many cases. Why might it be hard to make predictions about the future effects of a proposed project?

(d) Why is it important that an EIS deal with alternatives to any proposed project?

(e) What are some kinds of environmental safeguards which might be included in a proposed development project on the Great Barrier Reef?

4. Often, Environmental Impact Statements prepared under federal law are used mainly to give members of the public some say in what is going to happen in an area.

(a) Do you think public participation in planning is worth encouraging in this way? Why?

(b) How are members of the public given a chance to review an EIS? (See information sheet B, paragraphs 8,9, and 10.)

(c) Do you think that these provisions are enough? How could they be improved?

(d) Some people think that an EIS should be a large, highly technical document containing as much relevant data as possible. Other people consider that the document should be brief and not too technical. What are the advantages and disadvantages of each approach? How could difficulties be overcome?

5. **Read paragraphs 14 and 15 of information sheet B. This makes clear that the Australian government does not always make environmental considerations an overriding factor in making its decisions.**
   (a) Do you think that environmental protection should be the overriding consideration when a development proposal is made for the Great Barrier Reef? Why?
   (b) Could future changes of circumstances affect your point of view?
6. **Try to obtain a published Environmental Impact Statement to look at.**
   (a) Peruse the index of the EIS and the rest of its contents. How useful do you think this material might be to members of the general community? For example, is it too technical or long? Is it detailed enough? (Old EISs are available from the Department of the Arts, Sport, the Environment, Tourism and Territories, or through state environment centres.)
   (b) Compare the contents of the EIS with the points mentioned in paragraphs 2 and 3 of information sheet B. Does your EIS contain all the necessary information?

INFORMATION SHEET A

155. Environmental impact statements

PROPOSED FLOATING RESORT FITZROY REEF OFF GLADSTONE, QLD.

Draft Environmental Impact Statement Public comment invited

The proponent, Mr Colin Soars, proposes to construct a floating resort and locate it in the lagoon at the Fitzroy Reef east of Gladstone. The resort will accommodate 3000 guests and 65 staff and will offer tourists a reef facility that will enable them to visit the reef in a controlled manner. The resort, which will be constructed in Bundaberg, will operate an underwater restaurant and two semi-submersibles as part of its activities.

In accordance with the provisions of the Commonwealth Environment Protection (Impact of Proposals) Act, a draft environmental impact statement which describes the proposed facility and its probable effects on the environment has been prepared by Mr Soars.

This document will be available for public review between 27 January, 1988 and 23 March, 1988

Copies are available for examination from:

Department of the Arts, Sport, the Environment, Tourism and Territories
2nd Floor, Colonial Mutual Building
University Avenue, Canberra City, ACT 2601. Phone (062) 46 7358

Environment Centres in:
Rockhampton, Sydney, Melbourne, Brisbane, Adelaide, Perth, Hobart, Darwin

Public Libraries in Gladstone, Rockhampton and Bundaberg.

The Great Barrier Reef Marine Park Authority, 61-71 Denham Street, Townsville, Qld. 4810

City Council offices at Gladstone, Rockhampton, Bundaberg

Australian Conservation Foundation, 672B Glenferrie Road, Hawthorn, Vic.

State Libraries in Sydney, Melbourne, Brisbane, Adelaide, Perth, Hobart, Darwin

Copies of the draft environmental impact statement may be purchased for the sum of $20.00 (post included) from:

Johnson and Tennent
Public Accountants
248 Musgrave Street
N/Rockhampton, Qld. 4700

BY POST
Applied Design
Box 5752, Rockhampton Main Centre, N/Rockhampton,
Qld. 4702

Interested persons and organisations wishing to comment on the environmental impact of the proposals are invited to make written submissions by 23rd March, 1988 to:

The Secretary
Department of the Arts, Sport, the Environment,
Tourism and Territories
PO Box 787, Canberra City, ACT 2601
ATTENTION: Mrs J. Tomkins (062) 46 7411
Environment Assessment Branch

The Commonwealth Government will undertake an environment assessment of the proposal. All submissions will be forwarded to the proponent to be taken in to account in the preparation of the final impact statement. Submissions will be treated as public documents unless confidentiality is requested.

Source: Courier-Mail, January 1988.

INFORMATION SHEET B

155. Environmental impact statements

Commonwealth EIS law and procedures

1. ***The Australian Environment Protection (Impact of Proposals) Act (1974) aims to make sure that environmental matters are thoroughly considered when the Australian government makes decisions. Under this law, the Australian government can make use of ENVIRONMENTAL IMPACT STATEMENTS and/or it can set up ENVIRONMENTAL ENQUIRIES.***

2. **What is an environmental impact statement (EIS)**
An EIS is a report which describes the likely environmental impact of a proposed new activity or development. An EIS first gives reasons for the new activity and then describes the activity, the existing environment, and the effects on this environment expected to result from the new activity. Alternatives to the proposed action (including the alternative of doing nothing) and their likely environmental effects must be put forward and compared. Finally, measures proposed to protect the existing environment should be described in the EIS (these are called safeguards).

3. **What environmental factors may be considered in an EIS?**
These include factors such as: Natural factors — air, water, land and minerals; animals, birds and fish; trees, plants and grasses. Material factors — buildings, machines and products. Social factors — health, employment, community, shelter, recreation and privacy.

4. **In what cases is an EIS required?**
The Australian government requires that an EIS be written for any proposed new activity which:
(a) falls within the jurisdiction of the Australian government and which
(b) is likely to have a significant or controversial effect upon the environment.

5. **Can the Australian government require an EIS to be prepared for any proposal in Australia?**
No. The Australian government can request an EIS only for proposals which come within its constitutional jurisdiction. Most of these are proposals which:
(a) are to be completed by, or on behalf of, or in conjunction with the Australian government, or
(b) require the approval of the Australian government, or
(c) involve the spending of Australian government funds.
This means that most types of private development, and most local and state government actions are not subject to Australian government EIS requirements.

6. **What are some types of project proposals about which an EIS might have to be prepared for the Australian government?**
There are three main categories involved:
(a) Construction projects — including buildings, bridges, roads, railways, regional growth centres and redevelopment schemes, academic and research institutions, airports, shipping facilities, and defence and sometimes industrial facilities — where these are funded wholly or in part by the Australian government.
(b) National policy initiatives — including the operation of supersonic transport aircraft into Australia, changes to taxes or subsidies, Australian participation in international agreements, and changes in levels of protection afforded different industries — where these are the constitutional responsibility to the Australian government.
(c) Export and import proposals — including foreign capital, minerals, woodchips and some other primary products — where these require Australian government approvals.

7. **Who prepares an EIS?**
The initiator of a proposal for development is responsible for preparing the environmental impact statement. In some cases, the proponent has suitably qualified staff who can write impact statements. Often, however, the proponent uses the services of specialist consultants, either to write the EIS, or to make expert contributions to it.

155. Environmental impact statements (cont.)

8. How is an EIS reviewed by the public?
A draft EIS is prepared and then is usually made available for written comment by members of the public. Copies of the comments are supplied to the proponent, who then has the opportunity to amend the original proposal by incorporating public comment, criticism, and suggestions. A final EIS is then produced, forwarded to the department for assessment, and made available to the public. For a small proportion of EISs, the environmental impact will be sufficiently significant to warrant a public enquiry being set up.

9. How do members of the public get to know that a draft EIS is available for comment?
When a draft EIS has been prepared an announcement is made in the Australian government Gazette and in local, state, and national newspapers. The advertisement includes a summary of the proposal, details of where the draft EIS can be obtained and/or read, and an address to which comments should be sent.

10. How much time is the public given to comment on a Draft EIS?
From the date of appearance of the first advertisement, at least four weeks has to be allowed for public comment.

11. What are the reasons for getting public comment if an EIS has been written by "experts"?

- People who prepare impact statements often do not live in the area affected by a proposal, or are not thoroughly familiar with it. Local residents can draw attention to factual errors in, and omissions from, an impact statement which may arise from this lack of direct local knowledge.
- Because many environmental assessments involve value judgements, an EIS may also contain judgements of local factors which do not reflect the views of local residents.
- In addition, some technically expert members of the public may not agree with the evaluations and assessments of the authors of an EIS.
- Any member of the public has a right to comment on environmental matters, whether or not that person has any technical qualifications.

12. What is the final environmental impact statement?
A final EIS is a document which is prepared after comments on the draft EIS have been reviewed. The final EIS summarises the information and comments on the proposal which has been received through review of the draft EIS (and, where applicable, through a special public enquiry). The final EIS is released for public information before a decision is taken on the particular proposal.

13. Who assesses the final EIS?
It is usually the Department of Arts (or other responsible government authority) which assesses te final impact statement.

14. If an EIS has been prepared, does this mean that environmental quality will be maintained?
Not necessarily. Environmental considerations are not an overriding factor in the making of Australian government decisions. In some circumstances environmental considerations will be overriden by other factors which the Australian government considers more important.

15. How does the preparation of an EIS help protect the environment?
Having to prepare an EIS forces the proponent to study and take environmental factors into account from the earliest stages in the designing of a new proposal. The preparation of an EIS also encourages a proponent to examine possible alternatives to the action proposed, and to compare the relative environmental impacts of these alternatives (including the alternative of doing nothing.) A proponent must also develop, where appropriate, environmenal safeguards. Because they are included in an EIS, these safeguards, including procedures and designs, are subject to public check and criticism.
In addition, an EIS presents the government with comprehensive information about environmental impact; this helps it to make a decision. It enables the public to argue a case publicly, to have that case published, and to force the government to justify its decisions.

156. What impact? ¾ hr + • •

Concepts
Interaction
Environmental impact
Liability
Benefits
Matrix

Skills
Analysing data
Applying data
Evaluating

Attitudes
Appreciation of need for wise management of natural resources
Interest in social and environmental issues

Aim

- To prepare a statement of possible environmental impacts of a hypothetical Great Barrier Reef tourist development.

You will need

- General reference books which depict and describe Great Barrier Reef environments (optional).
- Pamphlets, booklets or other material which depict or describe tourist activities and facilities in reef areas (optional)
- Pencil and rough working paper

> *An environmental impact statement is a document which is prepared to help government bodies make decisions about whether a proposed new development such as a road, building, resort or harbour work should be allowed to go ahead. It describes the existing environment and analyses the proposed development and environmental impacts it will cause.*

What to do

1. In some environmental impact statements, the impact of a proposed development project has been summed up using a grid.
2. The grid is basically a checklist of all the possible interactions between:
   - the activities of the project, and
   - the factors of the environment which may be changed.

   These interactions are the effects or impacts.
3. The worksheet briefly describes a hypothetical proposed tourist development on the reef. Make up a grid listing probable factors of the environment and actions of the proposed project. Mark the boxes on the grid to show possible impacts of each "Project Action" on each "Environmental Factor". Discuss your ideas with others in small groups.
4. Discuss with others your assessment of the overall impact of the project. On environmental grounds, do you think it should be allowed to go ahead? Are there other considerations that should be taken into account? What information is needed to do this with a greater degree of accuracy?

Readings

Australian Conservation Foundation. 1975. *The EIS technique* Melbourne: ACF.
Gilpin, A. 1980. *Environmental policy in Australia.* St Lucia: Univ. Queensland Press.
Great Barrier Reef Marine Park Authority. 1988. *The Four Seasons Barrier Reef floating resort: an information brief.* Townsville, GBRMPA.
Fisher, D.E. 1980. *Environmental law in Australia.* St Lucia: Univ. Queensland Press.
Pigram, J.J., and Soles, C.V. 1976. *Enviornmental impact analysis and resource management.* Australian Geographer 13(4): 255-64.

WORKSHEET

156. What impact?

Imaginary proposed development on Great Barrier Reef
Imagine that a developer has proposed setting up a floating hotel to accommodate 20 people for week-long diving and fishing holidays near an outer reef in the Great Barrier Reef Marine Park north of Cairns. The hotel will be serviced regularly by boat and by daily seaplane flights. It will be moored about 500 metres from an uninhabited sparsely vegetated cay which is frequented by birds and turtles. What will be its environmental impacts? The impacts can be shown on the matrix below.

Using the matrix to show impacts
What kinds of actions will this proposed project involve? What are some of the existing characters of the environment? Discuss these questions with others. Then make lists of project actions and environmental characters along the top and side of a matrix. Using the symbols on the key, mark the boxes on the matrix to show possible impacts of each project action on each environmental character. Impacts are interactions between actions and environmental characters. Show the impacts you think most likely. (You'll have to use some guesswork!)

PROJECT ACTIVITIES

ENVIRONMENTAL FACTORS														

Key
O No interaction likely
* Minor beneficial impact
* * Major beneficial impact
– Minor detrimental impact
= Major detrimental impact

157. Follow a scientist ½ day •

Concepts
Science
Investigation
Research
Ecosystem
Place

Skills
Observation
Using research methodology
Communicating
Evaluating

Attitudes
Curiosity
Interest in scientific enquiry

Aim

- To learn about research methods on the Great Barrier Reef.

You will need

- A person carrying out scientific research
- Pencil, notebook and paper
- Camera (optional)

What to do

1. If you are staying at an island where reef research is being carried out, contact a scientist or research assistant and find out if he or she is agreeable to your following and observing him or her for about half a day. (At a research station, the arrangements should be made through station management personnel.)
2. Do some preliminary reading on the scientist's project, if available, and draw up a list of questions you want to have answered, e.g.,
   (a) What are the aims of the project?
   (b) How much field work needs to be done?
   (c) Who is providing funds to support the project?
   (d) What equipment is needed?
3. Observe the places visited, and note the activities at each.
   (a) Why are these sites selected?
   (b) Is the project an ongoing or short-term one?
   (c) Is it related to any topics you study?
4. If possible, take photos of aspects of field work or lab work carried out as part of the research project.
5. Describe the project as you see it.

158. Were you lucky enough? •

Concepts
Individual responsibility

Skills
Observing
Recording
Mapping

Attitudes
Responsibility
Interest in scientific enquiry

Aim

- To develop a feeling of responsibility for observations and to understand that everyone's observations are needed to contribute to the scientific research in this immense, unpopulated Reef region.

You will need

- Notebook and camera at the ready.

> *This is an activity everyone can be involved in. Keep your eyes peeled all the time you are visiting the Reef region and make careful observations if you come across any of the following. These observations are all vital to marine research, so the better your observations, the more you are contributing to posterity.*

What to do

1. **Whale watch**
   Humpback whales migrate along the east coast of Queensland — north from April to September and south from September to December. Sightings of humpbacks have increased over recent years. It is important that all sightings be recorded in as much detail as possible. Sightings also have been recorded of the rare blue and southern white whales as well as the minke.
   Reports can be made in writing to:

   Dr R. Paterson
   P.O. Box 160
   ANNERLEY QLD 4103

   All reports will be acknowledged.

2. **Crown-of-thorns**
   The crown-of-thorns starfish eats live coral polyps. During the last twenty years there have been large increases in populations of crown-of-thorns starfish in some areas of the reef. Where this has happened the starfish have seriously affected the reef. There is still a great deal of argument as to whether this is a natural phenomenon or is caused indirectly by interference with the natural system in some way. It is important to find out what is happening, where and why, so if you see any crown-of-thorns starfish on the reef, please send reports to:

   Great Barrier Reef Marine Park Authority
   P.O. BOX 1379
   TOWNSVILLE QLD 4810

   Numbers, size, position and distribution should be included in your report.

3. **Tagged fish**
   The Great Barrier Reef is zoned as a multiuse marine park. In certain areas, commercial fishing takes place, in others only recreational fishing is allowed, and there are also sections where no fishing at all is allowed. A continuing research program monitors fish populations in order to keep a constant check that areas are not being overfished. This program involves tagged fish.
   If you find a tagged fish, it is most important to return the tag to the address on the tag or to:

   Queensland National Parks and Wildlife Service
   P.O. Box 190
   NORTH QUAY QLD 4000

   Please note the site the fish was caught, the date and the place, as well as fish measurements and weight.

4. **Turtle populations**
Turtle populations are also carefully monitored and the Queensland National Parks Turtle Research Team are working on the islands every summer recording the number of female turtles laying, and tagging turtles. Through this research they hope to discover how often females lay, whether they always return to lay on the same island, and perhaps even where turtles disperse to during the maturing stage. If you are on an island where there are no turtle research staff, your records will be very important. Note the tag number of any tagged turtle you see. Wait until the female is laying her eggs before you try to get close enough to read the tag. Any other information you have from this activity should also be enclosed. Send information to:

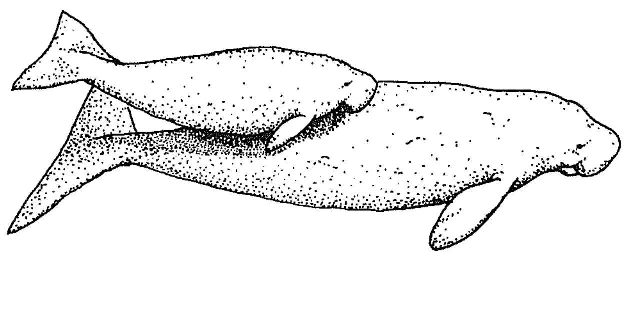
   Turtle Research
   Queensland National Parks and Wildlife Service
   P.O. Box 190
   NORTH QUAY QLD 4000

5. **Current drift cards**
Oceanographers are trying to determine the various currents in the region. One of their methods is to put out current drift cards. If you find one on a beach please return it to the address on the tag or to:

   Queensland National Parks and Wildlife Service
   P.O. Box 190
   NORTH QUAY QLD 4000.

6. **Introduced animals**
Cats, rats, goats, domestic birds. Some islands have some introduced animals living on them and the Queensland National Parks and Wildlife Service plans to cull these where possible. If you do see any introduced animals on islands you visit, please inform:

   Queensland National Parks and Wildlife Service,
   212 Quay Street
   ROCKHAMPTON QLD 4700



↑ Dugong

159. Researching the research 1½ hr • •

Concepts
Funding
Research
Science
Priorities

Skills
Analysing
Evaluating

Attitudes
Interest in science and society

Aim

- To explore the following questions related to scientific research on the Great Barrier Reef.
- How is a research project carried out?
- Who does the research?
- How are research topics decided upon?
- How do scientists communicate about their research to other scientists and to members of the public?
- Where does the money for research projects come from?
- What are some current areas of reef research?
- How can members of the public contribute to reef research?

You will need

- Information sheets A to D
- Pencil

- *In recent years, the Great Barrier Reef has been the focus of intense scientific research. The immense size and exciting diversity and complexity of the reef system have enticed many research workers to take an interest in the area. Since research findings are needed to help in making decisions about marine park planning and management, government funds have been made available for a wide range of research projects related to the reef.*
- *At the present time, many physical, chemical, biological and geological features and processes of the Great Barrier Reef are being explored. Land and sea areas, and their living things, are being studied. Both present-day systems, and past events, are under investigation. Humans, as well as non-humans, are being scrutinised. How people use the Reef in such activities as recreation, tourism, shipping and fishing are being looked at and the effects of use are being monitored and appraised.*
- *One vital task for scientific researchers is finding money to support their work. Since reef research often requires study in remote locations, and since boats and high-technology equipment are often needed, research may be very costly to carry out. So getting enough money is of special significance for these kinds of studies. Scientific research of all kinds in Australia has, up until now, largely been supported by funds from the public purse. But in recent years, government policies have placed steadily increasing pressures on research organisations such as universities to:*

(a) concentrate on research projects which seem likely to make a clear-cut and rapid contribution to solving our community problems,
(b) add to research funds provided by government bodies by obtaining additional money from other sources such as large corporations.

Although the second of these forces has not yet made itself felt to any extent in reef research, the influence of the first can be seen clearly in looking at the type of research being carried out today on reef topics. There is no doubt that science is an activity of immense importance for our society. By analysing reef research we can get an insight into ways in which scientists tend to go about their work in other fields of science. Many factors which influence the way scientific research is conducted in Australia today are illustrated by the pattern of research into reef areas.

What to do

1. **Introducing some research projects**
   (a) Information sheet A is a copy of a leaflet distributed to visitors at Heron Island Reef. It gives an outline of a research project being carried out on the reef. Read the sheet to answer the following:
   - What is the problem being investigated in the project described in the leaflet?
   - What do you think are the reasons this problem is being studied?
   - What experimentation or field work is being carried out here? What type of data is being collected?
   - Why do you think information about this project is being made available to members of the public?
   - Is information about the results of the project given in this leaflet? Why is this the case, do you think?
   - To what organisation(s) do the researchers mentioned here belong?
   - Make a list of some of the things which might have to be paid for to carry out a research project like this.
   - What do you know about the source of funds for this project?
   - What organisation(s) do you know to be involved in financially supporting this project? Why might this support be given?

   (b) Information sheet B is part of a summary of another research project concerning corals. Read the sheet and answer the following:
   - Do you think this summary is aimed at members of the general public or at scientists?
   - How does the style and tone of language used in this summary differ from the style and tone of language used in information sheet A?
   - What was the main aim of the research project summarised?
   - What were its main findings?
   - Why do you think the author has published this description of his work?
   - Comparing the research studies dealt with in information sheets A and B, which do you think would be more likely in the near future to influence procedures used in managing a coral reef?
   - Could the study mentioned in information sheet B make a contribution to the planning or the managing of a coral reef marine park? If so, how?

   (c) Information sheet C is an article from the Sydney Morning Herald, 14 March 1986, concerning a coral research project.
   - Compare the language styles and tones used in information sheets B and C. Why are they different? Does the newspaper article attempt to shape readers' attitudes to the research? How?
   - How do you think the research discussed in this article could make a contribution directly or indirectly to the planning or the management of a coral reef marine park?

2. ***Supporting reef research***
   Although people have recognised for a long time how important the Great Barrier Reef is, it was not until the 1970s that government money began to become available for large-scale research of the reef. A major factor in bringing about support for increased research was that members of the community became concerned that proposed drilling for petroleum in the Reef area might damage the Reef through pollution.
   The Australian government decided to set up the Great Barrier Reef Marine Park Authority and the Australian Institute of Marine Science, both with headquarters in Townsville. It set aside special funds for marine research. A high priority in allocating funds for marine research was given to the Great Barrier Reef.

The Great Barrier Reef Marine Park Authority has the job of planning and managing the Great Barrier Reef as a marine park. Its aims are to conserve the Reef while allowing reasonable use to continue. To make decisions about the park, greater scientific understanding of the region is needed. What kinds of human activities to allow, where and when are the kinds of questions which must be answered. The Authority needs research fundings which allow it to:

- *understand the "normal" state of the Great Barrier Reef;*
- *recognise changes from the "normal" state;*
- *respond to changes which may occur as a result of natural or human activities.*

The Authority is a major consumer of marine research. It makes use of the research findings produced by other government-funded organisations and uses its own funds to carry out research, or to support the research of others. By law, it is restricted in the kind of research it can pay for: the research must be related to the care and development of the Great Barrier Reef Marine Park.

The Great Barrier Reef Marine Park Authority is interested in research in the fields listed in the table below. Look at information sheet D, an extract from an annual report of the GBRMPA, and select an example of a research project which fits each of the categories shown in the table. Insert in the table the names of the research projects and the organizations which carry them out.

3. **Some issues to think about**
An issue is a topic about which people have significantly different views. The following are some issues concerning scientific research in Australia. Discuss some of these with other people and make brief notes about your conclusions.
(a) Who should have the major say in deciding what scientific research is carried out — scientists who carry out the research or those who provide the funds for the research? Think of some pros and cons for each idea.
(b) Should public funds be spent only on research which is clearly likely to be of benefit to our society? How does this issue relate to Reef research?
(c) In the case of the Great Barrier Reef, should all research efforts be concentrated on projects which might rapidly provide information needed to solve management problems, or are there advantages in also carrying out other types of projects?
(d) In general, should science be subjected to controls or limits which direct the progress of scientific research, or should scientists be free from interference or restriction in carrying out their work? (Control over funding is one way of directing research in particular directions —think of some other ways.)

References and readings

Baker, J.T. 1983. Research for management. In *Proceedings: Inaugural Great Barrier Reef Conference,* edited by J.T. Baker, pp. 473-74. Townsville, 28 August to 2 Sept. Townsville: JCV Press.

Gilmour, A., and Craik, W. 1984. Research for management. In *The Capricornia section of the Great Barrier Reef — past, present and future,* edited by W. Ward and P. Saenger, Roy. Soc. Qld. and Aust. Coral Reef Soc.

Table 159.1

Research area of interest to GBRMPA	*Example of relevant project in this area and organisation carrying it out (information sheet D)*
1. Great Barrier Reef Oceanography (To describe the dynamics of the waters of the region so that management can assess changes in processes and probable effects)	
2. Marine Geology and Geomorphology (To understand the processes which formed the Great Barrier Reef in order to place present-day changes in perspective)	
3. Marine Chemistry (To describe the chemistry of the waters of the region)	
4. Bathymetry and Survey (To provide detailed bathymetric charts and maps of the region)	
5. Marine Biology (To describe the ecosystems of the region in order to establish parameters against which deviations can be evaluated)	
6. Impacts of Use (To define users of the region and their purposes, and to record the intensity and frequency of usage)	
7. Management Strategies (To evaluate current and alternative strategies for management, consistent with conservation)	
8. Environmental Design (To specify uses of the region that are compatible with conservation of the resource)	
9. Socio Economic Analysis (To evaluate social attitudes and economic dependency upon uses of the resources of the region)	
10. Great Barrier Reef Data Bank (The establishment of a data bank about the region)	
11. Mechanics of Information Transfer (To communicate information from the data base)	

INFORMATION SHEET A

159. Researching the research

The zones of the Reef

Sand cays such as Heron Island have been formed by the movement of wind and water collecting sand at one point on a platform reef. The reef can be divided into a series of zones between the shore and the reef edge. Those areas exposed at low tide have a wide variety of coral forms and are the natural habitat for many kinds of invertebrate animals and fish.

Natural forces may damage corals. Storms and crashing waves break off branches, fish and seastars eat them and sudden downpours during a low spring tide may kill them. All these forces have been affecting the corals on the Great Barrier Reef for many thousands of years and a dynamic state has been achieved where the natural regenerative processes are balanced against the destructive ones.

Recently, however, tourists have been visiting the Great Barrier Reef in increasing numbers. This is a new ecological force in this habitat. Man is capable of breaking numerous coral colonies when he walks across a reef flat. However, no one really knows if the amount of damage caused by reef walkers is significant when compared to natural damage.

What are the project study plots?

Out on the reef flat opposite the resort are four cordoned off plots. They are designed to keep people from walking over certain areas. After several months or years, comparison of the coral within these plots with coral outside will tell us how the walkers are affecting this area of the reef.

Man and the Reef project

Mr Mike Liddle and Dr Alice Kay from the School of Australian Environmental Studies at Griffith University, Nathan, Brisbane are investigating the impacts of tourists on reef corals. These plots are part of that investigation. They are willing to talk about the project to anyone who is interested. They can both be contacted at Griffity University or at the Heron Island Research Station during their field trips.

This study is being financed by the Great Barrier Reef Marine Park Authority and is being run with the cooperation of the Queensland Marine Park Authority.

Help us by **not** *walking on these marked plots.*

INFORMATION SHEET B

159. Researching the research

Geographic Patterns in Coral Growth Rates on the Great Barrier Reef

Peter Isdale
(Australian Institute of Marine Science, Townsville)

Abstract

The mean annual growth rates of 100 colonies of the massive reef-building coral *Porites* from the Great Barrier Reef Province were measured using density band analysis. The corals were taken from two widely spaced transects across the continental shelf. The northern transect was near Cooktown, and the southern transect was near Townsville. Measurements were made on three species of *Porites* which have been shown to have similar growth rates. All colonies were collected from similar environments.

Corals from the northern transect grew consistently faster than those from the southern transect. Mean annual growth rates decreased with increasing distance from the mainland.

No continuous record of the growth of presently living organisms in a marine ecosystem competes with that revealed by x-radiographic analysis in the skeletal density patterns of some massive scleractinians. In as much as these patterns are modified by environments in which the corals grew, the spatial variations of growth is then a record of the distribution of the environmental variables which moderate growth.

Differences in the growth rates of coral skeletons in response to some important environmental variables have been investigated locally (summary in Buddemeier and Kinzie) but studies at larger geographic scales are few. Most recently, Hudson analysed the skeletal growth records of 144 colonies of *Montastrea annularis* from inshore, midshore, and offshore zones of the Key Largo Marine Sanctuary, Florida. That study showed that growth varied according to shelf locations: high growth occurred in midshore areas, the next lowest in the inshore zones, and the lowest annual increments in offshore locations. The width of the shelf area studied was, however, less than 6 km in extent.

The Great Barrier Reef Province is large and encompasses a wide range of climatic zones and water qualities, which also vary on a temporal basis. Consequently, large-scale or aereal growth rate comparisons are possible on contemparaneous corals. This paper reports such as analysis.

Extract from Isdale, P. 1983. In *Proceedings: Inaugural Great Barrier Reef conference*, pp. 327-30. Townsville. 28 Aug. to 2 Sept. Townsville: JCV Press.

INFORMATION SHEET C

159. Researching the research

Coral lets us look at weather of 1381

by Bob Beale

How many times did it rain in the Townsville area in January 1381? Was the Burdekin River shrivelled by drought or swollen by flood in 1720?

Until now, Australian meteorologists and historians would have laughed politely at such questions: detailed weather records of that sort just haven't existed.

Next year, however, the answers should be readily available in unprecedented detail as a result of an extraordinary discovery by Dr Peter Isdale and his colleagues at the Australian Institute of Marine Science.

Dr Isdale is confident that by then his team will be able to provide an amazing quantity and quality of information about northern Australia's recent climatic past by "reading" about it in the skeletons of the common dome-shaped *Porites* coral.

"Using our technology, you can pick out a piece of coral skeleton and know that you're dealing with the third week in January 1381," Dr Isdale said yesterday.

To prove the point, he can say with certainty that in 1750, long before Captain Cook reached the Australian east coast, the Burdekin River was in the grip of an awesome drought that lasted 19 years. In the mid-1830s, the region experienced a terrible wet season, an event recorded in story form by local Aborigines.

What Dr Isdale and his innovative technical team have discovered is that the *Porites* coral faithfully records fluctuations in its environment. It does so in much greater detail than the more familiar growth rings in trees, which provide reliable records only in temperate zones.

In Australian tropical waters the coral builds domes to a height of 10 metres. Cores taken from these domes are up to 1000 years old at their deepest point.

Dr Isdale found that the corals pick up decayed plant material carried out by coastal rivers, and incorporate it into their skeletal structure. Under ultra—violet light, these bands of material fluoresce, and can be counted and measured, indirectly revealing when and where rain fell.

With the help of a recent $380 000 grant, his team now expects by mid-1987 to be able to provide data for the whole of northern Australia, specifying month by month what the coastal sea-surface temperatures and rainfall patterns were for the past 500 years, and the drought sequence going back 900 years.

The new long-term data will have practical applications for such things as dam-building, bushfire control, meteorology, agriculture and water conservation, to name just a few.

Dr Isdale points out that *Porites* is the oldest-growing, has the finest internal skeleton, and has the widest distribution of all the corals. As such, the benefits of the discovery will flow on to the many Third World nations in the world's tropical belt.

He has found that the coral drought sequence pattern correlates closely with so-called El Nino events, the irregular outpouring of the warm South American El Nino ocean current that is thought to wreak climatic havoc in the South Pacific.

From Sydney Morning Herald, 14 March 1986, p3.

INFORMATION SHEET D

159. Researching the research

The program aims to evaluate the effectiveness of current and altemate strategies for the management of the Marine Park consistent with conservation of the resources of the area. Studies include risk analysis of activities that occur in the park such as shipping as well as reviews of the zoning plans to determine whether objectives are being met.

217 *Reef walking capability assessment
PROJECT LEADERS: Dr A Kay, Dr M Liddle (Australian Environmental Studies, Griffith University)

218 *Shipping risk analysis
PROJECT LEADERS: Prof K Stark, Dr M K James (Civil and Systems Engineering, James Cook University), Mr T Jenssen (Det Norske Veritas)

262 *Workshop on offshore effects of cyclone Winifred
PROJECT LEADER: Dr W Craik (GBRMPA)

263 The recreational usage of private boats in the Whitsunday Islands+
PROJECT LEADER: Ms W Goodburn (Geography, University of Sydney)
SUPERVISOR: Mr B O'Rourke

264 The Great Barrier Reef Marine Park: an appropriate management tool for the Australian Fishing Zone?+
PROJECT LEADER: Mr L Kriwoken (Centre for Environmental Studies, University of Tasmania)
SUPERVISORS: Dr P Hay, Dr B Davis

265 Planning study of the Capricornia Section, Great Barrier Reef Marine Park+
PROJECT LEADER: Ms D J Rosier (Regional and Town Planning, University of Queensland)
SUPERVISORS: Prof J Kozlowski, Dr G Hill

287 *Fringing Reefs Workshop
PROJECT LEADER: Ms C Baldwin (GBRMPA)

288 Fringing reef studies including fish study
PROJECT LEADERS: Mr S Domm (Q.NPWS), Mr R van Woesik, Mr A Steven

289 Review of research
PROJECT LEADER: Ms K Watson (Consultant)

133, 293 Monitoring Replenishment Areas: Stages 1 and 2
PROJECT LEADER: Mr K Beinssen (Q.NPWS)

312 Toward the development of a spatio - temporal atlas of the high island fringing reefs for the southern sections of the Marine Park+
PROJECT LEADER: Mr R van Woesik (James Cook University)

Chemical analysis of the Great Barrier Reef environment is necessary to determine the background concentrations and distributions of possible contaminants of the environment. This allows the assessment of impacts of pollutants such as organochlorine pesticides.

160 Analysis of soils from coral islands in the Capricornia Section of the Great Barrier Reef Marine Park+
PROJECT LEADERS: Chemistry students (Capricornia Institute of Advanced Education)
SUPERVISORS: Dr G Pegg, Dr J Hughes

236 *Particulate matter as an indicator of terrigenous and anthropogenic inputs to corals of the Great Barrier Reef+
PROJECT LEADER: Mr B Currie (Organic Chemistry, University of Melbourne)
SUPERVISOR: Dr R B Johns

282 *Investigation of the presence of chlorinated hydrocarbon residues in Great Barrier Reef birds+
PROJECT LEADER: Mr N Waldron (Australian Environmental Studies, Griffith University)
SUPERVISOR: Dr D W Connell

300 Waste water disposal guidelines
PROJECT LEADERS: Dr P Bell, Dr P Greenfield (Griffith University), Dr D Connell (University of Queensland)

There is a need for understanding of the processes which formed the Great Barrier Reef so that contemporary development and degradation can be placed in perspective. The research includes analysis of sediments, growth rates of reefs and study of the processes of degradation of senile reefs.

151 Biologic reef destruction - products, rates and causes
PROJECT LEADERS: Dr P A Hutchings (Australian Museum), Dr P J Davies (Bureau of Mineral Resources), Mr W Kiene (Geology, Australian National University)

152 Coastal processes forming and maintaining the coral cays of the Great Barrier Reef and their implications for Marine Park management
PROJECT LEADER: Dr M Gourlay (Civil Engineering, University of Queensland)

153 Stratigraphy of lagoon sediments and reef margins - Lady Musgrave Island
PROJECT LEADER: Assoc Prof C V G Phipps (Geology and Geophysics, University of Sydney)

155 *Role of *Acanthaster planci* in reef degradational processes – a preliminary study
PROJECT LEADER: Assoc Prof R Henderson (Geology, James Cook University)

156 *Modern sediment dispersal at the Burdekin River mouth (Pilot Study)
PROJECT LEADERS: Prof R M Carter, Dr D Johnson and Ms A Way (Geology, James Cook University)

193 Sedimentary setting of fringing reef at Donovan Point
PROJECT LEADERS: Dr D Johnson, Prof R M Carter (Geology, James Cook University)

195 *Terrigenous sedimentation and change on Low Isles since 1929+
PROJECT LEADER: Ms C Rasmussen (Geography, James Cook University)
SUPERVISOR: Assoc Prof D Hopley

196 Past, present and future changes in the Cairns urban coastline+
PROJECT LEADER: Ms J Spriggs (Geography, James Cook University)
SUPERVISOR: Assoc Prof D Hopley

232 Coral recruitment on fringing reefs near Cape Tribulation
PROJECT LEADER: Mr D Fisk (Reef Research and Information Services)

233 Monitoring of Cape Tribulation fringing reefs
PROJECT LEADER: Dr A M Ayling (Sea Research)

234 Effects of disturbed rainforest catchments on adjacent fringing reefs – Cape Tribulation++
PROJECT LEADERS: Assoc Prof D Hopley, Mr D Hoyal and Mr B Partain (James Cook University)

235 Townsville's urban coastline – past, present and future changes+
PROJECT LEADER: Ms J Spriggs (Geography, James Cook University)
SUPERVISOR: Assoc Prof D Hopley

314 The burrowing activities of *Callianassa* sp: geological and ecological implications+
PROJECT LEADER: Mr P Walbran (Geology, James Cook University)
SUPERVISOR: Assoc Prof R A Henderson

Studies of wave patterns, tides and currents in the Region allow better understanding of the processes by which larvae and pollutants are dispersed throughout the Region. Modelling work will allow better prediction of dispersal and the inter-connectivity of reefs.

119 Circulation and sediment movement on and around North Queensland bayhead fringing reefs
PROJECT LEADERS: Assoc Prof D Hopley (Sir George Fisher Centre for Tropical Marine Studies, James Cook University), Mr K Parnell (University of Auckland)

150 Flow modelling in the central Great Barrier Reef Region – a collaborative research project
PROJECT LEADERS: Dr J C Andrews (Australian Institute of Marine Science, Dr L Bode (Civil and Systems Engineering, James Cook University)

191b Installation of tide gauges: collaborative research
PROJECT LEADERS: Dr J C Andrews (Australian Institute of Marine Science), Dr L Bode (Civil and Systems Engineering, James Cook University), Mr T Savory (Bureau of Meteorology)

229 Establishment of remote weather stations on the Great Barrier Reef
PROJECT LEADER: Dr J C Andrews (Australian Institute of Marine Science)

230 Influence of coral reefs on wave attenuation and circulation
PROJECT LEADER: Dr I Young (RMC Duntroon)

231 Vertical and cross-shelf velocity structure of the tides of the central Great Barrier Reef+
PROJECT LEADER: Mr C Steinberg (Earth Sciences, Flinders University)
SUPERVISORS: Prof G W Lennon (Flinders University), Dr J C Andrews (Australian Institute of Marine Science)

302 Physical oceanography review
PROJECT LEADERS: Prof G Pickard, Dr J C Andrews (Australian Institute of Marine Science)

303 Coral spawning experiment (CORSPEX)
PROJECT LEADER: Dr E Wolanski (Australian Institute of Marine Science)

317 A LANDSAT approach to modelling sediment movement to determine the extent of influence on the Whitsunday fringing feefs+
PROJECT LEADER: Mr A Hoffenberg (Geography, University of Queensland)
SUPERVISOR: Prof K Lyons

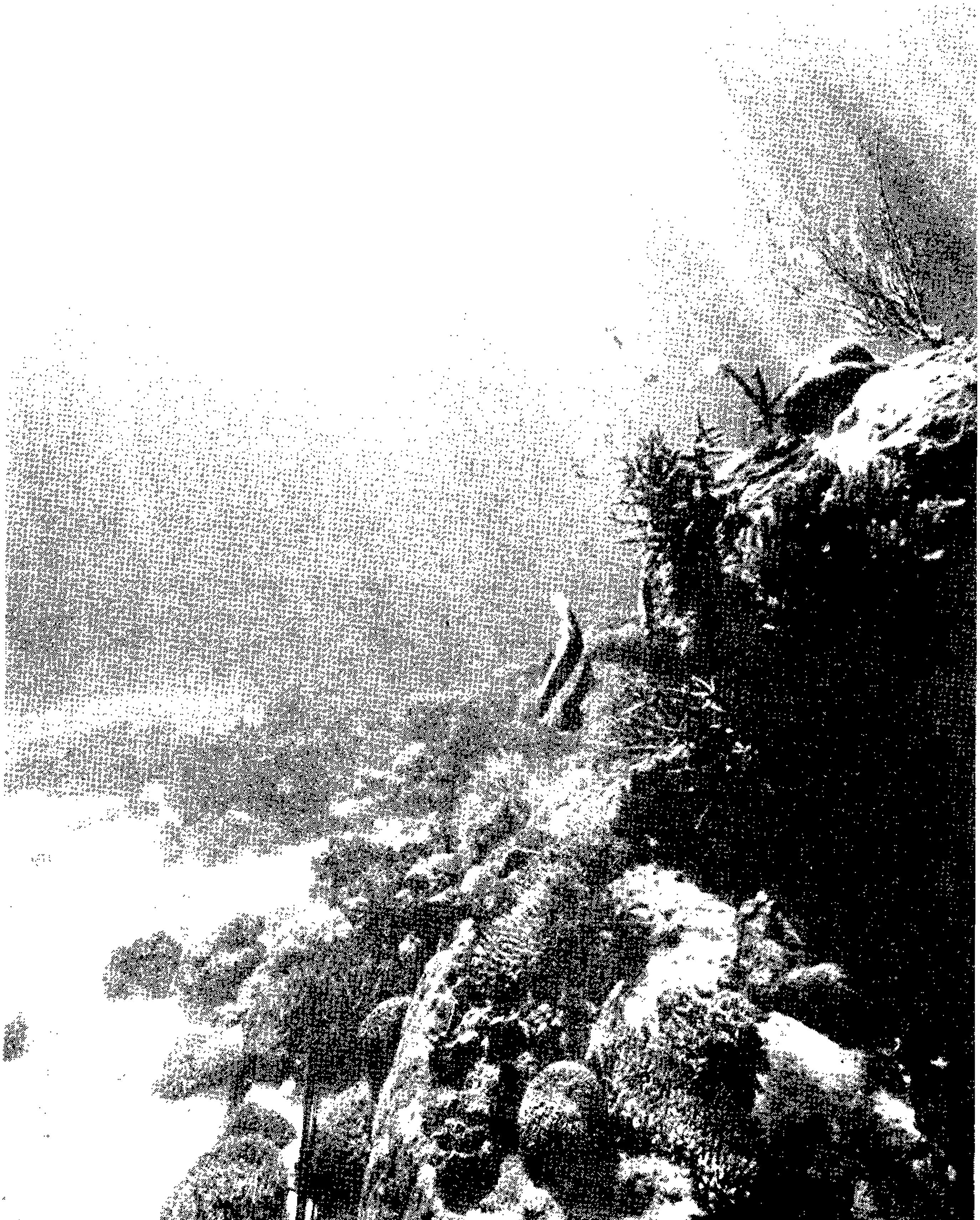
The objective of these projects is to provide detailed charts and maps of the Great Barrier Reef Region and to establish the ability of remote sensing to assist in classifying the area. Work has taken place using both aerial and satellite survey methods.

198 Spectrographic analysis of reef features
PROJECT LEADERS: Dr D Jupp (CSIRO, Division of Water and Land Resources), Dr D Kuchler (CSIRO, Davies Laboratories)

285 The Northeast Australian Satellite Imagery System (NASIS)
PROJECT LEADERS: JCU, AIMS, GBRMPA, CSIRO, Qld Department of Mapping and Surveying

286 *Australian Survey Office Reef Survey
PROJECT LEADER: Australian Survey Office

Appendix: REEF EDUCATION



REEF EDUCATION

Why focus on the Reef?

The Great Barrier Reef is a natural wonder of the world and one of the best known of Australia's scenic landscape features. Both a magnet for overseas tourists and a focus of pride and concern for Australians, it is now also being recognised as a powerful medium for education.

The outstanding aesthetic and scientific value of the Great Barrier Reef in itself makes the Reef worthwhile as a curriculum topic. As well, the Reef can be used as a case study exemplifying many fundamental geographical, biological and geological concepts and principles. It can highlight issues related to environmental impact of human activity, reconciliation of competing demands for natural resources, strategies of resource management, and processes of decision making and conflict resolution within the community at large.

A visit to the Reef can provide immensely satisfying social, physical and aesthetic experiences for students and can help them develop important skills and thinking abilities in the areas of enquiry, problem solving, creativity, social interaction, valuing and communicating. Environmental awareness and sensitivity, feelings of concern for the environment and willingness to participate in environmental improvement and protection can be promoted through activities at the Reef.

In a field setting, reef education can assist in the pursuit of many aims of existing school syllabuses, particularly those in science, geography, physical education and marine studies, but also those in areas such as history, art, music, English, legal studies, home economics and mathematics.

An important contribution to environmental education can be made through reef experiences. Students can be helped to acquire an awareness and understanding of the functions of natural systems, to develop field skills in investigation, to gain insights into the effects of modifying the environment and to develop an appreciation of the need to manage natural resources.

The IUCN's World Conservation Strategy (1980) and the National Conservation Strategy for Australia (1984) were important landmarks in the articulation of principles and objectives for living resource conservation. However, their conservation objectives can be achieved only if the behaviour of people towards the biosphere becomes transformed.

> *A new ethic, embracing plants and animals as well as people, is required for human societies to live in harmony with the natural world on which they depend for survival and well being.*
>
> World Conservation Strategy, Section 13, 1980

Environmental education has a vital task to perform in building support for conservation by fostering attitudes and behaviour compatible with this ethic. A significant part in this task can be played by reef education.

Why a reef field trip?

Although the Reef can be brought into a classroom using visual media, its full educational potential is realised only when students are given the opportunity to visit and explore it themselves. Ask anyone who leads student field trips to the Reef. There is something quite exceptional about the Reef as a learning environment. All the usual advantages of fieldwork in a natural setting are accentuated at the Reef, and an air of intense excitement and eagerness to learn pervades the whole group experience.

Like field trips to many other areas, reef trips can be beneficial in education in that they tend to:

- generate curiosity and enthusiasm among students
- help in concept formation by providing opportunities for first-hand experience
- help students understand, and develop skills in, ways in which environmental problems are investigated
- provide valuable social experiences as students share living and working together
- assist in development of physical recreation skills
- appeal to students' sense of adventure and exploration

A reef visit has special advantages:

- The exceptional clearness of the water and the beauty of the underwater scenery can provide students with a totally new way of viewing the world. Wonder, amazement and exhilaration are almost inevitably evoked. With appropriate supervision, even the most hesitant can find new self-awareness and confidence in snorkelling there. Attitudes of responsibility for the well-being of oneself and others can be fostered extremely effectively in that setting.
- The abundance and diversity of animal life which presents itself to a student is unparalleled. Movement and colour are everywhere. Forms of life such as corals, sea-cucumbers and coral fish, which a student may never encounter elsewhere in a natural setting, can be seen. To swim among schools of reef fish; to live at close quarters with nesting sea-birds on a cay; to watch fascinated on a summer night as a sea turtle lays her eggs in the sand; such intensely moving experiences may await a student who visits the reef.
- The sense of closeness to the sea and remoteness which comes from visiting a reef island helps students feel strongly the interconnectedness of people and their ecosystem. Staying on a cay makes everyone highly conscious of the material inputs and outputs of everyday human life. The small size of the island and its vulnerability to human intervention are conspicuously apparent. The variety of demands which humans may make on a natural system are brought most clearly into focus. Students are faced with the immediate necessity of making decisions about their own activity and its impact on the surroundings. Formulating and putting into action their own code of conduct, compatible with conservation, seems an almost inevitable and intrinsic part of living at the reef for students on a well-planned excursion.
- The high profile adopted by the Great Barrier Reef tourist industry can add to, rather than detract from, the usefulness of a reef visit as an environmental education experience. Students are at once aware of the high value society places on using the Reef for tourism and of the possible incompatibility of nature conservation and human activity.

Students of all ages find enjoyment in a reef visit. In a suitable location, with appropriate planning, a reef experience can be provided even for young school children. Primary school pupils can make day trips to some locations and secondary school groups can undertake both day trips and longer stays to some reef islands. Student activities outlined in this handbook can be carried out by Year 10–12 students, and will be useful for other groups such as those from adult education organisations, tertiary institutions and teacher professional development programs.

The Great Barrier Reef is a unique feature of the world and unique approaches are being attempted in its management and conservation. As many students as possible should be given an opportunity to experience for themselves such an important part of Australia's heritage. A learning experience at the Reef now, in an educational group, with peers, may be more influential than a mere holiday at the Reef. Moves have been made throughout Australia to increase the participation of older adolescents in schooling, Great Barrier Reef visits have much potential to provide new and worthwhile kinds of educational experience for such students.

Achievement of the objectives of the National Conservation Strategy for Australia (1984) will demand an informed and sympathetic climate of community opinion. Reef fieldwork for students can make an important contribution to the building of such a climate.

BUILDING A PROGRAM OF REEF EDUCATION

Deciding upon aims for a reef education program

Experiences which involve the Great Barrier Reef can help in the pursuit of a wide range of educational aims. The four broad aims below are ones towards which the teaching materials in this handbook can collectively contribute. Some areas in which objectives might be developed are listed with each aim.

Aim 1

To assist students to acquire an increased sense of self-awareness and to be more conscious of, and sensitive to, their surroundings.

- Awareness of oneself and one's own qualities
- Awareness of and sensitivity to other people and their activities
- Awareness of and sensitivity to natural environments
- Awareness of interactions between humans and their environments

Aim 2

To enable students to develop greater knowledge and understanding of natural phenomena which occur in their environments and of various processes and outcomes of human/environment interaction.

Listed below are some areas in which knowledge might be extended. These are elaborated upon in the conceptual framework given later.

- Interactions between materials of the ocean's atmosphere and earth
- Distribution, structure and origin of reefs as landform features
- Ecosystem structure and function
- Distinctive characteristics of the Great Barrier Reef system
- Natural environments as resources for humans
- Human impact on natural environments
- Influence of natural environments in human affairs and history
- Human well-being in natural environments
- Creative responses to natural environments
- Human perceptions, perspectives, values and ethics in relation to natural environments
- Management, conservation and preservation of natural environments
- Scientific investigation of natural environments

Aim 3

To provide opportunities for students to develop the skills and abilities needed to increase their environmental awareness, to identify and investigate problems in their environment, to function effectively in outdoor settings, to communicate with and relate successfully to other people, to respond creatively to their environments and to engage in outdoor leisure activities.

Both physical and intellectual development are involved here. Thinking and physical skills which can be fostered readily through Great Barrier Reef studies include the following:

- Observing
- Collecting data
- Recording and organising information
- Interpreting and analysing information
- Synthesising information
- Applying information
- Identifying problems and issues
- Hypothesising
- Experimenting
- Controlling variables
- Inferring
- Predicting
- Making conclusions
- Devising explanatory models
- Thinking critically and evaluating information and ideas
- Valuing — analysing, clarifying, developing and applying values
- Communicating
- Relating to others
- Using equipment
- Handling biological and geological specimens
- Functioning efficiently outdoors
- Living in remote locations
- Surviving in emergencies
- Expressing creatively
- Participating in recreation activities

Aim 4

To assist students to develop feelings, interests, attitudes and values which are inherent in deriving enjoyment from encounters with natural environments, in acting responsibly and relating effectively to others in a group situation, in carrying out environmental investigations in a scientific manner and in being concerned for, and prepared to act in the cause of, the maintenance and improvement of environmental quality.

Interests, feelings, attitudes and values which can be fostered through Great Barrier Reef studies include:

- Curiosity
- Willingness to cooperate with others
- Acceptance of responsibility for one's own actions
- Self-reliance and self-discipline
- Persistence and perseverence in carrying out a task
- Confidence in one's own abilities
- Appreciation of the importance of health and safety procedures
- Tolerance and respect for the rights of others
- Interest in, and enjoyment of, the company of others
- Intellectual honesty
- Desire to question and seek evidence or reasoned argument for claims
- Willingness to be convinced by evidence and to change one's mind
- Willingness to suspend judgment if evidence or reasoned argument is lacking
- Willingness to work with precision
- Interest in the methods and products of scientific enquiry
- Acceptance of the limitations of science
- Enjoyment of outdoor experiences
- Appreciation of the value of skills in outdoor pursuits for development of physical fitness and for recreation
- Appreciation of qualities of natural environments
- A sense of national identity
- Pride in the heritage value of the Great Barrier Reef
- Interest in the interrelatedness of humans and their environment
- Interest in social and environmental issues
- Concern for the magnitude of changes made by humans to their environment
- Concern for the maintenance and improvement of environmental quality
- Appreciation of the need for wise management of natural resources
- Appreciation of the contribution scientific enquiry can make to increasing understanding of the natural world
- Appreciation of the contribution scientific enquiry can make to the solution of environmental and social problems
- Willingness to initiate and become involved in action on behalf of maintenance or improvement of environmental quality

Selecting learning experiences for a reef education program

The FOUR Es of reef education

A reef studies program with an environmental education emphasis can be built around learning experiences in four areas: encountering, enquiring, evaluating and expressing.

Encountering	Experiences in which students meet with and become aware of their environment. Ideally these experiences involve direct (first-hand) contact with the environment, with opportunities to use all of the senses: sight, hearing, smell, touch, taste. Alternatively, or additionally, they may involve indirect (second-hand) experiences. Movement of the body and use of the kinaesthetic senses are usually part of the environmental encounter.
Enquiring	Experiences in which students formulate questions, find answers to problems and draw conclusions for themselves. Enquiries can take many forms.
Evaluating	Experiences in which students enquire into, clarify, develop and apply attitudes and values—particulary those that relate to the interrelationship of people and their environment.
Expressing	Experiences which involve students in translating their interest in, or concern for, environment into forms of expression or social action: • Expressing for oneself • Cómmunicating with others (i.e., expressing for the benefit of others) • Taking social action

Some student activities outlined in this handbook include elements from all four learning experience areas. But usually fewer areas are represented in any one activity. A suitable balance and sequence of experiences within a program can be achieved by using a combination of contrasting kinds of student activities.

The four Es in action

Encountering

We become aware of our environment through touching, seeing, hearing, smelling, tasting and moving. The phenomena we meet with may be "natural", "social", "spatial" or "built". Our encounters may be first-hand, or filtered through pictures, music, literature or stories.

In environmental education, concern for the development of sensory awareness is evident in the widespread development of strategies focused specifically on this aspect of learning.

Sensory trails, touch tanks and blindfold walks are some commonly used techniques which can be adapted for reef work. Increasingly, too, there is emphasis in environmental education on providing experiences which combine cognitive with affective learning. Efforts to foster feeling, fantasy and intuition are part of this emphasis. In part, the powerfulness of reef environments as settings for cognitive learning may spring from the strength of the emotional responses they evoke. In classroom settings, aesthetic support such as music, art and literature is being used to bring feelings into play.

When introducing students to the Great Barrier Reef, one major challenge is to find ways to help them use their senses more fully and to grow in their perceptual abilities. Initially there may be some students who are apprehensive of reef environments. Some may be reluctant about deliberate multi-sensory exploration of their surroundings. Some may lack confidence in the capacity of their own senses to obtain valid data, and may be more inclined to accept information provided by others. Given encouragement, support and suitable opportunities for practice, however, such feeling can generally be overcome. Considerable enhancement of students' self-esteem and enjoyment are possible outcomes.

Five basic principles for sharing nature with children (Cornell 1975):

- ***Teach less, and share more***
- ***Be receptive***
- ***Focus the child's attention without delay***
- ***Look and experience first; talk later***
- ***A sense of joy should permeate the experience.***

Many of the potential benefits of a reef encounter stem from the richness of the sensory stimulation available and the sensory contrasts the reef can provide with other environments previously met by the student. Underwater experiences may be especially significant. The wetness, buoyancy and increased pressure common to aquatic environments combine with less familiar elements. These may include unexpected warmth and unusual light effects. Underwater scenery at the reef can provide contrasts in texture, form, colour, movement and scale and can be viewed in magnificent perspective because of the transparency of the water.

Novelty of the kind experienced on the Great Barrier Reef can be an extremely powerful generator of exploratory drives. Even though these drives may sometimes interfere with structured learning tasks which teachers might devise, they must be regarded as an extremely valuable factor in field studies.

The majority of student activities set out in this handbook are based on direct environmental encounters. Observation of some aspect of the Great Barrier Reef system is invariably called for and tactile encounters with water are involved in many. Some activities which specify wider sensory exploration are listed below:

- Your first reef walk (No. 2)
- Introductory nocturnal studies (No. 5)
- Map an algae forest (No. 31)
- Getting to know an active reef creature (No. 32)
- Cucumbers are cute (No. 53)
- Love a tree (No. 81)
- Wrong song - bird calls (No. 91)
- Guess the texture (No. 130)
- Blindfold walk (No. 131)
- A sound map (No. 132)

Enquiring

Introduction

Many types of reef subject matter lend themselves to enquiry, both in field and classroom settings. Enquiry learning experiences can take many forms: the common factor is that students are focused on gathering and organising data with the aim of finding out an answer to a question. Ways in which enquiry learning experiences can differ include the following:

- ***Objective orientation vs subjective orientation of the enquiry method.*** Some methods of enquiry (such as those used in science) have an emphasis on striving for ***objectivity.*** They are concerned with investigation of a real world which is assumed to exist independent of any observer. The gathering of factual knowledge by direct observation of the real world has primacy of place in such enquiries. In contrast, enquiry with a **subjective** orientation is concerned with personal knowledge based on subjective (i.e., an individual's) interpretation of experience. The emphasis here is on imagination, feelings and values.
- ***Closed enquiry vs open enquiry.*** In closed enquiry, the investigation is intended to lead to a single correct answer. In open enquiry, no particular correct answer is called for. The outcome may simply be, for example, the best resolution of a problem, arrived at through deliberation.
- ***Enquiry highly structured by the teacher vs enquiry designed mainly by the student.*** In some enquiry situations, teachers maintain considerable control over the enquiry process. In other situations, teachers will wish students to have a good deal of autonomy. Here the teacher's role is mainly to support and encourage.

In this handbook, the following student activities exemplify these forms of enquiry learning experiences:

- Enquiry with objective orientation — Weather station (No. 16)
- Enquiry with subjective orientation — How do I feel? (No. 125)
- Closed enquiry — Wind and waves (No. 17)
- Open enquiry — Showing off (No. 147)
- Enquiry mainly teacher-structured — Reef-top transect (No. 73)
- Enquiry mainly student-designed — Colour patterns in reef fishes (No. 62)

Examples of different enquiry learning strategies

- ***Science-oriented enquiries***

An enquiry with a science orientation might involve some of the following processes:

Identifying a problem or asking a question (What? How? What for? How come?)

Formulating one or more hypotheses

Testing a hypothesis. This may take the form of simply gathering more data, testing by experiment or testing by prediction

Interpreting the results and formulating generalisations

Predicting some event or relationship not previously known on the basis of the tentative conclusion

Testing the validity of the prediction by further experiment.

However, although such a sequence is often put forward as the method routinely employed by scientists, this is a misleading notion. Practising scientists, in fact, attack problems in a variety of different ways. Nevertheless, some components of the sequence are widely employed.

- ***Perception studies***

Perception studies are types of enquiry carried out by social scientists in an effort to determine how individuals perceive their environment and how these perceptions guide decision making. Perception studies can be useful in education because they may:

allow students to develop greater self-awareness

enable students to recognise that different individuals differ in their perceptions of a particular phenomenon or situation

be linked with studies of values because of the way values interact with perception in determining how individuals behave or make decisions.

- ***Behavioural map studies***

These are essentially human territoriality studies. One teaching technique involves finding several contrasting settings in which patterns of behaviour are considered likely to be different. Observations are made of people's behaviour in each setting. Results are depicted as maps which form the basis for discussion about themes such as different uses of space, use of space as a barrier, size and dimension of personal space.

- ***Cognitive (mental) map studies***

Cognitive mapping is an enquiry technique used by geographers who are interested in the mental images which people have of their environment. The "mental" map can be thought of as a representation of the environment which people somehow carry within them as a store of information about the environment.

In mental mapping studies, an effort is made to externalise people's personal, cognitive maps. This can be done directly, asking people to draw free-hand sketch maps. The maps produced by an individual, or set of individuals, can be analysed. Indirect mental mapping methods involve an interviewer seeking verbal descriptions which are later placed on a map. In other forms of mental mapping studies, writings such as newspapers or novels are used as the source of data from which maps are constructed.

Examples of enquiry-based student activities

- ***Science-oriented enquiries***

  How clear is the water? (No. 8)
  Monitoring tides (No. 13)
  Air photo interpretation (No. 18)
  Sediment rain (No. 22)
  Colour in invertebrates (No. 36)
  Microatolls (No. 45)
  Cucumber count (No. 54)
  Ecology of a reef pool (No. 75)
  Litter on the island (No. 103)

- ***Perception studies***

  Arousal evaluation (No. 127)
  The best place and the worst place (No. 135)

- ***Behavioural map studies***

  I want to reserve my personal space! (No. 137)

- ***Cognitive map studies***

  Can we map it? (No. 133)
  Perception of place (No. 134)

- ***Aesthetic enquiries***

  Art and photography (No. 122)
  Reefscape aesthetics (No. 126)

Evaluating

Introduction

In Great Barrier Reef studies, students are almost inevitably confronted with the environmental effects of actions that are based on people's values and with environmental issues in which values are a significant factor. These experiences can help students to become aware of the important role values and attitudes play in shaping people's decision-making and other behaviour. Students can be provided with opportunities to clarify and develop their own values in relation to environmental matters and they can develop enhanced skills in evaluation, the thinking process in which values are applied.

A direct focus on values and attitudes can be seen as a critical part of any reef education program. Many of the now widely used strategies and techniques of values education can be applied readily to the reef system. A reef program can work towards developing a particular set of values and attitudes and can highlight various processes which involve values.

Applying values — the process of evaluating

In many reef education activities, evaluating may form a culminating part of enquiries which students carry out. Evaluation of a thing, idea or situation involves making a judgment about its worth. In the making of such a judgment, we use criteria or standards as yardsticks against which we compare the phenomenon. The process of evaluation may thus involve both developing or identifying the criteria which are to be used as yardsticks *and* making qualitative or quantitative judgments about how closely the phenomenon meets the criteria.

In making evaluations, processes in which your students might be involved include: judging a phenomenon; judging an idea; justifying a point of view; discussing evidence critically; finding fallacy in an argument; and defending their position in a discussion.

Student activities in this book which exemplify these processes are:

- ***Judging phenomena***
  Reefscape aesthetics (No. 126)
  The best place and the worst place (No. 135)
  Selecting a reef walking area (No. 148)
- ***Judging ideas***
  Decisions! Decisions! (No. 141)
- ***Justifying point of view***
  User roles and zoning game (No. 143)
  Am I willing to be committed? (No. 145)
- ***Considering evidence critically***
  Trampling effects on a reef flat (part) (No. 105)
  Cucumber count (No. 54)
- ***Defending one's position in a discussion***
  Under the influence (No. 145)

In enquiries which have a scientific orientation, criteria which are commonly explicitly invoked in making evaluations include, for example: internal criteria such as accuracy, consistency and logic, or external criteria—derived from major accepted theories or procedures of recognised excellence. In other types of enquiries (or in non-enquiry oriented activity), a vast range of other criteria, both explicit and implicit come into play when decisions are made. For example, criteria used might be aesthetic, legal, economic or related to health and safety.

The criteria which people use when making decisions are ultimately related to the values they hold. (For example, people who apply the criterion of logicality in evaluating an argument are indicating a respect for logic in their value system.) Thus, the decision-making processes of an individual or in the community at large are inherently bound up with values. Viewed broadly, everything people do or say is a reflection of their values. When students are involved in making or examining decisions, an exploration of the values which underlie the decision making is highly desirable.

Values and reef education

Although aims and objectives involving attitudes and values are probably a feature of most Australian school curricula, education in this complex area tends to give rise to some sensitivity among educators and the community at large. This largely comes from the question of whether particular attitudes and values are to be encouraged, and, if so, which ones. Little controversy surrounds educational approaches which foster those attitudes and values about which there is widespread community consensus. But the opposite may be true for more sectionally held attitudes and values.

Values education is a field of education which focuses on attitudes and values. In particular, it sets out to help students to explore and appreciate the value positions of other people, to clarify and develop their own values, and to recognise the relationship of people's values and attitudes to their perceptions and behaviour. An important concern is to prepare students to make their own decisions about appropriate personal and social conduct. There is major emphasis on developing skills in valuing which can be transferred to new situations. Much recent development in values education has been directed at extending students understanding of, and skills in, the process of recognising and applying values, rather than at developing any particular set of values.

Five direct approaches to values education which are well established in schools are: **values inculcation**, **values analysis**, **moral development**, **values clarification** and **action learning** (see table A1). Among these direct approaches, values inculcation differs from the others in that it is teacher-centred and is primarily concerned with education for a particular set of values. Conversely, the other approaches are student-centred and are more concerned with helping students to develop their own values and to acquire skills in valuing.

Techniques employed in values education approaches include **games**, **simulations**, **role play** and techniques such as **Likert scales**, **semantic differentials** and **ranking of choices**. In the treatment of controversial issues, simulation and role play have proved to be particularly useful.

Table A.1: Profiles of five commonly used approaches to values education

Approach	Comments
Values clarification	Involves the creation of a situation in which students are given the opportunity of clarifying their own values in a non-judgmental enviroment.
Values inculcation	Aims to instil particular values in students and to shift students' values towards those which are approved of by school, community, etc. Methods commonly used include: • lecturing or exhorting • teacher setting personal example • praise and reprimands • giving students experience of behaviour consistent with the value being instilled.
Values analysis	Emphasises the role of logical thinking and scientific investigation processes in making value judgments rather than exploring emotional or intuitive processes involved. Relevant facts are used as a basis of determining what is a worthy value judgment or action.
Moral development	Based on theories that a child's ability in moral reasoning develops progressively in a series of universal stages which are each passed through before the person attains moral autonomy. In presentation of a moral dilemma episode, the student is confronted with problematic situations which pose conflicts and disagreement around such moral values as fairness, justice, equality and human dignity. A choice of possible actions is suggested and the question posed, "What should we do?"
Action learning	Provides students with opportunities for personal and social action based on their values. Encourages students to learn from real-life situations, giving them the opportunity of acting on personal values in the context of real issues and problems.

Values and environmental education

The notion that education ***for*** the environment should be a fundamental aspect of environmental education has led to great interest in values education strategies among environmental educators. It is widely recognised that merely increasing a person's knowledge ***about*** the environment is not sufficient to engender attitudes of environmental concern or ensure appropriate action towards the environment. Something more is needed. As Caduto (1983a) notes, "Changes in environmental attitudes and behaviour are most effectively brought about by . . . environmental education strategies that increase [not only] the learner's level of knowledge [but also the] amount of emotional involvement and experience in the area being addressed."

One goal of encouraging student visits to the Great Barrier Reef is to foster opportunities for students to become emotionally engaged with reef environments. The enjoyment and exhilaration which can be derived from encounters with the Reef can make a significant contribution towards developing students' sense of the worth of the Reef and of the importance of conserving it.

In environmental education, values-education strategies which have attracted much recent attention have been those concerned explicity with the valuing process rather than with any particular set of values. Values clarification, in particular, has been very widely used. Many enviromental educators now urge that greater direct emphasis should be given to education for particular conservation values and to development of an ***enviromental ethic***. In their view, values clarification and similar methods are worthwhile components of environmental education programs, but in themselves are inadequate; environmental education must also involve instilling a particular set of values. Although attempts to instil values are often avoided by teachers in environmental education for fear of attracting the label "indoctrination", the process of instilling is not regarded as a controversial one in the community when it involves values on which there is community consensus. Methodologies for teaching behavioural attitudes, such as work attitudes and willingness to cooperate with others, are known to every school teacher, and methodologies for teaching particular substantive values are already well established in moral education, for example.

With the publication of consensus statements such as the World Conservation Strategy and the National Conservation Strategy for Australia, it will perhaps be possible for teachers in the near future to identify more easily conservation values which are widely endorsed and which therefore seem appropriate to being instilled in the course of school education.

A reef field trip provides excellent opportunities for instilling conservation values. The example teachers set in their own interest and concern for the natural enviroment and the way teachers reinforce student behaviour are vital. Even teachers' interest in organising a trip to such a sensitive area and engaging in activities which focus on enviromental management strategies may act as a form of values inculcation. So may the experience of behaving in an enviromentally responsible manner during the field trip. In this handbook, a number of student activities stress the need for care when encountering reef and island environments. These are all intended to help foster the development of positive attitudes towards environmental protection.

Examples of value education activities

Activities in this handbook which exemplify different values education approaches are listed below:

- ***Moral dilemma***
  Shell jewellery (No. 140, part)
  Following the rules (No. 151, part)
- ***Values inculcation***
  Were you lucky enough? (No. 158)
- ***Values analysis***
  Selecting a reef walking area (No. 148, part)
- ***Values clarification***
  Graffiti wall (No. 124)
  Arousal evaluation (No. 127)
  The best place and the worst place (No. 135)
  Decisions! Decisions! (No. 141)
  Under the influence (No. 145)
  Am I willing to be committed? (No. 146)
  Do the right thing (No. 152)
- ***Action learning***
  Whale watch (No. 68)

Activities exemplifying particular values education techniques are:

- ***Simulation***
  User roles and zoning game (No. 143)
  Showing off (No. 147)
- ***Role play***
  User roles and zoning game (No. 143)
- ***Likert scale***
  Decisions! Decisions! (No. 141)
- ***Semantic differential***
  How do I feel? (No. 125)
  Reefscape aesthetics (No. 126)
  Arousal evaluation (No. 127)

Expressing

Student responses to the reef may be expressed in a variety of ways. They may involve, for example, use of spoken or written words, movement, sounds, pictures. They may take the form of communication of ideas, information or feelings to others, or they may simply involve expression for self-satisfaction. They may, or may not, entail a significant degree of creativity. Prose, poetry, drama, music, art, craft and dance are some forms which expression may take. Expressing concern for the environment by taking social action on behalf of environmental improvement is one form of expression strongly encouraged in environmental education.

Examples of expressive activities:

Reef orchestra (No. 118)
Film makers (No. 123)
Graffiti wall (No. 124)
Me and the reef (No. 136)

Choosing content for a reef education program

Some major facts, concepts, theories and principles which are important for understanding the Great Barrier Reef system are summarised here as a conceptual framework for reef studies. This can assist with the planning of a reef studies program by providing some guidelines for selecting content and helping to interrelate different subject areas.

Summary of Project Reef Ed conceptual framework

1. **The natural world**

   The Great Barrier Reef is a unique and complex natural system whose components include an assemblage of calcium carbonate reefs built up in marine enviroments on the Queensland continental shelf, the living communities they support, the ocean waters and atmosphere which surround them and the underlying and adjacent sections of continental shelf and coastal margin.

   1.1 Ocean, atmosphere, earth interaction
   1.2 Structure, development and distribution of reefs
   1.3 Ecosystem structure and function
   1.4 Comparison with other systems

2. **The human dimension**

   People are part of the Great Barrier Reef system. Human activity and well-being are influenced by the functioning of other parts of the system, and the quality of reef environments is affected by human activities.

   2.1 The reef as a resource for humans
   2.2 Human impact
   2.3 The reef in human affairs and history
   2.4 Human well-being
   2.5 Creative response
   2.6 Human perceptions, perspectives, values, ethics
   2.7 Management, conservation and preservation
   2.8 Scientific investigation

Conceptual Framework for Reef Studies

1. **The natural world**

   The Great Barrier Reef is a unique and complex dynamic natural system. Its components include an assemblage of calcium carbonate reefs built up in marine environments on the Queensland continental shelf, the living communities they support, the sea and atmosphere which surround them and the underlying and nearby parts of the continental shelf.

   1.1 ***Oceanic and atmospheric components of the Great Barrier Reef system interact with each other and the solid earth and its surface materials and with the biota of the reef system.***

   Movements within the atmosphere and sea are influenced by the rotation and revolution of the earth, by its position in the solar system and by its topography. Current patterns are affected by the earth's rotation and absorption of the solar energy; tides result from gravitational forces involving earth, moon and sun.

   Energy is transferred at interfaces between ocean water, atmosphere and solids:

   - Atmospheric movements generate waves and surface currents in the sea
   - Topography of earth surfaces is shaped by moving water and air
   - Material is carried in solid and/or dissolved form by moving water and air
   - The marine environment helps to stabilise the earth's climate.

   Materials such as sediment, fresh water and minerals carried from land masses and other eroding areas influence the chemical and physical features of the ocean.

   Sediments are deposited when transportation stops.
   Water is recycled through the atmosphere and ocean.
   Living things interact with ocean and atmosphere.
   Many elements dissolved in sea water are recycled through biological, geological and chemical cycles.

   Sea level changes can result from earth movements or climatic change.

1.2 ***Reefs in the system are calcium carbonate build ups. These have been produced, over a long period of time, by an interplay between biological and non-biological processes, involving both constructive and destructive phenomena.***

An essential part of calcium carbonate reef construction is the building of a rigid wave-resistant framework by the growth of corals and certain algae. The production of wave-resistant frameworks allows these organisms to modify their own environment and diversify the physical conditions in which they exist.

Local coral growth and the distribution of reefs are affected by water depth, temperature, salinity, emersion, water turbulence, wave energy and the amount of sediment in water.

Non-framework-building organisms contribute their skeletal material to reef sediment. Sediment is also derived from pre-existing reef material which has been broken down and, in some cases, from non-biogenic sources.

Consolidation of reef material takes place by storm compaction, cementation and growth of encrusting organisms.

Breakdown of reef material is achieved by biological processes, such as boring, and non-biological processes, such as solution and ware action.

Water movement and gravity are important in sediment transport on reefs.

Reefs typically display strong physical zonation, with elements such as reef slope, reef crest, reef flat, lagoon and cay commonly being distinguishable.

Global changes in sea-level and subsidence and elevation of the continental shelf are important historical factors in reef development.

Reefs exist in a variety of forms, reef forms being related to stage of reef development and physical setting.

1.3 ***Living things of the Great Barrier Reef interact in complex ecosystems with one another and with the non-living components of their environments.***

A reef ecosystem contains a diversity of living species.

Abiotic factors of the environment affect living things of a reef ecosystem.

Living things of a reef ecosystem can modify their non-living environment.

Living things within a reef ecosystem are adapted to particular environments through their structural, functional and behavoural characteristics. All species live in characteristics habitats.

Living things interact with one another in a reef ecosystem:

- Interactions can occur between members of the same species or different species
- Kinds of interactions include: predator/prey relationships; competition; symbiosis.
- Interactions can relate to resources such as food, shelter, substrate, space.

Populations of living things within a reef ecosystem are unevenly distributed - the distribution and abundance of any one species being affected both by factors of the physical environment and by members of the same and other species in the ecosystem.

A flow of energy occurs within a reef ecosystem and materials are constantly being recycled. Food chains and food webs can be used to describe such flows:

- Energy for maintenance of the ecosystem comes from the sun
- Green plants convert solar energy to food energy through photosynthesis
- Organisms transfer energy and materials through food webs
- Decomposing organisms, such as bacteria, reduce organic materials to simpler forms.

Reef ecosystems change through time, such changes arising from processes occurring within the system or from external phenomena:

- A change in one part of an ecosystem can affect the system as a whole
- The stability of an ecosystem tends to be directly proportional to the diversity of its populations and the complexity of relationships among them.

All ecosystems in the biosphere are linked to one another through biogeochemical cycles and hence they affect one another.

1.4 ***Many attributes of the Great Barrier Reef system are common in natural ecosystems, but some are characteristic only of coral reef systems, or of this system in particular.***

All ecosystems have some structural and functional aspects in common.

Distinctive aspects of a coral reef ecosystem are high productivity, high diversity at all levels of organisation and complexity of linkages and flows within the ecosystem.

- High productivity makes a coral reef ecosystem distinctive among the marine ecosystems which surround it (like an "oasis in a desert")
- The productivity and diversity of a coral reef ecosystem are comparable to a rainforest ecosystem in the terrestrial environment

Unique aspects of the Great Barrier Reef system include its location, its extensiveness, and its geological history

2. **The human dimension.**

People are part of the Great Barrier Reef system. Human activity and well-being are influenced by the functioning of other parts of the system, and the quality of reef environments is affected by human activities.

2.1 ***The Great Barrier Reef can provide many natural resources to meet human needs.***

The Great Barrier Reef meets human needs by contributing to the maintenance of the earth's global life-support system, through its biogeochemical cycles and links with other ecosystems.

The Great Barrier Reef can meet human needs, present and future, by acting as a source of genetic diversity through the species it contains.

The Great Barrier Reef provides biological resources such as fish, crustaceans and molluscs for food, substances for pharmaceutical purposes and corals, shells and other molluscs for ornamental use.

Deposits of minerals which are exploited in other environments may be available in the Great Barrier Reef region (Limestone, prosphate and gravel have been mined here in the past; petroleum may occur here.)

The Great Barrier Reef provides opportunities for recreation, both passive and active in character. Such recreation includes some which does not take place in the reef area but which involves vicarious experience of the reef through, for example, reef films and reef literature.

The Great Barrier Reef provides a stimulus for creative expression in music, art, literature, drama and debates.

The aesthetic qualities of the natural environments of the reef can contribute to a sense of well-being in humans.

Reef environments can provide people with physically, mentally and socially stimulating and challenging experiences which may lead to an increase in their feelings of enjoyment, satisfaction and achievement.

The Great Barrier Reef system provides resources for scientific enquiry and for education.

Tourist, fishing and other industries have been able to grow out of use of reef resources, and employment has been generated through them.

Reef waters act as transport routes for shipping.

Natural resources of the Reef are unevenly distributed. Their distribution and location in relation to human populations and to technological and economic factors are critical to the way in which they may be used.

The perceived value of a natural environment is dependent on the goals, skills and way of life of the people involved. Resources are culturally defined. (See also 2.6.)

Many uses of the Reef are compatible with one another, but some may be temporarily or permanently incompatible.

Use of a natural resource on a sustained yield basis ensures that supplies will be available for future needs.

Weather, sea conditions and climate (including hazards such as cyclone and storm surge) are important factors governing people's activities in the Reef area.

2.2 ***Human activities may have many impacts on the natural systems of the Great Barrier Reef.***

Human activities create five main kinds of direct impact: introduction of pollutants; physical damage; extraction of living species; interference with species; introduction of exotic species.

Direct impacts may arise through the following activities:

- tourism (development of tourist facilities; charter boat operators; reef visits for diving, reef walking, boating; waste disposal from island resorts)
- fishing (commercial and recreational fishing; illegal poaching by foreign fishing vessels; professional shell and aquarium fish collecting)
- shipping (development of shipping channels, harbours and associated works; shipwrecks; discharge of cargoes and fuel being carried by vessels passing through reef waters)
- air transport (building of facilities; traffic noise)
- coastal activities (development of mainland and island coasts; generation of pollutants by mainland and island activities)
- extraction of mineral resources.

Humans may affect reef ecosystems indirectly as well as directly.

Human impacts on one part of a reef ecosystem will affect other parts of that ecosystem and other ecosystems with which it is linked.

2.3 ***The Great Barrier Reef has influenced human activities in the Reef region and has affected the course of local and Australian history.***

Reef navigation routes have long been used in the dispersal of people and their goods but the Reef has also acted as a barrier to free movement.

Aboriginal communities have a long history of use of reef environments.

James Cook's journey along the north-east coast of Australia in 1770 meant that there was awareness of the Great Barrier Reef from the earliest days of European settlement on this continent.

Reef resources contribute substantially to the economic foundation of many Queensland coastal communities and provide the reason for existence for some.

The Great Barrier Reef has been the catalyst for significant political and legal events in the recent evolution of Commonwealth–State relations in Australia.

2.4 ***Human enjoyment, comfort, satisfaction and well-being are attainable in reef environments and can be achieved in ways compatible with conservation of the Reef.***

A group field trip to a reef environment requires detailed planning, especially when camping in an isolated situation is involved.

Potential dangers to people who visit reef areas include encounters with dangerous marine organisms, boating and swimming accidents, sunburn, ill-health and cyclones; but suitable planning and knowledge of appropriate precautions and remedies can minimise problems which these might pose.

Weather, sea conditions and climate (including hazards such as cyclone and storm surge) are important factors governing people's activities in the reef area.

New skills and knowledge may have to be developed in preparation for a visit to the reef (e.g. snorkelling, boat handling, first aid, safety precautions).

Members of a group living together on a reef island need to co-operate and communicate effectively with one another to take responsibility for their own actions, and to adopt a caring and responsible attitude towards the well-being of other members of the group.

One's awareness and understanding of one's own characteristics and qualities can be enhanced through experiences in reef locations.

Enjoyment and improved physical skills and fitness can arise from physical activities carried out at the Reef.

Improved skills in relating to others and in providing for our own day-to-day needs can result from the experience of living and working as a member of a group at the Reef.

A knowledge of survival techniques can be useful to people who stay in wilderness locations such as reef islands.

Visitors to the Reef should adhere to the park regulations which are designed to contribute to conservation of the Reef, and should consciously attempt to minimise their impact on reef environments.

Fishing is enjoyed by many people as a recreation and limited fishing for subsistence (in accordance with the stipulations of Marine Park zoning and fisheries regulations) may not be inimicable to reef conservation. "Enough fish for one meal" is a policy which individuals might apply to limit their own fishing.

Observing, photographing, drawing and being close to living things in their natural environments are great sources of pleasure to many people. In natural areas of great heritage value such as the Reef, these kinds of recreation activities are more appropriate than those which involve harvesting or damage of living things or other natural materials.

Developing love and concern for the natural environment can be a source of pleasure and can lead to people being wise in their use of natural resources.

2.5 ***The Great Barrier Reef inspires creative responses in many people.***

Creative forms of expression which can be stimulated by reef environments include: music, painting, prose, poetry, craftwork, dance.

2.6 ***Perceptions of the Great Barrier Reef and values placed on the Reef differ widely among different people.***

People's behaviour and actions in relating to the Reef are closely related to their values and perceptions.

Decision making about the Reef is influenced by people's values.

There may be a discrepancy between people's verbal expressions of values and attitudes and their behaviours.

Value differences between individuals and groups may be assumed to exist when different actions are taken in similar situations.

Conflicts involving different values may occur within an individual or group when a choice must be made between different actions.

People's perceptions and values of the Reef may be largely conditioned by their cultural background.

Knowledge and understanding of the Reef need not necessarily result in feelings of concern for the reef.

The values which some people hold may be in conflict with strategies aimed at protecting reef environments.

Clarifying one's own values and analysing the values of others in relation to environmental issues can be helpful in enabling the governing role of values in human activity to be understood.

Contrasting ethical positions which may be discerned in human responses to reef environments include:

- the perspective that the Reef is a resource for humans whose existence is justified by the extent to which it meets human needs now, or now and in the future
- the perspective that non-human entities, either living or non-living, have an inherent right to exist, quite apart from the extent to which they serve humans.

Ethical considerations which are involved in human use of the Reef include:

- the issue of equitable access among the ***present*** generation of humans to resources available in reef environments
- the issue of access to reef resources being available to ***future*** generations of humans, as well as those of the present day.

2.7 ***Management of a natural environment entails control of the environment for a specific purpose. Planning and management of marine areas of the Great Barrier Reef as a marine park are being undertaken with a view to protecting the Reef, while allowing reasonable human uses to occur. Decision-making processes concerning the Park involve attempts to predict the possible environmental consequences of certain actions and attempts to find compromises between the desires of different groups of people.***

The Great Barrier Reef Marine Park was established by the Commonwealth government in order to:

- conserve the Great Barrier Reef
- regulate the use of the Marine Park so as to protect the reef while allowing reasonable use of the Great Barrier Reef region to take place
- regulate activities which exploit the resources of the Reef region so as to minimise the effect of those activities on the Reef

- reserve some areas of the Great Barrier Reef for appreciation and enjoyment of the public
- preserve some areas of the Reef undisturbed by humans except for scientific research.

The concept of conservation expressed in the management objectives of the Great Barrier Reef Marine Park is compatible with the view of conservation set out in the World Conservation Strategy (of IUCN), i.e., that conservation is "management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspiration of future generations".

The main objectives of living resource conservation, according to the World Conservation Strategy, are:

- maintenance of essential ecological processes and life-support systems
- preservation of genetic diversity
- ensuring the sustainable use of species and ecosystems.

Sustainable use is the management of production, harvesting and other usage at levels which protect the living resource base in perpetuity. This ensures that human communities derive maximum long-term benefit. Without sustainable use of living resources the living resource base is degraded and the options of present and future generations are restricted.

If development is regarded as "modification of the biosphere and the application of human, financial, living and non-living resources to satisfy human needs and improve the quality of human life" (WCS), then the view may be taken (as in the World Conservation Strategy) that living resource conservation and sustainable development are interdependent. They are fundamentally linked by their dependence on living resources —conservation providing for today's needs and conservation providing the stock of living resources for tomorrow.

Establishment of the Great Barrier Reef Marine Park resulted from political acceptance of widely expressed public concern within Australia and overseas, that there was a need to protect the Reef. Four main areas of concern were:

- concern that one of the major natural heritage areas of the world should be conserved and preserved for future generations
- concern at local deterioration in Reef areas
- concern at the possibility of over-exploitation of the resources of the Reef
- concern at the effects of pollutants.

Park planning and management can provide a means of separating imcompatible uses of the Reef, reconciling the claims of competing user demands and resolving conflict which arises from such demands. Adjudicating between non-compatible uses involves options ranging from the banning of particular uses to restricting uses to specific locations zoned for that purpose.

Decision making for effective management of a natural resource, such as the Great Barrier Reef, partly depends on sufficient knowledge and skill being available to predict and evaluate the impact of a specific management policy.

- Prerequisites for a comprehensive management plan of the Reef to be developed might ideally have been: an inventory of the Reef; an understanding of the direct impact of each form of usage upon the Reef and upon the resource being exploited; a basal understanding of reef ecosystems to enable the interactive effects of individual and multiple usage to be predicted.
- Where inadequate information is available as a basis for management, the capacity to manage can be improved by monitoring the effects of particular management policies and carrying out research programs on reef ecology and human usage.

Although decision making concerning the management of reef environments has an empirical basis, related to facts on the reef and its use, ultimately decisions are founded upon people's values and ethics. (See section 2.6)

Political processes are significant in decision making in relation to natural resources such as the Great Barrier Reef.

- Politicians, in dealing with the allocation of scarce natural resources, try to arrive at policy which not only reflects considered goals for the community as a whole, but which is also likely to maintain their support base.
- Politics often involves trade-offs between two equally worthy goals and the adjustment of policy to maintain power.

Many individuals and organisations share responsibility for Reef conservation.

- Commonwealth and State each have control over areas of the Reef province, Commonwealth jurisdiction mainly being limited to marine environments. Management of the Great Barrier Reef Marine Park is in the hands of the Commonwealth's Great Barrier Reef Marine Park Authority but, through delegation, is carried out on a day-to-day basis by the Queensland National Parks and Wildlife Service.
- Community support is needed for implementation of Marine Park management plans.
- Public participation is involved in the establishment and planning of the Marine Park, and in evaluation of its management regimes.
- Individuals may need to modify their lifestyles, and public and private organisations their practices, to ensure Reef conservation.
- Community support for Reef conservation can be built through community education and the provision of opportunities for community involvement in decision-making processes concerning the Reef.

To contribute effectively to decision-making about issues such as reef conservation, community members need to have as good an understanding as possible of the processes by which decisions are made. Awareness of the values which affect a decision and the persons and organisations who influenced decision making is important.

The Reef and environmental education

What are concerns of environmental education

Environmental education is concerned with the interrelatedness of people and their environment and with the need for skilled management of natural resources. It is based on concern for the quality of human life and seeks to encourage personal commitment to environmental conservation.

According to a statement in ***Environmental Education for Schools*** (Curriculum Development Centre, Canberra, 1980), environmental education aims:

- to help students acquire an ***awareness*** of and ***sensitivity*** to the total environment
- to help students develop a basic ***understanding*** of the total environment and the interrelationship of humans and the environment
- to help students develop the ***skills*** necessary for investigating the total environment and for identifying and solving environmental problems
- to help students acquire the ***motivation for actively participating*** in environmental improvement and protection
- to help students ***identify alternative approaches and make informed*** decisions about the environment based on ecological, political, economic, social and aesthetic factors
- to provide students with ***opportunities to be actively involved*** at all levels in working towards the resolution of environmental problems.

Environmental education is often portrayed as being education ***in***, ***about*** and ***for*** the environment. Education ***in*** the environment refers to direct, personal experiences of the environment such as those involved in fieldwork. Education ***about*** the environment involves the development of knowledge and understanding of the environment. Education ***for*** the environment involves developing attitudes and values which entail concern for environmental conservation and willingness to participate actively in working towards it. It is this latter dimension which is often seen as the critical distinguishing feature of environmental education. According to such a view, education ***in*** and ***about*** the environment makes a contribution to, but is not sufficient of itself to constitute environmental education.

Because of recognition among environmental educators that increasing knowledge and understanding about environmental problems and conservation do not necessarily or automatically lead to feelings of environmental concern, teaching approaches particularly directed at affective outcomes are adopted. Attitudes are emphasised as outcomes, on the assumption that the human behaviours which environmental education hopes to encourage are shaped by an interplay between people's knowledge and the feeling side of their make-up.

In general, environmental education is not being implemented in Australian schools as a separate subject. In secondary schools, it is being taught in various traditional subject areas as an across-the-curriculum perspective. Science and the social sciences are the disciplines which have mainly taken up the environmental education philosophy, though there is considerable potential for other subject areas to do so.

How can reef studies contribute to environmental education

There is little doubt that reef learning experiences, particularly those which occur on a field trip, can assist significantly in the pursuit of environmental education aims. Ideally, all programs for students who visit the reef will be constructed with generally accepted aims of environmental education in mind. Environmental education can be provided either through use of an interdisciplinary theme or in the context of single discipline studies, e.g. geography, science or physical education. Desirably, all students will be offered at least some experiences which heighten their concern for their environment and which increase their willingness to work towards environmental improvement and wise use of natural resources.

Nevertheless, it is possible to design reef programs which are valuable educationally but whose main emphasis or orientation is not that of environmental education. Although education ***in*** and ***about*** the environment may not, in itself, constitute environmental education (in the now conventional sense) it may serve quite valid educational objectives in other areas. For example, a biology course of study with an emphasis on ecology (i.e., education ***about*** the environment) may not be sufficiently oriented towards education ***for*** the environment to be regarded as environmental education, but may be able to achieve widely acceptable objectives in areas of biological education.

Although such approaches to using the Reef in education are provided for in this material, it is suggested here that, no matter what its overall emphasis, every reef program should contain a nucleus of activities which enable the student to become more concerned about environmental issues and more skilled and interested in working towards resolution of environmental problems.

The Reef and science education

What are concerns of science education?

Aims of science education generally emphasise:

- the part science education can play in maintaining and enhancing the level of scientific literacy and competence in our community
- the role of science education in contributing to individual development.

Most school science courses strongly emphasise the processes of science - in particular its empirical modes of investigation, and the development of scientific attitudes among students. Many courses are aimed at developing a knowledge of the impact of science on humans and their culture. Developing an interest in the methods of scientists and in the application of science to personal, community, national and international problems is also commonly an area of concern.

Australian science courses at the Year 7-10 level are currently multidisciplinary, intergrated or "general". Such courses also exist in some states for Years 11 and 12 students, but there are usually also courses in the separate sciences (such as physics, chemistry, biology and geology) at this level.

How can reef studies contribute to science education?

Some ways in which reef study can be used in education in science are suggested here. Reef studies related to some major concerns of science education as set out in the Australian Science Education Project (1974) are listed in table A.2. For each of some major branches in science, examples are given of some relevant reef focus questions in table A.3. Some further examples represented in student activities in this handbook are indicated in table A.4. Major areas of some existing Australian school science syllabuses which can be related to reef topics or themes are identified in table A.5.

Table A.2: Aims of science education and reef study

Some major concerns of science education	**Examples of relevant reef learning**	**Examples of some relevant student activities in this handbook**
Understanding of humans, their environment and interpersonal relationships	Understanding requirements for human health and survival in reef areas Understanding processes of material and energy transfer which occur in the reef system Understanding ways in which people make decisions which affect reef environments	Human comfort on a cay (No. 116) Wind and waves (No. 17) Dangerous reef creatures (No. 112) Food web of a coral cay and reef (No. 78) Effects of humans (No. 102) User roles and zoning game (No. 143)
Skills and attitudes important for scientific investigation	Reading maps and air photographs of reef areas Observing, measuring and counting reef organisms Interest in methods and products of scientific enquiry in reef areas	Air photo interpretation (No. 18) Reef and island cross-sections (No. 19) Cucumber count (No. 54) Were you lucky enough? (No. 158)
Understanding of nature, scope and limitations of science	Science methods employed in many areas of reef enquiry Data gained through scientific enquiry is one input into decision making about GBR resources Peoples' values are also important factors in decision making about reef resources	Follow a scientist (No. 159) Were you lucky enough? (No. 158) Researching the research (No. 159) User roles and zoning game (No. 143)
Understanding of and concern for, consequences of science and technology	Scientific research can contribute to reef management Technological change is resulting in new ways of investigating reef environments and exploiting reef resources	Researching the research (No. 159) Environmental impact statements (No. 155)

Table A.3: Branches of science and reef education

Branches of science	Examples of relevant reef focus questions	Examples of some relevant student activities in this handbook
Biology	What forms of life occur in a reef community? How are different life forms distributed on a reef? Which are the producers and which are the consumers in a reef community? How are reef organisms adapted to their environments?	Animal roll call (No. 33) Who's who in the fish families (No. 61) Reef-top transect (No. 73) Boulder communities (No. 74) Animal survival tricks (No. 85)
Geology	What are the sedimentary materials of a reef made of, and how are they distributed? What building-up and breaking-down processes are involved in the making of a reef? How do living things contribute to the formation of earth materials in a reef environment?	Getting down to the nitty gritty (No. 21) Formation and development of a cay (No. 20) Beach rock (No. 25) Sediment-organism interaction (No. 24)
Physics	How and why does the environment experienced by a diver at depth differ from that experienced by a swimmer in shallower water? Where does wave refraction occur in reef environments and why is it important to reef development?	How clear is the water? (No. 8) Formation and development of a cay (No. 20)
Chemistry	What are the sedimentary materials of a reef made of and what is their origin? How can the age of reef sediment be determined? What are the chemical properties of sea water in a reef area? What are some chemical characteristics of cay soils?	Getting down to the nitty gritty (No. 21) Reef waters — oxygen and pH (No. 10) Formation and development of a cay (No. 20) Reef waters — temperature (No. 9)
Marine science	What are the main characteristics of tides in a reef area? How are the characteristics of sea water investigated? What are the main forms of life which occur in a reef community?	Monitoring tides (No. 13) Reef waters — temperature (No. 9) Coral polyp – architect of the reef (No. 41) Algae are important (No. 30)
Environmental science	In a community on a reef, how do living things interact with one another? How do the activities of humans affect reef communities? What are some ways in which scientific enquiry can contribute to management of reef areas?	Food web of a coral cay and reef (No. 78) Effects of humans (No. 102) Researching the research (No. 159)

Table A.4: Reef education and key science concepts

Science concepts	Examples of relevant student activities in this handbook
Cause and effect	Wind and waves (No. 17)
Change	Reef-top transect (No. 73)
Cycle	Tidal changes (No. 11)
Community	Boulder communities (No. 74)
Energy and matter	Food web of coral cay and reef (No. 78)
Force	Your trip by sea (No. 100)
Interaction	Sediment-organism interaction (No. 24)
Model	Formation and development of a cay (No. 20)
Organism	Getting to know an active reef creature (No. 32)
Population	Colour in invertebrates (No. 36)
Quantification	Cucumber count (No. 54)
Replication	How clear is the water? (No. 8)
Scale	On location (No. 1)
Significance	Reef-top transect (No. 73)
System	Boulder communities (No. 74)
Time and space	Formation and development of a cay (No. 20)
Validation	Cucumber count (No. 54)

Table A.5: Reef education and school science syllabuses—Great Barrier Reef studies are applicable to many content areas of existing science syllabuses. Examples include:

Science syllabus	**Syllabus content area**
Qld Board of Secondary Schools Junior Syllabus in Science (Draft, 1985)	Planet Earth The Living Environment People, Science and Society Matter Energy The Human Body
Qld Board of Secondary Schools Senior Syllabus in Biological Science (Draft, 1985)	Nature of Life Physiology of Plants and Animals Organisms and Communities Ecosystems Humans Who Live in Ecosystems Outdoor Studies Classification Reproduction, Growth and Development Evolution Population Ecology Behaviour Development of Theories and Models
Qld Board of Secondary Schools Senior Syllabus in Multistrand Science (Draft, 1984)	*Core topics:* Ecology Man, Resources and Environment Science for Recreation Personal Health Nature of Science Science, Technology and Society Matter and Materials
Qld Board of Secondary Schools Senior Syllabus in Chemistry (Draft, 1986)	Particle Theory Energy and Chemical Change Acids and Bases An Important Substance (water may be used as an example)
Qld Board of Secondary Schools Senior Syllabus in Physics (Draft, 1985)	Physical Quantities Measurement Forces and Motion Thermal Physics Wave Motion The Physics of Materials
Qld Board of Secondary Schools Senior Syllabus in Earth Science (Draft, 1981)	Mineralogy Petrology Physical Geology Geotectonics Structural Geology and Geological Mapping Palaeontology and Geological Time Stratigraphy Astronomy
NSW Secondary Schools Board Science Year 7-10 (1985)	The Things Around Us—Within and Beyond Our Local Experience (Life Forms; The Earth Around Us); Natural Changes (Changes in the Earth's Atmosphere; Changes in the Earth's Crust; Changes in Life Forms and Living Communities) Changes Caused by People Relationships between Living Things and the Earth
NSW Board of Senior Studies Years 11 & 12, 2-unit course — Geology (1980)	Core Unit 1—Surface Processes Core Unit 6—Geology and Society Elective 2—Contemporary Sedimentary Processes

Science syllabus	Syllabus content area
NSW Board of Senior School Studies Years 11 & 12, 2-unit course-- Biology (1986)	Core Section f- Ecology Core Section e- Diversity and Evolution Elective A5--Classification and the Species Concept Elective A3--Living on Water; Living on Land Elective B5- Human Environment Impact
NSW Board of Senior School Studies Years 11 & 12, 2-unit course -Physics (1979)	Core Unit f- Waves Elective 4- Physics in Technology (e.g., Photography; Fluid Dynamics)
NSW Board of Senior School Studies Years 11 & 12, 2-unit course--Chemistry (1979)	Elective C1—Chemistry and the Environment Elective C5—The Social Dimension of Chemistry
NSW Board of Senior School Studies Years 11 & 12, 3/4 unit general course (1985)	Option B3—Ecology and Diversity in an Australian Context Option C1—Surface Processes and Stratigraphy Option C3- Geological Resources Option C4--Chemistry and the Environment
NSW Board of Senior School Studies Years 11 & 12, 2-unit general course (1982)	Survey Unit 1: The Techniques We Use to Explore Our Surroundings Survey Unit 4: Natural & Human Communities Survey Unit 7: Management of Resources Depth Study A17: Water Depth Study B1: Biological Succession Depth Study B13: The Aquatic Environment Depth Study B8: People Despoiling the Environment Depth Study B6: Landforms and Scenery Depth Study B17: The Science of Sport Depth Study B12: Soil

The Reef and geography education

What are the concerns of geography education?

Geography education draws upon the methods and insights of geography to provide experiences which can contribute to the development of students. Students are helped to achieve an understanding of our environment and the way we interact with it; to develop mapping, enquiry, social and decision-making skills; to gain a clearer picture of their own values and to analyse those of others. One of the most practical outcomes of a study of geography is the contribution it can make to planning and decision-making about the spatial dimensions of the world.

How can reef studies contribute to geography education?

Some ways which reef studies can contribute to geography education are suggested in tables A.6 to A.8. For each of some major questions asked by geography, different perspectives of geography, major concepts, and different methods of enquiry in geography, some examples are given of enquiries or focus questions which might be used in a reef context. Additionally, some relevant student activities in this handbook are listed.

Some major areas of existing Australian school geography syllabuses which can fruitfully involve exploration of reef topics, are identified in table A.9.

Table A.7: Perspectives in geography and reef education

Perspectives in geography	***Reef examples***	***Examples of relevant student activity in this handbook***
Spatial organisation perspective	What is the direction of prevailing winds along the GBR? How is living coral distributed on the top of a reef? How far is the edge of the continental shelf from the mainland?	Wind and waves (No. 17) Weather station (No. 16) Your first reef walk (No. 2) Your trip by sea (No. 100) On location (No. 1)
Regional studies perspective	What are the distinctive characters of the reef region? What conservation measures are being attempted in the reef area? How do people's activities affect the Reef region?	On location (No. 1) It's tropical (No. 15) Recreational fishing (No. 99) Effects of humans (No. 102)
Landscape perspective	What are the physical zones of a reef? What buildings exist at a resort? What is the difference between a cay and a continental island?	Reef and island cross-sections (No. 19) Formation and development of a cay (No. 20)
Ecosystem perspective	How do humans affect other living things in the Reef area? In reef environments, what organisms are producers? Why do animals depend on green plants?	Effects of humans (No. 102) Are you a perfect camper? (No. 107) Food web of a coral cay and reef (No. 78)
Environmental perception and behaviour perspective	How does an individual perceive different parts of the reef and cay? What are people's reactions to reef experiences? How do different individuals differ in their perceptions of reef phenomena?	Perception of place (No. 134) Arousal evaluation (No. 127)

Table A.6: Questions in geography and reef education

Questions geography asks	Reef examples	Examples of relevant student activities in this handbook
What is there?	What are distinctive features of a coral reef and cay? What is the GBR Marine Park? What kind of tourist facilities are located on reef islands?	Reef and island cross-sections (No. 19) Your first reef walk (No. 2) Tourist survey (No. 98)
Where is it located?	Where is the GBR Marine Park located? On what part of the sea floor are reefs located in the GBR area? On which end of reefs are sand cays usually located?	On location (No. 1) Your first cay walk (No. 4) Wind and waves (No. 17)
Why is it there?	Why are coral reefs found only in warm shallow seas? Why has the GBR Marine Park been established? Why have tourist facilities been developed in the GBR area?	On location (No. 1) How clear is the water? (No. 8) Compatible uses (No. 142)
What are the effects of it being there?	What effect has tourism had on Heron Island? What effect does the GBRMPA have on people's activities? What effect do reefs have on the movement of the water?	Effects of humans (No. 102) Recreational fishing (No. 99) Tidal changes (No. 11)
What alternative should be considered in making decisions about its being there?	What alternative patterns of marine park zoning might be used in an area? Should new floating hotels be permitted in the marine park or should further tourism be discouraged?	Environmental impact statements (No. 155) User roles and zoning game (No. 143)
By whom and for whom are decisions made about its being there?	Who contributes to decisions about zoning of the Great Barrier Reef Marine Park? Who is responsible for deciding whether new floating hotels should be established in the Marine Park? Who or what will benefit if these hotels are established? Who or what will be harmed if the hotels are established?	Compatible uses (No. 142) Environmental impact statements (No. 155) User roles and zoning game (No. 143)
Enquiry with objective orientation	Investigating variation in air temperature and humidity on a cay by taking regular measurements with instruments. Investigating the age and sex distribution of visitors to island using questionnaire	Weather station (No. 16) Tourist survey (No. 98)
Enquiry with subjective orientation	Exploring people's views of reef environments as expressed in poetry	Perspectives (No. 128)

Concepts in geography	Examples of some relevant reef focus questions	Examples of some relevant student activities in this handbook
Environment	What is the climate at Heron Island? How does tourism affect the reef? How does the weather influence activities for tourists?	Human comfort on a cay (No. 116) Are you a perfect camper? (No. 107) Trampling effects on a reef flat (No. 105) Effects of humans (No. 102) Wind and waves (No. 17)
Interaction	How do a cleaned fish and wrasse affect each other? In what ways do the ocean and atmosphere interact?	Cleaner wrasse (No. 72) Wind and waves (No. 17) Your trip by sea (No. 100)
Community	How are decisions made about use of this island's facilities? What tasks need to be carried out in camp catering and who will do them? How are decisions to be made about allocation of reef resources?	An island management plan (No. 154) Keep cooking (No. 110) User roles and zoning game (No. 143)
Landscape	What are the physical features of this reef? What trees are located on this cay?	Air photo interpretation (No. 18) Love a tree (No. 81) Vegetation distribution on a cay (No. 87)
Perception	How can we investigate people's perceptions of the Reef environment? How do visitors differ in their perceptions of this cay?	Tourist survey (No. 98) Perspectives (No. 120)
Planning	How is planning of the Great Barrier Reef Marine Park carried out? Is there a management plan for this island?	User roles and zoning game (No. 143) Environmental impact statement (No. 155) An island management plan (No. 154)
Sense of place	How do you feel about this place on the cay?	Perception of place (No. 134)
System	Is a coral cay a closed system? How is energy transferred in a cay community?	Food web of a coral cay and reef (No. 78)
Spatial justice	How can we ensure that different groups in our society are given an opportunity to share in use of reef resources?	Compatible uses (No. 142) User roles and zoning game (No. 143)
Culture	Is culture a factor which influences people's perception of reef environments?	Tourist survey (No. 98) Showing off (No. 147)

Table A.8: Concepts in geography and reef education

Concepts in geography	Examples of some relevant reef focus questions	Examples of some relevant student activities in this handbook
Location	Where are resorts located in the area? What are the geographic coordinates of the northern end of the GBR? Is Heron Island located on the windward or leeward side of Heron Island Reef? Where is the wreck located on the Heron Island Reef?	On location (No. 1) Wind and waves (No. 17) Wrecks (No. 109)
Distribution	What zones are recognisable on the reef top? Where are sea-cucumbers most concentrated on the reef top? Where are most buildings located on Heron Island? Why? What is the distribution of tree species on the cay? Where are mutton-birds found at Heron Island?	Air photo interpretation (No. 18) Cucumber count (No. 54) Vegetation distribution on a cay (No. 87) Those magnificent birds in their flying machines (No. 94)
Association	On the reef-top, are sea-cucumbers always found on sand? Are noddy tern nests found in *Pisonia* trees? What benefit does the clownfish gain from its association with the sea anemone?	Sea-cucumber habitats (No. 55) Bird nests (No. 93) Clownfish and anemone (No. 71)
Movement	How do tourists travel to reef islands? How do tidal currents affect snorkellers?	Tourist survey (No. 98) Your trip by sea (No. 100) Snorkelling over the edge (No. 3)
Change	How does reef-walking change the reef? How do cays change through time? What will happen to this reef as the tide falls?	Trampling effects on a reef flat (No. 105) Formation and development of a cay (No. 20) Monitoring tides (No. 13) Effects of humans (No. 102)
Direction	What is the prevailing wind direction at Heron Island? In which direction is Green Island from Cairns?	Weather station (No. 16) Your trip by sea (No. 100)
Distance	How far is North West Island from Gladstone? How far is it from the reef-edge back to the cay? Why is it easy to make reef day trips from Cairns?	Your trip by sea (No. 100) Reef-top transect (No. 73) On location (No. 1)
Scale	How much of the earth's surface is visible in this air photo of the Reef? What scale must be used to represent this island on an A4 size page?	Air photo interpretation (No. 18) Reef and island cross-sections (No. 19)
Region	What phenomena or features occur throughout the whole reef area but not in adjoining areas? What are the characteristics which make the reef area distinctive?	On location (No. 1) Ranger's work (No. 153) Love a coral clump (No. 42) It's tropical (No. 15)
Energy	Why is the sun's energy important to fish? How do the island campers get energy for lighting and cooking?	Algae are important (No. 30) How clear is the water? (No. 8) Keep cooking (No. 110)

Table A.9: Reef education and school geography syllabus—Great Barrier Reef studies are applicable to many content areas of existing geography syllabuses. Examples include:

Geography syllabus	**Syllabus content area**	
Queensland Board of Secondary Schools Senior Geography Syllabus (Reprinted 1987)	Unit V: The living environment	Section C: Regional Studies in Biogeography Section D: Human Impact
	Unit II: People and the environment	Section B: Areal Studies of Environmental Impact Section C: Conflict Studies
	Unit I: Geomorphology	Unit 6: Coastal Processes Unit 8: Activities of Man Unit 9: Macroregional Study
	Unit IX: Physical Geography	Topic 1: The Oceans—with applied options
	Unit III: Australian Geographical Inquiries	(Inquiry topics allow studies of the Great Barrier Reef in Physical/Environmental/Social units).
	Unit VII: Economic geography	Unit IV: Tertiary Occupations—Tourism and Recreation Studies
Queensland Board of Secondary Schools Junior Geography Syllabus (Reprinted 1987)	Australia	Patterns of Land in Australia Contemporary Geographical Issues
	Local area	Schools near reef could study reef as home area
New South Wales Secondary Schools Board, School Certificate Syllabus in Geography 1983	Communities and Environments Contemporary Issues and World Affairs Australian Geography People and Their Actions in Relation to Each Other and Global Environments	
New South Wales Board of Secondary Education Years 11 and 12, Geography (1987)	Australia and its World Context (Year 11): Global Environments Lobe (Year 12):	Topic 1 the Australian Environment Topic 2 Australians and Their Biophysical Environment Topic 1 Use and Misuse of Natural Resources Option 1 Fragile Environments Option 2 Food and Agriculture (minor)

RESOURCES

References and Resources about the Reef are divided into the following categories:

- Books and articles about the reef
- Periodicals and magazines for class use
- GBRMPA publications
- Audio visual teaching aids
- Curriculum documents
- Teacher readings on education and environment
- Organisations for further information

Books and articles about the Reef

Barnes, D. ed. 1983. *Perspectives on coral reefs.* Canberra: Clouston/Aust. Inst. Marine Science.

Bennett, Isobel. 1982. *The Great Barrier Reef.* Sydney: Lansdowne.

Carcasson, R. H. 1977. *A field guide to reef fishes of tropical Australia and the Indo-Pacific region.* London: Collins.

Clark, I., and Cook, B. J. 1983. *Geological science: perspectives of the earth.* Canberra: Aust. Academy of Science.

Coleman, N. 1983. *Australian sea fishes north of 30°S.* Sydney: Doubleday.

Cribb, A. B., and Cribb, J. W. 1985. *Plant life of the Great Barrier Reef and adjacent shores.* St Lucia: Univ. Queensland Press.

Deas, W., and Domm, S. 1976. *Corals of the Great Barrier Reef.* Sydney: Ure Smith.

Endean, R. 1982. *Australia's Great Barrier Reef.* St Lucia: Univ. Queensland Press.

Frith, H. T. 1976. *Reader's Digest complete book of Australian birds.* Sydney: Reader's Digest.

George, J. D. and George, J. J. 1979. *Marine life — an illustrated encyclopedia of invertebrates in the sea.* Adelaide: Rigby.

Goreau, T. F., Goreau, N. I. and Goreau, T. J. 1979. Corals and coral reefs. *Scientific American, August.*

Grant, E. 1982. *Guide to fishes.* Brisbane: Dept of Primary Industry.

Great Barrier Reef Marine Park Authority. 1981. *Nomination of the Great Barrier Reef for inclusion on the World Heritage List.* Townsville: GBRMPA.

Heatwole, H. 1981. *A coral island.* Sydney: Collins.

Hughes, R., ed. 1985. *Australia's underwater wilderness.* McMahon's Point: Weldon.

Hopley, D. 1982. *The geomorphology of the Great Barrier Reef.* New York: Wiley.

Jones, O. A., and Endean, R., eds. 1973-1977. *Biology and geology of coral reefs.* Vols 1 to 4. New York: Academic Press.

Mather, P., and Bennett, I. 1984. *A coral reef handbook.* Brisbane: Australian Coral Reef Society.

Maxwell, W. G. H. 1968. *Atlas of the Great Barrier Reef.* Amsterdam: Elsevier.

Morgan, D. ed. 1981. Biological science: *the web of life.* Canberra: Aust. Academy of Science.

Pizzey, G. 1980. *A field guide to the birds of Australia.* Sydney: Collins.

Queensland. Dept of Geographic Information. 1988. *Discovering coastal Queensland.* St Lucia: Univ. Queensland Press.

Saenger, P. 1977. *The divers guide.* Brisbane AUF.

Sheppard, C. R. 1983. *A natural history of coral reefs.* Poole, Dorset: Blandford Press.

Short, J. W. and Potter, D. G. 1987. *Shells of Queensland and the Great Barrier Reef: marine gastropods.* Drummoyne, Golden Press.

Slater, P. 1970. *A field guide to Australian birds — volume one non-passerines.* Adelaide: Rigby.

Talbot, F., ed. 1984. *Reader's Digest book of the Great Barrier Reef.* Sydney: Reader's Digest.

Veron, J. E. N. 1986. *Corals of Australia and the Indo-Pacific region.* North Ryde: Angus and Robertson.

Ward, W. T. and Saenger, P. eds. 1984. *The Capricornia section of the Great Barrier Reef — past, present and future.* Brisbane: Royal Society of Queensland and Australian Coral Reef Society.

Periodicals and magazines

The following periodicals and series often contain popular articles which could be useful in reef education programs.

- Australian Natural History (published by the Australian Museum)
- Ecos (published by CSIRO)
- Habitat (published by the Australian Conservation Foundation)
- Australian Fisheries (published by the Commonwealth Department of Primary Industry)
- Oceanus (United States periodical. Special Issue on the GBR — Vol 29:2, 1986)
- Underwater
- Geo
- Australian Geographic

Publications of the Great Barrier Reef Marine Park Authority

- *Reef Notes* Pamphlet series on Reef topics, titles include 'Coral polyp', 'The Soft Touch', 'Turtles', 'Seabirds', 'Coral cays', 'Trochus Shells', 'Captain Cook'.
- *Reeflections* (newsletter)
- Zoning plans and zoning maps for sections of the Great Barrier Reef Marine Park

The GBRMPA also publishes a wide range of other material including research reports on topics such as tourism, fisheries and reef management. Contact GBRMPA for information on currently available titles.

Audio visual teaching aids

GBRMPA publishes a booklet of detailed reviews of some audio visual publications about coral reefs. GBRMPA's own productions include:

- Encounters with the Reef. (slide — tape kit)
- The Crown of Thorns Story. (30 min video)
- Reef Report (quarterly 20 min video news magazine)

Curriculum Documents

NSW Board of Secondary Education. 1987. *Syllabus, Years 11-12, geography*. Sydney: BSE.

NSW Board of Senior School Studies. 1979. *Science syllabus, 2 unit course — physics, Years 11-12*. Sydney: BSSS.

NSW Board of Senior School Studies. 1979. *Science syllabus, 2 unit course — chemistry, Years 11-12*. Sydney: BSSS.

NSW Board of Senior School Studies. 1980. *Science syllabus, 2 unit course — geology, Years 11-12*. Sydney: BSSS.

NSW Board of Senior School Studies. 1985. *Science syllabus, 3/4 unit (general) course, Years 11-12*. Sydney: BSSS.

NSW Board of Senior School Studies. 1986. *Science syllabus, 2 unit course — biology, Years 11-12*. Sydney: BSSS.

NSW Secondary Schools Board. 1985. *Science syllabus, Years 7-10*. Sydney: SSB.

NSW Secondary Schools Board. 1983. *School certificate syllabus in geography*. Sydney: SSB.

Queensland Board of Secondary Schools. 1981. *Senior syllabus in earth science (draft)*. Brisbane: BSS.

Queensland Board of Secondary Schools. 1984. *Senior syllabus in multistrand science (draft)*. Brisbane: BSS.

Queensland Board of Secondary Schools. 1985. *Junior syllabus in science (draft)*. Brisbane: BSS.

Queensland Board of Secondary Schools. 1985. *Senior syllabus in biological science (draft)*. Brisbane: BSS.

Queensland Board of Secondary Schools. 1985. *Senior syllabus in chemistry (draft)*. Brisbane: BSS.

Queensland Board of Secondary Schools. 1985. *Senior syllabus in physics (draft)*. Brisbane: BSS.

Queensland Board of Secondary Schools. 1987. *Senior geography syllabus (reprint)*. Brisbane: BSS.

Queensland Board of Secondary Schools. 1987. *Junior geography syllabus (reprint)*. Brisbane: BSS.

Teacher readings on education and environment

•Books

Anderson, H. O., ed. 1969. *Readings in science education for the secondary school.* New York: Macmillan.

Ajzen, I., and Fishbein, M. 1980. *Understanding attitudes and predicting social behaviour.* Englewood Cliffs, N. J.: Prentice Hall.

Alun Jones, P. 1968. *Fieldwork in geography.* London: Longmans.

Australia. Dept Home Affairs and Environment. 1984. *National conservation strategy for Australia.* Canberra: AGPS.

Australian Science Education Project. 1974. *A guide to A.S.E.P. (Introduction to A.S.E.P.).* Melbourne: Govt Printer.

Barman, C. R., Rusch, J. J., and Cooney, T. M. 1981. *Science and societal issues.* Ames, Iowa: Iowa State University Press.

Bartlett, L., and Cox, B. 1982. *Learning to teach geography.* Brisbane: Wiley.

Bentley, Ian. 1984. *Research investigation.* Melbourne: Nelson.

Brumby, M. 1984. *Issues in biology.* Melbourne: Nelson.

Cornell, J. B. 1979. *Sharing nature with children.* Nevada City, Calif.: Ananda.

Curriculum Development Centre: 1981.*Environmental education: A source book for secondary education.* Canberra: CDC.

Fien, J., Gerber, R., and Wilson, P. 1984. *The geography teachers guide to the classroom.* Melbourne: Macmillan.

Fien, J. 1988. *Education for the Australian environment. Bicentennial Australian Studies Schools Project Bulletin 3.* Canberra: CDC.

Fraenkel, J. 1973. *Teaching students to think and value.* Englewood Cliffs, N. J.: Prentice Hall.

Great Barrier Reef Marine Park Authority. 1983. *Workshop on northern sector of Great Barrier Reef Marine Park.* Townsville: GBRMPA.

Greenall, A. 1980. *Environmental education for schools.* Canberra: Curriculum Development Centre.

International Union for Conservation of Nature and Natural Resources. 1980. *World conservation strategy.* Gland, Switz.: IUCN.

Joseph, D. B., et al. 1976. *Enquiry in science — a guide for teachers.* Sydney: McGraw Hill.

Kohlberg, L. 1976. *Development and behaviour.* New York: Holt.

Linke, R. 1980. *Environmental education in Australia.* London: Allen & Unwin.

McAllister, Robert. 1982. *Science processes — their role in teaching and learning.* in *Guidelines* series, Qld Department Education, Curriculum Branch.

Martin, M. 1972. *Concepts of science education.* Glenview Ill.: Scott, Foresman & Co.

NSW Department of Education, Personal Development Unit, Directorate of Special Programs. 1983. *Ideas for values education: Moral dilemma, values clarification.* Sydney.

Oates, C., et al. eds. 1980. *Science education: Australian principles and practices.* Canberra: CDC.

Passmore, John. 1974. *Man's responsibility for nature — ecological problems and western tradition.* London: Duckworth.

Raths, L. E., Harmin, M., and Simon, S. B. 1978. *Values and teaching, working with values in the classroom* (2nd ed.). Columbus, Ohio: Merrill.

Romey, W. D. 1968. *Inquiry techniques for science teaching.* London: Prentice Hall.

S.A. Secondary Science Curriculum committee. 1977. *The do it yourself curriculum guide for junior secondary science.* Adelaide: Education Dept S. Australia.

Saarinen, T. 1976. *Environmental planning: Perception and behaviour.* Boston: Houghton-Mifflin.

Sharpe, G. W. 1982. *Interpreting the environment.* Toronto: Wiley.

Simon, S. B., Howe, L. W., and Kirschenbaum, H. 1978. *Values clarification — a handbook of practival strategies for teachers and students. New York: A & W.*

Simpson, R. D., and Anderson, N. D. 1981. *Science, students and schools.* New York: Wiley.
Stapp, W., and Cox, D. 1974. *Environmental education activities manual.* Michigan: Stapp & Cox.
Superka, D., et al. 1975. *Values education: Approaches and materials.* Boulder, Colorado: Social Sciences Education Consortium, Inc.
Sutton, C., and Haysom, J. 1974. *The art of the science teacher — science teacher education project.* London: McGraw-Hill.
Swan, J., and Stapp, W. 1974. *Environmental education — strategies toward a more livable future.* New York: Wiley.
Van Matre, S. 1972. *Acclimatization — a sensory and conceptual approach to ecological involvement.* Martinsville, Indiana: American Camping Association.
Van Matre, S. 1974. *Acclimatizing.* Martinsville, Indiana: American Camping Association.
Weigand, P., and Orrell, K., eds. 1982. *New leads in geographical education.* Sheffield: Geographical Association.
Wheeler, K., and Waites, B. eds. 1976. *Environmental geography.* St Albans: Hart-Davis.
Yi-Fu Tuan. 1974. *Topophilia — a study of environmental perception, attitudes and values.* Englewood Cliffs, N. J.: Prentice Hall.

•Articles

Ajzen, I., and Fishbein, M. 1977. Attitude-behaviour relations: a theoretical analysis and review of empirical research. *Psychological Bulletin* 84:888-918.
Birch, C. 1982. Ecological ethics and economics. *Habitat* 10 (5): 13-14.
Blachford, K. 1979. Morals and values in geographic education: toward a metaphysics of the environment. *Geogr. Ed.* 3:423-57.
Brockmeyer, F. M., Bowman, M. L., and Mullins, G. 1982/83. Sensory versus nonsensory interpretation: a study of senior citizens' preferences. *J. Environ. Ed.* 14 (2).
Caduto, M. 1983a. A review of environmental values education. *J. Environ. Ed.* 14 (3): 1321.
Caduto, M. (1983b). Toward a comprehensive strategy for environmental values education. *J. Environ. Ed.* 14 (4): 12-18.
Elliot, R. 1978. *Ethics and conservation.* Habitat 6 (2): 9-13.
Elliot, R. 1979. *Should we preserve species.* Habitat 7 (5): 9-10.
Fensham, Peter J., and May, John B. 1979. Servant not master — new role for science in a core of environmental education. *Australian Science Teachers Journal* 25 (2): 15-24.
Fien, T. 1980. Perception studies in human geography. In *Geographical issues,* edited by R. Gerber and D. Biddle, pp 1-39. Brisbane: AGTA.
Fien, J., and Slater, F. 1981. Four strategies for values education in geography. *Geogr. Ed.* 4: 39-52.
Fox, W. 1986. *Approaching deep ecology: a response to Richard Sylvan's critique of deep ecology. Environmental Studies Occasional Paper No. 20.* University of Tasmania, Hobart: Centre for Environmental Studies.
Gerber, R., and Biddle, D., eds. 1980. *Geographical issues.* Brisbane: AGTA.
Godfrey-Smith, W. 1979. The value of wilderness. *Environmental Ethics.* 1: 309-19.
Gough, N. P. 1979. Moral dimensions of environmental education. *Unicorn* 5 (2): 150-60.
Huckle, J. F. 1983. Values education through geography: a radical critique. *J. Geogr.* (March-April): 59-63.
Knapp, C. E. 1983. A curriculum model for environmental values education. *Dialogue* 14 (3): 22-26.
Lucas, A. M. 1980. The role of science education for the environment. *J. Environ. Ed.* 12(2): 33-37.
Partington, G. 1983. Clarifying student's values. *Unicorn* 9 (1): 34-38.
Perdue, R. R., and Warder, D. S. 1981. Environmental education and attitude change. *J. Environ. Ed.* 12 (3): 25-28.
Pluhar, E. G. 1983. The justification of an environmental ethic. *Environmental Ethics* 5 (1): 47-62.
Robottom, I. 1983. Science: a limited vehicle for environmental education. *Aust. Sci. Teachers Journal* 29 (1): 27-31.
Schoer, G. 1979. An integrated approach to pupil-centred field studies in geography using multisensory observational techniques. *Geography Bulletin* 11 (2): 42-51.
UNESCO. 1978. The Tbilisi declaration. *Connect UNESCO-UNEP Environmental Newsletter* 3 (1): 1-8.
Young, R. A. 1980. The relationship between information levels and environmental approval: the wilderness issue. *J. Environ. Ed.* 11 (3): 25-30.

Organisations for further information

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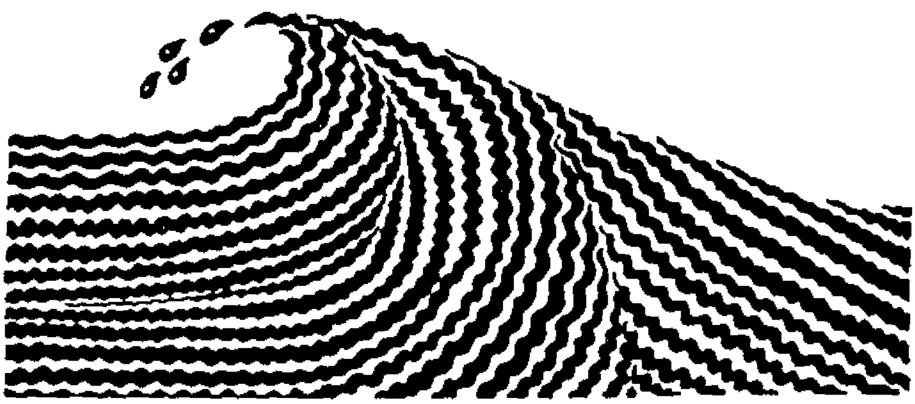

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