The *Outstanding Universal Value* of the Great Barrier Reef World Heritage Area

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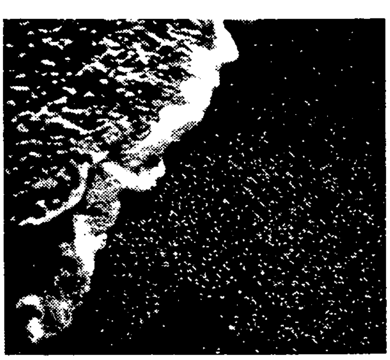

GREAT BARRIER REEF
MARINE PARK AUTHORITY

Environment Australia
Australian and World Heritage Group

QUEENSLAND GOVERNMENT
Department of Environment

Published May 1997 by the Great Barrier Reef Marine Park Authority
Reprinted April 1998

National Library of Australia Cataloguing-in-Publication data:

The outstanding universal value of the Great Barrier Reef World Heritage Area.

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ISBN 0 642 23028 5.

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333.78209943

Acknowledgments
We wish to express our gratitude to the many individuals who gave their time and expertise to assist in the completion of this project. It was evident from the outset that without the considerable assistance from a range of experts this report would have been lacking. Accordingly more than 60 individuals assisted in providing information and examples for this report. These experts provided the backbone of this report. We thank them for their accessibility and willingness to be involved in this project. Their names are included in Appendix 2.

Members of the steering committee for the project gave invaluable input and direction at an initial workshop and an interim results presentation. This group included Dominique Benzaken, Barbara Curnow, Deirdre Howard, Prue Keen, Geoff Kelly, Peter McGinnity, Geoff Mercer, Warren Nicholls and Colin Trinder.

We gratefully acknowledge the effort taken by Paul Dingwall, Graeme Kelleher, Richard Kenchington, Bernd von Droste and John Whitehouse in reviewing drafts of this document.

The financial support of the project by the Commonwealth Government through the Great Barrier Reef Marine Park Authority and the World Heritage Unit, and by the Queensland Government through the Department of Environment is gratefully acknowledged.

Our gratitude goes to Corryn Costello, Cathy Everett and Michelle Warrington, for their administrative and finance skills when our manual and intellectual dexterity could not cope with facsimile machines, manual typewriters, binding machines and the University accounting system.

Thanks go to Barbara Pannach, Jasper Taylor and Bevan Williamson for their assistance in negotiating contract details.

While acknowledging the many contributions, we take full responsibility for all views expressed and for the quality of the report.

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The Great Barrier Reef is an immense, unique environment of global aesthetic and scientific significance comparable to any of the largest reef structures that have existed in the last 450 million years of the geological past...

(Hopley & Davies 1986:7)

Contents

Summary

- Recent public disputes over the management of the Great Barrier Reef World Heritage Area have highlighted difficulties in considering the World Heritage nature of the region. The original nomination document for the region is brief and has proved inadequate for guiding management decisions. Consequently, the Great Barrier Reef Marine Park Authority initiated a series of three consultancies to clarify the nature of World Heritage as it applies to the Great Barrier Reef, and the resultant management implications.
- This report fulfils the first of these consultancies. It provides an expansion and clarification of the basis upon which the Great Barrier Reef Region is justified as a natural heritage property for inscription upon the World Heritage List.
- The re-evaluation of the Great Barrier Reef for inclusion upon the World Heritage List necessitates placing the natural heritage attributes of the property in a global context. A consultancy team of four people, regardless of their individual expertise, could not have the breadth and depth of knowledge required for describing the 'outstanding universal value' of the Great Barrier Reef World Heritage Area. Consequently, we consulted more than 60 people in depth to provide information for this report.
- The World Heritage Convention (the convention) was concluded at the General Conference of the United Nations Education Scientific and Cultural Organisation in November 1972. The central tenet of the Convention is that there are places that are of such 'outstanding universal value' that their disappearance constitutes a harmful impoverishment of the heritage of all humanity. To this end, the Convention establishes mechanisms for the conservation and protection of the World's heritage. States parties to the Convention are obligated to ensure the identification, protection, conservation, presentation and transmission to future generations of this World Heritage.
- Central to these efforts is the World Heritage List, a list of the World's properties of 'outstanding universal value'. Assessment for inclusion upon the World Heritage List is carried out by the World Heritage Committee with reference to two sets of criteria: one for cultural heritage and one for natural heritage. These criteria have been amended several times over the life of the Convention. Currently the natural heritage criteria focus upon:
  - geological phenomena;
  - ecological and biological processes;
  - aesthetics and natural beauty; and
  - biological diversity, including threatened species.
- In the 25 years since the Convention's inception, there have been changes in its operational emphasis. In particular, there is a growing emphasis upon monitoring the state of conservation of the properties upon the list complementing the identification of new properties. Additionally, the processes of evaluating site nominations for the list have become increasingly rigorous. This project is timely within this context.
- The idea that the Great Barrier Reef should become a marine park was mooted as early as 1963 by the Wildlife Preservation Society of Queensland. Concerns over the level of foreign fishing within reef waters, the effects of crown-of-thorns starfish, and growing fishing and tourism industries highlighted the lack of protection for the Great Barrier Reef in the 1960s. The prospects of oil drilling and limestone mining upon the reef were pivotal in initiating a campaign that culminated in the *Great Barrier Reef Marine Park Act 1975* (Cwlth), the legislative basis for the Great Barrier Reef Marine Park. This Act also established the statutory authority to coordinate the management of the Park, the Great Barrier Reef Marine Park Authority.
- The Great Barrier Reef was accepted for inclusion upon the World Heritage List in 1981, meeting all four of the natural heritage criteria. Prior to inscription, the nomination had been reviewed by the International Union for the Conservation of Nature, who supported the inscription. During this review, concerns were raised regarding the adequacy of the management regime envisioned for the region.

- The management of the Great Barrier Reef World Heritage Area is complicated by several factors:
    - The World Heritage Area is different from the area proclaimed as the Great Barrier Reef Marine Park.
    - The complex jurisdictional mix of state and federal responsibilities means that no single body has primary responsibility for the World Heritage aspects of the Great Barrier Reef World Heritage Area. Recently, a Memorandum of Understanding among Federal agencies gave the Great Barrier Reef Marine Park Authority lead agency status. However, mechanisms for ensuring that World Heritage values are protected by managers of activities under Queensland control (e.g. fishing, use of islands) have not been resolved.
    - The massive size of the Great Barrier Reef World Heritage Area, by far the largest World Heritage Area ever established, creates specific problems. In particular, it is difficult to determine:
        1. the level of activity that should be allowed to occur in the World Heritage Area; and
        2. how local-scale impacts affect the World Heritage value of the entire site.
- In documenting the basis upon which the Great Barrier Reef is included upon the World Heritage List, we interviewed a total of 60 people with expertise covering a total of 29 natural heritage attributes. These attributes covered a range of phenomena from individual species, groups of species, habitats, geological features, aesthetic considerations and ecological and biological processes. Twenty-nine summary papers were written based upon interviews with the identified experts.
- No expert interviewed questioned the inscription of the Great Barrier Reef on the World Heritage List. Based on the papers, we found that the Great Barrier Reef World Heritage Area is justifiable upon all four current natural heritage criteria. Furthermore, the changes in criteria between 1981 and 1996 do not necessitate any changes in the justification for World Heritage inscription.
- Several individual phenomena are world class; for example, the Great Barrier Reef is the largest coral reef system that has ever existed. However, there are two factors that were primary in the expert summaries. Thus the 'outstanding universal value' or the World Heritage value, of the Great Barrier Reef World Heritage Area, and its integrity rests upon:
    - the scale of the Area; and
    - its potential for effective conservation management.
- These two factors do not, in themselves, justify the listing of the Great Barrier Reef on the World Heritage List. However, they are fundamental and pivotal factors in enabling the expression of those aspects of the region that justify its inscription.
- The size of the Great Barrier Reef World Heritage Area, from the low water mark on the mainland coast to past the edge of the continental shelf, and from the tip of Cape York Peninsula to just north of Fraser Island, ensures that a highly diverse suite of habitats and environmental regimes at a range of spatial scales are represented in the one World Heritage Area. This habitat diversity gives rise to a vast number of species and ecological processes. Acknowledging that the size of the Great Barrier Reef World Heritage Area underlies its 'outstanding universal value', there is considerable danger in attempting to reduce the significance to specific site locations. The World Heritage value of the Great Barrier Reef is a consequence of many attributes combining to produce a whole which cannot be reduced, without loss, to disconnected components.
- Australia is fortunate in being able to afford the resources to ensure the protection and conservation of the Great Barrier Reef World Heritage Area. The relatively pristine state of the region compared with other tropical coral reef ecosystems, can be maintained. Most other systems in the Indo-West Pacific region are under considerably more pressure. The future of tropical reef ecosystems of this region and the species they support may well depend upon the conservation of the Great Barrier Reef World Heritage Area.

- Despite the extent of research that has taken place in the Great Barrier Reef World Heritage Area, there remain considerable gaps in our knowledge. In particular, the level of knowledge regarding aesthetic attributes of the Area is poor. The lack of methodologies and the limited understanding of what constitutes aesthetic value have hampered the documentation of these qualities.
- In reviewing the management of several other World Heritage sites from around the World, we found that few of them had specifically built World Heritage status into their management and planning regimes. However, more explicit recognition of World Heritage is being introduced to the planning and management regimes of some properties. At several sites, the designation of World Heritage has given extra force to arguments to limit damaging developments. It appears to be universally accepted that public education, understanding and support of World Heritage is of vital importance in achieving effective management.
- An investigation of World Heritage Cities demonstrated the ability to achieve a balance between protection of the World Heritage and continuing economic activity. In the case of the City of Bath, World Heritage is explicitly incorporated into planning regimes as a 'key material consideration' in planning and decision making.
- The lack of appropriate planning regimes over World Heritage properties leaves them open to considerable threats that may devalue the property. Tourism may be particularly threatening to World Heritage Areas. The very status of World Heritage is a powerful attraction to tourists. In the case of the Great Barrier Reef World Heritage Area, terrestrial development has great potential to threaten the basis of the Great Barrier Reef World Heritage Area. Terrestrial run-off resulting from unsustainable land use is probably the most serious threat to the integrity of the Great Barrier Reef World Heritage Area.
- The *25 Year Strategic Plan for the Great Barrier Reef World Heritage Area* (the Strategic Plan) provides a vision for a management approach for the Area that overtly recognises its World Heritage status, and the objectives and strategies to realise this vision. By fulfilling the objectives set out in the Strategic Plan, in particular those relating to education, conservation, legislation and monitoring, Australia will meet its international obligations under the World Heritage Convention.
- We found that any reduction in the spatial extent of the Great Barrier Reef World Heritage Area would severely reduce its 'outstanding universal value'. In contrast, expanding the area to include the Coral Sea reefs would enhance the World Heritage value through increased habitat and process diversity. Extension to include the Torres Strait reefs would also increase the Area's 'outstanding universal value'. However, while the former expansion option is likely to be widely accepted, the latter is likely to receive opposition from Torres Strait Islanders, and should not be pursued at this time. Any reduction in the size of the Great Barrier Reef World Heritage Area would also be met with considerable public opposition.
- This report does not deal with cultural heritage attributes at a level commensurate to that for natural heritage attributes. While the Great Barrier Reef World Heritage Area was not listed on the basis of its cultural heritage attributes, there is a general obligation under the World Heritage Convention to protect, conserve, present and transmit the cultural heritage of the Area. The Strategic Plan identifies objectives and strategies that will ensure Australia's general obligation to the cultural heritage of the Great Barrier Reef World Heritage Area is upheld.

Recommendations

1. That the Great Barrier Reef Marine Park Authority initiate negotiations with other relevant state and federal agencies on whether the coastal boundaries of the Great Barrier Reef Marine Park and the Great Barrier Reef World Heritage Area should be identical.
2. That, to enable Australia to meet its international obligations under the World Heritage Convention, the Great Barrier Reef Marine Park Authority take a more pro-active approach to its agreed role as lead agency for the implementation of the *25 Year Strategic Plan for the Great Barrier Reef World Heritage Area*, particularly the objectives and strategies relating to education, conservation, legislation and monitoring.
3. That, in view of the considerable gaps in our knowledge of the Great Barrier Reef World Heritage Area, all agencies adopt the precautionary principle as the basis for their management of the Area.
4. That the Great Barrier Reef Marine Park Authority instigate a new research program 'Aesthetics and Natural Beauty Research Program' in order to document and better understand aesthetic values of the natural heritage attributes of the area so that they can be incorporated into the management and planning of the Great Barrier Reef World Heritage Area.
5. That the Great Barrier Reef Marine Park Authority initiate discussion with the following Queensland agencies to ensure that the management of the following activities in or adjacent to the Great Barrier Reef World Heritage Area does not adversely affect its World Heritage value:
   - Queensland Fisheries Management Authority regarding commercial and recreational fishing;
   - Queensland Department of Environment regarding the use of offshore islands; and
   - Queensland Department of Natural Resources regarding terrestrial run-off.
6. That the Great Barrier Reef Marine Park Authority initiate discussion with relevant Queensland state departments and agencies and local governments to develop planning guidelines to ensure that activities in or adjacent to the Great Barrier Reef World Heritage Area do not adversely affect its World Heritage value.
7. That the Great Barrier Reef Marine Park Authority initiate negotiations with other relevant state and federal agencies on whether the boundaries of the Great Barrier Reef World Heritage Area should be changed so that the Area includes the Coral Sea Reefs.
8. That the Great Barrier Reef Marine Park Authority ensure that representative examples of all habitats within the Great Barrier Reef World Heritage Area are managed to meet the criteria for IUCN category I or II protected areas. Such protected areas should be distributed throughout the entire Area.
9. That legislation, underpinning resource use and its management in the Great Barrier Reef World Heritage Area, be amended to require the consideration of the World Heritage value in planning and decision-making processes.
10. That monitoring reports detailing the state of conservation of the Great Barrier Reef World Heritage Area be prepared at five-year intervals, preferably coincident with the proposed timing of periodic reviews of the 25 year Strategic Plan.
11. That the Great Barrier Reef Marine Park Authority initiate discussion with relevant Queensland state departments and agencies with a view to negotiating a Memorandum of Understanding between the Queensland and Commonwealth Governments regarding the management of the Great Barrier Reef World Heritage Area.
12. That the Great Barrier Reef Marine Park Authority initiate negotiations with Aboriginal and Torres Strait Islander peoples concerning a project to investigate the cultural heritage attributes of the Great Barrier Reef World Heritage Area and its possible renomination as a cultural landscape.

Abbreviations

ACF	Australian Conservation Foundation
ACIUCN	Australian Committee for IUCN
ANZECC	Australian and New Zealand Environment and Conservation Council
CONCOM	Council of Nature Conservation Ministers
COTS	crown-of-thorns starfish
GBR	Great Barrier Reef
GBRMP	Great Barrier Reef Marine Park
GBRMPA	Great Barrier Reef Marine Park Authority
GBRR	Great Barrier Reef Region
GBRWHA	Great Barrier Reef World Heritage Area
ICCROM	International Centre for the Study of the Preservation and Restoration of Cultural Properties
ICOMOS	International Council for Monuments and Sites
IGAE	Inter-Governmental Agreement on the Environment
IUCN	The World Conservation Union
MAB	UNESCO Man and the Biosphere Programme
MOU	Memorandum of Understanding
MPA	marine protected area
NGO	Non Government Organisation
OECD	Organisation for Economic Cooperation and Development
QDoE	Queensland Department of Environment
QFMA	Queensland Fisheries Management Authority
UNCED	United Nations Conference on Environment and Development
UNESCO	United Nations Educational Scientific and Cultural Organization
WCMC	World Conservation Monitoring Centre
WHU	World Heritage Unit
WPSQ	Wildlife Preservation Society of Queensland

Chapter One: Introduction

1.1 International Significance of the Great Barrier Reef

The Great Barrier Reef World Heritage Area (GBRWHA) covers a huge region, spanning some 14° of latitude from the tip of Cape York Peninsula to just north of Fraser Island, from the low water mark to beyond the edge of the continental shelf. The 348 700 km^2 area encompasses a vast array of marine and terrestrial habitats which are home to numerous species. The World Heritage Area is unique in its size and has an impressive expression of biological diversity at ecosystem, species and genetic levels. The Great Barrier Reef World Heritage Area is within the legal jurisdiction of one nation state. Moreover, Australia is fortunate to be affluent enough to afford the area a level of protection that few other countries in the tropical regions could afford. The vast extent and the potential to offer the area a high level of protection are foremost in giving the Great Barrier Reef World Heritage Area an unique place among the world's land and seascapes.

1.2 International Conventions and the Great Barrier Reef

The importance of the Great Barrier Reef World Heritage Area to conservation has been recognised under a number of international instruments, of which Australia is a party. The area includes habitats for migratory species listed in the Appendixes of the *Convention on the Conservation of Migratory Species of Wild Animals*[1] (1979, Bonn Convention): sea turtles and dugongs, for example. Similarly, the area contains habitats for a number of migratory bird species included in the annexes to the *China and Australia Migratory Birds Agreement* (1986, CAMBA) and the *Japan and Australia Migratory Bird Agreement* (1979, JAMBA), both being agreements concluded under the auspices of the Bonn Convention.

A number of species listed in Appendix I and II to the *Convention on International Trade in Endangered Species of Wild Fauna and Flora*[2] (1973, CITES), have ranges that include the Great Barrier Reef World Heritage Area. Bowling Green Bay and Shoalwater Bay are recognised as providing important habitat for waterbirds through their listing under the *Convention on Wetlands of International Importance Especially as Waterfowl Habitat*[3] (1971, Ramsar Convention). The importance of the Great Barrier Reef's rich diversity of ecosystems, habitats, species and genetic material presents an obvious case for Australia to meet its obligations to protect and conserve biodiversity under the recently concluded *Convention on Biological Diversity*[4] (1992).

Finally, the area is recognised as being of 'outstanding universal value' from a number of perspectives for the purposes of the *Convention Concerning the Protection of the World Cultural and Natural Heritage* – the World Heritage Convention.

1.3 Terms of Reference for the Consultancy

In an invitation to tender dated 2 August 1995, the Great Barrier Reef Marine Park Authority (GBRMPA), sought to engage suitably qualified consultants to:

> ...conduct a literature search of publications that relate to the Great Barrier Reef, including the supporting bibliography of the Great Barrier Reef World Heritage nomination and subsequent literature;
>
> extract authoritative statements on Great Barrier Reef natural attributes;
>
> and, through a process of matching those statements with the criteria for World Heritage listing and the Great Barrier Reef nomination document, derive a descriptive, comprehensive list of Great Barrier Reef World Heritage values, including their approximate geographic distribution where known.

We drafted a proposal to carry out the tasks and submitted this to GBRMPA on 10 August 1995. It became apparent there were concerns within the funding agencies (GBRMPA, Queensland

1 Australia deposited its instrument of accession to the Bonn Convention on 26 June 1991, the Convention came into force for Australia on 1 September 1991.

2 CITES came into force for Australia on 27 October 1976 (Emonds 1981).

3 The Ramsar Convention came into force for Australia on 21 December 1975 (Mathews 1993).

4 Australia ratified the Convention on Biological Diversity on 18 June 1993, and the Convention came into force on 29 December 1993.

Department of Environment (QDoE) and the World Heritage Unit (WHU) of the Commonwealth Department of the Environment, Sport and Territories), regarding the consultancy and its terms of reference. GBRMPA established a Steering Committee for the consultancy, and convened an internal workshop on the terms of reference. The modified terms of reference required the consultancy to:

A. Answer the following questions:
   a) i) Are there social values that the Commonwealth has obligations to protect under the current World Heritage Listing?
      ii) If so, what are they?
      iii) If not, is there a need/opportunity to have it re-listed?
   b) i) Are there [Aboriginal and Torres Strait Islander] cultural values that the Commonwealth has obligations to protect under the current World Heritage listing?
      ii) If so, what are they?
      iii) If not, is there a need/opportunity to have it re-listed?

B. Using evaluation criteria developed by UNESCO in 1993 following the 4th World Congress on National Parks and Protected Areas, define a comprehensive list of the attributes of the Great Barrier Reef which meet these criteria by conducting a literature search of publications that relate to the Great Barrier Reef, including the supporting bibliography of the Great Barrier Reef World Heritage nomination and subsequent relevant literature.

C. Using the attributes determined in B and based on your expert judgement, i) assign values to those attributes in terms of their contribution to World Heritage, ii) describe the approximate geographic location of those values, and iii) describe the process used to derive i) and ii).

D. Identify the information gaps.
   NB 'Value' = 'quality' of attribute

In response to the considerably revised tasks, we detailed how we proposed to carry out the new tasks. Following a meeting with GBRMPA staff to clarify aspects of our response we were awarded the consultancy on 9 November 1995. Initial contact with GBRMPA regarding the consultancy had been made as early as March 1995, however our prior time commitments and the revision of tasks delayed commencement until January 1996. This extended lead up to the beginning of the consultancy was further complicated through the resignation of the principal GBRMPA contact most cognisant with the evolving nature of the consultancy. Consequently, in the initial stages of the consultancy, we convened a workshop inviting members of the GBRMPA, the WHU and QDoE, to clarify and if necessary modify the consultancy and its methodology.

The workshop was attended by 3 staff from GBRMPA, 2 staff from WHU, and 1 from QDoE. The workshop proved to be a fundamental component in the process of this consultancy. It provided the opportunity to discuss and clarify the methodology to be undertaken, and the form that the final report would take. We saw the workshop as a crucial component of the consultancy, facilitating a high level of consensus regarding issues of World Heritage 'values' among agencies primarily focused upon 'facts'. Agreement was easily reached upon both the methodology for the consultancy and an outline for the final report which detailed its contents. The structure of this report reflects the consensus reached at this workshop and reflects the agreed modifications to the Terms of Reference. The completion of this consultancy to the expectation and satisfaction of those involved is largely as a result of this initial workshop.

It should be noted that this consultancy forms the first in a proposed series of three. The remaining two stages build upon this consultancy. Step 2 focuses upon the responsibilities, current decision-making processes and appropriate changes required in GBRMPA's consideration of World Heritage within the Great Barrier Reef Marine Park (GBRMP), while Step 3 will consider similar aspects but in reference to those parts of the World Heritage Area not within the Great Barrier Reef Marine Park.

1.4 Rationale for the Consultancy

Recent public disputes over the management of activities within or adjacent to the Great Barrier Reef World Heritage Area have highlighted difficulties in considering the Great Barrier Reef region in the context of its World Heritage status. These difficulties have not been assisted by the minimalist approach to justification for World Heritage listing in the nomination document (GBRMPA 1981). In the first instance then, this consultancy seeks to expand and clarify the basis upon which the Great Barrier Reef Region is justified for inclusion upon the World Heritage List.

While there has been no public debate about reducing the area inscribed upon the World Heritage List, some interpretations of the World Heritage Convention imply that such a reduction is necessary to maintain the integrity of the Convention. Additionally then, this consultancy seeks to provide a basis from which the management responsibilities of Australia to the Great Barrier Reef World Heritage Area could be further enhanced.

1.5 Approach Adopted in the Consultancy

The evaluation of a property for inclusion on the World Heritage List necessitates placing the attributes of the property within a global context. A global approach is also needed in describing the attributes that give rise to the inclusion of the Great Barrier Reef on the World Heritage List. A consultancy team of four people, regardless of their individual expertise, will not have the breadth and depth of knowledge required to describe the attributes of an area as large and diverse as the Great Barrier Reef World Heritage Area. Furthermore, the literature relating to the area is so vast that access to it without appropriate guidance is fraught with difficulties. Accordingly our expertise was extended by the specialist knowledge of a range of other known experts.

Appendix 2 gives details of the 63 people who were consulted or interviewed through the execution of this consultancy. The use of these experts facilitated efficient access to the most relevant literature, and more importantly, expert opinion in areas where no documented information exists.

1.6 The Consultancy Team

It follows that this report is the product of many people's ideas and contributions. However the synthesis of this information to form this report was our sole responsibility.

We were led by Mr P.H.C. ('Bing') Lucas, a New Zealand national with extensive experience in matters relating to the international implementation of the World Heritage Convention. Other team members were Mr P. Valentine, Prof. H. Marsh and Mr T. Webb, all from the Department of Tropical Environment Studies and Geography, James Cook University.

Mr Valentine is a senior lecturer in protected area and World Heritage management and is regularly called upon to assist in the technical evaluation of World Heritage nominations. Prof. Marsh is an international expert in marine mammal ecology, and has had long involvement in management of the Great Barrier Reef Marine Park. She has been the Chair of the Great Barrier Reef Consultative Committee for its last two terms. Mr Webb is a PhD student investigating the social construction of World Heritage in relation to the Great Barrier Reef World Heritage Area.

While the report is the joint product of our labour, a number of sections were completed independently. In particular Chapter Two, and Chapter Three (Sections 3.1–3.5 inclusive) were entirely Mr Webb's responsibility and product. These will be incorporated into Mr Webb's PhD dissertation to be submitted in 1997.

1.7 Cultural Heritage and this Consultancy

It should be noted that while Task A of the Terms of Reference focuses considerable attention upon cultural heritage, particularly that of Aboriginal and Torres Strait Islander peoples, we have not considered this realm of World Heritage at a level of detail commensurate to our treatment of natural heritage. There is not enough expertise within the consultancy team to approach such a documentation of cultural heritage. Furthermore, we believe that if such a project were to be undertaken, and we believe it should, then it would be best carried out by, and under the direction of, appropriate indigenous peoples.

Accordingly we have limited our discussion of cultural heritage to a review of the cultural heritage attributes discussed within the nomination document, a brief overview of the obligations to cultural heritage under the Convention, and a discussion of management considerations within the Great Barrier Reef World Heritage Area and some other areas.

1.8 Outline of this Report

Chapter Two briefly reviews the history and development of the World Heritage Convention from its germination as an idea in the 1960s through to its realisation and continued evolution to become the premier international instrument concerned with conservation of the world's cultural and natural heritage. The operation of the Convention and the obligations taken on by States Parties to the Convention are outlined before highlighting recent themes in the contemporary implementation of the Convention, and Australia's response to it.

Chapter Three discusses the nomination and subsequent evaluation of the Great Barrier Reef and environs for inclusion on the World Heritage List, which took place in October 1981. The management regime, and the complexities involved in managing the World Heritage Area are discussed. This is followed by a review of recent developments in the management regime for the Great Barrier Reef World Heritage Area that more overtly recognise the Area's World Heritage status.

Chapter Four discusses the methodology used to expand and further clarify the basis upon which listing of the Great Barrier Reef as a natural heritage property is justified. The major themes and patterns elicited from the experts interviewed are drawn out. A justification for the inclusion of the Great Barrier Reef on the World Heritage List in relation to both the 1981 and the 1996 criteria is presented.

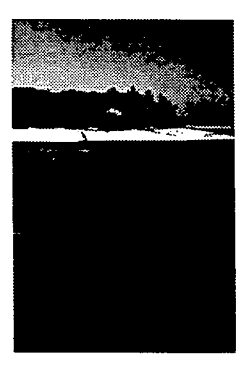
Chapter Five focuses upon the future direction of management for the Great Barrier Reef as a World Heritage Area. The types of threats to the integrity of the Great Barrier Reef World Heritage Area are reviewed. Following this a review of World Heritage management elsewhere is presented. Future spatial and procedural options for management of the Great Barrier Reef World Heritage Area that recognise its World Heritage designation are suggested. This discussion is set against a review of the management of World Heritage properties elsewhere.

Chapter Six discusses the recognition of cultural values within sites inscribed as a result of their natural heritage attributes. The obligations under the Convention to consider cultural attributes, and those attributes in the nomination of the Great Barrier Reef World Heritage Area are highlighted. Experience from other World Heritage sites is presented, and the chapter concludes with a review of the considerations the 25 year Strategic Plan gives to the cultural heritage attributes of the Great Barrier Reef World Heritage Area.

Chapter Seven concludes the report by drawing out the main themes and findings.

The Appendixes include summaries of the information obtained from experts with respect to the natural heritage attributes, amongst other materials.

Chapter Two:
The World Heritage Convention Beginnings and Practice



2.1 The Nature of the World Heritage Convention

2.1.1 The Birth of the World Heritage Convention

The World Heritage Convention has roots in the White House Conference on International Cooperation, held in the United States during 1965. Specifically, one of the Conference's Committees, the Committee on Natural Resources Conservation and Development recommended that:

> There be established a Trust for the World Heritage that would be responsible to the world community for the stimulation of international cooperative efforts to identify, establish, develop, and manage the world's superb natural and scenic areas and historic sites for the present and future benefit of the entire world citizenry (Quoted in Train 1974:379).

Following discussions at the IUCN[5] General Assemblies at Lucerne (1966) and New Delhi (1969), the World Heritage Trust idea began to take form and, by February 1971, the Secretariat of the IUCN had completed the draft text for a *Convention for the Conservation of the World's Heritage*. While this draft convention covered both cultural and natural heritage (Meyer 1976; Train 1974, 1992), it was largely influenced by the growing North American wilderness movement.

Independent of the IUCN initiative, the 16th Session of the General Conference of UNESCO[6], held in 1970, passed a recommendation requiring the initial draft of a convention entitled the *International Protection of Monuments, Groups of Buildings and Sites of Universal Value* to be presented to the 17th Session of the General Conference to be held in 1972 (Meyer 1976). This draft convention was primarily concerned with cultural heritage, particularly European built heritage.

In preparation for the United Nations Conference on the Human Environment in Stockholm held in September 1972, the Intergovernmental Working Group on Conservation reviewed the draft IUCN convention and drew the attention of UNESCO to it. UNESCO convened an Experts Meeting to discuss both draft conventions and invited experts from member states in both natural and cultural heritage management. After much discussion, the Experts Meeting recommended that only one convention should be drafted to avoid the proliferation of international instruments. The convention was to be based upon the UNESCO draft, but expanded to cover both natural and cultural heritage. The Stockholm Conference noted the development of the convention and recommended that governments should examine the draft convention with a view to its adoption at the 17th Session of the General Conference of UNESCO (Commonwealth of Australia 1972).

The *Convention Concerning the Protection of the World Cultural and Natural Heritage* was adopted by the General Conference of UNESCO at its 17th session on 16 November 1972, by a show of hands: 75 for, 1 against and 17 abstentions (Meyer 1976). The Convention came into force on 17 December 1975, after a required 20 states had deposited instruments of ratification, acceptance or accession with the Secretariat of UNESCO. The Convention gained substance when, on 8 September 1978, the first properties were inscribed on the Convention's main instrument, the World Heritage List. Yellowstone National Park (USA), the Aachen Cathedral (Germany), the Rock-hewn Churches of Lalibela (Ethiopia), and the Galapagos Islands (Ecuador) were among the first 12 properties listed.

This decision to draft an international instrument aimed at conserving the world's outstanding natural and cultural heritage was consistent with escalating popular concern for

[5] Previously known as the International Union for the Conservation of Nature and Natural Resources, the IUCN is now known as the World Conservation Union. It is a union of sovereign states, government agencies, and non-governmental organisations established in 1948. The IUCN seeks to ensure the conservation of nature, to ensure that where natural resources are utilised this is done in an equitable and sustainable manner, and to guide development that provides life of good quality that is in harmony with the biosphere. The IUCN is composed of the General Assembly of members, a Council elected from the General Assembly, and a range of Commissions made up of expert volunteers for example the Species Survival Commission (SSC) and the World Commission on Protected Areas (WCPA) formerly the Commission on National Parks and Protected Areas (CNPPA).

[6] The United Nations Educational Scientific and Cultural Organisation (UNESCO) was established in 1946, with the aim of international cooperation in areas of education, science and culture. It is one of the largest of the United Nations' specialised agencies, others of which include the United Nations Environmental Programme (UNEP), the World Health Organisation (WHO), the International Labour Organisation (ILO) and the Food and Agriculture Organisation (FAO).

the welfare and future health of the earth's environment during the 1960s and early 1970s. Scientists had begun to discuss the human impact upon the environment in books such as *Silent Spring* (Carson 1962), *The Population Bomb* (Ehrlich 1968), and *A Blueprint for Survival* (Goldsmith et al. 1972). National governments met in 1972 in Stockholm for the world's first international conference of governments to consider the escalating threats to the human environment. The loss of the world's cultural heritage was highlighted by the damage to paintings, frescoes and sculptures of artists such as Donatello, Bronzino, Cimabue and Orcagna by floods in Venice and Florence during 1966 (Meyer 1976). Earlier, the benefits of international cooperation to protect the world's cultural heritage had been demonstrated by the UNESCO organised campaign to dismantle and reassemble the Abu Simbel temples, saving them from inundation by the rising waters of the Aswan High Dam in Egypt (Batisse 1992).

Domestically, confrontations to save Lake Pedder in south-west Tasmania, the Green Bans placed by NSW Builders Labourers to protect remnant vegetation and historic buildings in Sydney, and the growing spectre of oil-drilling on the Great Barrier Reef brought conservation into Australia's lounge rooms. Meanwhile, the social reformist Whitlam government initiated the first Commonwealth package of environmental legislation[7] which remains today as the backbone of much Commonwealth environment policy. Within this context, the Australian Commonwealth Government became the seventh nation to ratify the Convention, doing so on 23 August 1974. One hundred and forty-seven countries are States Parties to the Convention as of December 1996.

2.1.2 The World Heritage Concept

The central theme of the Convention is the idea that there are cultural and natural properties of such outstanding value from a global perspective that these sites and properties should be conserved and protected for the benefit of all humanity. The preamble to the Convention notes that:

> ...deterioration or disappearance of any item of the cultural or natural heritage constitutes a harmful impoverishment of the heritage of **all the nations of the world** [emphasis added] (UNESCO 1972);

and that:

> ...parts of the cultural or natural heritage are of outstanding interest and therefore need to be preserved as a part of the **world heritage of mankind** [*sic*] **as a whole** [emphasis added] (UNESCO 1972).

The World Heritage Convention thus legitimises a global interest in the protection and management of properties upon the World Heritage List. The concept of the common heritage of humankind is not new to international law as demonstrated by other agreements, such as *The Antarctic Treaty* (1959), *Declaration of Principles Governing the Sea-Bed and the Ocean Floor and the Subsoil Thereof, Beyond the Limits of National Jurisdiction* (1970), and the *United Nations Convention on the Law of the Sea* (1982). However, the World Heritage Convention is one among a number of international instruments concerned with the protection and conservation of the common heritage of humankind, rather than its exploitation which characterises the former group (Richardson 1990). These include the Ramsar Convention (1971), CITES (1973), the Bonn Convention (1979), the *Convention on the Conservation of Antarctic Marine Living Resources* (1980) and, more recently, the *Convention on Biological Diversity* (1992).

Prior to the adoption of the World Heritage Convention, UNESCO had established the Man and the Biosphere Programme (MAB). The overall goal of the MAB was:

> ...to develop the basis within the natural and social sciences for the rational use and conservation of the resources of the biosphere and for the improvement of the global relationship between man [*sic*] and the environment (UNESCO/MAB 1971 quoted in Francis 1985:24).

From one of the Programme's themes, on conservation of natural environments and genetic material, the concept of the Biosphere Reserve emerged. The theory behind the Biosphere Reserve concept aimed to integrate research and practical efforts towards sustainable development. It suggested that Biosphere Reserves should have a strictly protected core area, with a surrounding buffer zone, where controlled and non-destructive use

[7] This package included the *Environment Protection (Impact of Proposals) Act 1974*, the *National Parks and Wildlife Conservation Act 1975*, the *Australian Heritage Commission Act 1975*, and the *Great Barrier Reef Marine Park Act 1975*.

is permitted. Surrounding transitions zones would be used for research and sustainable resource use (Lucas 1992). The core and buffer zones provide control areas for research into appropriate environmental management techniques. The Biosphere Reserve concept aims to cover representative areas of the world's biogeographic provinces. Currently there are 328 Biosphere Reserves in 82 Countries. Australia has 12 Biosphere Reserves[8].

In some cases Biosphere Reserves and World Heritage Areas may coincide, for example, Uluru Kata-Tjuta National Park was a Biosphere Reserve prior to World Heritage Listing and Redwoods National Park (USA) was listed prior to Biosphere Reserve designation. However, whilst they may be coincident, both have different objectives and rationales. Biosphere Reserves attempt to establish a network of reserves where the focus is upon research to facilitate continuing use in conjunction with conservation. World Heritage Areas are the world's most outstanding properties and the primary aim of the concept is to protect, conserve, present and transmit these properties to future generations.

Behrens (1990) argues that the psychological aim of the Convention is to engender a sense of World Heritage; that aspects of the cultural and natural heritage are of such value that their loss is an impoverishment of all humanity and, accordingly, its protection is the responsibility of all humanity. The degree to which the Convention is effective in protecting the world's cultural and natural heritage will depend, in part, upon realising this psychological aim. The inscription of a property upon the World Heritage List attracts additional status and significance to the property by virtue of the listing itself. This elevated status is an additional psychological factor which contributes to the management and protection of the property[9].

The Convention is notable because the one instrument is concerned with the protection of both cultural and natural heritage. Typically, their protection and conservation are seen as quite separate fields of endeavour, being reflected in the usual division of administrative and political units responsible for cultural and natural heritage within a country. The importance of re-affirming the connection between nature and culture is supported by an increasing recognition that their separation is, in part, the source of contemporary environmental problems (Merchant 1980). Nowhere has this connection been highlighted and strengthened more than through the growing recognition of the connection between environment and the world's indigenous cultures[10] (see 2.4.5).

The spirit of the Convention is grand indeed. Not only does it attempt to bridge the divide between culture and nature, but also to meet the even greater challenge of carrying an international perspective by cutting across the divides between nation-states. The late Justice Murphy of the High Court of Australia saw the value of the Convention in a truly internationalist perspective. In the Tasmanian Dams Case[11] (see 2.6) he remarked:

> The preservation of the world's heritage must not be looked at in isolation but as part of the co-operation between nations which is calculated to achieve intellectual and moral solidarity of mankind [*sic*] and so reinforce the bonds between people which promote peace and displace those of narrow nationalism and alienation which promote war [12].

2.1.3 World Heritage Value and Values

The World Heritage Convention and the Operational Guidelines which interpret the Convention, use the term 'value' only in the context of 'outstanding universal value'. A property is said to have 'outstanding universal value' if the World Heritage Committee is satisfied the property meets the specified criteria and conditions (see 2.2.3). However,

[8] Australian Biosphere Reserves are Croajingolong National Park (Vic., designated 1977), Danggali Conservation Park (SA, 1977), Fitzgerald River National Park (WA, 1978), Hattah-Kulkyne National Park and Murray Kulkyne Park (Vic., 1982), Kosciusko National Park (NSW, 1977), Macquarie Island Nature Reserve (Tas., 1977), Prince Regent River Nature Reserve (WA, 1977), Southwest National Park (Tas., 1977), Unnamed Conservation Park of South Australia (SA, 1977), Uluru-Kata Tjuta National Park (NT, 1977), Wilsons Promontory National Park (Vic., 1982), Yathong Nature Reserve (NSW, 1977).

[9] We are indebted to John Whitehouse for highlighting this additional factor.

[10] This was particularly evident at the follow up conference to the 1972 Stockholm Conference, the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992.

[11] *Commonwealth v. Tasmania* (1983) 46 ALR 625

[12] Murphy J (1983) 46 ALR 625 at 733

discussion of World Heritage properties is often in terms of World Heritage 'values'. For a natural site these 'values' typically refer to those biophysical attributes that are seen as the reason why the property is of 'outstanding universal value'. Indeed, in the Terms of Reference initially established for this consultancy, value was equated to the 'quality of [the] attribute' (see 1.3).

In this consultancy, we have attempted to document the attributes that give rise to the Great Barrier Reef's 'outstanding universal value'. The difficulty in identifying important localities for most individual attributes severely undermined any attempt to characterise particular sites as being more valuable (see 4.5). Additionally, the connectivity of Great Barrier Reef habitats (e.g. see Bode et al. 1992) further highlighted the difficulty of locating attributes at discrete localities. In the light of this, we consider that the 'outstanding universal value' of the Great Barrier Reef World Heritage Area should be treated as distributed though the whole of the Area, rather than being found in discrete locations unevenly distributed throughout the Area. In discussing Australia's World Heritage properties Bridgewater (1993:36–37) notes:

> ...even though some areas may be viewed as fragmented nodes within a matrix, **it is the holistic nature of the area which is critical** [emphasis added].

Thus, it is the totality of the interrelated natural attributes of an area that give rise to the area's 'outstanding universal value'. Indeed at the operational heart of the World Heritage Convention is the notion that prospective properties be assessed in sum, not part. Accordingly, where appropriate, we have used the term 'outstanding universal value' rather than 'World Heritage values' to emphasise the holistic nature of a property's 'outstanding universal value'.

2.2 The World Heritage Convention at a Glance

The Convention provides the vehicle for the recognition of the world's outstanding fixed cultural and natural properties and emphasises the need for their protection. It recognises that protection at a national level may be inadequate as countries often lack economic or technical resources in order for their heritage to be adequately managed (Meyer 1976). Accordingly, the Convention seeks to establish an 'effective system of collective protection' (UNESCO 1972) that complements and extends measures at national levels.

In order to achieve its aims, the Convention establishes the World Heritage List (a list of properties making up the world's cultural and natural heritage), the List of World Heritage in Danger, and a World Heritage Fund derived from voluntary and obligatory payments from States Parties. The World Heritage Committee is the body primarily responsible for the maintenance of the two World Heritage lists and the World Heritage Fund. Upon accession to the Convention, each State Party takes on a number of obligations (see 2.3).

The Convention is divided into 8 sections. Section I (Art. 1–3) defines the cultural and natural heritage; Section II (Art. 4–7) sets out the duties and obligations for the protection of World Heritage; Section III (Art. 14) establishes the Intergovernmental Committee for the Protection of the World Cultural and Natural Heritage – the World Heritage Committee; Section IV (Art. 15–18) establishes the World Heritage Fund; Section V (Art. 19–26) outlines the arrangements for international assistance; Section VI (Art. 27–28) concerns educational programmes to build local support for World Heritage; Section VII (Art. 29) requires States Parties to submit regular reports on their implementation of the Convention; and Section VIII (Art. 30–38) deals with a range of procedural and administrative processes for the Convention.

2.2.1 The World Heritage Committee

The World Heritage Committee comprises 21 members[13] elected by the States Parties to the Convention meeting in General Assembly. Its essential functions are:

- to identify, on the basis of nominations, properties which are to be inscribed on the World Heritage List;

[13] The initial number of members on the World Heritage Committee was held at 15 until there were 40 parties to the Convention whereupon it was increased to 21.

- to monitor the state of conservation of properties inscribed on the list;
- to decide which properties are to be placed upon the List of World Heritage In Danger; and
- to determine how the World Heritage Fund can be most advantageously used to assist States Parties to protect their properties of outstanding universal value (World Heritage Committee 1996a).

Experts from the IUCN, the International Council for Monuments and Sites (ICOMOS) and the International Centre for the Study of the Preservation and Restoration of Cultural Property (the Rome Centre, now known as ICCROM) assist the Committee in its deliberations. Administrative support for the Committee is provided by the Director-General of UNESCO through a Secretariat housed within the World Heritage Centre under a Director.

Membership of the Committee must ensure an equitable representation of the different regions and cultures of the world (Art. 8.2), where representatives are expected to be 'persons qualified in the field of the natural or cultural heritage' (Art. 9.3). Eidsvik (1990:16) notes that members tend to be 'experts in diplomacy' rather than heritage and debate has shifted from issues of natural and cultural heritage to issues of a political nature. Australia was a member on the World Heritage Committee from its establishment in 1976 until 1989 (Turner 1990). During November 1995, the 10th General Assembly of States Parties to the Convention elected Australia for a further term.

The Committee meets annually in December to carry out its functions. An executive-like World Heritage Bureau meets twice a year; once in June/July and then immediately preceding the Committee's annual meeting. The Bureau comprises seven members of the Committee, namely the Chair, five Vice-Chairs and the Rapporteur. The Chair, Vice-Chairs and Rapporteur are elected at the beginning of each ordinary session of the World Heritage Committee. The Bureau coordinates the work of the Committee.

The Committee has developed the *Operational Guidelines for the Implementation of the World Heritage Convention* (World Heritage Committee 1996a). These establish the procedures by which the Committee carries out its functions. In essence, the Convention sets out the broad framework and establishes an infrastructure for the identification and protection of the world's cultural and natural heritage, and the Operational Guidelines provide the processes to operationalise the Convention. The Convention is largely immutable, having never been, nor ever likely to be amended. Rather, the periodic amendment of the Operational Guidelines provides a degree of operational flexibility.

2.2.2 The World Heritage List

The World Heritage List provides the primary mechanism under the Convention for the recognition of the world's cultural and natural heritage. Properties are inscribed upon the World Heritage List by virtue of their 'outstanding universal value' from the viewpoint of history, art, aesthetics, archaeology, ethnology, science, conservation or natural beauty. The World Heritage List has variously been described as 'nature's hall of fame' (McNeely & von Droste 1992:10), 'the modern equivalent of the biblical seven wonders of the world'[14] (Slatyer, R. quoted in Helsham et al. 1988:25), and the 'Nobel prize of protected areas' (Thorsell, J. quoted in Thongtham 1993:38). It's aim is to contain the best examples of the world's fixed cultural and natural heritage.

The Committee has the responsibility to define criteria by which nominations to the World Heritage List can be assessed. These criteria serve to interpret the definitions of cultural and natural heritage contained within the Convention. Cultural heritage is defined by Article 1 of the Convention as:

> **monuments** – architectural works, works of monumental sculpture and painting, elements or structures of an archaeological nature, inscriptions, cave dwellings and combinations of features, which are of outstanding universal value from the point of view of history, art or science;
>
> **groups of buildings** – groups of separate or connected buildings which, because of their architecture, their homogeneity or their place in the landscape, are of outstanding universal value from the point of view of history, art or science;

[14] Indeed one of the Seven Wonders of the Ancient World, Memphis and its Necropolis – the Pyramid fields from Giza to Dahshur, was inscribed upon the World Heritage List in 1979.

> **sites** – works of man or the combined works of nature and of man, and areas including archaeological sites which are of outstanding universal value from the historical, aesthetic, ethnological or anthropological points of view (UNESCO 1972).

The list covers a range of buildings, monuments and sites from the prehistoric artwork and artefacts found in the Decorated Grottoes of the Vézère Valley in France, to the traditional and contemporary associative landscapes of the Anangu at Uluru-Kata Tjuta National Park, and the Maori at Tongariro National Park in New Zealand; from the high Gothic masterpiece of Chartres Cathedral in France to the 19–20th century industrial landscape dominated by the Völklingen Ironworks in Germany. City landscapes inscribed upon the list include the historic centre of Mexico City founded by the Aztecs around AD 1300, and the City of Jerusalem.

In contrast to cultural heritage, natural heritage as defined by Article 2 of the Convention comprises:

> ...natural features consisting of physical and biological formations or groups of such formations, which are of outstanding universal value from the aesthetic or scientific point of view;
>
> geological and physiographical formations and precisely delineated areas which constitute the habitat of threatened species of animals and plants of outstanding universal value from the point of view of science or conservation;
>
> natural sites or precisely delineated natural areas of outstanding universal value from the point of view of science, conservation or natural beauty (UNESCO 1972).

Well known natural properties on the World Heritage List include the world's first national park, Yellowstone in the United States, and the vast sprawling plains of the Serengeti National Park in Tanzania home to immense herds of wildlife. The spectacular landscapes of the Canadian Rockies and Sagarmatha (Mount Everest) National Park are likewise inscribed upon the World Heritage List.

The definitions of cultural and natural heritage reflect their Western birth, with cultural heritage referring to the fixed artefacts of human endeavours, and natural heritage being concerned with those parts of the world largely devoid of humanity. However, in a number of cases, and increasingly so, the connection between culture and nature is reflected in listings of properties reflecting both cultural and natural dimensions. This is evident in the aforementioned associative landscapes of the Anangu and Maori, in the listing of so-called 'mixed' sites for both cultural and natural values and in recognition from 1992 of 'cultural landscapes'.

There were 506 sites inscribed upon the World Heritage List as of December 1996. Of these 380 were cultural properties, 107 were natural and 19 were mixed exhibiting outstanding universal value as both a natural and cultural property.

2.2.3 Nomination and Assessment of Properties for Inscription on the World Heritage List

States Parties are solely responsible for nominating properties on their territory for inscription on the World Heritage List. A nomination must include the property's location; juridical information including type of land tenure and management regime currently in place; identification information describing the property, its history backed by photographic evidence and bibliography; information on the property's state of preservation; and finally a justification for inclusion upon the World Heritage List (World Heritage Committee 1996a).

The World Heritage Committee assesses which properties are of 'outstanding universal value' for the purposes of the World Heritage List. Helsham et al. (1988:25) note that this test of 'outstanding universal value' is 'a most rigorous test', adding that a

> ... property which may be rated to be 'of great interest to Tasmanians' or 'of great interest and value to Australians' or 'of international significance' or 'very beautiful' could not, on that assessment alone, be recommended to be of world heritage quality. The property must have nothing short of outstanding value in the international context (Helsham et al. 1988:25).

Indeed, the World Heritage List is not intended to cover 'all properties of great interest, importance or value, but only for a select list of the most outstanding of these from an international viewpoint' (World Heritage Committee 1996a:2). It follows that nomination of a property is not automatically met with inscription. Of the 122 natural heritage sites evaluated in the 1984–1994 period 73 were inscribed, 23 were deferred subject to further investigations, 22 were declined and 4 were withdrawn (IUCN 1995).

Furthermore, the Convention is not concerned with all properties of 'outstanding universal value', but rather those that have outstanding universal value from particular points of view, namely, history, art, aesthetics, archaeology, ethnology, science, conservation or natural beauty. Article 12 of the Convention states:

> The fact that a property belonging to the cultural and natural heritage has not been included in either of the two lists [namely the World Heritage List and the List of World Heritage in Danger] ...shall in no way be construed to mean that it does not have an outstanding universal value for purposes other than those resulting from inclusion in these lists (UNESCO 1972).

The definitions of cultural and natural heritage are interpreted through the use of two sets of criteria, one for each type of heritage. For a property to be inscribed upon the World Heritage List by virtue of its natural heritage, the Committee must be satisfied that it meets at least one or more of the natural heritage criteria *and* the associated conditions of integrity. Similarly a cultural heritage property must meet at least one of the cultural heritage criteria *and* the associated tests of authenticity. A mixed property will meet at least one natural and one cultural heritage criterion. A property may be inscribed upon the List for meeting just one criterion. However, the Operational Guidelines note that most inscribed sites have met two or more criteria (World Heritage Committee 1996a). The natural heritage criteria and their associated conditions of integrity as of December 1995, and as they were at the time that the Great Barrier Reef was nominated, are reproduced in Table 2.1. (Section 2.4.2 discusses the changes that have occurred in World Heritage criteria.)

Of the natural heritage criteria currently in use, the first criterion focuses upon geological processes and phenomena, including the evolution of the earth. Ongoing ecological and biological processes are reflected within criterion (ii), while criterion (iv) focuses attention upon biological diversity and the habitats of threatened species. Criterion (iii) focuses upon the more subjective aesthetic components of the natural world. The associated conditions of integrity give guidance to the biophysical components that are needed to ensure the long term viability of a World Heritage site based upon a particular criterion. The Operational Guidelines include several examples to demonstrate the conditions of integrity. For example, if a waterfall is nominated as an outstanding example of a superlative natural phenomena under criterion (iii), its nomination should also include

> adjacent catchment and downstream areas that are integrally linked to the maintenance of the aesthetic qualities of the site (World Heritage Committee 1996a:13).

Additional conditions of integrity required for each natural heritage nomination require that:

- properties nominated should contain the most important sites for the conservation of biological diversity;
- properties nominated should have a management plan in place, or at least indicate when and how such a plan will be prepared and implemented;
- properties nominated should have adequate long-term legislative or institutional protection;
- the boundaries of the nominated property should reflect the spatial requirements of the features providing the basis for nomination; and
- such boundaries should include sufficient buffer areas to protect the site's features from adjacent anthropogenic impacts (World Heritage Committee 1996a).

The evaluation of natural heritage nominations will assess the natural attributes of the property against the established criteria, and assess the management regime and long term viability of protection of the property against the conditions of integrity. Similarly the evaluation of cultural heritage nominations will assess the nomination against the criteria and the associated test of authenticity.

Evaluations of properties nominated are carried out adopting a broad comparative approach to ensure the World Heritage List represents properties of 'outstanding **universal** value'. Accordingly, States Parties are requested to submit a list of properties that form part of its natural and cultural heritage suitable for

Table 2.1 Natural Heritage Criteria and Conditions of Integrity

	1981 Criteria	1981 Conditions of Integrity	1996 Criteria	1996 Conditions of Integrity
(i)	be outstanding examples representing the major stages of earth's evolutionary history. This category would include sites which represent the major 'eras' of geological history such as 'the age of reptiles' where the development of the planet's natural diversity can well be demonstrated and such as the 'ice age' where early man and his environment underwent major changes	should contain all or most of the key interrelated and interdependent elements in their natural relationships; for example, an 'ice age' area would be expected to include the snow field, the glacier itself and samples of cutting patterns, deposition and colonisation (striations, moraines, pioneer stages of plant succession etc);	be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features;	should contain all or most of the key interrelated and interdependent elements in their natural relationships; for example, an 'ice age' area would be expected to include the snow field, the glacier itself and samples of cutting patterns, deposition and colonisation (striations, moraines, pioneer stages of plant succession etc); in the case of volcanoes, the magmatic series should be complete and all or most of the varieties of effusive rocks and types of eruptions be represented.
(ii)	be outstanding examples representing significant ongoing geological processes, biological evolution and man's interaction with his natural environment. As distinct from the periods of the earth's development, this focuses upon ongoing processes in the development of communities of plants and animals, landforms and marine and freshwater bodies. This category would include for example (a) as geological processes, glaciation and volcanism, (b) as biological; evolution, examples of biomes such as tropical rainforests, deserts and tundra (c) as interaction between man and his natural environment, terraced agricultural landscapes	should have sufficient size and contain the necessary elements to demonstrate the key aspects of the process and to be self-perpetuating. For example, an area of 'tropical rain forest' may be expected to include some variation in elevation above sea level, changes in topography and soil types, river banks or oxbow lakes, to demonstrate the diversity and complexity of the system	be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals	should have sufficient size and contain the necessary elements to demonstrate the key aspects of processes that are essential for the long-term conservation of the ecosystems and biological diversity they contain; for example, an area of tropical rain forest should include a certain amount of variation in elevation above sea-level, changes in topography and soil types, patch systems and naturally regenerating patches; similarly a coral reef should include, for example, seagrass, mangroves or other adjacent ecosystems that regulate nutrient and sediment inputs into the reef.
(iii)	contain unique, rare or superlative natural phenomena, formations or features or areas of exceptional natural beauty, such as superlative examples of the most important ecosystems to man, natural features, (for instance rivers, mountains, waterfalls), spectacles presented by great concentrations of animals, sweeping vistas covered by natural vegetation and exceptional combinations of natural and cultural elements should contain those ecosystem	components required for the continuity of the species or of the objects to be conserved. This will vary according to individual cases; for example, the protected area for a waterfall would include all, or as much as possible , of the supporting upstream watershed; or a coral reef area would be provided with control over siltation or pollution through the stream flow or ocean currents which provide its nutrients	contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance	should be of outstanding aesthetic value and include areas that are essential for maintaining the beauty of the site; for example, a site whose scenic values depend on a waterfall, should include adjacent catchment and downstream areas that are integrally linked to the maintenance of the aesthetic qualities of the site.
(iv)	be habitats where populations of rare or endangered species of plants and animals still survive. This category would include those ecosystems in which concentrations of plants and animals of universal interest and significance are found	should be of sufficient size and contain the necessary habitat requirements for the survival of the species	contain the most important and significant natural habitats for in situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation	should contain habitats for maintaining the most diverse fauna and flora characteristic of the biographic province and ecosystem under consideration; for example, a tropical savannah should include a complete assemblage of co-evolved herbivores and plants; an island ecosystem should include habitats for maintaining endemic biota; a site containing wide-ranging species should be large enough to include the most critical habitats essential to ensure the populations of those species; for an area containing migratory species, seasonal breeding and nesting sites, and migratory routes, wherever they are located, should be adequately protected; international conventions, e.g. the Convention of Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention), for ensuring the protection of habitats of migratory species of waterfowl, and other multi- and bilateral agreements could provide this assurance.

(Source: GBRMPA 1981; World Heritage Committee 1996a)

inscription upon the World Heritage List. These tentative lists constitute the 'inventory' provided for in Article 11 of the Convention and assist the Committee to 'evaluate within the widest possible context the **outstanding universal value** of each property nominated' (World Heritage Committee 1996a:3).

Focusing on the criteria against which attributes are justified can promote a disjointed view of what makes a property of 'outstanding universal value', leading to discussions of discrete and, often, through implication, quantifiable World Heritage 'values'. The conditions of integrity, however, refocus the attention back onto the whole, recognising the importance of conserving components integrally linked to the viability of particular attributes. It must be remembered that it is the totality of the interrelated natural attributes of an area that give rise to the area's 'outstanding universal value'.

The process and timeline for the nomination and assessment of properties to the World Heritage List are outlined in Figure 2.1. The nominations are reviewed by the appropriate non-governmental organisation (NGO): IUCN for natural heritage nominations (see 2.4.3), ICOMOS for cultural heritage nominations, both for mixed nominations. Their technical assessments and any additional information that has been requested are passed onto the Bureau to be considered at its mid-year session. At the annual Committee meeting, the nominations are considered along with the Bureau's recommendations. Based upon this information, the Committee will decide to either inscribe the property on the World Heritage List, defer the nomination or decline to list the property.

2.2.4 The List of World Heritage in Danger

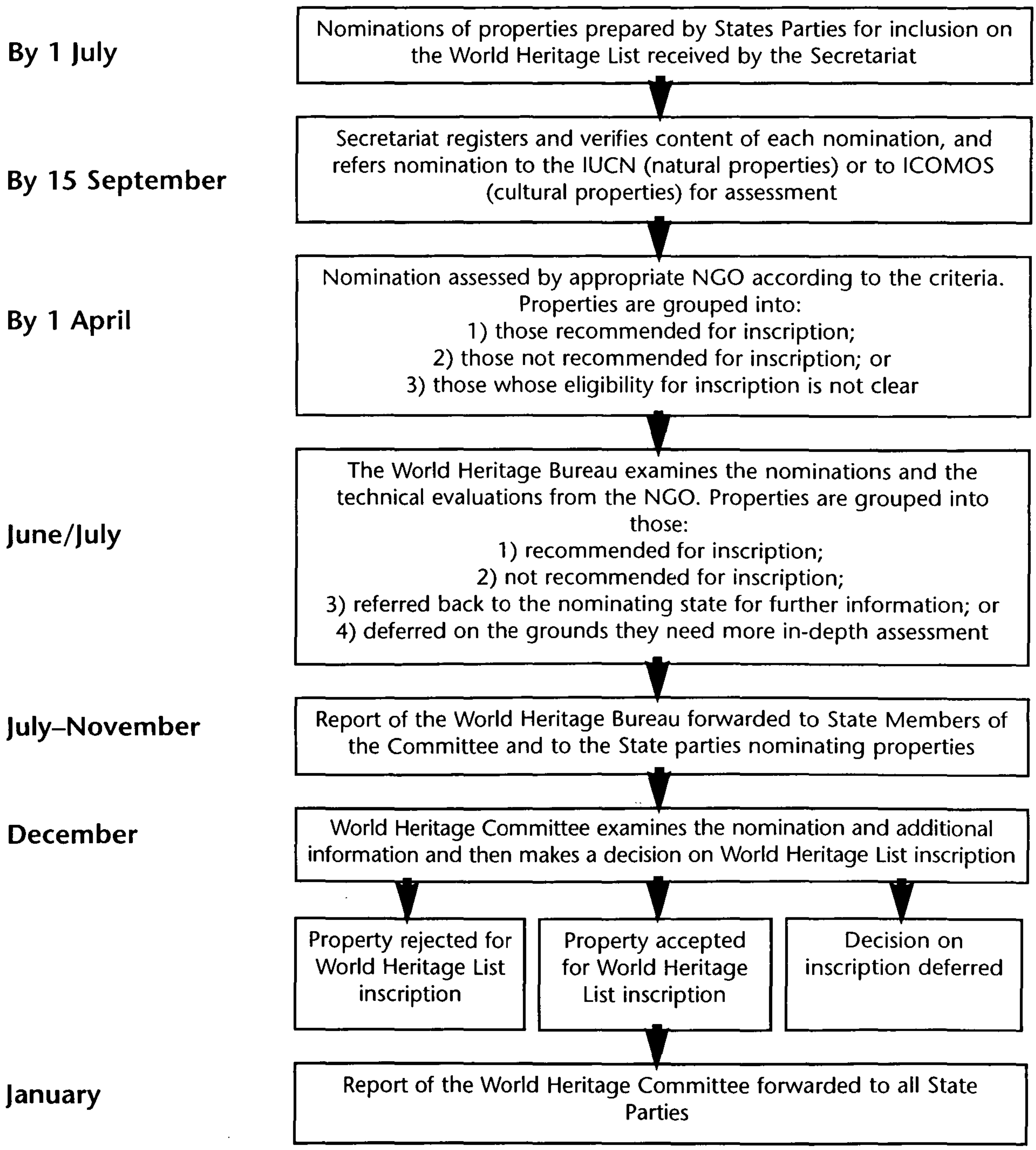
Where the Committee is satisfied that a World Heritage Listed property is threatened by a serious and specific danger, they may choose to inscribe the property on the List of World Heritage in Danger (World Heritage Committee 1996a). The Committee distinguishes between ascertained danger and potential danger. Ascertained danger refers to a specific and proven imminent danger, such as the serious structural deterioration of a cultural site, or a serious decline in the population of a species of outstanding universal value for which a property was inscribed. Potential danger includes threats such as a diminution in the protective regime of a property, or planned developments that threaten the property.

Procedural requirements requiring a State Party to submit a programme outlining the corrective measures a property needs have previously restricted the effectiveness of the List of World Heritage in Danger (Thorsell 1992). However, even with a less restrictive process for inscription upon the List of World Heritage in Danger, the increasingly political style of the Committee inhibits the likelihood of threatened properties being listed if the State Party concerned is strongly opposed to such a listing. This was recently exemplified by Ecuador's successful lobbying against the Galapagos Islands being included upon the danger list (World Heritage Committee 1995).

It is unfortunate that the List of World Heritage in Danger tends to be perceived by some States Parties as a 'blacklist', rather than as originally intended, an early warning system to alert the international community to threats to the world cultural and natural heritage. Thus the danger list should work to protect heritage by enlisting international support to reduce or remove threats (Vernhes 1990). Furthermore, the danger list helps to prioritise the financial assistance awarded from the World Heritage Fund as well as encouraging support from other funding sources.

As of December 1996, the List of World Heritage in Danger comprised 22 properties, one of the most notable being the world's first national park, Yellowstone, which was one of the first properties inscribed upon the World Heritage List (World Heritage Committee 1996b). Yellowstone was listed as World Heritage in Danger in 1995 as a consequence of various threats to its integrity including a gold, silver and copper mining proposal outside the park, that would threaten the watershed of the Yellowstone River (World Heritage Committee 1995). Australia has not yet had any property included upon the List of World Heritage in Danger.

Figure 2.1 World Heritage Inscription Process and Timeline



(Source: World Heritage Committee 1996a)

2.2.5 The World Heritage Fund

The Convention establishes the World Heritage Fund, derived from biennial contributions from States Parties. A compulsory contribution[15] to the Fund is set at one percent of the State Party's contribution to UNESCO's regular budget, and there is also provision for additional voluntary payments. While the potential uses of the fund are numerous, its modest size (approx. US$2.5 million per year) is a limiting factor. Structurally, it is reaching a limit to growth as most countries are now party to the Convention (Batisse 1992). Further reducing the capacity of the Fund are the arrears in contributions from States Parties, amounting close to a year's budget in itself by the end of 1995 (World Heritage Committee 1995). Other charitable organisations have donated project money to the World Heritage Fund, and in Article 17, the Convention visualises the establishment of foundations in order to raise money for the protection of the cultural and natural heritage[16].

Assistance from the World Heritage Fund may be sought by States Parties for:

- **Preparatory assistance:** in the preparation of tentative lists and nominations of properties to the World Heritage List;
- **Emergency assistance:** for properties included or eligible for inclusion upon the World Heritage List that have suffered or are likely to suffer severe and sudden damage. Such assistance may be to prepare nominations or take emergency actions to safeguard the property;
- **Training:** of specialised staff in the management and conservation of World Heritage properties, often taking the form of group training at a local or regional level;
- **Technical cooperation:** to provide expertise, equipment and financial assistance for the management and protection primarily of properties inscribed upon the World Heritage List; and
- **Promotional activities:** small amounts of 'seed money' may be given to projects that create a greater awareness of the Convention (World Heritage Committee 1996a).

Emergency assistance to save listed or nominated property is given highest priority when allocating the World Heritage Fund, followed by assistance in preparing nominations and tentative lists. In allocating funds, the Committee must take into account the State Party's facility to fund the operation itself. Thus the Convention provides a mechanism for economically well-off countries to assist those less well-off in the protection and management of their cultural and natural heritage.

2.3 Obligations of States Parties

The primary obligation is spelled out in Article 4 where the Convention places a duty upon a State Party **'to do all it can'** and **'to the utmost of its own resources'** to ensure

> ...the identification, protection, conservation, presentation, and transmission to future generations of the cultural and natural heritage referred to in Articles 1 and 2 and situated on its territory... (UNESCO 1972, Art. 4).

It is important to note that the duty refers to a country's cultural and natural heritage as referred to in Articles 1 and 2, not just its property that is inscribed upon the World Heritage List, though this is clearly a subset of the above. **That is to say a State Party is bound by a duty to identify, protect, conserve, present and transmit to future generations all of their properties that are of outstanding universal value, regardless of their inscription on the World Heritage List.** This broader obligation to the cultural and natural heritage of a State Party has been largely neglected in the operation of the Convention (Lucas 1995).

Article 5 of the Convention expands upon this duty by identifying a range of 'active measures'

[15] At the time of accession to the Convention a State Party may declare that it shall not be bound to pay the compulsory payments. These States Parties would normally be expected to pay a voluntary payment at the equivalent amount.

[16] The establishment of a World Heritage Area Foundation for the Great Barrier Reef World Heritage Area is one strategy envisioned in the *25 Year Strategic Plan for the Great Barrier Reef World Heritage Area* (GBRMPA 1994). There were active initiatives to establish the foundation in 1996.

to be taken for the protection, conservation and presentation of the States Parties' cultural and natural heritage. These required measures are:

- to adopt policies which give cultural and natural heritage a function in the community, and integrate its protection into planning;
- to establish services with appropriate staff and resources for the protection, conservation, and presentation of the cultural and natural heritage;
- to develop technical skills through research to counteract any threats to the cultural and natural heritage;
- to take appropriate legal, scientific, technical, administrative and financial measures necessary for the identification, protection, conservation, presentation and rehabilitation of the cultural and natural heritage; and
- to encourage the development of centres for training and research in the protection, conservation and presentation of the cultural and natural heritage.

Recognising the differing capacity that States Parties, particularly the less developed nations, bring to their World Heritage management, the duty to undertake these measures is qualified by the phrase 'in so far as possible, and as appropriate for each country' (Meyer 1976). However, in considering the obligation imposed by Article 4 during the Tasmanian Dams Case, Brennan J noted that:

> Article 4 of the Convention leaves no discretion in a Party as to whether it will abstain from taking steps in discharge of the 'duty'...[17]

Consequently, by acceding to the Convention, a State Party takes on a binding obligation to identify, protect, conserve, present, rehabilitate and transmit to future generations the natural and cultural heritage, as defined in Articles 1 and 2 on its territory.

Justice Brennan explored the nature of this duty in his judgement, drawing upon the *travaux preparatoires* for clarification. He noted that the use of the term 'presentation' came about following the United Kingdom's objection to the use of either 'development' or 'active development'. The French version of the text remained unchanged as '*mise en valeur*', which the drafting secretariat had stated:

> ...when applied to monuments, groups of buildings and sites, is taken to mean conserving and arranging them to bring out their potentialities to best advantage[18].

Brennan J argued that the duty of presentation may entail lighting or access provision

> ...so that the outstanding universal value of the property can be perceived[19].

However, such presentation should not sacrifice the property's protection and conservation. Thus the duty under the Convention

> ...requires the protection and conservation of the features which give the property its outstanding universal value. It is the 'object and purpose' of the Convention to ensure that those features are protected and conserved...[20]

Others have since argued that the duty applies to a World Heritage property as a whole, rather than to the features that give it outstanding universal value (Haigh 1994; Environmental Lawyers Group of the Cairns Community Legal Centre 1995). These features are considered to be of relevance only to justify the property's inclusion upon the World Heritage List, after which the World Heritage duty covers the whole property.

Article 11 requires States Parties to submit the inventory or tentative list of properties to the Committee. Despite their important role in evaluating nominations, this is one of the more poorly adhered to obligations. As of December 1995, only 50 States Parties out of 141 had submitted tentative lists which met the requirements specified in the Operational Guidelines (World Heritage Committee 1995). Due to the large numbers of cultural heritage nominations received, the Committee has decided not to assess any future nominations from States Parties unless they have submitted a tentative list (World Heritage Committee 1996a). Australia has yet to deposit a tentative list with the World Heritage Committee.

Articles 4 and 5 place obligations for the identification and protection of the cultural and natural heritage within a State Party's territory;

[17] Brennan J (1983) 46 ALR 625 at 778

[18] Brennan J (1983) 46 ALR 625 at 775

[19] Brennan J (1983) 46 ALR 625 at 775

[20] Brennan J (1983) 46 ALR 625 at 775

Articles 6 and 7 extend the duty to protect the natural and cultural heritage of other States Parties. Article 6.2 places a duty upon States Parties to

> ...give their help in the identification, protection, conservation, and presentation of the cultural and natural heritage referred to in paragraphs 2 [the World Heritage List] and 4 [the List of World Heritage In Danger] if the States on whose territory it is situated so request (UNESCO 1972).

Furthermore Article 6.3 requires States Parties

> ...not to take any deliberate measures which might damage directly or indirectly the cultural and natural heritage referred to in Articles 1 and 2 [the definitions] situated on the territory of other States Parties to the Convention (UNESCO 1972).

Again it is the broader obligation to the cultural and natural heritage of a State Party, not just that component that is inscribed upon either of the World Heritage lists that is the focus of the obligation under Article 6.3, while under Article 6.2, the duty is restricted to the subset included upon either of the two lists. The obligation not to harm another State Party's cultural and natural heritage has the potential to be quite strong, particularly in the case of a government agency causing damage. However, it is weakened to the extent that a State Party is able or willing to control the actions of its private sector (Cameron 1992). For example, at the World Heritage Committee's 15th session in 1991 at Carthage, the United States reported to the Committee, that it was not involved by direct activity or financing in an iron-ore mining project that threatens the Mount Nimba World Heritage site in Guinea and Ivory Coast, and thus was not in breach of its obligations, despite the project's backing by an international consortium of companies including those from the United States (World Heritage Committee 1991).

Writing from a Canadian perspective, Cameron (1992) suggests there is a great lack of awareness of the existence of the Convention, and its purpose and meaning. Given the high profile disputes concerning World Heritage in Australia, there is likely to be more awareness of the Convention's existence in Australia than elsewhere. However, the purpose and meaning of World Heritage is still not clearly understood in Australia (for example see Duncan 1989; Suter 1994). Article 27 establishes a duty to educate about the operation of the Convention, to build an awareness of the cultural and natural heritage, and the threats to it. Dissemination of information about the Convention will assist in realising the Convention's psychological aim (Behrens 1990).

Whilst the term 'monitoring' is not used within the Convention text, Article 29.1 obliges States Parties to submit regular reports concerning their implementation of the Convention to the Committee. The monitoring and reporting of World Heritage implementation was an issue of considerable substance at the 1995 Committee meeting in Berlin (World Heritage Committee 1995). This is discussed in greater detail in 2.5.3 below.

2.4 Evolution of World Heritage Practice

During the 20th anniversary of the Convention, in 1992, the Committee reviewed the Convention's implementation. Additional international forums in 1992, such as the IVth World Parks Congress held in Caracas, and the United Nations Conference on Environment and Development provided further opportunities for review and reflection. Among the concerns raised about the Convention were imbalances within the World Heritage List, and the rigorousness of the processes used to evaluate nominations. More generally, UNCED focused attention upon the need to involve local communities, in particular indigenous communities, in environmental decision making and policy formulation. These issues are briefly discussed below.

2.4.1 Site Identification

The numerical imbalance between cultural and natural sites inscribed upon the World Heritage List has been a continuing issue of concern for the Committee. In part, this difference can be ascribed to the different approaches to evaluating the 'outstanding universal value' that ICOMOS and IUCN apply to cultural and natural site evaluations respectively (Cleere 1995). The difference can also be attributed to the different nature of cultural and natural heritage. However, of more concern than different numbers, is the distinct Eurocentric bias in the properties inscribed upon the list. Of cultural properties inscribed at the beginning of 1994, 48% were grounded in European culture, in particular, historic towns and Christian monuments (Cleere 1995).

In attempting to overcome this bias, the Committee has encouraged States Parties with poorly represented cultural heritage to seek assistance for nomination and tentative list preparations, while those with well represented cultural heritage are urged to slow down their nominations (World Heritage Committee 1996a). The responsibility for the nomination of sites to the World Heritage List lies solely with the State Party on whose territory the site lies. Historically, this bottom up approach has also been applied to the identification of potential World Heritage sites. Increasingly, however, a regionally or thematically coordinated approach is developing to counteract the Eurocentric bias of the list. To this end, ICOMOS has convened a number of specialist workshops and experts meetings to investigate under-represented cultural heritage. Recent studies have focused upon African cultural heritage, cultural landscapes, and canals and cultural routes as cultural heritage. Similar thematic studies may serve to identify further sites worthy of nomination as natural World Heritage, in turn reducing the numerical imbalance. The potential for a Global Strategy approach to achieve a better coverage of natural sites with thematic studies, for example on fossil sites and into geophysical and geomorphological diversity, were among the subjects of an Expert Meeting in the Parc National de la Vanoise, France in March 1996.

2.4.2 Evolution of Criteria

Criteria to assist in the assessment of 'outstanding universal value' were first adopted in the Operational Guidelines by the World Heritage Committee in 1977 following proposals made in the previous year by ICOMOS and IUCN. There have been frequent revisions of the text of these and the criteria under which the nomination of the Great Barrier Reef was made were those adopted in October 1980. Both sets of criteria are reproduced in Table 2.1

The natural heritage criteria were significantly amended in 1992, following several reviews. In particular, a Geological Taskforce and a subsequent workshop at the IVth World Parks Congress. The Taskforce found that the criteria were imprecise with respect to geological and fossil sites. They proposed redefining one criterion and recommended two further criteria to cover geological phenomena and processes. The Parks Congress workshop concluded that:

- the criteria are not sufficiently precise to enable a rigorous evaluation;
- references to human interaction with the environment and cultural elements are inconsistent with the definition of natural heritage in Article 2; and
- biological diversity is not explicitly reflected and is overshadowed by an emphasis upon threatened species (Mishra & Ishwaran 1992).

In light of the workshop recommendations and discussions by the Bureau, the Secretariat prepared a revised set of criteria, which after some modifications were accepted at the World Heritage Committee meeting in December 1992 at Santa Fe, USA. The revision saw the following refinements of the natural heritage criteria:

- references to 'geological processes' in criterion (ii), and to 'formations or features' in criterion (iii) were removed, and geological, geomorphic and physical features are focused upon in the current criterion (i);
- references to cultural components, *viz.* 'man's [*sic*] interaction with his natural environment' in criterion (ii) and 'exceptional combination of natural and cultural elements' in criterion (iii) were removed from the criteria; and
- whilst retaining a reference to 'threatened species' in criterion (iv), the prior focus upon 'rare and endangered species' was de-emphasised and an explicit focus upon biological diversity introduced.

Criterion (iii) referring to 'superlative natural phenomena' and to 'areas of outstanding natural beauty' has remained essentially the same. The criteria now represent (i) geological phenomena (ii) ecological and biological processes, (iii) aesthetics, and (iv) biological diversity. No further changes have been made to the natural heritage criteria since then although there have been regular versions of the Operational Guidelines published, the most recent being dated February 1996 (World Heritage Committee 1996a).

Revisions to the cultural heritage criteria were adopted at the same Committee meeting in 1992, most notably, by the inclusion of criteria and evaluation guidelines for cultural landscapes. The basis for these changes was an Experts Meeting held in La Petite Pierre in France in October 1992. The revisions extended the narrowly focused concept of rural landscapes to recognise the past and present role of hunter–gatherer societies in maintaining landscapes, and the continuing association of landscapes and landscape features to indigenous peoples (Titchen 1993).

2.4.3 Increased Rigour in the Evaluation of Nominations

For earlier inscriptions upon the World Heritage List, it is difficult to determine exactly why the property was nominated, other than a broad compliance with the criteria (Paine 1992). Along with a clearly enunciated set of criteria, the process of evaluation of nominations has become increasingly more rigorous. It is likely that some properties listed in the early years of the Convention would not be inscribed if nominated today (Batisse 1992).

As mentioned, the NGO's are responsible for the technical evaluations of nominations. Their basis for involvement is found in the Convention[21] , and further elaborated in the Operational Guidelines. These require the NGO's to be 'as strict as possible' in the evaluation of nominations.

An IUCN evaluation would normally consist of the following components:

1. Data Assembly: including the compilation of a standardised data sheet on the property using the nomination and other sources;
2. External Review: where the nomination is sent to experts knowledgable about the site for their comments;
3. Field Inspection: of the site normally takes place and incorporates discussions with local and national authorities;
4. Panel Review: where the information gathered from the above three steps is reviewed by a Technical Evaluation Panel (IUCN 1995).

[21] See Articles 8, 13 and 14.

Following step 4, the evaluation report is submitted to the Bureau for review, where clarifications may be sought. Changes based upon the Bureau's recommendation and any further information from the State Party is compiled into a final report to the World Heritage Committee.

Field visits and panel reviews were introduced to the process in 1986 (IUCN 1995). The field visits serve to clarify details on the site and increase local awareness of the Convention (IUCN 1995).

The evaluation process and decisions must be systematic and well documented. This is of particular importance where IUCN advises against listing a property, which often sparks extensive debate and disagreement at the Committee. In contrast, positive recommendations are seldom debated. In general the Committee has accepted the recommendations of IUCN, only three inscriptions occurred contrary to IUCN advice during the 1984–1994 period (IUCN 1995).

2.4.4 Public Involvement in World Heritage

The increased recognition of the value and importance of involving people affected by the decisions and policies in the processes of decision making and policy formulation is a trend not isolated to World Heritage implementation but across all facets of environmental policy formulation and decision making, and indeed through most sections of western liberal government. The logical benefit of public participation is decision making which has been better informed of public preferences and values (Brenneis & M'Gonigle 1992).

In the case of World Heritage nominations and their subsequent management, public participation of local peoples can help engender a sense of World Heritage; a pride and ownership of the universally important site located nearby. The World Heritage Committee regards the involvement of local people to be

> essential to make them feel a shared responsibility with the State Party in the maintenance of the site (World Heritage Committee 1996a:5).

The Committee's commitment to public involvement was strengthened at the 1995 Committee meeting where a section of the Operational Guidelines that may have been interpreted as conflicting with public involvement was deleted (World Heritage Committee 1995).

2.4.5 Indigenous Involvement in World Heritage

A related but qualitatively different issue to public involvement is the involvement of indigenous peoples in World Heritage. This issue brings into sharp focus the false dichotomy between culture and nature. Until the inclusion of criteria for cultural landscapes, the Convention and Operational Guidelines were unable to accommodate indigenous heritages easily (Domicelj et al. 1992). This is largely due to the framing of heritage within a European context which serves to obscure the cultural construction of nature.

However, the value of indigenous peoples' involvement in cultural and natural heritage management has been recognised internationally, (for example see the Biodiversity Convention and the *Rio Declaration on Environment and Development*), and domestically, (for example see the *National Strategy for Ecologically Sustainable Development* (Commonwealth of Australia 1992a), the *Recognition of Aboriginal Customary Laws* (Australian Law Reform Commission 1986); the *Royal Commission into Aboriginal Deaths in Custody* (Johnston 1991); and the *Coastal Zone Inquiry* (Resource Assessment Commission 1993a)).

Similarly the World Heritage Committee has recognised the value of indigenous peoples' involvement in World Heritage nomination and management. Indeed without such involvement the integrity of sites may be compromised, particularly in the case of cultural landscapes. On occasions, the Bureau has sought further information regarding the role of indigenous peoples in the management of World Heritage areas (for example see Brennan 1992). Recent nominations of properties to the World Heritage List have taken place with the support and assistance of indigenous peoples, for example the involvement of the Ngai Tahu Maori Trust Board in the nomination of Te Wahipounamu (south-west New Zealand) (Department of Conservation 1989).

At a workshop convened by the Australian Committee for IUCN Inc., indigenous peoples along with a range of other interested parties developed the Richmond Communique (ACIUCN 1995), a set of principles and guidelines for the management of Australia's World Heritage Areas. These guidelines recognise the importance of indigenous involvement in World Heritage management:

> Because of the long and special relationship of indigenous people with the land and seas in Australia, we recognise the inseparability of natural and cultural values, and the special role of indigenous Australians in the identification, protection, conservation and presentation of world heritage properties in Australia (ACIUCN 1995:2).

The Richmond Communique also contains a section that was developed by the indigenous peoples attending the workshop, and subsequently adopted by all workshop participants. This, inter alia, calls for the revision of the Operational Guidelines to recognise indigenous rights and interests, and to base nominations upon the assumption that an indigenous cultural landscape exists at any proposed World Heritage property (ACIUCN 1995).

2.5 The Contemporary Implementation of the World Heritage Convention

As the Convention matures, its primary focus is moving away from the identification and designation of the world's cultural and natural heritage, to focus increasingly upon the protection, conservation, presentation, and transmission to future generations of that identified heritage. While it is not the primary focus of this consultancy, it is worthwhile to outline a number of issues primarily concerned with the protection of World Heritage.

2.5.1 Impacts upon World Heritage Areas

The monitoring reports presented to the Committee indicate that the possible impacts upon World Heritage are very broad. The reports discuss such impacts as mining and logging near World Heritage Areas, the construction of roads and tourism developments within World Heritage Areas, and the effects of pollution and armed conflict, among others. Whilst specific impacts are numerous, it is possible to recognise a simple typology in the type of impacts upon both cultural and natural World Heritage Areas. Such a typology recognises the origin of the impact to be either external, such as a mining project in the headwaters of watershed included in a World Heritage Area, or internal, such as the construction of a road through an area. Furthermore, the impact can be described as having either originated from a point source e.g. a sewage outfall, or from a diffuse source where the impact originates over a broad area. Cumulative impacts add a temporal dimension to this typology.

2.5.2 The Development /Protection Debate

There appear to be two schools of thought with regard to the management of natural World Heritage properties. One suggests that the attributes that make a property of 'outstanding universal value' for the purposes of the World Heritage List are the attributes that need to be protected and conserved. The other position argues that the whole area must be protected and conserved. Support for both positions can be found within the Convention and the Operational Guidelines.

The process of evaluation for inscription upon the World Heritage List focuses upon whether attributes meet the criteria; similarly, the removal of a property from the World Heritage List occurs when 'it has irretrievably lost those characteristics which determined its inclusion in the List' (World Heritage Committee 1996a:16).

The conditions of integrity for inclusion on the list promote a broader perspective. For example, if a coral reef was used to justify criterion (ii), the conditions of integrity suggest that the nomination should also include 'seagrass, mangrove or other adjacent ecosystems that regulate sediment or nutrient inputs into the reef' (World Heritage Committee 1996a:13). Furthermore, the boundaries of the area should include sufficient adjacent areas to the area of outstanding universal value to protect the site's values from anthropogenic impacts. The general principles outlined at the beginning of the Operational Guidelines suggest that a buffer zone surrounding the property should be established to provide an extra layer of protection.

Ultimately, the type and style of management regime that property enjoys will be at the discretion of the State Party involved. Vernhes (1990) argues that the World Heritage List is not an honours list but, rather States Parties must recognise the heavy obligations and responsibilities that the Convention demands. Some States Parties forget the responsibilities in ensuring the protection, conservation, presentation and transmission to future generations of the cultural and natural heritage, viewing the World Heritage List as merely a marketing tool (McNamee 1992). Furthermore, there is often conflict within government concerning the management of World Heritage, with departments responsible for conservation pitted against other, typically more powerful, resource and finance departments (Vernhes 1990).

In Australia, a range of regimes provide for the protection and management of World Heritage sites. For example, several of the sites are managed as protected areas either as state owned national parks, such as Tasmanian Wilderness World Heritage Area, or Aboriginal owned national parks as is the case with Uluru and Kakadu. In these cases, the World Heritage Area is coincident with the protected area. The protection and conservation of World Heritage is assumed to be achieved through management as a protected area.

In other properties, where the World Heritage Area overlays a large number of jurisdictions and tenures, a multiple use philosophy has tended to predominate, as is the case with the Great Barrier Reef World Heritage Area and Lord Howe Island World Heritage Area. On the whole the Australian government's approach to World Heritage management has been one of allowing exploitative activities to continue

> ...as long as they do not threaten World Heritage values, are sustainable, are backed up by research and monitoring, and come under a planning and management umbrella (Turner 1990:36).

We believe that a focus upon the World Heritage 'Values' is too narrow. Given that the World Heritage Value of a property is assessed in sum, protection and management for World Heritage should focus upon the property as a whole. Obviously identification and knowledge of particular attributes is of utility in determining management priorities and the effects of impacts.

In focusing upon the whole of a property, particularly with very large properties such as the Great Barrier Reef World Heritage Area, a question of appropriate scale presents itself. Should the scale of impact on a World Heritage Area be related to the scale of the property? For a small site, for example the Statue of Liberty, it would be relatively easy to reach community consensus upon what is an inappropriate level of impact. However, for a much larger area, such as some of the large natural sites or World Heritage Cities such a consensus would elude most planning regimes.

2.5.3 Monitoring of World Heritage Sites

In 1990, at a workshop session during the 18th session of the General Assembly of IUCN in Perth, the then Chair of the Commission on National Parks and Protected Areas stated that:

> ...at the very root of the Convention lies the concept of monitoring and the placement of sites under natural or [hu]man-made threat on the list of World Heritage in Danger (Eidsvik 1990:18).

As noted, the term 'monitoring' is not included in the text of the Convention. Rather 'monitoring' usually refers to the reporting of the status of World Heritage implementation as per Article 29 of the Convention. However, a stricter interpretation of monitoring, i.e. the repeated measurements according to a standard methodology over a period to detect trends, is clearly accommodated by the Convention in Articles 4 and 5 where the States Parties are obliged to protect and conserve the cultural and natural heritage through 'effective and active measures' including 'scientific and technical studies and research to work out such operating methods as will make the State capable of counteracting the dangers that threaten its cultural or natural heritage'.

The World Heritage Committee recognises that monitoring the state of conservation will receive greater emphasis than identification and designation of World Heritage in the future implementation of the Convention (World Heritage Committee 1992). Indeed, evidence that the Committee views monitoring as one of its essential functions lies in its distinguishing between three types of monitoring in 1994, namely: administrative, systematic and reactive.

Administrative monitoring is the continuous follow-up to Committee decisions and recommendations. This is carried out by the World Heritage Centre.

Systematic monitoring comprises the continuous observation of the conditions of World Heritage sites accompanied with periodic reporting (World Heritage Committee 1996a). Systematic monitoring is the responsibility of the State Party with the assistance of the World Heritage Centre and its associated experts. In 1994, the Operational Guidelines were amended to invite States Parties to submit every 5 years, a scientific report on the conservation status of their World Heritage sites.

In contrast to systematic monitoring, reactive monitoring is reporting about specific sites under serious threat (World Heritage Committee 1996). Thus, reactive monitoring may be a precursor to the inscription of a property on the List of World Heritage in Danger, and the eventual deletion of entirely compromised sites, something which has yet to happen. Reactive monitoring of natural heritage sites is undertaken by IUCN with the assistance of the World Conservation Monitoring Center (WCMC). Such monitoring has been useful in channelling technical assistance where needed and eliciting interventions from governments (IUCN 1995).

Reactive monitoring is initiated by the WCMC or IUCN following the reception of reports concerning the deteriorating conservation status of a natural World Heritage property. Such information may originate from the media, non-government conservation organisations or the State Party itself. Initially, further information and verification will be sought from the relevant government authorities. If necessary, the threat or issue will be presented to the Bureau's June meeting, following which further information may be sought from the relevant State Party. The Committee meeting will then make any necessary recommendations regarding follow-up activities or possible inclusion in the List of World Heritage in Danger at its annual meeting.

Such reactive monitoring is essentially a desk-based task, largely reflecting the funds available for monitoring. However, in some instances a field visit will be undertaken (IUCN 1995).

The World Heritage Workshop held at the IVth World Parks Congress suggested the adoption of a sunset clause in the Operational Guidelines which would require that a site's 'outstanding universal value' be re-evaluated after a certain number of years. The time period suggested by the workshop participants ranged from 10 to 20 years. This would mean that its nomination should be revisited to ensure that it is still worthy of inscription upon the List (Thorsell 1992). Monitoring a site would thus become a crucial component of its management and its continued World Heritage status. Given that a number of earlier nominations appear to have limited justifications for World Heritage inclusion, such a process could be crucial in the future effective management of these sites. The World Heritage Committee has not yet adopted the concept of a sunset clause.

The monitoring of sites has become a sensitive issue in the implementation of the Convention. Some States Parties, arguing the primacy of Sovereignty as specified in the Convention[22], object to any role of the Committee, the Secretariat or its advisory bodies in the preparation of monitoring reports unless invited to do so by the relevant State Party. This was particularly apparent at the 10th General Assembly of States Parties to the World Heritage Convention (Thorsell & Valentine 1995), where the World Heritage Centre presented new initiatives for monitoring causing much debate.

2.6 Australia's Response to the Convention

Australia has eleven properties inscribed upon the World Heritage List (Table 2.2); seven are recognised as natural heritage properties and four are recognised as mixed properties. Australia has no properties on the World Heritage List solely for their cultural significance.

Table 2.2 Australian World Heritage Properties

Property Name	Location	Size (ha)	Year Inscribed	Cultural Criteria	Natural Criteria
Kakadu National Park	NT	1 975 700	30/10/81 11/12/87 14/12/92	(i) (vi)	(ii) (iii) (iv)
Great Barrier Reef	Qld	34 870 000	30/10/81		(i) (ii) (iii) (iv)
Willandra Lakes Region	NSW	240 000	30/10/81	(iii)	(i)
Tasmanian Wilderness	Tas.	1 380 000	17/12/82 15/12/89	(iii) (iv) (vi)	(i) (ii) (iii) (iv)
Lord Howe Island Group	NSW	146 300	17/12/82		(iii) (iv)
Central Eastern Aust. Rainforest	NSW & Qld	366 455	28/11/86 17/12/94		(i) (ii) (iv)
Uluru-Kata Tjuta National Park	NT	3 500	11/12/87 17/12/94	(v) (vi)	(ii) (iii)
Wet Tropics of Queensland	Qld	894 000	9/12/88		(i) (ii) (iii) (iv)
Shark Bay	WA	2 300 000	13/12/91		(i) (ii) (iii) (iv)
Fraser Island	Qld	184 000	14/12/92		(ii) (iii)
Australian Fossil Mammal Sites (Riversleigh/Naracoorte)	SA & Qld	10 300	17/12/94		(i) (ii)

(Source: World Heritage Committee 1996b)

[22] See Articles 3, 6 and 11.3.

World Heritage has achieved widespread attention in Australia, not so much as a consequence of giving it 'a function in the life of the community' (Art. 5(a)), but rather through bitter and extended conflicts between state and territory governments and the Commonwealth Government over nominations of properties to the World Heritage List, and the subsequent management of inscribed properties. Typically these conflicts have seen the Commonwealth Government, with the pressure and support of the conservation movement, move to nominate an area for inclusion in the list or halt some particular activity, while the state/territory government has opposed nomination or supported some continuing exploitation of an area. These domestic conflicts have also been played out within the international arena of the IUCN, the Committee and the Bureau, where Australia is beginning to gain a reputation for its eccentricity (Toyne 1994). Suter notes:

> ...in no other nation has the Convention created as much controversy as it has in Australia. In so far as calculation is possible, Australia has probably had more litigation and political challenges to the Convention than all other States Parties to the Convention combined (Suter 1991:4).

Behrens (1990) situates these conflicts within their inter-related economic, political and constitutional contexts. Economically, areas suggested for nomination to the World Heritage List often contain extensive natural resources, for example timber, hydro-electricity potential, minerals etc. If listing also requires that exploitation of these resources is not allowable or constrained, then the state government will have reduced access to those economic resources. Furthermore given the parochialism of some states, arguments of states rights and the spectre of an interventionist central government gives political mileage to a state government in opposing a Commonwealth Government. Finally the federal nature of our governance vests the responsibility to enter into conventions and their implementation with the Commonwealth Government by virtue of section 51(xxix), the external affairs power, of the Australian Constitution. The states however retain the primary responsibility for the use and management of land and internal waters. The political and economic forces at play have lead to a number of challenges to the constitutional validity of Commonwealth Government action. These challenges and the judgements handed down have clarified and validated the interventionist actions of the Commonwealth Government in carrying out its obligations under the Convention.

In the Tasmanian Dams Case, the newly elected Hawke federal Labor Government, in fulfilling election pledges, legislated to halt the construction and associated works of the Franklin-below-Gordon Dam in south-west Tasmania[23]. Hawke acted quickly to stop the dam, following his Government's election, by gazetting regulations under the *National Parks and Wildlife Conservation Act 1975*. The Tasmanian Government responded by issuing a writ in the High Court challenging the validity of the regulations. Before the matter was heard the first session of the new Federal Government passed the *World Heritage Properties Conservation Act 1983*.

This legislation is to provide for the protection of properties forming part of Australia's natural and cultural heritage that are likely to be damaged. The legislation, designed with a constitutional challenge in mind, rests upon a number of powers reserved to the Commonwealth, including the race power s. 51(xxvi) of the Australian Constitution, the external affairs power s. 51(xxix) and the corporations power s. 51(xx). To be subject to the legislation, a site must be an 'identified property', which is a property that is: subject to an inquiry established by Commonwealth law to consider whether the property forms part of the cultural or natural heritage; or is subject to World Heritage List nomination; or is included on the World Heritage List; or is proclaimed by regulation to form part of the cultural and natural heritage. In order to take any action to halt any activities on a property, the Governor-General must first be satisfied that the identified property is 'being or is likely to be damaged or destroyed' and consequently a Proclamation made under the Act. Permission is then required from the Federal Minister for Environment to carry out any prescribed activities. The Commonwealth Government has used the Act to stop activities damaging to Australia's

[23] The area in which the dam was to be built had been nominated for inscription upon the World Heritage List by the Fraser Liberal/Coalition Government at the request of Tasmanian State Premier (Mr Lowe) in mid 1981, and was listed in December 1982.

cultural and natural heritage on three occasions; in 1983 to stop the construction of the Franklin-below-Gordon Dam; in 1988 to stop logging and road construction in the Wet Tropics of Queensland; and in 1994 to stop the removal of mangroves and channel dredging at Oyster Point in the Great Barrier Reef World Heritage Area.

In the Tasmanian Dams case, the High Court held that the Commonwealth could legitimately enact the *World Heritage Properties Conservation Act* using the external affairs powers. While some sections of the legislation were held to be invalid, the construction of the dam was effectively halted. Following the Dams case, the July 1984 meeting of the Council of Nature Conservation Ministers (CONCOM) adopted procedures to facilitate cooperation in the protection and nomination of World Heritage properties (Richardson 1990). Whilst these were successful in the nominations of the Central Eastern Australian Rainforest and the Lord Howe Island Group, the procedures were unable to defuse the next two major disputes involving World Heritage; the logging of wet tropical forests in northern Queensland and temperate forests in Tasmania. In both disputes High Court decisions further elaborated the valid role of the Commonwealth Government in domestically implementing the World Heritage Convention.

In the Tasmanian Forests Case[24] the High Court held that the Commonwealth could prohibit activities on an interim basis for the purposes of establishing if the property is a part of the World Heritage (for a discussion of the case see Tsamenyi & Bedding 1988; Tsamenyi et al. 1989). Finally the Queensland Forests Case[25] held that the decision of the World Heritage Committee is final and cannot be challenged in a municipal court (for a discussion of the case see Tsamenyi & Bedding 1990). Following these cases it is obvious the Commonwealth has substantial legal power to act to protect World Heritage.

However, this is not to suggest that the Commonwealth has unlimited constitutional power to protect World Heritage properties in Australia. In particular, Murphy J noted in the Tasmanian Dams Case that the type of legislation that would be valid must be

> ...confined to what may reasonably be regarded as appropriate for the implementation of the treaty...[26]

Consequently some sections of the *World Heritage Properties Conservation Act 1983*, were held to be invalid. In the Tasmanian Forests Case the

> ...majority judges found it a necessary limitation on interim protection that there be a reasonable foundation for the decision that the property has likely world heritage values (Behrens 1990:4).

Despite these legal limitations upon the Commonwealths power to act, Bates (1984) noted, following the Dams case that:

> Any constraints on the exercise of federal power will be political rather than legal (Bates 1984:344).

In May 1992 the State, Territory, Commonwealth and the Local Governments Association signed the Intergovernmental Agreement on the Environment (IGAE). The primary aim of the agreement is to enhance cooperation between spheres of government in environmental policy and decision making. Schedule 8 to the IGAE covers issues specifically related to implementation of World Heritage. It recognises the Commonwealth's international obligation to identify, protect, conserve, present and transmit Australia's properties of 'outstanding universal value'. Under the IGAE the Commonwealth is obliged to consult with the states and 'use its best endeavours to obtain their agreement' to nominations to the World Heritage List. While 'management arrangements will take into consideration the continuation of the State's responsibilities for the property while preserving the Commonwealth's responsibilities under the World Heritage Convention' (Commonwealth of Australia 1992b).

On World Heritage matters, the IGAE contains no real departure from previous practice; the Commonwealth has always attempted a negotiated approach to World Heritage listing, and has acted unitarily only as a last resort (Davis 1989). However, taken as a whole Toyne (1994) argues the IGAE represents a shift away from increased Commonwealth involvement in environmental policy. Since conclusion of the IGAE, the successful nominations of Fraser Island (Qld), and the Australian Fossil Mammal

24 *Richardson v. Forestry Commission of Tasmania* (1988) ALJR 158

25 *Queensland v. The Commonwealth* (1989) ALJR 473

26 Murphy J (1983) 46 ALR 625 at 730

Sites (Qld and SA), the expansion of the Central Eastern Australian Rainforest World Heritage Area and the inscription under cultural criteria of Uluru-Kata Tjuta National Park have all occurred with little conflict between governments.

In contrast, the perceived lack of due process by the Queensland Government in assessing the environmental impact of the proposed mega-resort at Oyster Point, in particular its effects upon the 'outstanding universal value' of the Great Barrier Reef World Heritage Area led to a sustained and continuing campaign to stop the development which received national coverage. The then Minister for the Environment Senator Faulkner sought and obtained a proclamation from the Governor-General under the *World Heritage Properties Conservation Act*, for an area of the Great Barrier Reef World Heritage Area adjacent to the development site. The proclamation and subsequent regulations under the Act prohibited without consent the further removal of mangroves, and earth works associated with the establishment of a marina including the building of a breakwater and dredging of an access channel.

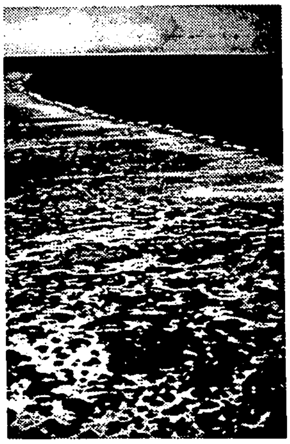
Following the election of the conservative Howard government in 1996, the new Minister for the Environment, Senator Hill, assessed applications for dredging a marina access channel and implementing a beach and foreshore management plan. Senator Hill required further information from the developer about the likely impacts upon the immediate environment from the development. Based upon an experts review of this information consent was granted for the two activities. The conservation movement questioned the legality of Senator Hill's decision making process and initiated legal action in the Federal Court. At this stage the judgement has been reserved, and work on the development continues.

2.7 Summary

The *Convention Concerning the Protection of the World Cultural and Natural Heritage* is one of the international community's most successful instruments of conservation. From its inception as an idea in the 1960s through to its realisation in 1972 and its subsequent maturity to the present day, the Convention has undergone significant evolution and consolidation. The primary focus of implementation of the Convention has moved away from the identification and inscription of properties upon the World Heritage List, towards a consolidation of the representativeness of those sites and their management as the world's premier cultural and natural heritage.

The next chapter will focus attention upon the Great Barrier Reef World Heritage Area, outlining its nomination and assessment for World Heritage inclusion. The complexities that arise for management of this area are discussed briefly. Finally evidence is presented demonstrating the growing recognition that management of the Area must be premised upon its inclusion on the World Heritage List.

Chapter Three:
The Great Barrier Reef as a World Heritage Area



3.1 Genesis of the Great Barrier Reef Marine Park and World Heritage Area

The 1960s was a period of rapid economic change in Queensland, strong markets developed for sugar and beef, the major primary products of north Queensland, and economic development become the priority of the conservative Queensland Government. The Great Barrier Reef was seen as a vast resource waiting to be exploited; oil exploration in the Great Barrier Reef was established; mining of reefs for limestone was proposed; increases in fisheries and tourism were foreshadowed (Kenchington 1990).

As mentioned earlier this period was also a time of growing public concern over the effects of unrestrained economic growth on the natural environment. Organisations advocating conservation became established, in particular the Wildlife Preservation Society of Queensland (WPSQ) in 1963, and later the Australian Conservation Foundation (ACF), in 1965, and the Australian Littoral Society (1967). Members of the WPSQ first mooted the idea of the Reef 'becoming a great underwater park' in 1963 (Wright 1977:2), following concerns over reports of rapid increases in tourism, and in shell and coral collection.

In 1967 an application to mine Ellison Reef, near Innisfail, was lodged with the Queensland Department of Mines. The WPSQ, ACF and the Littoral Society all lodged written objections to the application. The WPSQ was concerned over the effects upon Ellison Reef itself, but moreover was concerned over the precedent that such an operation would set for the rest of the Reef (Wright 1977). In a widely publicised case the Mining Warden's Court refused the application, and the decision was accepted by the Minister for Mines, who had discretionary powers to grant the application regardless of the Warden's decision.

Other threats to the Great Barrier Reef were also becoming more apparent. Outbreaks of the coral eating crown-of-thorns starfish (*Acanthaster planci*) were occurring, killing as much of 95% of the living coral on severely affected reefs (Kenchington 1990). The north Queensland trawl fishery was expanding rapidly, and foreign fishing vessels started trawling in Great Barrier Reef waters. Additionally, foreign fishers were collecting giant clams, turtles, reef fish and ornamental shells from the region (Kenchington 1990). These issues drew attention to the lack of adequate management regime for the Great Barrier Reef, and highlighted the need for Australia to lay claim to its resources. In 1968 the *Continental Shelf (Living Natural Resources) Act* was passed, giving the Commonwealth Government responsibility for sedentary living resources out to the outer barrier of the Great Barrier Reef.

Unlike the application to mine Ellison Reef, the granting of oil exploration permits was not subject to public review. By September 1967, 80 920 square miles (209 583 km^2) of the Great Barrier Reef had been leased for mineral or oil exploration (Wright 1977). Exploratory drilling had begun in the Swain group of reefs in the southern region of the Great Barrier Reef (Kenchington 1990). Public disquiet grew over the prospect of oil drilling in the Great Barrier Reef following oil tanker accidents, and in particular of the offshore oil leaks from the Santa Barbara, California, oil fields in January 1969 (Wright 1977). There were growing concerns regarding the level of environmental protection the Queensland Government would require of any drilling operations, and the public was increasingly looking to the national government in Canberra for protection of the region. Following increased public pressure and union work bans a moratorium was declared on further drilling in 1970. Furthermore the Queensland and Commonwealth Governments established a conjoint Royal Commission to inquire into the issue of oil exploration and production on the Great Barrier Reef.

Jurisdictional issues were central to finding a suitable management regime for the Great Barrier Reef. Furthermore it was apparent that any logical approach to management had to involve both governments (Kenchington 1990). In 1975 *the Great Barrier Reef Marine Park Act 1975* (Cwlth) was passed establishing the basis for the Great Barrier Reef Marine Park. On 14 June 1979 the 'Emerald Agreement' was signed by the then Prime Minister, Fraser, and the Premier, Bjelke-Peterson. The agreement clarified jurisdictional issues for the Great Barrier Reef complementary to the Offshore

Constitutional Settlement, established the Great Barrier Reef Ministerial Council, and formalised Queensland's role in the day-to-day management of the Marine Park. The first Section, Capricornia, of the Great Barrier Reef Marine Park was declared on 17 October 1979.

3.2 The Nomination of the Great Barrier Reef to the World Heritage List

The Great Barrier Reef was nominated for inclusion on the World Heritage List during January 1981 (GBRMPA 1981). The nomination document consisted of 9 pages (B5) of text and maps, and a further 27 pages of appendixes, of which 11 contained information supporting the case for World Heritage Listing. Such a slimline nomination was not uncommon for the time as the nominations for the Lord Howe Island Group (New South Wales et al. 1981) and the first stage of the Western Tasmania Wilderness National Parks (Tasmania & Australian Heritage Commission 1981) clearly demonstrate. However, in response to the increasingly rigorous assessment process (see 2.4.3) recent nominations are considerably more detailed. Thus the nomination for the Wet Tropics of Queensland, covering an area of just 2% of the Great Barrier Reef World Heritage Area, consists of 31 pages (A4) of text, and an extensive series of supporting appendixes (Valentine 1994).

The nomination of the Great Barrier Reef is broad and general, with the primary focus on the coral reef ecosystems of the area, with only passing mention of other marine and terrestrial components of the area. Not surprisingly the document has been inadequate for management purposes of the World Heritage Area (Valentine 1994). The nomination of the Great Barrier Reef included justification for both cultural and natural heritage criteria. For cultural heritage criteria the justification stated that:

> The area of this nomination contains many middens and other archaeological sites of Aboriginal or Torres Strait Islander origin. There are over 30 historic shipwrecks in the area, and on the islands there are ruins and operating lighthouses which are of cultural and historical significance (GBRMPA 1981:5).

To justify its listing upon natural heritage criteria the nomination claims:

> The Great Barrier Reef is by far the largest single collection of coral reefs in the world. Biologically the Great Barrier Reef supports the most diverse ecosystem known to man [*sic*]. Its enormous diversity is thought to reflect the maturity of an ecosystem which has evolved over millions of years on the north east Continental Shelf of Australia.
>
> The Great Barrier Reef provides some of the most spectacular scenery on earth and is of exceptional natural beauty. The Great Barrier Reef provides major feeding grounds for large populations of the endangered species *Dugong dugon* and contains nesting grounds of world significance for the endangered turtle species green turtle (*Chelonia mydas*) and loggerhead turtle (*Caretta caretta*).
>
> The Great Barrier Reef thus meets all four criteria set out in Article 2 of the World Heritage Convention (GBRMPA 1981:5–6).

Whilst both cultural and natural heritage attributes are covered in the justification and description sections of the nomination, it is clear that the nomination is essentially focused upon the area's natural heritage attributes. The nomination concludes that 'the area nominated is of outstanding universal value on the basis of its natural heritage' (GBRMPA 1981:6). Accordingly the nomination was reviewed by the IUCN (IUCN 1981).

In a report assessing the impacts of the Oyster Point mega-resort proposal on the World Heritage value of the Hinchinbrook Area, Valentine (1994) analysed the nomination document deriving the following list of attributes that contribute to the 'outstanding universal value' of the area:

a) largest and most complex expanse of living corals;

b) unique forms of marine life;

c) great diversity of life forms;

d) most spectacular scenery on earth;

e) exceptional natural beauty;

f) major feeding grounds of dugongs and turtles;

g) the area meets the conditions of integrity required (Valentine 1994:6).

As required, the nomination document also details how the conditions of integrity are met for the property, stating that 'the area nominated also meets the conditions of integrity in that it includes the areas of sea adjacent to the reef' (GBRMPA 1981:6). Furthermore the management regime for the Great Barrier Reef World Heritage Area is described, including information on the zoning scheme for the Capricornia Section, the only section proclaimed as the Great Barrier Reef Marine Park at the time of World Heritage nomination. The implementation of the zoning schemes was to be carried out through 'management plans and guidelines' (GBRMPA 1981:20). The document also describes the cooperative arrangement for Queensland involvement in management of marine areas, and the State's primary role in management of the non-Commonwealth owned islands (see 3.5.2).

The nomination identified two perceived threats to the integrity of the Great Barrier Reef World Heritage Area, namely 1) mining and oil drilling on the reef; and 2) the crown-of-thorns starfish. Presumably the scale of contemporary impacts, for example tourism, terrestrial run-off and commercial fishing[27], on the Great Barrier Reef at the time of nomination, were not seen as warranting mention in the nomination document or, alternatively, the threats to World Heritage value that these activities pose were not realised at the time. Furthermore, it is noteworthy that the use of the World Heritage Area as a major shipping route for the east coast was not mentioned, particularly as the fear of oil spills were major concerns in the campaign for protection of the Great Barrier Reef.

3.3 The IUCN Review of the Great Barrier Reef World Heritage Nomination

The technical review of the Great Barrier Reef World Heritage nomination was carried out by the IUCN, incorporating a review by five international experts (IUCN 1981). There was no field inspection as was the practice at that time. The review acknowledged the outstanding universal value of the area nominated, remarking that:

> It seems clear that if only one coral reef site in the world were to be chosen for the World Heritage List, the Great Barrier Reef is the site to be chosen (IUCN 1981:2).

This review recognised the importance of the area to the continued survival of dugongs and marine turtles given the pressures upon these species elsewhere. The evaluation concluded that the area meets all four of the natural heritage criteria, and recommended to the World Heritage Committee that the area be inscribed upon the World Heritage List.

The evaluation report also highlighted some concerns regarding the conditions of integrity for the area. The vast size of the area nominated was raised as a concern noting that

> ...the proposed site may be too large to ensure that a 'precisely delineated area' as defined in Article 2 of the Convention, can be effectively managed and protected as a World Heritage site (IUCN 1981:2).

One consultant, questioning the adequacy of the then current legal measures to ensure the long-term integrity of the site suggested 'it may be worth considering to restrict the World Heritage site to the fully protected core area of a larger managed zone' (IUCN 1981:2), perhaps in the form of a Biosphere Reserve. In contrast, the IUCN evaluation report also expressed concern over the exclusion of other areas, in particular the deltaic and dissected reefs north of the area nominated, and recommended that the World Heritage Committee 'express a willingness to accept the addition of this area should it become available in the future' (IUCN 1981:2). In further contrast to the suggestion of reducing the size of the site to be listed, the IUCN congratulated the Government for including 'virtually the entire Great Barrier Reef' in the proposed World Heritage Site, noting that:

> this is clearly the only way to ensure the integrity of the coral reef ecosystems in all their diversity (IUCN 1981:1).

Concerns were also raised over the adequacy of the management regime to maintain the long term integrity of the nominated area. Specifically, attention was drawn to the manner in which management responsibility is divided between the Commonwealth and Queensland Governments, the lack of sufficient legal protection, particularly for the areas lying outside sections considered for a zoning plan, and the lack of a firm temporal commitment to the declaration of other sections of the Great Barrier Reef Marine Park (IUCN 1981). Furthermore, it is apparent that the IUCN confused the boundaries of the Great Barrier Reef World Heritage Area with that of the Great Barrier Reef Marine Park, assuming them to be coincident. The final recommendation states:

> The **Great Barrier Reef Marine Park** meets the criteria of the Convention and therefore should be placed on the World Heritage List (IUCN 1981) [emphasis added].

[27] The commercial line reef fishery landed 404 metric tonnes in 1980–81, compared with 2791 metric tonnes in 1990. Note that the 1980–81 data are likely to be an underestimate (Williams & Russ 1994).

However, the Great Barrier Reef Marine Park and the Great Barrier Reef World Heritage Area, while largely overlapping, are not entirely coincident (see 3.5.1). Important components of the nominated area fall outside the Marine Park, and thus do not fall under the management regime envisioned within the nomination document, contrary to the conditions of integrity.

The evaluation recognised the potential for increased pressures for the exploitation of the area's resources and questioned the fortitude of the governments in maintaining the prohibition of oil drilling, that could damage the reef, in the face of economic pressures. The IUCN recommended that the Committee request periodic reports detailing how 'development pressures are being managed so as to maintain the integrity of the site' (IUCN 1981:2).

The World Heritage Committee at its Fifth Session meeting in Sydney from 26–30 October 1981 decided on 30 October to include the Great Barrier Reef on the World Heritage List. The Committee noted, however, that only a small portion of the area nominated was proclaimed under the *Great Barrier Reef Marine Park Act*, and requested the:

> Australian government to take steps to ensure that the whole area is proclaimed under relevant legislation (World Heritage Committee 1982:4).

3.4 Management Regime for the Great Barrier Reef World Heritage Area

The management regime for the Great Barrier Reef World Heritage Area is complicated by jurisdictional and boundary issues (see 3.5). The bulk of the area (93%) is constituted as the Great Barrier Reef Marine Park and its management as a multiple use area is coordinated by the Great Barrier Reef Marine Park Authority, a commonwealth statutory authority. The park is primarily managed at two spatial scales, a macro scale in the form of zoning plans for each section of the Park, and a micro scale of assessing permit applications for various activities requiring permits under the zoning scheme. Meso scale management through the use of management plans is less developed, with many plans remaining in draft stages for many years. Management planning and permit assessment for the Park is carried out jointly by GBRMPA and Queensland Department of Environment (QDoE), while operational aspects and the day-to-day on ground management is delegated to a number of Queensland agencies, principally the QDoE. The Queensland Fisheries Management Authority (QFMA) is the lead agency for fisheries management in Queensland, and is responsible for both commercial and recreational fisheries management in the Great Barrier Reef World Heritage Area.

The *Great Barrier Reef Marine Park Act 1975* establishes the park and the various administrative processes for its management. The object of the Act is:

> ...to make provision for and in relation to the establishment, control, care and development of a marine park in the Great Barrier Reef Region[28]

The multiple use philosophy behind the park is clearly expressed through the objects that the Authority must have regard to in developing zoning plans. These are:

> (a) the conservation of the Great Barrier Reef;
>
> (b) the regulation of use of the Marine Park so as to protect the Great Barrier Reef while allowing the reasonable use of the Great Barrier Reef Region;
>
> (c) the regulation of activities that exploit the resources of the Great Barrier Reef Region so as to minimise the effect of those activities on the Great Barrier Reef;
>
> (d) the reservation of some areas of the Great Barrier Reef for its appreciation and enjoyment by the public; and
>
> (e) the preservation of some areas of the Great Barrier Reef in its natural state undisturbed by man [*sic*] except for the purposes of scientific research[29].

Zoning plans are in place for the four sections of the Great Barrier Reef Marine Park: Far Northern, Cairns, Central and Mackay/Capricorn. The Authority uses a range of zoning categories with the vast majority (73%–85% of a Section) of the park being zoned General Use 'A', which allows general use consistent with the conservation of the Park. This has been interpreted as allowing all activities other than mining, oil drilling and spearfishing on SCUBA.

[28] *Great Barrier Reef Marine Park Act 1975* (Cwlth), s. 5(1)

[29] *Great Barrier Reef Marine Park Act 1975* (Cwlth), s. 32(7)

Only a very small area (less than 5%) of the Marine Park is zoned at a level of protection comparable to a terrestrial national park (Marine National Park 'B' Zone) (Whitehouse 1993). Furthermore the areas that are highly protected are unevenly distributed over the habitats of the Great Barrier Reef Marine Park. Thus in the Central Section of the Marine Park, nearly 7% of 'reefal' areas are highly protected while less than 0.5% of the inner 'lagoonal' area and none of the outer 'slope' area are highly protected[30]. Similarly the distribution of highly protected areas is uneven throughout the extent of the Great Barrier Reef Marine Park. For example, the seagrass beds on which dugongs depend are not nearly as well protected in the southern Great Barrier Reef (where dugong numbers are declining (Marsh et al. 1995)) as in the north where they appear to be stable (Marsh et al. 1993). A dugong sighted in the Great Barrier Reef Region north of Cooktown is 11 times more likely to be protected by a zone with a higher protection than General Use 'B' than a dugong occurring in the remainder of the Region (Marsh et al. 1995). Similarly in the Far Northern Section more than 26% of 'reefal', 18% of 'lagoonal' and around 3% of the 'slope' areas are highly protected, while around 5% of 'reefal', less than 1% of 'lagoonal' and none of the 'slope' areas are highly protected in the Mackay/Capricorn Section. The vast majority of the highly protected area of the Marine Park occurs in the Far Northern Section (72%) (Whitehouse 1993). Indeed 58% of this highly protected area of the Great Barrier Reef Marine Park is within the single 'cross-shelf transect' in the Far Northern Section (Whitehouse 1993). The GBRMPA has acknowledged these discrepancies and is currently undertaking a process to address the distribution and amount of highly protected areas in the Marine Park.

For the large part the Great Barrier Reef Marine Park does not include the islands although, where they are Commonwealth owned the option for their inclusion in the park exists. The majority of Islands are owned by Queensland and most of these are declared as protected areas under relevant state legislation. Consequently a range of smaller scale management plans have been drafted to assist management of some of these islands and surrounding waters. In his review of the GBRMPA, Whitehouse (1993) foreshadowed a shift in importance away from large scale zoning plans towards management plans in the planning for the Great Barrier Reef Marine Park. This trend was formalised through amendments to the *Great Barrier Reef Marine Park Act* in 1995, that give statutory backing to management plans (see 3.6), and the requirement to have consideration to World Heritage values in their preparation.

The Great Barrier Reef Marine Park constitutes 93% of the World Heritage Area, the balance being made up of Queensland waters outside the Great Barrier Reef Marine Park (2%) and islands (5%) (GBRMPA 1994). Some of the Queensland waters are designated as complementary state marine parks managed along similar lines to the Commonwealth managed area but under state legislation[31]. The remaining waters, mainly along the coast, do not fall under any form of conservation management. Importantly, however, the *Great Barrier Reef Marine Park Act 1975*, in section 66(2)(e), gives the Governor-General the power to make regulations for:

> ...regulating or prohibiting acts (whether in the Marine Park or elsewhere) that may pollute water in a manner harmful to animals and plants in the Marine Park...

To date this provision has not been used.

3.5 Complexities of the Great Barrier Reef as a World Heritage Area

3.5.1 Areas, Regions and Parks

The Great Barrier Reef World Heritage Area encompasses 348 700 km^2 of both land, sea and their interface. The geographical description of the nominated area is included in Schedule 1 to the nomination, and is presented in Appendix 1. The World Heritage Area commences at the tip

[30] Unless otherwise acknowledged the figures in this section are preliminary figures derived from the GBRMPA GIS kindly provided by Mr Fancis Pantus. In this discussion reefal area refers to an area of the GBRMP incorporating the mid and outer-shelf reefs and the inter-reefal areas between, the lagoonal area refers to the area the west of this reefal area to the inshore park boundary, while the slope area refers to the area to the east of the reefal area out to the outer edge of the GBRMP.

[31] *Marine Parks Act 1982* (Qld)

of Cape York Peninsula and extends east to a point beyond the edge of the continental shelf. From here the boundary runs generally south-east to just north of Fraser Island. Here the boundary returns to the Queensland coast and then extends generally northwards at the low water mark to the tip of Cape York. The World Heritage Area includes both Queensland and Commonwealth owned lands and waters.

The Great Barrier Reef Region (GBRR) is defined as the area described in Schedule 1 of the *Great Barrier Reef Marine Park Act 1975*. This is the same area as the World Heritage Area with two specific exclusions. The Great Barrier Reef Region does not include any Queensland owned islands, nor any waters excluded by virtue of s. 14 of the *Sea and Submerged Lands Act 1973* (Cwlth), namely bay, gulf, estuary waters that were Queensland waters at the time of federation, for example Hinchinbrook Channel. Thus, the Great Barrier Reef Region stops at the low water mark on the Queensland owned islands such as Hinchinbrook and Magnetic Island, while Commonwealth owned islands such as Lady Elliot Island and Low Isles are included within the Great Barrier Reef Region.

The Great Barrier Reef Marine Park covers those parts of the Great Barrier Reef Region that are proclaimed to be Park by the Governor-General in accordance with s. 30 of the *Great Barrier Reef Marine Parks Act 1975*. Thus the park has the potential to include the Commonwealth owned islands (as they are part of the Great Barrier Reef Region) but not the Queensland owned islands. The Great Barrier Reef Marine Park has been proclaimed over most of the Great Barrier Reef Region. Some inshore areas of the Great Barrier Reef Region, particularly around population centres, have not been proclaimed.

Thus the Great Barrier Reef World Heritage Area covers all land and seas within the boundaries described in Appendix 1, the Great Barrier Reef Region covers all the Commonwealth owned lands and seas in the area, stopping at low water mark on Queensland owned islands, and finally the Great Barrier Reef Marine Park covers nearly all the Great Barrier Reef Region save some inshore areas that may yet be proclaimed to be part of the Great Barrier Reef Marine Park.

3.5.2 Jurisdictions and Boundaries

The position of the boundaries is important in determining which government has jurisdiction over various parts of the Area. In the case of the Great Barrier Reef Marine Park, the Commonwealth has jurisdiction. In the case of the Queensland owned islands, the Queensland Government has jurisdiction. In addition, the Commonwealth has international obligations under the World Heritage Convention (see 2.3) and may therefore assert some jurisdiction over Queensland territories that are included within the Great Barrier Reef World Heritage Area.

The situation is further complicated by the dynamic nature of the marine environment, where seasonal influences may cause sandy shores to change in shape and position, or even disappear in the case of some sand cays (Kenchington 1990). Furthermore, the State and Commonwealth Governments define different low water marks, the Commonwealth taking mean low water, while Queensland uses the low of Indian Springs (Kenchington 1990). In addition, the actual position of low water mark, regardless of its definition may be difficult to place. Thus, the boundary of the World Heritage Area along the coast at low water mark may be open to question across complicated regions such as river deltas, for example, the mouth of the Burdekin River.

To demonstrate the complexity of jurisdictions and boundaries for the park, Kenchington (1990:129) uses the example of marine turtles which:

> ...hatch from nests on land under Queensland jurisdiction, move to the sea across intertidal areas under state jurisdiction, cross the low water mark to enter Commonwealth jurisdiction, and then move on to feed and grow for years in international waters. Eventually they return to the Great Barrier Reef to mate in areas under Commonwealth jurisdiction and for females to lay eggs on Queensland territory.

Within Commonwealth and Queensland jurisdictions, rights, responsibilities and obligations in relation to the lands and seas of the Great Barrier Reef World Heritage Area are distributed to various departments, agencies and statutory authorities. In all, over 20 state and Commonwealth bodies have some interest in the Great Barrier Reef World Heritage Area, under more than 60 pieces of legislation (Environment Science and Services 1993).

Recommendation 1:

That the Great Barrier Reef Marine Park Authority initiate negotiations with other relevant state and federal agencies on whether the coastal boundaries of the Great Barrier Reef Marine Park and the Great Barrier Reef World Heritage Area should be identical.

3.5.3 Scale

The Great Barrier Reef World Heritage Area is the largest World Heritage area listed under the Convention, accounting for more than 32% of the total combined area of natural heritage properties as of December 1993 (IUCN 1994a). It is one of only 15 sites greater than one million hectares in size, and one of only two sites greater than ten million hectares in area. The other is the recently enlarged Tatshenshini-Alsek/ Kluane National Park/ Wrangell-St. Elias National Park and Reserve and Glacier Bay National Park World Heritage Area, in Canada and USA, which is about half the size of the Great Barrier Reef World Heritage Area. The Great Barrier Reef World Heritage Area is nearly two million times larger than the smallest natural World Heritage site, the Vallée de Mai Nature Reserve in the Seychelles, at just 18 ha, and it is nearly one and a half times larger than the United Kingdom.

A World Heritage Area the size of the Great Barrier Reef World Heritage Area creates some specific problems with regard to management of the site. With smaller World Heritage areas the whole site can easily be managed as a single highly protected area. It would not be feasible to allow such a high level of protection to the whole Great Barrier Reef World Heritage Area. For example such a designation would severely constrain access to most ports on the east coast of Queensland. Rather, the area is managed for a number of objectives, including reasonable use and the extraction of resources, primarily fishing, while mining and drilling for oil have been prohibited in the Great Barrier Reef Region. The important issue is: what level of impact is commensurate with the Area's World Heritage status? Furthermore, is the scale of the Area at all relevant in determining the appropriate level of impact? For example, one position might place any impact on the Area as inconsistent with its World Heritage status. Such a position of not allowing, say, any impact on a single blade of seagrass, whilst ideologically appealing, is unachievable. In contrast, the current situation with less than 5% of the Great Barrier Reef World Heritage Area covered by a management regime equivalent to that of a terrestrial national park or higher seems to suggest a minimalist approach to the obligations placed on the Commonwealth to ensure the protection, conservation, presentation and transmission of the Great Barrier Reef World Heritage Area to future generations. This problem is compounded by the varying amounts of protection afforded to different habitats and in different regions.

3.5.4 The Timing of the Inscription

The Wet Tropics of North Queensland was inscribed on the World Heritage List in 1988, an action which provided the rationale for the subsequent establishment of the Wet Tropics Management Authority and the ban on logging in the area (Valentine 1990). The sequence of events in the Great Barrier Reef Region was reversed: the legislative basis for management preceded the World Heritage Listing. This difference has had some advantages; the community is less polarised about the listing than is the case for the Wet Tropics. It has also had a profound effect on subsequent management of the region as a World Heritage Area, especially by the relevant local, State and Commonwealth governments.

The Great Barrier Reef was inscribed on the World Heritage List in 1981, six years after the proclamation of the *Great Barrier Reef Marine Park Act 1975*, which established the GBRMPA and forms the basis for the Commonwealth's role in the protection and management of the Great Barrier Reef.

The lack of specific legal protection for the World Heritage value of the Great Barrier Reef World Heritage Area had a major influence on the perceptions of how the area should be managed. For example, the Whitehouse Review does not mention the impact of the Magnetic Island Marina Development on the integrity of the World Heritage value of the Island as an issue in the controversy surrounding the development (Whitehouse 1992). Indeed concerns about the impact of the Magnetic Quays development on the World Heritage value of Magnetic Island were not identified until 1993 when a member of 'Island Voice', Mr H. McColl, raised the issue in the Townsville Bulletin of July 17.

Concerns about the capacity of the GBRMPA and the Queensland Government to comply with the requirements of the World Heritage Convention have been reinforced by:

- the direct intervention of the Commonwealth Government in the proposed development at Oyster Point in November 1994 under the *World Heritage Properties Conservation Act 1983* (Cwlth) (Haigh 1994, 1995);
- submissions to IUCN by Morris (1995a, 1995b, 1995c).

Interestingly, these concerns were foreshadowed by IUCN (1981) in the Technical Review of the World Heritage Nomination (see 3.3).

3.6 Subsequent Developments in the Management of the Great Barrier Reef as a World Heritage Area

3.6.1 Emerging Recognition of Australia's Obligations to Protect the Great Barrier Reef World Heritage Area

In 1995, the Great Barrier Reef Marine Park Act was amended to reflect the World Heritage Listing of the Great Barrier Reef. This amendment, which was proposed by the Australian Democrat Senator John Coulter, may have been prompted by recommendation 1.2 of Whitehouse (1993) in his review of the GBRMPA:

> The objects provisions contained in s. 5 of the Great Barrier Reef Marine Park Act should be amended to include specifically a reference to the concepts of ecologically sustainable development and ecosystem management, the protection of World Heritage values and the concept of multiple use of the Great Barrier Reef Marine Park (Whitehouse 1993:178).

The present amendment falls short of the Whitehouse recommendation. The objects provisions have not changed. Rather the amendment applies only to the preparation of management plans under Part VB of the Act:

> **39YA. (1)** The Authority in preparing management plans must have regard to:
>
> (a) the Protection of the world heritage values of the marine park[32]

The amendment does not affect existing zoning plan and permitting processes (Sparkes, S. 1996, pers. comm.). Legal issues with the amendment have been discussed with Sparkes (1996, pers. comm.). For example, it is unclear whether, in preparing a management plan, the Authority has to have regard to all threats on the World Heritage value of the area rather than limiting the analysis to the management issues which caused the plan to be prepared. For example, in preparing a management plan for a specific island and its surrounding reef, does the Authority have to address the generic issue of offshore run-off to that reef or merely address the problems of activities on the reef itself?

It is our view that limiting the consideration of the Great Barrier Reef Marine Park's World Heritage value to management plans is an inappropriate method of protecting the 'outstanding universal value' of the Great Barrier Reef. Management plans are generally local or regional scale planning instruments (although they may also be developed for species and ecological communities). As explained in Chapter 4 (4.5), the experts we consulted were generally not prepared to associate specific natural heritage attributes with particular sites in the Great Barrier Reef World Heritage Area.

In addition, there is still no legislative requirement to protect the World Heritage value of the 7% of the Great Barrier Reef World Heritage Area which is not included in the Great Barrier Reef Marine Park. Indeed, at a Great Barrier Reef Consultative Committee meeting in 1995, the Deputy Mayor of Townsville, Councillor Ann Bunnell, who is a member of the Committee, expressed surprise on learning that Magnetic Island was included in the Great Barrier Reef World Heritage Area[33]. This situation is not unusual. It is still relatively

[32] *Great Barrier Reef Marine Park Act 1975* (Cwlth)

[33] Councillor Bunnell has recently taken a leadership role raising the awareness of local governments in the Reef region to their responsibilities under the Convention.

uncommon for the agencies with the responsibility to manage World Heritage sites to have specifically incorporated their World Heritage status into their planning and decision making processes (see 5.1). However it should be noted the vast majority (85%) of the world's natural World Heritage sites are Category I or II Protected Areas[34](Valentine 1994).

The *Nature Conservation Act 1994* (Qld) provides a mechanism to achieve such protection in those parts of the Great Barrier Reef World Heritage Area which are not in the Great Barrier Reef Marine Park. This Act allows for declaration of World Heritage Management Areas which are to be managed to:

(a) meet international obligations in relation to the area;

(b) protect the area's internationally outstanding cultural and natural resources and its biological diversity; and

(c) transmit the area's world heritage values to future generations[35].

We consider that the wording of this legislation more appropriately reflects Australia's obligations under the World Heritage Convention than the 1995 amendment to the Great Barrier Reef Marine Park Act. However no such areas have thus far been declared; such declarations would reinforce World Heritage management.

3.6.2 The Great Barrier Reef World Heritage Area Strategic Plan

Despite the fact that the protection of the World Heritage value of the Great Barrier Reef World Heritage Area was not then specifically required by the Great Barrier Reef Marine Park Act, the GBRMPA initiated and coordinated the development of the *25 Year Strategic Plan for the Great Barrier Reef World Heritage Area* (GBRMPA 1994) from August 1991. This bold initiative appears to have been prompted by a formal recommendation in the Gilmour et al. (1991) report into the day-to-day management of the Great Barrier Reef Marine Park which was commissioned by the GBRMPA.

The Gilmour review recommended:

> 1. A Great Barrier Reef World Heritage Area Corporate Plan to be developed jointly by the GBRMPA and the Queensland Agency responsible for the day-to-day management of the Great Barrier Reef Marine Park, Queensland Marine Parks and Queensland Island National Parks.
>
> 1.1 ...
>
> 1.2 The Corporate Plan should reflect the aims and philosophies of the two governments and of the World Heritage Convention and incorporate the principle of ecologically sustainable development. It should also reflect the corporate plans of the major agencies involved (Gilmour et al. 1991).

The Great Barrier Reef World Heritage Area Strategic Plan was a much more ambitious and inclusive endeavour than envisaged by Gilmour et al. (1991). Over 60 organisations were represented in the planning process including *user* groups such as tourist operators, commercial and recreational fishing groups, and scientists; *interest* groups including conservationists and canegrowers; Aboriginal and Torres Strait Islander groups and Commonwealth, State and local government agencies (GBRMPA 1994).

The final plan was seen by the penultimate and current Director-Generals of IUCN as:

> ...a series of guidelines for the management of the Area. We believe that its implementation will guarantee that this unique region is passed on to the future as it should be... (GBRMPA 1994:iii).

The Plan provides a framework for the conservation of the Great Barrier Reef World Heritage Area which is best summed up in its '25 Year Vision' for the region (GBRMPA 1994):

> **A healthy environment:** an Area which maintains its diversity of species and habitats, and its ecological integrity and resilience, parts of which are in pristine condition.
>
> **Sustainable multiple use:** non-destructive activities which can continue forever, that is, in such a way that maintains the widest range of opportunities for appropriate sustainable use, and does not adversely affect the ecological integrity of its natural systems.

[34] The IUCN's Commission on National Parks and Protected Area has developed a system of management categories to classify protected areas (IUCN 1994b). Category I are Scientific Reserve/Strict Nature Reserve with the main purpose of management is strict protection; Category II Protected Area are National Parks where the main purpose of management is ecosystem conservation and recreation.

[35] *Nature Conservation Act 1994* (Qld), s. 25

> **Maintenance and enhancement of values:** the continuation and enhancement of diverse aesthetic, ecological, economic, cultural and social values, providing for the aspirations of residents, users, Aboriginals and Torres Strait Islanders and the global community.
>
> **Integrated management:** management of activities which takes into account the ecological relationship between the Area and other adjacent areas, particularly the mainland.
>
> **Knowledge-based but cautious decision making in the absence of information:** decisions based on a commitment to research, monitoring and review using data and experience from all sources and erring on the side of caution in the absence of information.
>
> **An informed, involved, committed community** (GBRMPA 1994:13).

The Plan outlines objectives and strategies to achieve this vision.

The GBRMPA agreed to coordinate and monitor the implementation of the Plan on behalf of all stakeholders (GBRMPA 1994). The Plan promises that:

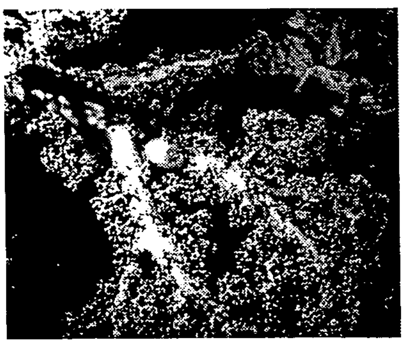
> Between July 1994 and December 1994, discussions and meetings with relevant organisations will be arranged regarding the incorporation of the Strategic Plan into their activities. The initial review of this implementation schedule will occur in December 1994 (GBRMPA 1994:8).

This review appears not to have been conducted as yet. We understand that the way in which the Plan is to be implemented is being reconsidered. The delay is unfortunate given the cost of the Plan to GBRMPA, the widespread community support for the plan and the considerable amount of stakeholder time donated to its development. It is estimated that the development of the Plan cost the community and GBRMPA collectively about $1 million (Craik, W. 1996, pers. comm.).

Recommendation 2:

We recommend that, to enable Australia to meet its international obligations under the World Heritage Convention, the Great Barrier Reef Marine Park Authority take a more pro-active approach to its agreed role as lead agency for the implementation of the 25 Year Strategic Plan for the Great Barrier Reef World Heritage Area, *particularly the objectives and strategies relating to education, conservation, legislation and monitoring.*

Chapter Four: Natural Heritage Attributes that Justify the Great Barrier Reef as a World Heritage Area



4.1 Approach

As noted in the introduction, we have consulted widely with experts in order to gain the requisite information and evaluations in order to expand and clarify the justification for World Heritage listing of the Great Barrier Reef Region. Experts were particularly relied upon to gain information about specific natural heritage attributes within the Great Barrier Reef World Heritage Area. For this component of the consultancy 38 experts were consulted, and their contributions appear in Appendix 4.

The methodology adopted for the identification and description of the outstanding universal value of the Great Barrier Reef World Heritage Area consisted of four steps:

1. Identification of natural heritage attributes and appropriate experts.
2. Interview with the identified expert.
3. Drafting of attribute summary and subsequent expert review.
4. Linking of attributes to the World Heritage criteria and conditions of integrity.

Step 1. Identification of natural heritage attributes and appropriate experts:

An analysis of the 1981 nomination document for the Great Barrier Reef World Heritage Area was carried out to locate the natural heritage attributes contained within that document. This list is contained in Appendix 3. Using this list as the basis, additional natural heritage attributes were identified at the workshop we convened with representatives from the GBRMPA, the WHU and the QDoE (see 1.3). Further natural heritage attributes were identified through the circulation of the original list to the scientific, technical and research staff of the GBRMPA. Coincident with the identification of natural heritage attributes, individuals considered to be experts for each attribute were identified. The attribute and expert lists were further refined, amalgamating overlapping attributes and identifying one expert per attribute. It is recognised that the final attribute list is not exhaustive, but was compiled within the constraints of resources, time and available expertise. Attempts were made to locate north Queensland or Brisbane based experts.

Step 2. Interview with identified expert:

Experts were initially contacted by phone and invited to be involved with the project. The aims of the consultancy were detailed, and its methodology outlined. The majority of experts were willing participants in the project and interviews were arranged. Background information further detailing what was expected from experts was forwarded to them, along with an extract from the Operational Guidelines covering the natural heritage criteria and their associated conditions of integrity. In most cases, expert involvement consisted of about 2 hours input; 1 hour interview, and a further hour to give feedback on a summary document. Experts were paid a small honorarium for their time. During the interviews information was sought on the following topics:

1. Description of the Attribute:
   - Taxa: estimates of abundance and diversity;
     estimate of endemism;
     identification of rare, restricted, threatened or relict taxa.
   - Habitat: location;
     estimate of extent;
     importance to species diversity.
2. Description of important trends:
   cross-shelf;
   latitudinal.
3. Importance of attribute to ecological processes
4. Identification of locations that are important examples for the attributes.
5. Importance of the Great Barrier Reef World Heritage Area to the scientific understanding of the attribute.
6. Any other unique or important aspects about the attribute.
7. The location of literature to support the comments made.
8. The identification of significant information gaps.

Step 3. Drafting of attribute summary and subsequent expert review:

Following the interview, a draft summary of information was written based upon the information obtained and the literature identified. Each summary was reviewed by the relevant expert and additional comments sought. In total 29 summary papers were written covering the topics listed in Table 4.1. The summary papers are contained in Appendix 4.

Table 4.1 Natural Heritage Attribute Summary Papers

• Aesthetics	• *Halimeda* Banks
• Algae	• Hard Corals
• Ascidians	• Mangroves
• Birds	• Marine Mammals
• Bryozoans	• Marine Turtles
• Butterflies	• Molluscs
• Crocodiles & Terrestrial Reptiles	• Octocorals
• Crustaceans	• Phytoplankton
• Echinoderms	• Polychaete Worms
• Fishes	• Proserpine Rock Wallaby
• Flatworms	• Seagrasses
• Fringing Reefs	• Sea Snakes
• Geological & Geomorphological Aspects	• Soft Bottom Habitats
• Geological Aspects of Continental Islands	• Sponges
	• Terrestrial Flora

In several cases the experts preferred to write their own summary document. Where this occurred the main conclusions were presented in a preface to the expert's document. These are also included in Appendix 4.

Step 4 Linking of attribute to the world heritage criteria:

Through a process of reviewing the attribute summaries in conjunction with the World Heritage criteria the links between the two were highlighted. The extensive experience of P.H.C. Lucas and P.S. Valentine in the technical evaluation of other World Heritage nominations assisted considerably in identifying the links.

4.2 Phenomena of World Class Importance

It should be noted that the approach taken to the consultancy and the results obtained are qualitative in nature. The varying levels of focus in considering the attributes (e.g. single species, phyla, habitats) and the lack of information for many attributes, defy any sensical reduction of the information to a quantitative format. Consequently the findings we present are done so in a discursive format. Initially we discuss the main themes arising from the expert consultations. This is followed by a summary of the attributes according to the natural heritage criteria. However, it should be stressed that in order to obtain a full understanding of the outstanding universal value of the Great Barrier Reef World Heritage Area, the attribute summaries within Appendix 4 should be consulted.

None of the experts interviewed questioned the Great Barrier Reef's inclusion upon the World Heritage List. The region is clearly of outstanding universal value, and its listing is justified. Additionally, in the course of reviewing the expert input, it became apparent that there were some phenomena that when taken individually are of world importance.

A number of these have their international importance recognised under other international or national instruments. In particular, the Great Barrier Reef World Heritage Area contains habitat and resources for a number of species that are threatened with extinction as recognised by the IUCN or ANZECC. These include six species of marine turtles, the dugong, the Proserpine rock wallaby, a number of cetaceans, and a suite of terrestrial flora. Additionally the international value of the region to shorebirds is indicated by the listing of Shoalwater Bay and Bowling Green Bay under the Ramsar Convention. Other sites within and adjacent to the Great Barrier Reef World Heritage Area have also been assessed as being internationally important for the conservation of shorebirds.

Other phenomena, while not recognised via some formal framework, are nonetheless of world class value. These include:

- a number of world significant dune areas (Geological & Geomorphological Aspects);

- the most extensive actively accumulating *Halimeda* beds in the world (*Halimeda* Banks);
- coral communities which are among the oldest living marine animals in the world (Fringing Reefs);
- some of the best examples of 'blue holes' in the world (Geological & Geomorphological Aspects);
- the largest reef system the world has ever known (Geological & Geomorphological Aspects);
- massive aggregations of the butterfly *Tirumala hamata* (Butterflies);
- habitat for the world's largest fish, the whale-shark (Fishes);
- the single largest coral reef in the world (Hard Corals);
- one of the most diverse areas in the world for mangrove habitat (Mangroves);
- the largest breeding green turtle population in the world (Marine Turtles);
- one of the most diverse cuttle bone faunas in the world (Molluscs);
- *Pisonia grandis* flora of world importance (Terrestrial Flora).

While a number of individual attributes were identified through interviews with experts, two factors were dominant throughout much of the expert input. Namely, the importance of the scale of the Great Barrier Reef World Heritage Area, and the ability for the region to be managed effectively for conservation. These two factors were apparent across the range of biological, physical and aesthetic expertise sought. It is acknowledged that neither of these themes can be justifications in their own right for World Heritage listing. However they are fundamental and pivotal in enabling the expression of those aspects of the region that do justify its inscription upon the World Heritage List.

4.2.1 Scale

As has been remarked upon in Section 3.5.3 the Great Barrier Reef World Heritage Area is the largest area inscribed upon the World Heritage List. It is also the single largest system of coral reefs in the world, and the largest that has ever been in existence. The size of the Great Barrier Reef World Heritage Area was seen by many experts as a fundamental and necessary antecedent to some other valued aspect by giving rise to particular conditions that permit the expression of phenomena or process of importance.

In particular, the expression of biodiversity within the Great Barrier Reef World Heritage Area is largely due to the Area covering an extensive latitudinal range and covering the entire shelf from low water to beyond the outer slope. Thus, the Great Barrier Reef World Heritage Area incorporates a large number of different habitats and environmental regimes at a range of spatial scales. The summary papers in Appendix 4 indicate that the size underlies the diversity of hard corals and the high diversity of fringing reefs. Similarly, the size of the Great Barrier Reef World Heritage Area provides a huge diversity of fish habitats and a significant refuge for marine mammal biodiversity. The reports show that six of the world's seven species of marine turtles are found in diverse locations, that crustaceans occur in an extensive range of habitats, and the Great Barrier Reef provides an extensive range of habitats and environmental regimes for flatworms, echinoderms, molluscs, crustaceans and algae. Importantly, the Great Barrier Reef acts as a bridge between tropical and temperate waters for ascidians, providing candidates for speciation in temperate waters thus contributing to ascidian biodiversity.

Most species exhibit significant cross-shelf and latitudinal trends in distribution and abundance. Such trends could not be exhibited in a World Heritage Area which focused solely upon reefal environments. Furthermore, the expression of such trends makes the Great Barrier Reef World Heritage Area a unique environment in which to further understand the range of biological, physical and aesthetic attributes. Consultation with experts identified a range of research in which the Great Barrier Reef World Heritage Area provides a unique field site, for example the evolution of mangroves, theories of island biogeography and the conditions necessary for the development of coral reefs.

4.2.2 Effective Conservation Management

The second main theme that was recurrent within the expert consultations was the importance given to the potential for effective conservation management. This theme was articulated in two dominant ways. In the first, experts made comments upon the value of the Great Barrier Reef World Heritage Area due to the low human pressure upon it in comparison with other similar coral reef systems. The Great Barrier Reef World Heritage Area is seen as vitally important among reefs in a world where most tropical regions are under more substantial development and use pressures and are in countries with fewer resources to manage sites effectively than Australia has.

In this respect, the various experts comment that the Great Barrier Reef has higher potential for effective conservation than other reefs in the Indo-West Pacific; that it is close to being the most pristine reef environment in the world with low fishing effort compared to many other reefs; and that it is one area in the Indo-West Pacific where resources for conservation management are available.

The theme was also expressed in terms of the value of the Great Barrier Reef World Heritage Area to the continued survival of specific species, rather than the more general conceptualisation as above. Accordingly, the Great Barrier Reef is seen as critical for the survival of the dugong, Irawaddy dolphin, the Indo-West Pacific dolphin and four species of marine turtles – loggerhead, green, hawksbill and flatback – and if these species are to survive, it will be in Australia and, particularly, in the Great Barrier Reef.

4.2.3 The World Heritage Value of the Great Barrier Reef World Heritage Area

While specific attributes of 'outstanding universal value', such as the world's largest coral reef system or the world's largest aggregation of breeding green turtles, can be identified, consultations with experts in the range of physical, biological and aesthetic attributes have led us to conclude that the 'outstanding universal value' of the World Heritage Area is dependent and predicated upon the two factors discussed, namely the scale of the Great Barrier Reef World Heritage Area; and the potential for effective conservation management. As noted above they do not, on their own merit, justify the inclusion of the region upon the World Heritage List. Rather they are fundamental pre-requisites for specific attributes to be expressed. Discussion of more specific attributes as they relate to the criteria is detailed below (4.5).

The expert consultations also highlighted two additional factors in relation to the Great Barrier Reef World Heritage Area. Namely the paucity of information relating to some attributes, and the reluctance of experts to identify specific locations of importance for a range of attributes.

4.3 Information Gaps

In the Technical Review undertaken in 1981 for the World Heritage Committee when the Great Barrier Reef was inscribed on the World Heritage List, IUCN noted that *The Bibliography of the Great Barrier Reef Province* (Frankel 1978) listed 4444 publications dealing with the site and its environs. IUCN said that this demonstrated 'the great interest in the area and the large amount of scientific work which has been done' and remarked that 'the area is clearly unmatched in the world for coral reef research' (IUCN 1981). This research has been generally strengthened since then. By February 1995 the REEF data base of publications relating to the Great Barrier Reef Region contained 11 500 records.

In spite of that and obviously because of the scale of the site, much more remains to be done to fill gaps in information. This is evident from the range of comments on information brought out in the expert summaries which generally show more knowledge available for the southern part of the region, and with obvious emphasis on locations close to the four main research stations: Heron, One Tree, Orpheus, and Lizard Islands.

A summary of comments shows that, in relation to corals, new species and new records are likely to be found in the northern region. With fringing reefs, significant discoveries are still being made, little is known about species diversity in the Bowen area while the northern area around Princess Charlotte Bay has not been documented and there are likely to be exceptional sites there. With seagrasses, the species list is likely to increase, much of the area has not been surveyed for deepwater meadows and little is known about the importance of seagrass habitat for non-commercial species other than for green turtle and dugong. No quantitative studies have been carried out on the fauna of *Halimeda* meadows, the diversity of fish in different habitats is not quantified and it is expected that species lists of fish will increase for the northern region. Most species of cetaceans are classified by IUCN as insufficiently known, reflecting the paucity of knowledge of the status of the order generally. In the Great Barrier Reef, the impacts of habitat loss, traditional hunting and incidental mortality in commercial gill-nets and in shark nets for bather protection on marine mammals and reptiles are unquantified and their relative importance in different parts of the World Heritage Area is not known. In the field of sponges, very little is known about the Australian fauna while, for bryozoans in the Great Barrier Reef, the taxonomy is poorly documented and insufficient work has been done to document any regional variation in reef associated bryozoans. Many crustacean groups are poorly studied with the majority unknown. There are large gaps in knowledge also about algae in the World Heritage Area, little information on algal distributions and the taxonomy of macroalgae is poorly resolved. There have been very limited studies of island butterflies and there is limited current research.

Recommendation 3:

That, in view of the considerable gaps in our knowledge of the Great Barrier Reef World Heritage Area, all agencies adopt the precautionary principle as the basis for their management of the Area.

Natural heritage attributes contributing to criterion (iii), natural beauty and aesthetics, were the poorest documented and least known set of attributes. There is a lack of consistent methodologies to document and understand the aesthetic qualities. Some work has been done in the Great Barrier Reef World Heritage Area, in particular the visual amenity of the Queensland coastline, and at a local scale, in the Whitsunday Islands. It is important, however, that the aesthetic qualities do not become reduced solely to visual amenity. Aesthetic values are more expansive and contain an array of meanings and attachments that people associate with particular places. It is fundamental that the GBRMPA and other managers of the Great Barrier Reef World Heritage Area investigate methodologies and processes for the documentation of aesthetic values and their incorporation into Great Barrier Reef World Heritage Area management and planning.

Recommendation 4:

That the Great Barrier Reef Marine Park Authority instigate a new research program 'Aesthetics and Natural Beauty Research Program' in order to document and better understand aesthetic values of the natural heritage attributes of the area so that they can be incorporated into the management and planning of the Great Barrier Reef World Heritage Area.

4.4 Location of Values

The expert input does, in a number of cases, identify specific locations which are of particular importance for particular species and habitats. Examples range from the fact that Bowling Green Bay and Shoalwater Bay are Ramsar Sites to identification of an island habitat of the endangered Proserpine rock wallaby. However, the key significance of the scale of the Great Barrier Reef World Heritage Area in establishing its 'outstanding universal value' and the substantial gaps in knowledge which still remain, underline the undesirability of placing an undue emphasis on site specific values.

Hinchinbrook and Curtis Islands are identified as having the most diverse terrestrial flora in the World Heritage Area. Flora of considerable scientific note also occurs within the Great Barrier Reef World Heritage Area, for example the presence of *Stackhousia tryonii*, a nickel hyper-accumulator, on the serpentine soils of South Percy Island. However, a significant value of the Great Barrier Reef World Heritage Area in relation to terrestrial flora lies in its expression of latitudinal trends in the composition of plant communities with the five floristic regions identified for continental islands and the two for coral cays.

Similarly, while Raine Island has the largest green turtle breeding aggregation in the world, green and hawksbill turtles are found throughout the Great Barrier Reef World Heritage Area and loggerhead and flatback turtles in the south. Dugongs occur all along the coast of the Great Barrier Reef World Heritage Area with 80% north of Cooktown of which more than a third occur in the Princess Charlotte Bay region and another quarter between Lookout Point and Cape Melville.

There is obviously value in identifying key sites for particular species but this must be balanced by recognition that it is the diversity of the whole of the site that makes the Great Barrier Reef of outstanding value and that it is important not to lose sight of this in focusing on specific sites. The connectivity within the Great Barrier Reef and implications which arise from this (Bode et al. 1992), further highlight the need for a property based perspective.

4.5 Justification for Listing the Great Barrier Reef According to Specific Criteria

As previously noted (Section 2.4.2) the current criteria for natural sites differ to some extent from those current at the time of nomination of the Great Barrier Reef. However, the changes made between 1981 and the present do not dramatically change the situation but rather have clarified it and removed some overlap.

What follows is a suggested text that could be used if the Great Barrier Reef were being nominated in the light of today's knowledge. It is assumed that the normal practice would be followed of setting out the justification in broad terms, supported by the greater detail which appears in Appendix 4 of this report. The higher degree of detail in the Appendix permits the extraction of more comprehensive data relating to particular components of the Site, always with the rider that it is the scale and totality of the Great Barrier Reef World Heritage Area as a whole which form the major basis for its 'outstanding universal value'.

The approach adopted below is to define each criterion in turn and describe more explicitly how the attributes of the Great Barrier Reef World Heritage Area meet each criterion. For each, the 1996 criterion is preceded by that at the time of Great Barrier Reef nomination. It will be noted that no references are shown, the text is based on the expert summaries of attributes which are contained in Appendix 4. Furthermore it was found to be unnecessary to make any adjustments to the justification due to the changes of criteria.

4.5.1 Natural Attributes Which Match Criterion (i)

Criterion (i) 1981 *'...be outstanding examples representing major changes of earth's history. This category would include sites which represent the major 'era' of geological history such as 'the age of reptiles' where the development of the planet's natural diversity can be demonstrated and such changes as the 'ice age' where early man and his environment underwent major changes...'*

Criterion (i) 1996 *'...be outstanding examples representing major changes of earth's history, including the record of life, significant ongoing geological processes in the development of landforms, or significant geomorphic or physiographic features...'*

The Great Barrier Reef is the largest reef system the world has known with 2904 coral reefs covering 20 055 km^2. Within this reef system are more than 300 coral islands and 600 continental islands, the latter comprised of mostly massive granites or silicic volcanics. The processes of geological evolution in this system are uniquely represented, linking islands, cays, reefs and changing sea levels, together with sand barriers, deltaic and associated dune systems. It is this interplay of all the coastal and marine geomorphological elements which give outstanding value to the Great Barrier Reef. The extraordinary size of the Great Barrier Reef and its morphological diversity capture a comprehensive record of past and ongoing processes in the development of coral reef and associated geomorphological systems. Major changes in sea level are recorded in the reef's structure and a total history of the reef's evolution is available. There are examples within the Great Barrier Reef of nearly all stages of reef development. Novel techniques have now yielded information about environmental conditions and processes extending back over many hundreds of years. There are also many less common formations including serpentine rocks of South Percy Island, intact and active dune systems, undisturbed tidal sediments providing an excellent record of Holocene sea level and vegetation changes and the exceptional examples of 'blue holes'. Great Barrier Reef *Halimeda* banks have been actively accumulating for up to 10 000 years. The extraordinary elevation range extends from sea level (sea-bed) to 1142 metres (Mt Bowen) and in addition to this elevation range for the terrestrial components, the cross-shelf extent provides the fullest possible representation of marine environmental processes within the reef system.

4.5.2 Natural Attributes Which Match Criterion (ii)

Criterion (ii) 1981 *'...be outstanding examples representing significant ongoing geological processes, biological evolution and man's interaction with his natural environment. As distinct from the periods of the earth's development, this focuses upon ongoing processes in the development of communities of plants and animals, landforms and marine and fresh water bodies. This category would include, for example (a) as geological processes, glaciation and volcanism (b) as biological evolution, examples of biomes such as tropical rainforests, deserts and tundra, (c) as interaction between man and his natural environment, terraced agricultural landscapes.'*

Criterion (ii) 1996 *'...be outstanding examples representing significant ongoing ecological and biological processes in the evolution and development of terrestrial, freshwater, coastal and marine ecosystems and communities of plant and animals...'*

The Great Barrier Reef is the largest reef system the world has known with 2904 coral reefs covering 20 055 km^2. Within this there is an extensive diversity of reef morphologies including deltaic, detached and dissected reefs. The high heterogeneity at a range of spatial scales gives rise to high habitat diversity with 359 species of hard corals recorded. Fringing reefs cover some 667 km^2 with most of this area adjacent to continental islands. The reefs contain some of the largest and oldest coral colonies with the genotype of some colonies suspected of being present on the reef for several thousand years. Inshore coral communities in southern regions may offer new insights into coral reef formation. The reef includes the most extensive actively accumulating *Halimeda* beds in the world.

Coastal seagrasses within the Great Barrier Reef occupy some 3000 km^2 and at least 2000 km^2 of deepwater seagrasses have recently been found. These seagrass beds provide outstanding examples of the ecological interaction between plants and animals including communities with numerous fish species, prawns and other animals including green turtles and dugongs.

Heterogeneity of the reef at various spatial scales provides an extensive range of habitats for the estimated 1500 species of fish found within the Great Barrier Reef. The Lizard Island region and Ribbon Reef shelf-break contains the major spawning ground in the world for the black marlin. Life histories of some species of fish demonstrate the connectivity of Great Barrier Reef habitats.

The Great Barrier Reef contains representatives from all marine phyla, for example algae, sponges, ascidians, echinoderms, fishes, polychaete worms, flatworms, corals, molluscs, crustaceans, marine mammals and bryozoans. It is clear that the combination of extensive latitudinal range and complete cross-shelf transect provides an outstanding example of ongoing ecological and evolutionary processes. Although much of the marine flora and fauna are shared within the Indo-Pacific Region, the state of preservation and prospects of survival, together with the scale, make the Great Barrier Reef unique.

There are some 2069 km^2 of mangroves in or directly adjacent to the Great Barrier Reef World Heritage Area and the presence of important trends at a range of spatial scales makes the Great Barrier Reef a prime location for research into mangrove ecology and evolution. Furthermore mangrove habitats provide crucial nursery habitat for many fishes and crustaceans. The extraordinary richness of terrestrial flora within the Great Barrier Reef World Heritage Area and its distribution amongst a vast number of variable islands provides an outstanding example of the processes of dispersal, colonisation and establishment of plant communities within the context of island biogeography. So far, 2195 species of plants, some 25% of the total flora for Queensland, have been recorded from the continental islands.

Many species occur at their latitudinal limits within the Great Barrier Reef and there are distinct latitudinal variations which display examples of evolutionary biogeography.

Terrestrial fauna also demonstrate ongoing ecological and biological processes including globally important breeding grounds for sea birds as well as a rich but sparsely known fauna on continental islands. Important feeding grounds for international migratory species occur within or adjacent to the Great Barrier Reef World Heritage Area including extensive communities of shorebirds and breeding areas for the Torresian Imperial Pigeon. The role of this pigeon, and other birds, is crucial in the dispersal and establishment of much of the coral cay and continental island floras. The insect fauna is poorly known but despite limited studies 30% of the Australian butterfly fauna has been recorded within the Great Barrier Reef (118 species) including some exceptional examples of overwintering aggregations by populations of *Tirumala hamata*. Island subpopulations appear to be showing evidence of recent speciation and there have been two endemic subspecies described.

4.5.3 Natural Attributes Which Match Criterion (iii)

Criterion (iii) 1981 *'...contain unique, rare or superlative natural phenomena, formations or features or areas of exceptional natural beauty, such as superlative examples of the most important ecosystems to man, natural features, (for instance, rivers, mountains, waterfalls), spectacles presented by great concentrations of animals, sweeping vistas covered by natural vegetation and exceptional combinations of natural and cultural elements.'*

Criterion (iii) 1996 *'...contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance...'*

The Great Barrier Reef provides some of the most spectacular scenery on earth and is of exceptional natural beauty. The vast extent of reef and island systems produces an unparalleled aerial vista. Individual islands range from towering forested continental islands of immense size and exceptional beauty (such as Hinchinbrook Island rising steeply from sandy beaches to 1000 metre peaks), to small coral cays clad in rainforest and peripatetic (mobile) unvegetated sand cays. Fringing reefs have very high aesthetic values also. Within the marine fauna there is a huge diversity in fishes' size, shape and colour which provides very special experiences for visitors to the underwater environments. The great diversity of marine life includes numerous conspicuous and colourful animals which collectively produce an extraordinary spectacle. There are many species and groups of organisms involved, including the polyclad turbellarians, the echinoderms, in particular the feather stars, fishes, hard corals, octocorals and bryozoans, particularly the lace corals. Within the Great Barrier Reef the presence of humpback whales and other marine mammals provides an additional superlative natural phenomenon which is highly valued by people. Concentrations of large fish such as the potato cod near Lizard Island and the megafauna at sites like the Yongala wreck, have demonstrated their singular value through the attraction of numerous international tourists as divers and snorkellers.

Significant aesthetic value is also derived from large breeding colonies of birds and great concentrations of overwintering butterflies. The variety of environments represented by the latitudinal and cross-shelf dimensions of the Great Barrier Reef ensures extraordinary variety in aesthetic appeal. There are many examples of rich variety in landscapes and seascapes within a small area, such as the Whitsunday Islands, which includes sweeping beaches and rugged mountains with dense and diverse vegetation and adjacent pristine fringing reefs. Extensive mangrove communities provide another example of exceptional natural beauty including the outstanding mangrove channels of Hinchinbrook Island. The vast and relatively unpopulated extent of the northern section of the Great Barrier Reef may be seen as the marine equivalent of the Serengeti Plains. Within this region there are also occurrences of spectacular wildlife including immense whale-sharks.

Aesthetic importance is not simply measured by reference to scenic beauty, or even to the varied notions of 'naturalness', but also, quite critically includes the range of values which the community places upon the Great Barrier Reef World Heritage Area. The Great Barrier Reef has become an Australian icon, being as quintessentially Australian as Uluru. Additionally aesthetic importance will include the important *in absentia* or existence values associated with a World Heritage Area. It is most likely that these values will correlate with community perception of the site being 'free from disturbance'; a condition not necessarily correlating with 'ecological integrity'. Unfortunately little applied research is available to guide managers on this topic.

4.5.4 Natural Attributes Which Match Criterion (iv)

Criterion (iv) 1981 *'...be habitats where populations of rare and endangered plants and animals still survive. This category would include those ecosystems in which concentrations of plants and animals of universal interest and significance are found.'*

Criterion (iv) 1996 *'...contain the most important and significant natural habitats for* in situ *conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation.'*

The Great Barrier Reef contains many outstanding examples of important and significant natural habitats for *in situ* conservation of biological diversity. Examples include fringing reefs which exhibit high species diversity and often high coral cover; fish species numbering around 1500 species in more than 130 families; 359 species of hard coral; 1500 species of sponges; 800 species of echinoderms; at least 5000 species of molluscs; at least 330 species of ascidian; between 300 and 500 species of bryozoans; an estimated 80 genera of octocorals; and high diversity in flatworms, crustaceans, polychaetes and algae. It is largely the extraordinary diversity of habitats, the product of latitudinal extent and cross-shelf completeness, which provides the Great Barrier Reef with the capacity to conserve such richness. The benthic flora is not constant across the soft-bottom areas of the Great Barrier Reef World Heritage Area, rather distinct zonation occurs, with a considerable increase in diversity occurring in mid-shelf regions due to the presence of 'natural isolates'.

The Great Barrier Reef is also a significant refuge for cetacean biodiversity with the Irawaddy River dolphin and the Indo-West Pacific humpbacked dolphin unlikely to survive outside Australia. Apart from regionally important habitat for the dwarf minke whale, the Great Barrier Reef provides a breeding ground for the humpback whale and Longman's beaked whale, the rarest whale in the world, has also been recorded. Extensive seagrass beds provide important food resources for threatened dugongs, supporting 15% of the dugongs recorded within Australian waters. This species is classified as vulnerable with poor long-term survival prospects outside Australia. The green turtle is also dependent on the seagrass beds. Six of the world's seven species of turtle are found in the Great Barrier Reef which contains globally important nesting and feeding grounds for the loggerhead, green, hawksbill and flatback turtles including one of the last significant breeding populations of the hawksbill turtle in the world, the largest green turtle breeding population in the world and 70% of the South Pacific population of the loggerhead turtle.

Mangrove communities are amongst the richest in the world with 37 species recorded being 54% of the world diversity. Given this richness and combined with their protected status, the Great Barrier Reef mangroves are of exceptional value. The island vegetation communities include 79 rare or threatened species of plants and the least threatened remaining habitat of the endangered Proserpine rock wallaby. Amongst the extensive breeding colonies of seabirds the Great Barrier Reef also contains populations of threatened species of birds including the roseate tern, the little tern and the vulnerable beach thick-knee. The internationally important Torresian imperial pigeon breeds in extensive colonies on Great Barrier Reef islands during its annual migration from Papua New Guinea.

Although the extensive biodiversity of the Great Barrier Reef marine and terrestrial flora and fauna contains few endemics, for many of the species there are few other locations in the world which provide secure *in situ* conservation.

Chapter Five:
Future Management of the Great Barrier Reef as a World Heritage Area

5.1 Approaches to World Heritage Management Elsewhere

5.1.1 Introduction

A range of inquiries made around the world in the time available suggests that, although some World Heritage site management agencies have specifically built World Heritage status into their planning and decision making procedures, these remain the exception rather than the rule. In spite of this, there are some significant cases where World Heritage status has been a vital factor in countering threats to the integrity of World Heritage sites.

A point which appears to be universally accepted is the recognition of the vital importance of public education, understanding and support in relation to the significance of World Heritage status.

The situation has been researched through records of recent meetings of the World Heritage Bureau and Committee, verbal and written communication with members of the World Heritage Centre and the advisory bodies identified in the Convention – ICOMOS, ICCROM and IUCN, from the Organisation of World Heritage Cities and from members of management agencies of some World Heritage sites, both natural and cultural.

A general inquiry was made of the World Conservation Monitoring Centre (WCMC) at Cambridge, UK which maintains a data base for both natural and cultural World Heritage sites. The data base does not, however, at this time extend to detailed information on management and planning mechanisms which may specifically cite the World Heritage Convention and its implications for the site.

The broad approach to management of World Heritage natural sites is similar to that for protected natural areas generally. Zoning, the ecosystem approach, management planning and buffers are all used to address management issues. A useful checklist for evaluating management effectiveness is published in *Managing Protected Areas in the Tropics* (MacKinnon et al. 1986) based on workshops at the World Congress on National Parks held in Bali, Indonesia in October 1982 and organised by the IUCN Commission on National Parks and Protected Areas. The checklist appears at pages 241–244 of the book.

The Operational Guidelines for the implementation of the Convention do not call for specific references to World Heritage status in management mechanisms for sites but only require that management systems are in place which will enable management to meet 'the test of authenticity' in the case of cultural properties and the 'conditions of integrity' in relation to natural sites. These latter require that a site should have both structural integrity (i.e. sites should contain all the necessary components to ensure that natural values are sustained) and functional integrity (i.e. protection from any damaging human impact on the values of the property.)

The fact that the Operational Guidelines devote section II to 'Monitoring the State of Conservation of Properties inscribed on the World Heritage List' underlines the importance the World Heritage Committee has placed on the importance of the management of listed sites, even though the issue of monitoring independently of monitoring undertaken by the relevant State Party is currently under question by some State Parties (see 2.5.3).

From the inquiries made, there does appear to be a modest but increasing trend to place greater significance on the importance of World Heritage status and, in some cases to refer more specifically to World Heritage status and its implications for management in relation to listed sites. It is believed that the current initiative by the GBRMPA may well provide a lead which others are likely to follow. Indeed, the result of inquiries made in quest of the information in this section of the report suggests that there is a good deal of international interest in this initiative.

Some examples illustrating the current situation follow.

5.1.2 Natural/Cultural Site Examples

5.1.2.1 Canada

Banff National Park forms part of the Canadian Rocky Mountain Parks World Heritage Site. For Banff National Park, the Park Planner says that, at this point, most references to the World

Heritage Site designation form part of the strategic role and vision statements rather than specific management guidelines or activities. The present situation is that:

> ...in essence, Parks Canada considers that in meeting its national park mandate, we will also meet our international commitments under the World Heritage Convention...

World Heritage has a significant profile in *Parks Canada's Guiding Principles and Operating Policies* (1994) which include a paragraph citing Canada's major role in devising the 1972 World Heritage Convention and emphasises its commitment to the principles of the Convention. In its 'Vision for Parks Canada' the document states that:

> Parks Canada's leadership in the management of protected heritage areas aims at promoting sound principles of stewardship and citizen awareness, and ecological and commemorative integrity.

It adds that this is done by, *inter alia,*

> ...adhering to international Conventions such as the World Heritage Convention and the Convention on Biological Diversity.

It goes on to say that:

> The future integrity of Canada's existing and proposed natural and cultural heritage areas will continue to be a priority for Parks Canada.

The statement continues by saying that:

> Parks Canada contributes to an international heritage agenda through its leadership role in, participation in, or support for, international conventions, programs, agencies and agreements

and cites, at the top of the list, 'UNESCO's World Heritage Convention'. The list of agencies includes the advisory bodies identified under the Convention - ICOMOS, ICCROM and IUCN. The concluding reference on World Heritage is the statement that:

> Canada can take pride in their internationally recognised contribution to heritage conservation – as exemplified by the many World Heritage sites found in Canada – and their emerging role in promoting responsible stewardship throughout the world.

The *Banff National Park Management Plan* (1988), under the heading of *The Protection and Management of Heritage Resources,* says simply that:

> The Four Mountain Parks Block has been designated as a World Heritage Site in recognition of its exceptional scenic beauty and internationally significant resources.

A draft Management Plan addendum dated 1995 says that:

> The 1988 park management plans were the result of on eight-year planning exercise involving nation-wide public consultation...

and adds that

> ...a review of the parks management plans was initiated in 1993 to ensure that the plans continue to provide sound guidance for the management of this important World Heritage Site.

The *Town of Banff Land Use By-Law* says that the by-law is to:

> ...provide for the orderly, economic, beneficial and environmentally sensitive development of the Town,

having regard for five objectives, one of which is 'to maintain the Town as part of a World Heritage Site.'

Commenting on this, an independent source notes the fact that direct responsibility for the Banff townsite has passed in recent years from the Superintendent of Banff National Park to an elected Mayor and Councillors and suggests that a main emphasis has been seeking to set limits to the growth of the town which had appeared to be well on the way to spreading right across the floor of the Bow Valley, a critical wildlife corridor which is currently the focus of *The Banff Bow Valley Study.*

It has been suggested that the more environmentally concerned see the potential for the Town of Banff to become a model of a sustainable town taking advantage of limits to its growth and capitalising on its consequent compactness. Among the desirable consequences envisaged would be to control vehicle parking and encourage a combination of public transport and walking to lessen vehicle congestion and pollution.

The *Banff Bow Valley Study* referred to was introduced by the relevant Canadian Minister in February 1995 saying that 'we urgently need a common vision for the Bow Valley' and that:

> ...many area residents believe that the current state of the Park serves as a strong argument for striking a balance between measures to ensure maintenance of ecological integrity and sustainable tourism.

The Study is due to be completed by mid-1996. It has been undertaken independently of Parks Canada, it has involved wide consultation and has produced a Core Vision for the Bow Valley and has identified 18 fundamental values and principles to guide all actions by government, business, communities and the public. One of the values identified is:

> The value of Banff National Park for all the people of the world as a World Heritage Site.

Apropos of that, the Park Planner consulted says 'I do see the importance and profile of our World Heritage Site status increasing in the future.'

5.1.2.2 The United States

In the United States, where much of the initiative for the Convention came in the person of people such as Russell Train, the Convention was written into Public Law in 1980 with the Secretary for the Interior being given the overall responsibility to direct, coordinate and execute all aspects of the Convention, including protecting World Heritage Sites. It is understood, however that this law has not yet been fully invoked and recent issues relating to threats to World Heritage sites in the United States have raised questions in some quarters as to why this is so. Questions are being asked, for example, as to why the Secretary for the Interior is not taking the lead role to ensure protection of World Heritage value in two World Heritage sites – the Taos Pueblo in New Mexico inscribed on 14 December 1992 and Yellowstone National Park, the world's first national park and one of the first natural sites to be inscribed on the list on 8 September 1978.

The Taos Pueblo issue relates to a proposal to extend Taos Airport which was discussed in monitoring reports to both the World Heritage Bureau and Committee in 1995. Here, the Environmental Impact Statement covering the proposed extensions is being prepared by the Federal Aviation Authority rather than under the Secretary for the Interior.

In the case of Yellowstone National Park, it was placed on the World Heritage in Danger List at the December 1995 Session of the World Heritage Committee because, in part, the site is seen as being endangered by a proposed Crown Butte mining development on US Forest Service land outside the World Heritage Site but located in a catchment of the Yellowstone River which flows through the World Heritage site. The National Environment Policy Act process for the Crown Butte mining proposal is being led by the US Forest Service in association with the State of Montana and is not being carried out under the aegis of the Secretary of the Interior in spite of his responsibility for World Heritage Sites under the 1980 Public Law.

Realisation of the potential of World Heritage Listing to counter pressures for potentially adverse developments has come slowly in the United States, World Heritage status seemingly having been regarded as little more than a badge of honour with potential to generate a greater level of international tourism. That is changing, particularly with the listing – at the request of the State Party itself – of an icon such as Yellowstone as World Heritage in Danger with the issue prompting concern at Presidential level and with strong representations from a consortium of prominent NGO's which identify strongly with the site's World Heritage status. The listing of Yellowstone as 'in Danger' followed a field mission led by the Chair of the World Heritage Committee in 1995 at the invitation of the State Party and has demonstrated the capacity of the World Heritage Convention to lift the issue of conservation of a World Heritage site above the hurly burly of local or national politics into the international arena.

This follows an earlier listing of the Everglades National Park (inscribed on 26 October 1979) as World Heritage in Danger. Here, the park's World Heritage status is considered to have been influential in a major effort to reverse the deterioration in the natural qualities of the site stemming from developments outside its boundaries affecting both the flow and quality of water on which the Everglades ecosystem depends. There has been ongoing litigation and negotiation involving the State of Florida and major industries leading to an ongoing programme designed to rehabilitate the Everglades involving US$1 billion over a 20-year period.

It is certainly accepted in the US that, even without intervention of the Secretary of the Interior under the 1980 Public Law, World Heritage Status was a major consideration in conserving the Redwood National Park, inscribed on the World Heritage List on 5 September 1980. Here, the California Department of Transportation proposed highway modifications which would have involved removal of 750 old growth redwood trees. Public and management agency concern at this proposal was reported to the World Heritage decision makers and led to a study of alternatives by a Value Engineering Team with the outcome that the highway proposals were so modified that no more than two redwoods will now be lost and possibly none.

5.1.2.3 France

A French case involving the highest levels in the State relates to a cultural site – Paris: Banks of the Seine – which was inscribed on the World Heritage List on 13 December 1991. The then President of France, Francois Mitterand was said to be a strong supporter of the construction of an international conference centre on the banks of the Seine, not far from the Eiffel Tower, in a location within the newly listed site. Jacques Chirac, then Mayor of Paris, was reportedly opposed to the proposed centre in that location and organised a well publicised dedication ceremony for the World Heritage Site with a plaque marking the occasion on the very location proposed for the conference centre. The development did not proceed.

5.1.2.4 Egypt

The Nineteenth Session of the World Heritage Bureau meeting in Berlin, Germany in December 1995 heard a good news story after a crisis in the conservation of an Egyptian World Heritage Site, Memphis and its Necropolis – the Pyramid Fields from Giza to Dahshur, inscribed on the list on 26 October 1979. There were a range of problems here, the most obvious being a motorway which was already under construction on a route which would cut across the site. Other problems were two refuse dumps in the vicinity of the Pyramids and proposed new housing developments in the vicinity. Into this crisis came a personal approach from UNESCO Director-General, Federico Mayor, to President Moubarak. The outcomes included a halt to highway construction and the choice of a new route passing north of the World Heritage site, improvement of one of the refuse dumps and elimination of the second and a halt to further housing construction in the vicinity.

5.1.2.5 United Kingdom

One of the few court cases dealing with World Heritage is an appeal against a decision of the Secretary of State for the Environment to refuse permission to allow the reclamation of a disused colliery and open-cast mining of coal within the Hadrian's Wall Military Zone World Heritage Site. This World Heritage Site includes a number of structures, forts and earthworks of the Roman period. While the appointed inspector recommended that the appeal be allowed as, *inter alia*, the effect of the proposed development in visual terms would only be very slight, the Secretary declined to accept the recommendation and the High Court upheld the decision[36]. It was argued that the inspector had failed to give sufficient weight to the World Heritage designation of the site, and that such designation 'introduced a new factor into the assessment, not present when merely the effects on the landscape were being considered'[37]. Thus the fact that a site has been designated as World Heritage necessitates a higher quality of protection and conservation than other sites.

5.1.2.6 World Heritage Cities

Many cities, or parts of them, figure on the World Heritage List and it is worthwhile to draw lessons from their experience of management, especially because the very scale of the Great Barrier Reef World Heritage Area precludes the strict limitations of uses which would generally be expected in a small site listed for its natural qualities and because of the varied status of its constituent parts.

Sir Bernard Fielden, an eminent architectural consultant from the United Kingdom and Director Emeritus of ICCROM has noted that, where a site is large, diverse and controlled by several authorities, it is desirable to set up one coordinating over-riding body which, he says, is what has happened in the case of the Hadrian's Wall World Heritage Site in the UK, listed on 11 December 1987.

Sir Bernard is co-author with Dr Jukka Jokilehto of ICCROM of a book on the management of World Heritage architectural and archaeological sites entitled *The Guidelines for Management of World Heritage Cultural Sites*. The book's central themes are taken up in an article by Dr Jokilehto under the title *Management for Historic Cities and Areas*. In this, Dr Jokilehto refers to the fact that some cultural sites may be:

> ...considered to have **'outstanding universal value'** either due to their specific intrinsic

[36] *Coal Contractors Limited v. Secretary of State for the Environment and Northumberland County Council* (1994) 6 Journal of Environmental Law 369

[37] Keene J (1994) 6 Journal of Environmental Law at 378

> qualities or as representative of a significant class of heritage, and thus qualify to the World Heritage List...

He goes on to say that:

> ...every historic area and its surroundings should be considered in their totality as a coherent whole whose balance and specific nature depend on the fusion of the parts of which it is composed...

a view expressed in relation to the Great Barrier Reef with consistency by contributors to Chapter 4 of this report.

Other points in the paper by Dr Jokilehto seen as relevant to the Great Barrier Reef as a World Heritage Site are his emphasis on heritage showing:

> ...its intimate connection with the general economic and land-use planning of the society [with] policies for protection, conservation and rehabilitation of...resources...understood as an essential part of the global policies and strategies for planning and management of the changing world.

He goes on to say that:

> ...it is necessary to go through a **critical process** aiming at cultivating an appreciation of the heritage as an integral part of present-day society...

and that:

> This process should allow to develop a framework for assessing resource values, establishing management objectives, and preparing presentation and interpretation policies.

Dr Jokilehto adds that:

> conservation...should be based on a clear **management** structure and continuous **monitoring** of changes against the **baseline information** and the statement of significance and character of the site concerned,

with

> **Regular inspections, professional reporting** every five years, and **preventative maintenance** programmes aimed at keeping the resources in a healthy condition.

He further states the need for a tourism management plan. Such planning for the management of World Heritage properties should be carried out in the context of an overall strategic planning process.

Further relevance to the Great Barrier Reef situation is seen in the record of the *International Symposium on World Heritage Towns* held in Quebec, Canada in mid-1991 in the form of a Management Guide made available by courtesy of Parks Canada. A central issue is the involvement of people, with the Guide pointing out that:

> The very survival of the bulk of our heritage to present day owes much to the attitude of its past custodians, the citizens of past eras (Parks Canada 1991).

After referring to the World Heritage Convention, the Management Guide says that:

> Less well known than the World Heritage Convention but ratified by UNESCO on the same day, the *Recommendation concerning the Protection at National Level, of the Cultural and Natural Heritage*, focused on the heritage-development dialogue. It noted that heritage 'may no longer be regarded as a check on national development but as a determining factor in such development'. Further, it encouraged measures for giving conservation: 'a place in community life', and invoked the need to involve 'the general public of the area' (Parks Canada 1991).

5.1.3 Citizen Involvement in World Heritage

The Great Barrier Reef World Heritage Area Strategic Plan is an excellent example of an initiative to give conservation of the Great Barrier Reef World Heritage Area a place in community life and the need for this approach of involving communities is an increasingly recurring theme in World Heritage (also see 2.4.4 and 2.4.5).

The Convention itself and the Operational Guidelines clearly expect States Parties to involve the public in the Convention's implementation. Article 17 of the Convention says that States Parties should consider or encourage the establishment of national, public and private foundations or associations whose purpose is to invite donations for the protection of the cultural and natural heritage. Article 27 urges States Parties to endeavour:

> ...by all appropriate means and, in particular by educational and information programmes, to strengthen appreciation and respect by their peoples of the cultural and natural heritage (UNESCO 1972).

It says that States Parties 'shall undertake to keep the public broadly informed of the dangers threatening this heritage and of activities carried out' under the Convention.

Here again, the reporting procedure to all stakeholders and to the public in general envisaged in the Great Barrier Reef Strategic Plan is directly relevant in carrying out the responsibilities under Article 27.

The Operational Guidelines say in Paragraph 14 that:

> Participation of local people in the nomination process is essential to make them feel a shared responsibility with the State Party in the maintenance of the site (World Heritage Committee 1996a:5).

The Operational Guidelines at Part H deal with 'Action at the National level to promote a greater awareness of the activities undertaken under the Convention'. At the entrance to some World Heritage sites a bronze plaque has been erected to highlight the properties inscription on the World Heritage List. Furthermore Paragraph 137 says that:

> States Parties should promote the establishment and activities of associations concerned with the safeguarding of cultural and natural sites (World Heritage Committee 1996a).

and in Paragraph 138 States Parties are reminded of Articles 17 and 27 of the Convention.

The Organization of World Heritage Cities based in Quebec, Canada, in a letter from their Secretary General (Marcel Junius) takes up the theme of citizen involvement. The Secretary-General says that:

> The issue of urban planning in world heritage cities and its tools, which are the plans and zoning regulations defining parameters to allowed uses, is not enough. We have to count on people's participation, such as the formation of 'safeguarding committees' and 'citizens committees', and to open a dialogue. It is the first step in a rather long process leading to the adoption of rules of conduct in order not to impede nor compromise priceless values...On the other hand, sometimes promoters have to be convinced to modify their projects and to invest differently. This is a difficult phase that must be won by administrators...

The Secretary-General suggested approaches to a number of cities and one particular reply underlines the overarching importance of public support. The Old City of Berne in Switzerland was inscribed on the World Heritage List on 9 December 1983. The City spokesperson responding to the inquiry pointed out that the planning and protection laws for the old town's core of historic buildings, densely built to a medieval plan, date from 1979 and 1981, thus predating the World Heritage Listing. Since Berne was listed, no important alterations to these laws have been made as the city authorities consider them sufficient although the State of Berne is about to renew its law on the preservation of monuments to replace one dating from 1905. The spokesperson goes on to point out that:

> Besides the law, there is of course the public opinion which we largely depend on for our results. In the past, the population has always been very much aware of the architectural value of the Old Town; nevertheless, we try to influence the public opinion and with that the opinion of decision makers in many different ways. Much is being achieved with information and educational work such as guided tours for the local population, lectures, publications and articles in local newspapers etc. We believe that these instruments very often are more effective and of greater importance than formal laws.

5.1.4 World Heritage 'a key material consideration' for the City of Bath

Inquiries into specific initiatives to conserve World Heritage values in the city environment led quickly to the City of Bath, nominated for World Heritage status by the United Kingdom and listed on 11 December 1987. Of this and other UK sites, Sir Bernard Fielden commented that:

> At first the UK Department of the Environment said that our sophisticated planning process needed no special additional action, but ICOMOS UK was soon able to disabuse them.

In this respect, Lord Hesketh is reported to have said some years ago in the House of Lords that:

> ...the Government do [*sic*] not consider that there is a need for special guidance for local authorities [in relation to World Heritage Sites as he considered such sites in the UK] adequately protected by the statutory provisions relating to development control and the additional safeguards in respect of the built and natural heritage.

However, information from the Bath City Council shows that the UK Government has issued *The Planning Policy Guidance Note PPG 15: Planning and the Historic Environment* which gives advice on World Heritage Sites. Giving details of World Heritage Sites in England, the note says that:

> No additional statutory controls follow from the inclusion of a site on the World Heritage List. Inclusion does, however, highlight the outstanding international importance of the site as a key material consideration to be taken into account by local planning authorities in determining planning and listed building consent applications, and by the Secretary of State in determining cases on appeal or following call-in.

The note goes on to say that each local authority:

> ...should formulate specific planning policies for protecting these sites and include these policies in their development plans...

and that

> ...policies should reflect the fact that all these sites have been designated for their outstanding universal value, and they should place great weight on the need to protect them for the benefit of future generations as well as our own.

PPG15 concludes by saying that:

> Local planning authorities are also encouraged to work with the owners and managers of World Heritage Sites in their areas, with other agencies, to ensure that comprehensive management plans are in place. These should:
> - appraise the significance and condition of the site;
> - ensure the physical conservation of the site to the highest standards;
> - protect the site and its setting from damaging development;
> - provide clear policies for tourism as it may affect the site.

In the case of the City of Bath, the World Heritage designation is for the whole city and the Assistant Director, Policy, Conservation and Landscaping most involved in the planning provisions says that he has:

> ...not sought to highlight any part. From time to time we refer to the nomination which mentions some parts of the city. For instance, we are trying to control quarrying in the hills to the south of the City which would affect the water supply to the hot springs. In this case, we have highlighted the reference to the springs in terms of World Heritage Status.

The Bath City Council has issued *The Bath Manifesto* as a statement of the Council's commitment to the conservation and protection of the City and the Council's acceptance of its responsibilities as guardian of a World Heritage Site. The significance of World Heritage status is evident from its opening words which say that:

> The UNESCO accolade of Bath being a World Heritage Site has been considered as an opportunity for the Council to reaffirm its conservation objectives and to extend the philosophy of conservation to wider aspects of the life of the City (Bath City Council 1995).

In the local plan for the City of Bath, a chapter entitled *Care of the Fabric* highlights the value placed on the World Heritage designation saying that:

> The City of Bath has been inscribed on the UNESCO List of World Heritage Sites. This inscription covers the whole City, and Bath is the only city in the United Kingdom to be included in the list. The inclusion affirms Bath's exceptional and universal value as a cultural site. The UNESCO accolade places an obligation on the City Council to maintain rigorously its conservation policies. Its serves as a stimulus to re-affirm the Council's conservation objectives and its philosophy for the conservation of the City. The Council will regard the status of a World Heritage Site as a key material consideration in determining planning applications, and applications for permission for development affecting a listed building or its setting or the character and appearance of the conservation area (Bath City Council 1995).

Policy C1 then follows with a similar wording:

> The City Council will regard the inclusion of the City of Bath on the UNESCO List of World Heritage Sites as a key material consideration in determining planning applications, and those for development affecting listed buildings and their setting in the conservation area.

This and the Bath Manifesto were put forward in the draft Replacement Plan first in 1993 and the word 'key' was added during the consultative process in 1995. The plan which includes the Manifesto and the Chapter on *Care of the Fabric* became a statutory document on 7 March 1996.

The consequence is that the status of the City as a World Heritage site is now a **key material consideration** in planning.

Currently, a group of local authorities in UK is examining a range of issues associated with the planning and management of World Heritage Sites and one of these is focusing on how the word 'key' is to be used as it has some eighteen different meanings. At present, the group favours an interpretation which lies between a definition 'of vital importance' and another which means 'a controlling factor' so that related considerations are brought together.

The value placed on World Heritage Status in the City of Bath is borne out by the fact that Policy C1 relating to World Heritage is the only planning policy given primacy by distinguishing it through the use of the word 'key'.

Bath does not, however, rely solely on its planning regime to maintain World Heritage value but is very conscious of the need to raise awareness in the people of the city. This recognises that:

> There are some who did not agree with the designation because they feared that it would be a further control on the expansion of business activity within the City. On the other hand, many businesses are using the designation to promote themselves, their products and the City as a tourist attraction. Some of this involves an overzealous approach and that could bring the World Heritage value into disrepute as a result of tacky promotion. Some individuals might also bring the concept into disrepute because they apply the World Heritage value to promote an off-centre view on very small planning issues. This will be a matter on which we will have to find our way. Nevertheless, there is a valid counter argument that the World Heritage designation requires an attention to detail.

Summing up, the comment is made that:

> Overall, the designation is helpful to the planning control process and will raise awareness in planning and other related conservation issues such as environmental control with respect to air and water quality. I am anxious to secure a collective responsibility and stewardship throughout the city.

As a footnote, our initial contact with Bath City Council was made by telephone by James Paine of WCMC and his comment makes interesting reading:

> The two people I spoke to were very switched on and understood immediately what I was getting at – World Heritage status is clearly a big deal for them.

Paine added that he was unable to speak to the key contact because he was, at the time, at a public inquiry debating an application by the Safeway supermarket chain to develop a site in the city. This application was being resisted by the City Council, very largely on the grounds that the increased traffic would elevate air pollution and that this, in turn, would damage the stonework of the buildings in the World Heritage area.

5.1.5 Summary

While the last resort appeals to State Presidents underline the potential of World Heritage as a tool for conservation, it is clearly highly desirable to have mechanisms in place which are designed to solve potential problems long before there is a need for international intervention at Head of State level. A number of key aspects suggesting appropriate mechanisms come out of the responses to the inquiries made including:

- the importance of ensuring World Heritage status is a 'key material consideration', and that management and planning for the site is of the highest possible standard;
- the importance of having clearly in place at the highest possible level in the management system, an overriding responsibility to maintain a World Heritage site's 'outstanding universal value';
- the importance of complementing this with appropriate decision making procedures which call for consideration of the implications of each decision – both direct and cumulative – on the site's World Heritage status;
- having staff in the management agency fully aware and committed to conserving the World Heritage value of the site; and
- the fundamental need for the management agency to build up public awareness, involvement, confidence and support for World Heritage as a matter of community and national pride; in turn meeting the psychological aim of the Convention.

5.2 Activities with the Potential to Impact on the Great Barrier Reef as a World Heritage Site

5.2.1 The Global Context of Threats to World Heritage Areas

In a review of World Heritage at risk, Paine (1992) draws attention to the expressed concerns of managers of World Heritage Areas from many parts of the world. The study was completed by the Protected Areas Data Unit of the World Conservation Monitoring Centre involving nine countries of OECD membership, including Australia, and 33 non-OECD countries, and covered 49 natural World Heritage Sites.

If considered jointly, the most commonly reported threat for both protected area and World Heritage values is tourism (about one-sixth of all World Heritage sites). For World Heritage values in OECD countries 21% of sites experience threats to values from tourism (about one-sixth of all World Heritage sites). For World Heritage values in OECD countries 21% of sites experience threats to values from tourism. As Paine points out:

> ...this finding in itself warrants further study as it contradicts the widely held assumption that tourism is generally beneficial to protected areas (Paine 1992:30).

Even in developing countries, where severe threats to World Heritage values come from poaching (39% of sites) and other illegal activities, tourism threats are experienced at 17% of the sites.

World Heritage designation is a powerful attractor for visitation, and can provide significant economic input into a region (e.g. Driml & Common 1995). Kenchington (1993) argues that tourism within an appropriate strategic framework need not compromise the aspects that give rise to the region's attractiveness. However, as Paine (1992) highlighted, the threat of tourism to a World Heritage property can be great. In reviewing tourism associated with the Great Barrier Reef World Heritage Area, tourism operations can be characterised as 'enclave' or 'roving'. An 'enclave' operation, for example a pontoon, concentrates activity in a small area and is easier to manage than 'roving' operations, for example recreational and charter boating, which disperse activities over a broad area. Additionally, other tourism operations act as 'nodes', for example marinas and cities, which attract people in and then may facilitate their dispersal over a wide area. Whilst the site of the 'node' itself is amenable to management, the dispersal of people over a broad area creates more difficulties including the possibility of unanticipated cumulative effects at other sites. The size of tourism operations is an additional factor that requires consideration. Small-scale, but poorly planned, tourism operations may cause greater environmental damage than larger tourism operations (e.g. see Kenchington 1989). However in consideration of large-scale tourism operations, the World Heritage Convention, in Article 11.4, specifically identifies 'large-scale public or private projects or rapid urban or tourist development projects' as 'serious and specific dangers' that may threaten cultural and natural heritage and necessitate its inclusion on the List of World Heritage in Danger.

Paine (1992) also found that 'exotic fauna' was a threat in 26% of the OECD World Heritage sites. While for both OECD and non-OECD countries another significant threat experience is development inside the World Heritage Area (16% and 12% respectively). These results indicate that worldwide there are many concerns amongst managers about future threats to the World Heritage Sites they manage. Many of these concerns are common with protected areas generally.

The formal acknowledgment of serious concern about World Heritage sites is manifest in the World Heritage in Danger List (see 2.2.4). The 2 sites listed from the USA indicates that threats to World Heritage are not confined to less affluent countries. Such listing is seen as a last resort action although, as for Yellowstone National Park, it might also be an attempt to bring additional political or social pressure on decision makers (see 5.1.2.2).

5.2.2 Threats and Concerns Within the Great Barrier Reef World Heritage Area

The recent State of the Marine Environment Report identified regional issues in the marine environment and listed a wide variety of specific concerns for the Great Barrier Reef. The following list of threats was adapted from Zann (1995):

- catchment alterations:
  - increases in suspended sediments;
  - change in the nature of suspended and transported sediments.
- elevated nutrients:
  - increases in nitrogen and phosphorus.

- effects of tourist developments on coast, reefs and islands:
  - direct physical effects;
  - effects on aesthetics locally;
  - effects on values.
- effects of trawling:
  - especially on benthic environment, physical alteration to sea bed;
  - on some aesthetic values.
- effects of fishing:
  - over-fishing and consequences for sustainability and for ecological integrity;
  - removal of some size classes significant for other users.
- risk of shipping accidents and oil spills:
  - direct and indirect;
  - introduction of exotic species.
- port development and dredging;
- industrial discharges;
- crown-of-thorns starfish outbreaks.

These concerns can be characterised in a number of ways, not all of which are directly under the control of the management agency responsible for the Great Barrier Reef World Heritage Area. Main sources of potential damage to the 'outstanding universal value' of the Great Barrier Reef World Heritage Area are:

a) diffuse but widespread effects associated with terrestrial land use:
   - riverine nutrient input:
     - derived from agricultural activities, especially cultivation and chemical fertiliser use;
     - domestic sewage associated with urban areas and other settlement;
     - nutrients entrained with suspended clay particles sourced from catchments.
   - increased sediment loads in streams:
     - derived from agricultural activities, especially cultivation;
     - product of tree clearance and other sediment mobilisation activities;
     - mobilisation of sediment through mining activities;
     - mobilisation of sediment through pigs and other feral or domestic livestock.

b) point-sourced contributions of nutrient and sediment:
   - sewage and other pollution:
     - from developments within the Great Barrier Reef (islands) or adjacent (coastal);
     - from boats and other vessels within the Great Barrier Reef;
     - oil spills from large vessels.
   - tourism developments on adjacent coast:
     - mangrove disturbance and clearance.

c) unintended effects of development and tourism:
   - increased boating activity with direct effects and added burden to other impacts;
   - destruction of natural beauty and aesthetic values through development scars;
   - direct impacts on corals through tourist activity;
   - sewage waste disposal at sea;
   - over-fishing pressures (e.g. size-reduction in populations of fish and threatened species such as marine mammals and sea turtles, e.g. CSIRO Division of Fisheries 1996; Marsh et al. 1995);
   - degradation of aesthetic qualities of the marine and terrestrial environments which make up the Great Barrier Reef World Heritage Area.

There is already a good understanding of the potential impacts of a wide variety of activities and developments on the Great Barrier Reef Marine Park and perhaps the least understood area is the effects on social values which may be directly relevant to Criterion (iii) attributes of the Great Barrier Reef World Heritage Area.

Recommendation 5:

That the Great Barrier Reef Marine Park Authority initiate discussion with the following Queensland agencies to ensure that the management of the following activities in or adjacent to the Great Barrier Reef World Heritage Area does not adversely affect its World Heritage values:

- *Queensland Fisheries Management Authority regarding commercial and recreational fishing;*
- *Queensland Department of Environment regarding the use of offshore islands; and*
- *Queensland Department of Natural Resources regarding terrestrial run-off.*

Recommendation 6:

That the Great Barrier Reef Marine Park Authority initiate discussion with relevant Queensland state departments and agencies and local governments to develop planning guidelines to ensure that activities in or adjacent to the Great Barrier Reef World Heritage Area do not adversely affect its World Heritage values.

5.3 Spatial Options for the Future Management of the World Heritage Area

In this section we discuss possible variations to the existing structure of management for the Great Barrier Reef World Heritage Area and the extent of the site. Various scenarios have been considered based on ideas raised in discussions and incorporating issues arising from the 1995 serial nomination of the Belize Barrier Reef by the Government of Belize. The framework we have adopted is to consider the essential needs for the management of the Great Barrier Reef World Heritage Area beginning with its World Heritage value and integrity, then considering conformity with the IUCN Marine Protected Area Guidelines, the Operational Guidelines, issues relating to ease of management and finally the question of community support which incorporates an assessment of political feasibility.

5.3.1 World Heritage Value

The protection of 'outstanding universal value' is central to the goal of World Heritage. In Chapter 4 we have identified and reviewed the large array of natural attributes which are represented within the Great Barrier Reef World Heritage Area. In the context of the expert views provided for the various attributes, it is clear that the Area's 'outstanding universal value' is captured to very large part because of two features:

1. the latitudinal and cross-shelf extent of the Great Barrier Reef World Heritage Area; and
2. the global rarity of well protected coral reefs, islands and tropical coastal habitats which retain much of their integrity as is the case with the Great Barrier Reef.

The combination of vast scale and effective management arrangements has ensured the survival of the outstanding value identified both at the time of the nomination and over the ensuing years. Many experts commented that the greatness of the Great Barrier Reef World Heritage Area is fundamentally linked to its scale. Further, while the attributes identified are also represented elsewhere, they are usually under severe threat as a result of mismanaged or unmanaged conditions. Tropical marine areas occur largely in the waters of developing nations and are frequently subject to destructive exploitation such as dynamite fishing, cyanide poison fishing and other unsustainable activities (Dayton 1995). In this context the Great Barrier Reef World Heritage Area may have become even more outstanding in the preservation of its World Heritage value since the original nomination, although concern exists about continued threats from coastal and subcoastal sources.

Considering the two critical elements identified by experts consulted as part of this study, how would the protection of these values fare under different management arrangements? The five Great Barrier Reef World Heritage Area boundary options we considered were:

(i) present area;

(ii) expanded area including

  (a) Torres Strait; and/or

  (b) the Coral Sea reefs[38];

(iii) limiting the Great Barrier Reef World Heritage Area to coincide with the Great Barrier Reef Marine Park;

(iv) adopting a subset of the area, as for example the present Far Northern Section;

(v) adopting a serial approach in which several core areas were identified and circumscribed as the Great Barrier Reef World Heritage Area.

With respect to the identified World Heritage value, it is clear that in the case of either expanded area there would be a qualitative

[38] However, it may be useful to give the GBRMPA the responsibility for Coral Sea sites without inclusion in either the Great Barrier Reef Marine Park or the Great Barrier Reef World Heritage Area.

improvement. As previously noted (3.3) the IUCN evaluation identified the lack of the Torres Strait portion of the Great Barrier Reef and urged that the World Heritage Committee:

> ...express a willingness to accept the addition of this area should it become available in the future (IUCN 1981:2).

Similarly, Whitehouse (1993) identified the ecological support for the inclusion of Coral Sea reefs but cautioned there was a need for close consultation with Torres Strait Islanders before even considering extensions in that direction.

All other variations from the present area would result in a reduction of value from the World Heritage Area, the extent of loss depending on precise boundary delineation. The serial approach is considered likely to produce the greatest loss although that also would depend on the extent and location of core areas selected.

5.3.2 Integrity issues: the IUCN Marine Protected Area Guidelines

In their benchmark publication for IUCN, Kelleher and Kenchington (1992) provide guidelines for the establishment of marine protected areas. They identify the progression of approaches from initial regulation of marine activities, to the protection of small reserves and most recently the development of extensive multiple use protected areas. The authors say:

> ...it is strongly recommend that legislation be based upon sustainable multiple-use managed areas (e.g. the Biosphere Reserve concept), as opposed to isolated highly protected pockets in an area that is otherwise un-managed or is subject to regulation on a piecemeal or industry basis (Kelleher & Kenchington 1992:19).

At the time of nomination, the IUCN evaluation report for the World Heritage Committee drew attention to the value of the extent of area nominated:

> The Australian Government is to be congratulated for including virtually the entire Great Barrier Reef in the proposed 350 000 square kilometre site. This is clearly the only way to ensure the integrity of the coral reef ecosystems in all their diversity (IUCN 1981:1).

In considering the potential variations to the World Heritage Area boundaries, it is clear that limiting the World Heritage Area to the Great Barrier Reef Marine Park boundaries would diminish conformity with the IUCN MPA guidelines. A subset of the present area might conform depending on the precise boundaries but a serial nomination would be unable to meet the guidelines.

5.3.3 Technical Issues: the World Heritage Operational Guidelines

Even at the time of nomination, concern about the capacity of World Heritage sites to retain all their value was frequently expressed in terms of integrity, as the quotation above shows. Subsequently, the Operational Guidelines have given increased emphasis to integrity issues and the effect of these is to argue for an extensive area rather than a small core. For Criterion (ii) for example, under conditions of integrity, specific reference is made in the Operational Guidelines that 'a coral reef should include, for example, seagrass, mangrove or other adjacent ecosystems that regulate nutrient and sediment inputs into the reef' (World Heritage Committee 1996a:13).

More recent research conducted for the GBRMPA has demonstrated the validity of such an approach with the identification of significant mainland run-off inputs to the Great Barrier Reef with some potential to threaten its 'outstanding universal value'. How to address these through management remains a complex and difficult issue. The GBRMPA does have the provision to 'regulate or prohibit activities that may pollute water in a manner harmful to plants and animals in the Marine Park' under section 66(2)(e) of the *Great Barrier Reef Marine Park Act 1975*. However, such a mechanism is reactive and is not suited to all situations, particularly where the source of the input is disputed.

Given the scale of the actual site it might be argued that the integrity conditions within the current operational guidelines imply a need for expanded borders to incorporate mainland terrestrial areas (e.g. 'adjacent ecosystems that regulate nutrient and sediment inputs into the reef'). Such structural change has been proposed as preferable even while recognised as difficult to achieve in practice (e.g. Ray 1976; Salm 1984; Valentine 1986). In reality this is more likely to be achieved within the Great Barrier Reef World Heritage Area by developing a coastal zone management environment which respects the 'outstanding universal value' of the adjacent marine areas and which seeks to limit negative impacts.

The Great Barrier Reef World Heritage Area Strategic Plan provides a basis for the development of such an environment. A consultancy is presently under way to provide a context which local and state government planners can use to develop controls to reduce the impacts of terrestrial and marine developments on the World Heritage Area. Cooperative management arrangements between the Great Barrier Reef World Heritage Area and adjacent terrestrial management agencies would also assist. Zoning which takes advantage of terrestrial land use and management situations might also help improve integrity outcomes. The existing boundary does incorporate all islands within the Great Barrier Reef and therefore provides a stronger basis for the management to deal with integrity issues which flow from proposed island developments.

To restrict the World Heritage Area to the present Great Barrier Reef Marine Park boundaries would aggravate the difficulty in addressing threats to integrity which are sourced outside the managed area. In this context, it might be fruitful to explore ways for more direct involvement with the terrestrial environmental management associated with adjacent lands including the islands which GBRMPA has no direct legislative control over as outlined in the Strategic Plan. Once again, depending on the precise boundaries, a subset approach might meet World Heritage guidelines but it is doubtful if a serial approach would be able to achieve a satisfactory integrity condition.

5.3.4 Ease of Management

At the time of the nomination, one of the IUCN comments related to a concern about whether such a large area could be effectively managed. A judgement on the level of success accorded to the management of the Great Barrier Reef World Heritage Area might vary depending on the criteria applied. Concerns about damage to the Great Barrier Reef environment are widespread and relate to a number of potential effects on World Heritage value (see Section 5.2). Whether the capacity to manage the Great Barrier Reef World Heritage Area would be enhanced or otherwise by modification of the boundaries is a difficult question. Any expansion of the area into the northern Great Barrier Reef (i.e. Torres Strait) is bound to impose significant additional management problems and costs. Confining the Great Barrier Reef World Heritage Area to the Great Barrier Reef Marine Park area may clarify the legal responsibilities involved, but may create greater difficulties in inter-government arrangements. In this sense it may be seen, on balance, as advantageous. In the case of a subset approach, it is difficult to be certain but due to the interconnectedness (e.g. see Bode et al. 1990) of the Great Barrier Reef it may prove to be no significant management benefit to have another adjacent area managed by yet another agency, or even unmanaged. A serial nomination would magnify this issue greatly and lead to more effort involved to manage less, especially in dealing with adjacent users.

5.3.5 Community Support for Boundary Review

In considering the community of interest for a World Heritage Site, there are at least three distinct levels (international, national, local), and in Australia perhaps four (with an additional state level). Initially there are the concerns of the international community to whom Australia has undertaken the responsibility of protecting the identified World Heritage value 'to the utmost of [our] own resources' (UNESCO 1972). Given the support for the existing boundary at the time of the nomination (see above and 3.3), it could be assumed that the international community would generally support the *status quo*, or expansion, but would not wish to see reduction of area by any of the alternatives considered here. In contradiction to that position, however, is the expressed concern about the ability to manage such a large area and associated recent informal discussions about whether a diminished area might be preferable. It is our view that once the wider community becomes aware of the critical role of scale in producing the World Heritage value any suggestion of size reduction would be opposed.

It is likely that the views of the national community would be similar to the international perspective and would oppose reduction but may not agree easily with suggestions of enlargement. At the local level, it is likely that expansion would be opposed within Torres Strait but it is unclear how local people might view the other options. At least some local people may oppose suggestions which saw their areas removed from World Heritage status. A serial approach is likely to be opposed locally also.

5.3.6 Conclusions

Taking into account the critical issues of World Heritage value, integrity of the site, IUCN MPA guidelines, World Heritage operational guidelines, ease of management and community support, potential variations in the boundaries of the World Heritage site have been considered.

A summary (Figure 5.1) shows the general pattern which we identify as positive and negative elements of the various proposals. From this the conclusion emerges that any reduction of the *status quo* would certainly affect the World Heritage value and such proposals are not feasible. While expansion is seen as a net positive prospect, it also remains unlikely to be feasible for the Torres Strait region. This analysis demonstrates the continued validity of the present boundary for maximum protection of the World Heritage Site.

Recommendation 7:

That the Great Barrier Reef Marine Park Authority initiate negotiations with other relevant state and federal agencies on whether the boundaries of the Great Barrier Reef World Heritage Area should be changed so that the Area includes the Coral Sea Reefs.

Figure 5.1 Possible Scenarios for Boundary Revisions, Great Barrier Reef World Heritage Area

	Present Area	Expanded Coral Sea	Expanded Torres St.	GBRMPA Area	Subset Area	Serial Area
Value	0	+	+	–	– –	– – –
MPA Guidelines	Y	Y	Y	N	?	N
Operational Guidelines	Y	Y	Y	N	?	?
Ease of Management	0	?	–	?	?	–
International Support	0	+	?	–	– –	– – –
National Support	0	?	?	–	– –	– – –
Local Support	0	?	–	?	?	–
Summary	Status Quo	Inc. Value support **Feasible**	Inc. Value Local Opp. **Not Feasible**	Dec. Value Opposition **Not Feasible**	Dec. Value Opposition **Not Feasible**	Dec. Value Opposition **Not Feasible**

Key:

Y Yes, indicating accordance with guidelines;
N No, indicating in conflict with guidelines;
? Indicates uncertainty;
O Existing situation, no change;
+ Improved situation, positive change;
– Worsened situation, negative change.

5.4 Suggested Procedures for Managing the Great Barrier Reef World Heritage Area

We endorse the views expressed by the penultimate and current Director-Generals of IUCN that the implementation of the *25 Year Strategic Plan for the Great Barrier Reef World Heritage Area* will fulfil Australia's obligations under the World Heritage Convention and recommend that the implementation schedule outlined in the Strategic Plan be adhered to as closely as possible. However some modification will be inevitable given the delays that have occurred already.

This Plan is extremely comprehensive and reflects the views of numerous stakeholders. The following objectives are but a few examples of the relevance of the Plan to the fulfilment of Australia's obligations under the World Heritage Convention in the areas of education, conservation, legislation and monitoring.

5.4.1 Education

5 year Objective 3.1

> To inform the community, through coordinated programs of the natural, cultural and heritage values of the Area and how to use it responsibly (GBRMPA 1994:23).

As the Plan stresses, an informed community is necessary if the Great Barrier Reef World Heritage Area is to be used in a way which ensures that Australia meets its obligations under the Convention. To further awareness of the Great Barrier Reef's inclusion upon the World Heritage List, the installation of commemorative plaques at selected locations should be undertaken. These could be placed, for example, on Magnetic Island, Green Island, and in the Whitsunday Area, and perhaps at the launching areas of day-trippers. Similarly, tourist brochures for the region should prominently display the World Heritage logo. The examples discussed in 5.1 demonstrate the benefit of having an informed public.

5.4.2 Conservation

5 year Objective 1.3

> To address and negotiate in the light of existing knowledge and the precautionary principle, the adequacy of the proportion of the Great Barrier Reef World Heritage Area in which impacts are constrained and which is free from structures and extractions (GBRMPA 1994:16).

5 year Objective 1.4

> To protect representative biological communities throughout the Area to act as source areas, reference areas and reservoirs of biodiversity and species abundance (GBRMPA 1994:16).

Implementation of these objectives would provide the opportunity to address the specific concerns, raised earlier (3.4), about the capacity of the existing zoning arrangements to protect World Heritage value namely:

- the very small area of the Park that is zoned at a level comparable to a terrestrial national park (< 5%); and
- the fact that the vast majority (58%) of this highly protected area occurs in the cross-shelf transect in the Far Northern Section (Whitehouse 1993).

The need to reconsider the proportion of and locations in the Great Barrier Reef World Heritage Area which are given high protection is highlighted by a resolution which was recently passed at the IUCN World Conservation Congress in Montreal, October 1996, recommending that:

> States, as part of their overall systems of marine protected areas, establish viable marine protected areas which meet the protection criteria for IUCN Categories I and II, so as to safeguard a representative proportion of marine ecosystems in a natural state and thus help maintain sustainable use and biodiversity throughout their marine ecosystems.[39]

We commend the GBRMPA for instigating a series of workshops in 1996 to consider the representativeness of highly protected areas in the Great Barrier Reef World Heritage Area.

> **Recommendation 8:**
>
> *That the Great Barrier Reef Marine Park Authority ensure that representative examples of all habitats within the Great Barrier Reef World Heritage Area are managed to meet the criteria for IUCN category I or II protected areas. Such protected areas should be distributed throughout the entire Area.*

[39] The final version of this resolution has not yet been disbursed. Its meaning will not change, though some grammatical editing may take place.

5 year Objective 1.7

To rehabilitate and/or redevelop seriously degraded sites which are unlikely to recover naturally within a time frame acceptable to stakeholders, while recognising that the biodiversity of the World Heritage Area must be maintained and protected (GBRMPA 1994:17).

5 year Objective 1.8

To prevent the introduction of, mitigate the impact of, and/or phase out ecologically unsustainable practices affecting the area (GBRMPA 1994:17).

The implementation of these objectives would alleviate many of the concerns of critics of the present status of parts of the Great Barrier Reef World Heritage Area such as Morris (1995a, 1995b, 1995c).

5.4.3 Legislation

5 Year Objective 8.1

To have the required streamlined legislation in place including legislation that acknowledges Australia's obligations under the World Heritage Obligations (GBRMPA 1994:40).

The Authority's proposal for an additional amendment to the *Great Barrier Reef Marine Park Act* to add 'the protection of World Heritage value' to the matters to which the Authority is required to have regard in considering an application for a permit would accord with this objective. Changing the objects provision of the Act in this manner would change the present emphasis from considering World Heritage value in the context of local scale planning (e.g. management plans) and obligates the Authority to consider World Heritage value at all scales of management. Similarly other bodies with resource management responsibilities in the Great Barrier Reef World Heritage Area (e.g. QFMA, QDoE) should have their legislative bases amended to incorporate consideration of World Heritage in decision-making processes.

Recommendation 9:

That legislation, underpinning resource use and its management in the Great Barrier Reef World Heritage Area, be amended to require the consideration of the World Heritage value in planning and decision-making processes.

5.4.4 Monitoring

5 year Objective 4.13

To develop methods for the evaluation of current and proposed management strategies (GBRMPA 1994:30).

This objective is in accord with the Operational Guidelines (Paragraph 70) which say that it is a prime responsibility of States Parties to put in place on-site monitoring arrangements as an integral component of day-to-day conservation and management of World Heritage Sites. The Guidelines state that this calls for annual recording of the conditions of the site; with States Parties invited to submit to the World Heritage Committee every five years a scientific report on the state of conservation of each site on their territory. The State of the Great Barrier Reef World Heritage Area Report which is currently being prepared by GBRMPA is presumably designed for this function.

Recommendation 10:

That monitoring reports detailing the state of conservation of the Great Barrier Reef World Heritage Area be prepared at five year intervals, preferably coincident with the proposed timing of periodic reviews of the 25 year Strategic Plan.

5.4.5 Issues Identified by the Strategic Plan as 'in continuance'

Only two major issues were not resolved in the Strategic Planning process. These were designated as 'in continuance' in the Plan with a view to their being reconsidered at a later date:

- Whether mining should be allowed in the World Heritage Area outside the Great Barrier Reef Region and island National Parks.
- The implications of the Mabo decision for the Plan. This issue prevented Aboriginal and Torres Strait Islander Groups from endorsing the Plan.

It will be important for the GBRMPA to implement procedures to consider these issues as soon as possible, especially if the Strategic Plan is to be the major instrument for ensuring that Australia's obligations under the World Heritage Convention are met.

5.4.6 Jurisdictional Issues

As discussed in 3.5.2, a number of Commonwealth and Queensland government bodies have responsibility for management of the Great Barrier Reef World Heritage Area, or parts of it. This complexity could be reduced through the development of appropriate mechanisms between and within the two governments. The *25 Year Strategic Plan for the Great Barrier Reef World Heritage Area* is one such mechanism.

The GBRMPA has recently negotiated a Memorandum of Understanding (MOU) with other Commonwealth departments and agencies that have responsibilities related to World Heritage in the Great Barrier Reef Region, namely the Australian Heritage Commission, the Environment Protection Agency and the Department of Environment Sport and Territories. The MOU identifies the GBRMPA as the lead agency for any actions that may affect the Commonwealth's obligations under the World Heritage Convention in relation to the Great Barrier Reef World Heritage Area. We support this initiative which is in accordance with the emphasis given to World Heritage by the current Chair of the Authority, Dr I. McPhail. Similarly consideration should be given to negotiating a MOU between Queensland and the Commonwealth Governments regarding the management of the Great Barrier Reef World Heritage Area. Such a MOU should be a public document and have provision for regular review.

Recommendation 11:

That the Great Barrier Reef Marine Park Authority initiate discussion with relevant Queensland state departments and agencies with a view to negotiating a Memorandum of Understanding between the Queensland and Commonwealth Governments regarding the management of the Great Barrier Reef World Heritage Area.

5.5 Australia's Global Responsibility

Australia, like other States Parties to the World Heritage Convention, has accepted a range of obligations under the Convention as outlined in Section 2.3 of this report. These obligations include the implementation of the Convention through participation in its management structure, specifically through the work of the World Heritage Committee. At the national level, the obligations involve active measures

> ...for the protection, conservation and presentation of the cultural and natural heritage situated on its territory... (UNESCO 1972, Art. 5)

and

> ...to strengthen appreciation and respect by their peoples of the cultural and natural heritage... (UNESCO 1972, Art. 27).

At the site level, there are specific responsibilities for the effective management of World Heritage sites in its territory inscribed on the World Heritage List to maintain the 'conditions of integrity'.

From the outset, Australia has demonstrated a strong commitment to meeting its obligations and has become a leader among the States Parties in implementing the Convention. Australia has demonstrated leadership both through hosting the Committee, through the past chairing of the Committee by Dr Ralph Slatyer and through membership of the Committee from 1976 to 1989 and, again, from 1995.

Australia has a Commonwealth, State and Territory-wide structure to conserve its overall cultural and natural heritage. Commonwealth responsibility for national heritage was given specific expression with the passing of the *Australian Heritage Commission Act* 1975 (Cwlth) which established the Australian Heritage Commission, and the Register of the National Estate. The Register has itself recorded the national values of all World Heritage Areas, in many cases before they were listed as World Heritage, and frequently involving a larger area than the World Heritage listed sites. This move by the Commonwealth raised awareness of the national values attached to the many state managed natural properties within the Australian protected area system. In addition specific action directly relevant to World Heritage can be seen in legislation in support of World Heritage, special arrangements for cooperative management, financial support and the establishment of the World Heritage Unit in the Department of the Environment, Sport and Territories.

Australia has nominated credible sites which have been listed recognising their 'outstanding universal value.' The first group of them, including the Great Barrier Reef, was inscribed on the World Heritage List in October 1981 when the Australian Government hosted the Fifth Session of the World Heritage Committee in Sydney, New South Wales.

In nominating the Great Barrier Reef as part of the World Heritage, Australia has recognised both the outstanding significance of what the nomination described as 'by far the largest single collection of coral reefs in the world' and its responsibility as part of the world community to manage the area to maintain its outstanding value.

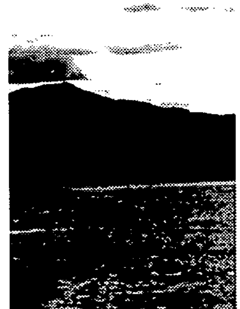
The conditions of integrity required are clearly spelled out in the World Heritage Committee's Operational Guidelines (see 2.4.2 & 2.4.3). They require, *inter alia*, 'adequate long-term legislative, regulatory or institutional protection' but the Operation Guidelines also call on States Parties to complement this protection with 'educational and information programmes to strengthen appreciation and respect by their peoples of this [world] heritage.'

In the case of the Great Barrier Reef World Heritage Area, most of which had a high profile life of its own as the Great Barrier Reef Marine Park prior to its World Heritage inscription, this means the conscious promotion of its global significance as a World Heritage site. The use of commemorative plaques and brochures which prominently identify the Great Barrier Reef as a World Heritage Site and its outstanding universal value would assist in increasing public awareness. Similarly, there is a need for maintaining an awareness among policy makers and managers, that the area is more than a very important Marine Park managed as a multiple use resource area. Rather it is a place of 'outstanding universal value' in a world context needing to be managed and respected in a manner which recognises its global significance.

The negotiation of the 25 year Strategic Plan, the inclusive manner in which it was produced and the initiative taken with this consultancy would be of great interest to the World Heritage Centre and Committee. These initiatives are commended, and they should be brought to the attention of both the World Heritage Centre and the Committee.

In 1996, fifteen years after the inscription of the Great Barrier Reef on the World Heritage List, with a cooperative management regime in place and the 25 year Strategic Plan developed through an exemplary participatory process, the commissioning of this consultancy report by the GBRMPA is further evidence of Australia's determination to exercise wise stewardship of the Reef for all the peoples of north Queensland, Queensland, Australia and the World.

Chapter Six:
Obligations to the Cultural Attributes of the Great Barrier Reef World Heritage Area



As noted elsewhere we have not explored the cultural heritage attributes of the Great Barrier Reef World Heritage Area in much detail in the course of this consultancy. This section briefly discusses the general nature of cultural attributes in properties listed for their natural heritage, along with reviewing the Great Barrier Reef World Heritage Area nomination and provisions within the 25 year Strategic Plan. We believe that a project similar to this one, should be funded to document the cultural heritage attributes and to investigate the possibility for nominating the Great Barrier Reef World Heritage Area as a cultural landscape.

> **Recommendation 12:**
>
> *That the Great Barrier Reef Marine Park Authority initiate negotiations with Aboriginal and Torres Strait Islander peoples concerning a project to investigate the cultural heritage attributes of the Great Barrier Reef World Heritage Area and its possible renomination as a cultural landscape.*

6.1 General Obligations to Cultural Heritage Under the Convention

As indicated in 2.3, apart from the obligations States Parties accept when nominating an area for listing under the World Heritage Convention, there are also general duties which a State Party accepts.

Each State Party bears the chief responsibility for protecting the cultural and natural heritage situated in its territory and international assistance is intended as a complement to national action. Under Article 4 of the Convention, a State Party undertakes to do 'to the utmost of its own resources,' all it can to ensure

> ...the identification, protection, conservation, presentation and transmission to future generations of the cultural and natural heritage... (UNESCO 1972).

The types of 'effective and active' national measures which each State 'shall endeavour' to undertake are specified in Article 5. These are listed in 2.3 and represent the adoption of policies and planning practices, establishing and researching appropriate conservation services, developing technical skills to counteract threats, undertaking research, identifying, protecting, conserving, presenting and rehabilitating the cultural and natural heritage and encouraging relevant training and research.

Meyer (1976) says that these commitments would appear to cover a nation's entire immovable cultural and natural heritage, not only that which is of 'outstanding universal value'.

Thus, there is a general obligation on the Australian Government to identify, protect, conserve, present and transmit to future generations the cultural and natural heritage of Australia including, of course, the Great Barrier Reef World Heritage Area's cultural and natural values. This applies irrespective of whether or not the Great Barrier Reef is listed as a cultural site.

6.2 Cultural Values in a Natural World Heritage Site

There are numerous examples of sites in various countries inscribed on the World Heritage List solely under natural criteria where significant cultural values have been identified in the nomination documents and/or where cultural values are identified in official publications of the World Heritage Centre and its associated advisory bodies. Cultural values cover a range of substantive issues. For example the Coastal Zone Inquiry carried out by the Resource Assessment Commission classified community groups' values into eight categories of 'value issues' (Resource Assessment Commission 1993b). 'Aesthetic and experiential issues' refers to the 'variety of pleasures obtained from a particular landscape or locale' (Resource Assessment Commission 1993b:17). 'Cultural heritage issues' are the 'meaning attributed to particular coastal place or artefacts in the cultural traditions of Aboriginal and non-Aboriginal Australians' (Resource Assessment Commission 1993b:17). In the case of many World Heritage properties listed for their natural attributes, the cultural values identified often relate to the meanings ascribed to landscapes by indigenous occupiers or past occupiers of the property. Two examples follow.

Sagarmatha National Park (Nepal) was inscribed as a natural site on 26 October 1979. The nomination document devotes eight pages to cultural aspects of the site nominated. Four pages relate to the:

> ...role of human settlement and its social and cultural significance...of a predominantly Sherpa population living and farming...

within the area. Another four pages discuss the history of mountaineering and tourism in the area and the significance of the mountains – especially Sagarmatha (Mount Everest) – to the people of the region and of Nepal and to the world mountaineering fraternity. The nomination, for example, cites the official Nepali name of Sagarmatha literally 'whose head touches the sky' and the old Tibetan name (used currently in China) of Chomolungma 'Goddess Mother of the World'.

Recognition of the cultural values in a site listed only for its natural values is borne out by technical assistance which has been provided from the World Heritage Fund to conserve artefacts of Sherpa culture and by the text of a November 1995 publication of the World Heritage Centre entitled *Sites Inscribed on the World Heritage List: Brief Descriptions* (UNESCO 1995). After listing a number of natural attributes, the entry for Sagarmatha National Park says:

> The presence of the Sherpas, with their unique culture, adds further interest to this site (UNESCO 1995).

Te Wahipounamu/South West New Zealand was inscribed as a natural site on 12 December 1990. Here, while there is no mention of cultural aspects in the brief description of the site in the 1995 World Heritage Centre publication, the nomination devotes five pages of printed text to Maori mythology, traditional history and ethnology as well as to the European history of the area. Significantly, too, the nomination document states that it was prepared by the Department of Conservation with the assistance of the Royal Forest and Bird Protection Society (New Zealand) Incorporated and the Ngai Tahu Maori Trust Board (Department of Conservation 1989).

Among many other sites listed for only their natural values but with significant cultural resources is the Talamanca Range–La Amistad National Park site (Costa Rica and Panama) inscribed on 9 December 1983 and extended on 12 December 1990. Here, the 1995 World Heritage Centre publication records the fact that 'Four different Indian tribes inhabit this property...'(UNESCO 1995).

Clearly, there is a recognition in the implementation of the Convention that cultural values are important in the management of World Heritage sites inscribed on the World Heritage List for their natural values.

6.3 Cultural Values in the Great Barrier Reef World Heritage Area

The nomination of the Great Barrier Reef which led to its listing as a natural World Heritage site on 30 October 1981 includes references to its cultural features in the justification as follows:

> The area of this nomination contains many middens and other archaeological sites of Aboriginal or Torres Strait Islander origin. There are over 30 historical shipwrecks in the area, and on the islands there are ruins and operating lighthouses which are of cultural and historical significance (GBRMPA 1981:5).

In describing the cultural heritage of the nominated area the nomination states:

> The Great Barrier Reef, and, in particular, the northern sector, is important in the history and culture of the Aboriginal groups of the coastal areas of north-east Australia. The Great Barrier Reef has received little systematic archaeological study but it is known that there are large, important Aboriginal or Torres Strait Islander sites on a number of the islands. Some notable examples occur on Lizard and Hinchinbrook Islands, and on Stanley, Cliff and Clack Islands in the vicinity of Cape Melville (14°S) where there are spectacular galleries of rock paintings (Chase 1978 and Beaton 1978).
>
> About thirty wrecks of historic importance are known to exist in the Great Barrier Reef area. One of the earliest, the wreck of HMS "Pandora" dates from 1791 and lies near the reef in the northern sector to which it gave its name. In the central sector is the well-preserved wreck of the coastal vessel SS "Yongala" which sank with the loss of 122 passengers and crew members during a cyclone in April 1911.
>
> The hazards of navigation in the Great Barrier Reef resulted in the construction of a large number of lighthouses, some of which have particular historical importance. The Raine Island lighthouse, constructed by convict labour in 1844 under the direction of Captain Blackwood of

> HMS "Fly" is now derelict but has been listed by the National Trust of Queensland. The lighthouses at Lady Elliot Island (built in 1856) and North Reef Island (1878) still operate and are fine examples of nineteenth century riveted steel plate construction (GBRMPA 1981:15).

The nomination goes on to devote almost two pages to *Cultural History*. Aspects covered include exploration by Aboriginal fishermen 'since before the development of the present form of the Great Barrier reef which began about 15 000 years ago'(GBRMPA 1981:16). It says that groups in the northern sector operated within a highly complex mosaic of marine environments and possessed large outrigger canoes with single and double outriggers capable of holding up to four adults. These canoes were used as hunting platforms as well as a means of transport. The nomination says that these beach people, lived normally within a small territory throughout the year, camps moving little more than half a kilometre at a time. Large gatherings were held at intervals of two to three years at well-established sites to carry out ceremonial activities and initiations of young men. The nomination states that:

> ...currently, people living in Aboriginal communities in the Great Barrier Reef Area (Palm Island, Wujal Wujal, Hopevale, Cooktown and Lockhart River) have access to the marine and near shore resources which played an important role in the Aboriginal economy during the past several thousand years (GBRMPA 1981:17).

The *Cultural History* section of the nomination also devotes significant coverage to the European history of the Great Barrier Reef including a possible Portuguese voyage of 1522–24 by Cristavao de Mendonca with considerable detail of the voyage of James Cook in 1770 when his ship *Endeavour* ran aground and was subsequently refloated after some cargo, including cannon, was jettisoned. There are many references to wrecks caused by the hazards of navigating the Reef , including HMS *Pandora* in 1791 while carrying, as prisoners, some of the seamen who had mutinied against Captain Bligh some years previously. Expeditions of survey and scientific explorations are listed and there is an outline of the history of mining for guano or phosphatic rock, particularly on North West and Lady Elliot Islands as well as bêche-de-mer and trochus fisheries.

The official publications of UNESCO and the World Heritage Centre show that the Great Barrier Reef was inscribed as a natural site. However, it follows from the earlier discussion and from the substantial references to cultural values in the nomination document, that there is a place in the context of the Convention for the conservation of cultural attributes.

6.4 Treatment of Cultural Values in the Strategic Plan

It is not part of the Terms of Reference for this consultancy to go further in identifying cultural values nor are we equipped to do this. However, we commend the attention paid to cultural aspects relating to Aboriginal Peoples and Torres Strait Islanders in the 25 Year Strategic Plan (GBRMPA 1994).

At the outset, the document states that:

> Nothing in this Strategic Plan is intended to diminish or extinguish native title. In implementing this Plan, agencies and other organisations will endeavour to ensure that they do not take any action which might unintentionally affect native title. In the implementation of this Plan the rights and interests of native title holders will be treated according to Commonwealth and State laws and the common law (GBRMPA 1994:viii).

The Strategic Plan records that the process involved in developing the plan specifically involved Aboriginal and Torres Strait Islander groups. Among the Shared Principles which managers and users of the Area should continue to use for guidance in implementing the Plan are:

- Recognition of the special situation of Aboriginals and Torres Strait Islander people, especially their needs for culturally appropriate negotiation, and the relationships of Aboriginals and Torres Strait Islander people with the resources of the World Heritage Area.
- Recognition of the right of Aboriginals and Torres Strait Islanders to determine if, and how, information regarding their cultures should be gathered and used (GBRMPA 1994:7).

The Strategic Plan has a section discussing the impact of the Mabo decision on the Plan and sets out the consequential position that Aboriginal and Torres Strait Islander groups are therefore currently unable to endorse the Plan.

The Strategic Plan is positive about the cultural values of significance to these groups, one of its 5 year Conservation Objectives (1.10) being:

> To protect the cultural heritage of the Area as represented by archaeological and historical sites and other places of importance and/or, in accordance with the Burra Charter, sites of religious or cultural importance to Aboriginals and Torres Strait Islander (GBRMPA 1994:17).

Strategies to meet this objective are:

- 1.10.1 Identify and record archaeological and historical sites and other places of significance.
- 1.10.2 In negotiation and cooperation with Aboriginals and Torres Strait Islanders accelerate, where appropriate, the identification and recording of archaeological, religious or cultural sites of historic significance which they wish to be documented.
- 1.10.3 Through a process of negotiation develop conservation and protective programs for sites and places and for Aboriginal and Torres Strait Islander sites with the agreement of the traditional owners.
- 1.10.4 Where, appropriate, assess the local, national and international significance of sites (GBRMPA 1994:17–18).

These provisions indicate a commendable degree of sensitivity to cultural attributes and this is further exemplified in one of the 5 year Resource Management Objectives (2.4) which is:

> To develop, implement and evaluate management plans for specific sites of high use and/or conservation and/or heritage value as required (GBRMPA 1994:21),

Strategy 2.4.1 adds, *inter alia,* that:

> Where this involves sites of significance to Aboriginals and Torres Strait Islanders, this should only be done where they desire it (GBRMPA 1994:21).

Research and Monitoring Objective 4.10 recognises the contribution which can be made to management by traditional knowledge. This proposes:

> To develop, in conjunction with Aboriginals and Torres Strait Islanders, an understanding of their marine resource use, management practices and maritime knowledge (GBRMPA 1994:29).

This objective's strategies are to:

- 4.10.1 Conduct research on ecological sustainability of traditional hunting, fishing and gathering.
- 4.10.2 Conduct research on the effects of non-traditional use on the harvesting of those resources used traditionally by Aboriginals and Torres Strait Islanders.
- 4.10.3 Conduct research with Aboriginals and Torres Strait Islanders on appropriate cultural uses and sites, use rights and traditional maritime tenure and management (GBRMPA 1994:29).

The sixth section of the Strategic Plan is entitled *Recognition of Aboriginal and Torres Strait Islander Interests,* the rationale for which is that for thousands of years Aboriginals and Torres Strait Islanders have used the natural environment of the Area for both cultural and economic purposes in a ecologically sustainable way. It goes on to say that present and future management of the World Heritage Area should recognise this continuing use and that population changes, modern technology and other activities may impose increased pressure on resources requiring innovative management. The 25 Year Objective for this section of the Plan seeks:

> To have a community which recognises the interests of Aboriginals and Torres Strait Islanders so that they can pursue their own lifestyle and culture, and exercise responsibility for issues, areas of land and sea, and resources relevant to their heritage within the bounds of ecologically sustainable use and consistent with our obligations under the World Heritage Convention and other Commonwealth and State laws (GBRMPA 1994:35).

While the Strategic Plan takes significant cognisance of the Great Barrier Reef World Heritage Area's Aboriginal and Torres Strait Islander cultural values, it is relatively silent in relation to the Area's European history. This is, of course, included in the Strategy's reference (already quoted) to a 5 year Conservation Objective:

> To protect the cultural heritage of the Area as represented by archaeological and historical sites and other places of importance... (GBRMPA 1994:17).

Furthermore there are subsequent references under *Resource Management* to developing, implementing and evaluating management plans 'for specific sites of high use and/or conservation and/or heritage value as required' (GBRMPA 1994:21), and, under the education section, to informing the community of, *inter alia,* the cultural and heritage values of the Area and how to use it responsibly.

6.5 Conclusion

If the very laudable and farsighted objectives set out in the 25 year Strategic Plan are implemented consistently with the Plan's Objectives and Strategies in relation to the Aboriginal and Torres Strait Islander communities, then the practices followed in the management of the Great Barrier Reef World Heritage Area in relation to obligations towards the Area's cultural attributes would rank among the world's leading examples of a positive and sensitive approach. As indicated, there is also a need to direct appropriate attention to the significant cultural values relating to European exploration and past resource use.

To ensure that the obligations in respect of the cultural values continue to be met, it would be appropriate for the management authorities for the Great Barrier Reef World Heritage Area to take the following steps:

- *Undertake annual monitoring and reporting on the implementation of the Objectives and Strategies in relation to the cultural values of the Great Barrier Reef World Heritage Area and produce a progress report for the relevant stakeholders;*
- *Build a step into the planning and decision making processes for the Great Barrier Reef World Heritage Area which refers planners and decision makers to the Objectives and Strategies covering cultural values of the Great Barrier Reef World Heritage Area at each phase of the planning process and when considering decisions on permit and other relevant applications.*

It is clearly important in the Great Barrier Reef World Heritage Area, as a site listed for its natural values but containing significant cultural values, that the initiatives in the Strategic Plan in relation to cultural aspects as well as natural aspects are implemented and the monitoring and reporting process is undertaken in a timely fashion. This will ensure that stakeholders and the public at large, with whom the plan was developed with significant consultation, are kept informed and are able to have an input in future management of these values.

Chapter Seven: Conclusion

It was apparent, perhaps even prior to the commencement of this project, that we could not focus solely upon the so-called 'World Heritage values' of the Great Barrier Reef World Heritage Area in expanding and updating the justification for the inclusion of the area on the World Heritage List. We needed to consider the manner in which this, the final product, may be used. Clearly an expanded understanding of the attributes that give rise to the Great Barrier Reef World Heritage Area's 'outstanding universal value' would best be used to ensure that Australia meets its considerable obligations under the World Heritage Convention. Accordingly, in writing the report we have considered the future management of the Great Barrier Reef World Heritage Area, for its World Heritage status, concomitantly with consideration of the attributes that give rise to that designation.

The significant finding of the project is the recognition that the 'outstanding universal value', or the World Heritage value, of the Great Barrier Reef World Heritage Area rests upon two primary factors, namely:

- the scale of the Great Barrier Reef World Heritage Area; and
- the potential for effective conservation management.

This was a consistent and recurring theme from the experts consulted, covering the range of physical, biological and aesthetic attributes. It is acknowledged that neither of these factors can be justifications in their own right for World Heritage listing. However they are fundamental and pivotal in enabling the expression of those aspects of the region that do justify its inscription upon the World Heritage List.

It became apparent that World Heritage designation of a site is not necessarily inconsistent with the use of that site. Indeed, in the case of World Heritage Cities ongoing economic activity could not be halted. Similarly in the Great Barrier Reef World Heritage Area, its World Heritage designation is not necessarily inconsistent with some types of activities. Clearly, however, not all types of uses will be consistent with World Heritage designation. In all cases, managers must be cognisant of the Area's World Heritage status and the extra obligations that this designation places upon them. Indeed, World Heritage status must become a **key material consideration** in the planning and management of the Great Barrier Reef World Heritage Area, and that management and planning for the Area is of the highest possible standard.

7.1 Issues of Scale

As noted, the scale of the Great Barrier Reef World Heritage Area is one of two fundamental factors giving rise to the 'outstanding universal value' of the Area. The longitudinal extent from low water mark on the mainland coast to past the edge of the continental shelf, and the latitudinal expanse from the tip of Cape York Peninsula to just north of Fraser Island, ensure that a highly diverse suite of habitats and environmental regimes at a range of spatial scales are represented in the one World Heritage Area. This habitat diversity gives rise to a vast range of species and ecological processes, natural beauty and experience opportunities.

Acknowledging that the size of the Great Barrier Reef World Heritage Area underlies its 'outstanding universal value', there is considerable danger, though much superficial attractiveness, in attempting to locate the significance at specific sites. The 'outstanding universal value' of the Great Barrier Reef World Heritage Area is a consequence of many attributes combining to produce a whole which cannot be reduced, without loss, to disconnected components.

7.2 Current Boundaries

It follows that any reduction in the area of the Great Barrier Reef World Heritage Area, to produce a site coincident with just a section or sections of the Great Barrier Reef Marine Park, or to identified core areas, would severely reduce the 'outstanding universal value' of the region. In contrast, expanding the area to include the Coral Sea reefs would enhance the World Heritage value through increased habitat and process diversity. It is likely that the community in general, (international, national and local), would be supportive of an expansion of the Great Barrier Reef World Heritage Area to include the Coral Sea reefs. The expansion of the Great Barrier Reef World Heritage Area to include the reefs of the Torres Strait would also increase the value of the Great Barrier Reef World Heritage Area. However, it is likely that local opposition by Torres Strait Islanders would be strong. Any reduction in the Great Barrier Reef World Heritage Area size is likely to be met with considerable public opposition.

7.3 Refuge Australia

The second fundamental factor giving rise to the Great Barrier Reef World Heritage Area's 'outstanding universal value' is the high potential for effective conservation management. The Great Barrier Reef World Heritage Area is relatively pristine in comparison to most comparable tropical coral reef ecosystems. Most other systems in the Indo-West Pacific region are under considerably more pressures from extractive uses, while the resources to effectively manage these sites are often limited or lacking. It has become apparent that, if the diversity of tropical coral reef ecosystems and the species they support is going to be conserved into the future, then the Great Barrier Reef World Heritage Area will play the fundamental and pivotal role.

7.4 Information Gaps

Despite the considerable research interest in the Great Barrier Reef, there are many areas where information is severely lacking. Even where research has primarily been focused, on coral reefs in the southern sections of the Great Barrier Reef World Heritage Area, there are still gaps in the knowledge base. This lack of knowledge demands judicious use of the precautionary principle when managing the Great Barrier Reef World Heritage Area. That is, where there are threats of serious of irreversible damage to the Great Barrier Reef World Heritage Area, the lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

In relation to World Heritage in general and the Great Barrier Reef World Heritage Area in particular, the most poorly understood natural heritage attributes are those concerned with criterion (iii), aesthetics and natural beauty. The lack of consistent methodologies to document, understand and assess these values must not be used as an excuse to ignore them. Furthermore, it is paramount to recognise that aesthetic value is not only about visual amenity, but rather incorporates considerable depth of meaning, understanding and attachment to a place or concept. It is likely that the rich tapestry of meanings that people associate with particular World Heritage Sites, rather than discrete biological or physical phenomena, are the basis for much conflict over what happens to these places. It is fundamental that the managers of the Great Barrier Reef World Heritage Area recognise the importance of aesthetic value and initiate research programmes to develop appropriate methodologies and management processes.

7.5 Cultural Attributes

The Great Barrier Reef was justified for inclusion upon the World Heritage List primarily for natural heritage, rather than cultural attributes, and was inscribed on the List as a natural site. Nonetheless the region contains attributes of significant cultural heritage value, both indigenous and European. These were not considered in detail in this consultancy, however we urge that a similar consultancy to this be charged with documenting the cultural heritage attributes of the Great Barrier Reef World Heritage Area. Furthermore we believe that such a study should investigate the benefits and disadvantages of renominating the Great Barrier Reef World Heritage Area as a cultural landscape.

We believe that the Strategic Plan offers a number of strategies and objectives in relation to cultural heritage that should be implemented. Furthermore, progress in achieving these objectives should be the subject of monitoring and annual reporting to relevant stakeholder groups. Similarly, planning and decision-making processes for the Great Barrier Reef World Heritage Area should have a reference to the Objectives under the Strategic plan built into them.

7.6 Implementing the Plan

It was refreshing for us to realise that much of the hard work in forging a new vision and way forward for the management of the Great Barrier Reef World Heritage Area had already been carried out. The *25 Year Strategic Plan for the Great Barrier Reef World Heritage Area* (GBRMPA 1994) presents a vision for the future, and establishes a number of objectives and strategies to achieve it. The sections dealing with education, legislation, conservation, education, monitoring and reporting are particularly relevant to meeting Australia's international obligation under the World Heritage Convention.

However, unless the plan is implemented effectively and with continuing commitment, its vision will not be realised. As the middle of the first five-year implementation segment is approaching, the initial implementation review has yet to commence. Undoubtedly, the resource implications of implementing the plan are considerable. It is incumbent, however, upon the Commonwealth to ensure its implementation as this will significantly contribute to meeting its obligations under the Convention and will also meet the expectations of those stakeholders who provided significant input into the evolution of the Strategic Plan.

7.7 Australia's Leadership

Internationally, Australia has taken a lead in implementing the World Heritage Convention, and, it is Australia's responsibility to continue to improve and advance its World Heritage practice by continuing to set an example for the rest of the world. It is clear that Australia is the primary hope for future conservation of the world's tropical coral reefs and associated ecosystems. The commissioning of this project itself has drawn considerable international interest, and further demonstrates that Australia is serious in its commitment to the Convention. However, Australia cannot afford to rest on its past record with World Heritage but, rather, it must improve and enhance its implementation of the Convention. Only by doing this will the Great Barrier Reef World Heritage Area remain truly of 'outstanding universal value' in the millennium to come.

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Appendixes

Appendix 1:

Boundaries of the Great Barrier Reef World Heritage Area

The Great Barrier Reef World Heritage Area is the area the boundary of which –

(a) commences at the point that, at low water, is the northernmost extremity of Cape York Peninsula, Queensland;

(b) runs thence easterly along the geodesic to the intersection of parallel of Latitude 10°41' South with meridian of Longitude 145°00' East;

(c) runs thence southerly along that meridian to its intersection by the parallel of Latitude 13°00' South;

(d) runs thence south-easterly along the geodesic to a point of Latitude 15°00' South Longitude 146°00' East;

(e) runs thence south-easterly along the geodesic to a point of Latitude 17°30' South Longitude 147°00' East;

(f) runs thence south-easterly along the geodesic to a point of Latitude 21°00' South Longitude 152°55' East;

(g) runs thence south-easterly along the geodesic to a point of Latitude 24°30' South Longitude 154°00' East;

(h) runs thence westerly along the parallel of Latitude 24°30' South to its intersection by the coastline of Queensland at low water; and

(i) runs thence generally northerly along that coastline at low water to the point of commencement.

(Source: GBRMPA 1981, Nomination of the Great Barrier Reef by the Commonwealth of Australia for Inclusion in the World Heritage List, *Great Barrier Reef Marine Park Authority, Townsville)*

Appendix 2: Individuals Interviewed or Consulted

Alderslade, P.	Museum and Art Gallery of the Northern Territory, Darwin
Arnold, P.	Museum of Tropical Queensland, Townsville
Batianoff, G.	Queensland Herbarium, Brisbane
Birtles, A.	Department of Tourism, James Cook University, Townsville
Brouwer, C.	Catherine Brouwer Landscape Architects, Brisbane
Bruce, A.J.	Queensland Museum, Brisbane
Cameron, C.	Parks Canada, Ottawa, Canada
Cannon, L.	Queensland Museum, Brisbane
Cappo, M.	Australian Institute of Marine Science, Townsville
Cleere, H.	ICOMOS, Paris, France
Corkeron, P.	Department of Tropical Environment Studies and Geography, James Cook University, Townsville
Craik, W.	National Farmers' Federation, Canberra
Davie, P.	Queensland Museum, Brisbane
De Vantier, L.	Australian Institute of Marine Science, Townsville
Dinesen, Z.	Great Barrier Reef Marine Park Authority, Townsville
Drew, E.	Australian Institute of Marine Science, Townsville
Duke, N.	Consultant, Townsville
Fielden, B.	ICCROM, Norfolk, United Kingdom
Fromont, J.	Department of Zoology, James Cook University, Townsville
Furnas, M.	Australian Institute of Marine Science, Townsville
Furrer, B.	Denkmalpflege der Stadt Bern, Berne, Switzerland
Haigh, D.	Law School, James Cook University, Townsville
Henderson, B.	Department of Earth Sciences, James Cook University, Townsville
Hopley, D.	Sir George Fisher Centre, James Cook University, Townsville
Hulsman, K.	Faculty of Environmental Studies, Griffith University
Hutchings, P.	Australian Museum, Sydney
Jokilehto, J.	ICCROM, Rome, Italy
Junius, M.	Organization of World Heritage Cities, Quebec, Canada
Kelleher, G.	IUCN Commission on National Parks and Protected Areas, Canberra
Kenchington, R.	Great Barrier Reef Marine Park Authority, Canberra
Kott, P.	Queensland Museum, Brisbane
Lee Long, W.	Northern Fisheries Centre, Department of Primary Industries, Cairns
Limpus, C.	Queensland Department of Environment, Brisbane
Loch, I.	Australian Museum, Sydney
Lough, J.	Australian Institute of Marine Science, Townsville

McNeely, J.A.	IUCN – The World Conservation Union, Gland, Switzerland
McColl, H.	Horseshoe Bay, Magnetic Island
Mellors, J.	Department of Tropical Environment Studies and Geography, James Cook University, Townsville
Miller, G.	Queensland Department of Environment, Townsville
Milne, R.C.	World Heritage Centre, UNESCO, Paris, France
O'Neill, P.	Queensland Department of Environment, Rockhampton
Otton, J.	Banff National Park, Banff, Canada
Owens, K.	Queensland Department of Environment, Brisbane
Paine, J.	World Conservation Monitoring Centre, Cambridge, United Kingdom
Pantus, F.	Great Barrier Reef Marine Park Authority, Townsville
Phillips, A.	Commission on National Parks and Protected Areas, IUCN – The World Conservation Union, United Kingdom
Ponder, W.	Australian Museum, Sydney
Pound, C.	Bath City Council, Bath, United Kingdom
Price, I.	Department of Botany and Agricultural Science, James Cook University, Townsville
Ramsy, J.	Australian Heritage Commission, Canberra
de Paz Campillos, R.	City of Toledo, Spain
Rossler, M.	World Heritage Centre, UNESCO, Paris, France
Short, M.	Queensland Department of Environment, Cairns
Sparkes, S.	Great Barrier Reef Marine Park Authority, Townsville
Stokes, T.	Great Barrier Reef Marine Park Authority, Townsville
Thorsell, J.	IUCN – The World Conservation Union, Gland, Switzerland
Veron, J.E.N.	Australian Institute of Marine Science, Townsville
von Droste, B.	World Heritage Centre, UNESCO, Paris, France
Walkden, J.	Picnic Bay, Magnetic Island
Ward, T.	Department of Tropical Environment Studies and Geography, James Cook University, Townsville
Williams, D.	Australian Institute of Marine Science, Townsville
Winkel, P.	Department of Zoology, James Cook University, Townsville
Zinkan, C.	Banff National Park, Banff, Canada

Appendix 3: Natural Heritage Attributes of the Great Barrier Reef World Heritage Area in the Original Nomination

- geological and geomorphological evolution of the reef structure;
- morphological diversity of the reef;
- evolution of coral cays;
- bird and plant colonisation of coral cays;
- area of great natural beauty;
- diversity of life-forms including:
  - endemic species;
  - 400 species of coral in 60 genera;
  - foraminifera;
  - echinoderms;
  - crustaceans;
  - polychaete worms;
  - ascidians;
  - over 4000 species of molluscs;
  - 1500 species of fishes;
  - 6 species of sea turtles;
  - whales and dolphins;
  - sea birds with breeding colonies;
  - land birds;
  - fleshy algae;
- diverse ecosystems:
  - coral communities;
  - seagrass beds;
  - mangrove communities;
  - low wooded islands;
  - sand cays.

(Source: GBRMPA 1981, Nomination of the Great Barrier Reef by the Commonwealth of Australia for Inclusion in the World Heritage List, *Great Barrier Reef Marine Park Authority, Townsville)*

Appendix 4:
Natural Heritage Attribute Summary Papers

Natural Heritage Attribute: Aesthetics

SOURCE:

Note: Unlike other natural heritage attributes, there was no 'expert' who provided the information for this summary, rather a number of people assisted in providing references or other information and comments.

CONCLUSIONS:

- attributes that satisfy natural heritage criterion (iii) are difficult to measure;
- the aesthetic qualities of the Great Barrier Reef World Heritage Area are significant, and contribute to the Area's 'outstanding universal value';
- aesthetic qualities incorporate visual and seen attributes, as well as a range of community held perceptions about the Great Barrier Reef World Heritage Area.

CRITERIA:

(iii)

DISCUSSION:

The legitimacy for considering the aesthetic qualities and natural beauty of properties nominated for inclusion in the World Heritage List is contained within the first and third paragraphs of the natural heritage definition given in Article 2 of the Convention. The definition is expanded upon in the Operational Guidelines where under criterion (iii) a property may be inscribed upon the list if it:

> contains superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance (World Heritage Committee 1996:13).

The associated condition of integrity requires that sites:

> should be of outstanding aesthetic value and include areas that are essential for maintaining the beauty of the site; for example, a site whose scenic values depend on a waterfall, should include adjacent catchment and downstream areas that are integrally linked to the maintenance of the aesthetic qualities of the site (World Heritage Committee 1996:13–14).

From past nominations it appears that once a nominated property has satisfied at least one other criterion, criterion (iii) seems to be satisfied by general and cursory statements in the nomination document. Past nominations have not canvassed the satisfaction of criterion (iii) in any systematic manner, as has been the case for the three other natural heritage criteria. Renewed attention was recently placed upon criterion (iii) during the evaluation of the Glacier Bay/Waterton site in 1995, in which IUCN drew attention to the lack of detailed guidance on the interpretation of criterion (iii) (IUCN 1995). Additionally, an Expert Meeting held in 1996 at Parc National de la Vanoise recommended that criterion (iii) be used only in conjunction with another natural or cultural heritage criterion, and that the Operational Guidelines be amended accordingly. This approach has been the informal practice in the past.

The difficulty in dealing with criterion (iii), in either a nomination phase or an evaluation phase, is that the criterion relates more to a social construct than some physical or biological phenomenon as do the other three criteria. This is not to suggest that criterion (iii) can not be evaluated systematically, but rather the type and style of such evaluation will be qualitatively different from those used for criteria (i), (ii) and (iv). It may be that the cursory attention that criterion (iii) receives in both the nomination phase, by States Parties, and the evaluation phase, by the IUCN, has its origins in the predominantly biological and physical science focus of the personnel generally involved.

In interpreting the natural beauty and aesthetic criterion, Turner (1990:38) remarks:

> The tallest mountain, the most spectacular waterfall, the longest glaciers, and in Australia's case, the largest rock, tend to be the features more generally thought of as world heritage properties.

The 'highest' and 'largest' interpretation stems from the initial version of criterion (iii) contained within the first set of Operational Guidelines. The first version of the Operational Guidelines contained references to 'Angel Falls

– the world's highest waterfall', and the '*Sequoia gigantea* trees of California – the largest living organism', as examples of phenomena that may satisfy criterion (iii). The focus on the highest and the largest was removed from the criterion in 1977.

In focusing upon the 'highest' and 'largest' features to satisfy criterion (iii) attention is placed primarily upon the visual qualities of the property. Such a focus may ignore the broader range of aesthetic qualities associated with a property. Schapper (1994:5) notes that:

> ...our concept of aesthetic value encompasses more than seen view, visual quality or scenery, and may include atmosphere, landscape character and sense of place.

The Expert Meeting noted that aesthetics and natural beauty can best be assessed through the cultural perceptions of an area. The *Burra Charter* developed by Australia ICOMOS remarks:

> Aesthetic value includes aspects of sensory perception for which criteria can and should be stated. Such criteria may include consideration of the form, scale, colour, texture and material of the fabric; the smells and sounds associated with the place and its use (Australia ICOMOS 1988:1).

Greater attention to the aesthetic qualities of a site during nomination, evaluation and subsequent management, will necessitate the development of appropriate methodologies to enable the more precise documentation of these qualities.

Two studies which have specifically dealt with aesthetic values in the context of World Heritage are worthy of consideration. Prineas and Allen (1992) carried out an assessment of the scenic quality of the Wet Tropics World Heritage Area, and Harding et al. (1987) assessed the aesthetic value of Stage Two of Kakadu National Park.

Using photographs to represent scenic units from within the Wet Tropics World Heritage Area Prineas and Allen (1992) asked respondents to rank each scene based upon their opinion of its attractiveness. Ranking was also sought on scenes from other Australian World Heritage Sites. Multiple regression analysis of scenic quality and quantifiable features (e.g. size of rivers and streams, presence of coastline, presence of coral etc.) in the scenes produced a predictive model of scenic quality for the Wet Tropics World Heritage Area. In general Prineas and Allen (1992) found:

> that scenic quality differences did exist and that there was a high level of consistency in people's preferences for the various landscapes represented (Prineas & Allen 1992:242).

It is important to note that this study focused upon scenic quality of the Wet Tropics World Heritage Area and not the totality of aesthetic value. Furthermore the study focused upon landscape rather than specific site locations.

Harding et al. (1987) adopted an expert approach in their assessment of the aesthetic quality of Stage Two of Kakadu National Park. Interviews with people who had long exposure to the region were used to initially identify phenomena of aesthetic importance. These were mapped and field visits were carried out to locate additional phenomena. Expert assessment of the various phenomena and comparison with the other areas of the biogeographic province was carried out both on-site and through the aid of video, print and transparencies. In some cases artistic and literary works were also included. Six aesthetic phenomena were identified for Stage Two of Kakadu National Park:

- evocative contrast between lushness of the flood plain and the dryness;
- scale of features;
- large numbers of magpie geese, crocodiles;
- contrast of form between escarpment/outliers and flood plain;
- dramatic seasonal change;
- Aboriginal culture (Harding et al. 1987).

In the case of the Great Barrier Reef World Heritage Area, the nomination contained the following remarks:

> It is acknowledged to be an area of great natural beauty and wonder (GBRMPA 1981:2).
>
> The Great Barrier Reef provides some of the most spectacular scenery on earth and is of exceptional natural beauty (GBRMPA 1981:6).
>
> The Great Barrier Reef thus meets all four criteria set out in Article 2 of the World Heritage Convention:
>
> (i) ...
>
> (ii) ...
>
> (iii) containing unique, rare and superlative natural phenomena, formations and features and areas of exceptional natural beauty... (GBRMPA 1981:6).

These general statements are supported through photographic evidence presented in the nomination. Additional comments contained in descriptions of biological phenomena also give support to satisfaction of criterion (iii). For example:

> Some of the better known [molluscs] are trochus shells which are found in coral rubble and on coral and rocky reefs, helmet shells which are readily visible on the sea floor and coral sands of the Reef, and the variously coloured species of cowrie shell. Perhaps the most conspicuous lamellibranchs on the Reef are the giant clams of the family Tridacnidae (GBRMPA 1981:13);

and

> There are approximately 1500 species of fishes in the Great Barrier Reef area, exhibiting a variety of size, shape, colour and behaviour...Large and colourful demersal (bottom-living) species... small [and] brightly coloured territorial fishes... (GBRMPA 1981:13).

Most research and studies into aesthetic values have focused primarily upon terrestrial environments, with studies into marine and coastal environments being rare. In the case of the Great Barrier Reef World Heritage Area, its aesthetic values have not been systematically investigated, although two recent initiatives have made important contributions in this area. However, they are limited to scenic amenity.

A visual landscape evaluation procedure tailored for the Queensland coastline was recently developed for the Queensland Department of Environment. The procedure was informed by a public perception study, and trialled in the Whitsunday region. Guidelines for development with regard to visual amenity were also drafted (Catherine Brouwer Landscape Architects & Chenoweth & Associates Pty Ltd 1994).

The coastal zone was regarded as a highly scenic landscape due to:

- expansive water views;
- the contrast and diversity of the land water interface;
- movement and diversity in the water, particularly at its edge; and
- the diversity due to coastal form (Catherine Brouwer Landscape Architects 1994).

A set of scenic quality criteria were developed in order to assess the scenic quality of coastal landscapes. The parameters determining scenic quality are naturalness; built: form and identity; vegetation: diversity and contrast; landform: diversity and contrast; shoreline: diversity and contrast; and water: presence, extent and visual character (Catherine Brouwer Landscape Architects & Chenoweth & Associates Pty Ltd 1994).

The procedure has been used in the Whitsunday region, and a set of guidelines for the management of visual qualities were drafted. The areas considered to be of high or very high scenic quality are identified in Table 1.

The second study of interest is entitled *A View of the Coast, An Overview of the Scenic Resources of the Queensland Coast.* This is a state-wide scenic quality assessment of the entire Queensland coast that is being carried out for the Coastal Management Branch of the Queensland Department of the Environment (EDAW 1996). The report is currently in draft form and should be finalised shortly. This study identifies a number of regional landscape types for the Queensland coast, for example 'major island group' and 'steep coastal range'. Based upon the assumptions that scenic quality increases with increases in topographic ruggedness, increases in the diversity of vegetation patterns and increases in water areas, scenic quality criteria are established for each regional landscape type. Following the classification of regional landscapes into the various types, assessment of scenic quality can be made within each landscape type. The benefit of this approach ensures that landscapes are assessed against other comparable landscapes. The study uses a rating scale for relative scenic quality of very high, high, moderate and common (EDAW 1996). Areas such as the Keppel Islands, Shoalwater Bay, Hinchinbrook, Whitsunday and Palm Islands are likely to receive very high scenic quality ratings.

Both the state-wide and Whitsunday studies focus only upon visual amenity and scenic beauty, thus they do not cover all aspects of aesthetic quality. During the Coastal Zone Inquiry, the Resource Assessment Commission analysed submissions and the transcripts of public hearings to identify the range of values and attitudes that groups and individuals hold about the coast zone (Resource Assessment Commission 1993). The Commission defined a range of value issue categories, one of which relates to aesthetic and experiential issues, referring to 'the variety of pleasures obtained from a particular landscape or locale' (Resource Assessment Commission 1993:17). Aesthetic importance will also include the existence and icon values associated with the Great Barrier Reef World Heritage Area.

It is clear that little work has been completed which allows the full range of aesthetic values which relate to the Great Barrier Reef World Heritage Area to be identified. As with other values, there are clearly many differences between individuals and some sense of the richness of these values may be gained by contrasting community views about Great Barrier Reef natural elements. For example the range of reactions to mangrove communities in Australian society or the different values placed upon a mudflat within the community. To date very few studies have been completed in this area of value description and analysis. One current study is exploring the underwater landscape elements which are most salient to snorkellers on the Great Barrier Reef (Birtles & Valentine CRC Reef project). Initial results indicate heterogeneity in form and colour are important for a positive snorkelling experience. Another study is attempting to identify the significance of the larger marine life for diving experience.

Additionally, aesthetic attributes were identified during interviews with experts on the range of natural heritage attributes. For example, comments were made concerning the aesthetic qualities of fringing reefs, large breeding colonies of birds, some species of bryozoans, polyclad turbellarians, diversity in the shape, size and colour of fishes, aggregations of fish, feather stars, other echinoderms, gorgonian and soft corals, and aggregations of butterflies.

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Table 1. Areas of the Whitsunday Region of High or Very High Scenic Quality

Cape Gloucester to George Point region	Cape Gloucester	very high
	George Point	very high
	Dingo Beach	high
George Point to Bluff Point	Mt Dryander	very high
	Olden Island	high
	Earlando	high
	Clark's Cove	high
	Charley's Creek	high
Bluff Point to Pioneer Point	Mandalay	high
	Funnel Bay	high
Pioneer Point to Cape Conway	Molle Channel	very high
	Shute Harbour	very high
	Grants Bank	very high
	Long Island Sound	very high
	Conway Range	very high
	Cape Conway	very high
Cape Conway to Midge Point	Repulse Bay	high
Molle Group Islands	South Molle East	very high
	North Molle West	high
	North Molle East	high
	South Molle	high
	Long Island East	high
Whitsunday Group	Cid Harbour	very high
	Whitehaven	very high
	Hamilton East	very high
	Hayman	high
	Lindeman	high

(Source: Catherine Brouwer Landscape Architects & Chenoweth & Associates Pty Ltd 1994)

Natural Heritage Attribute: Algae

SOURCE:

Prof. I. Price, Department of Botany and Tropical Agriculture, James Cook University, Townsville

CONCLUSIONS:

- Great Barrier Reef World Heritage Area benthic macroalgae are typical of the Indo-West Pacific region, with moderately high diversity but relatively low endemism;
- approximately 400–500 species of macroalgae occur in the Great Barrier Reef World Heritage Area;
- importance of the Great Barrier Reef World Heritage Area is by virtue of its latitudinal and cross-shelf extent giving rise to a huge variety of habitats;
- algae are important in cementing reef structures;
- algae are significant contributors to reefal and inter-reefal sediments;
- algae are the primary producers of reefal systems as zooxanthellae, macroalgae (including seaweed and turf algae) and phytoplankton;
- important food resource for numerous animals, especially fishes.

MOST RELEVANT CRITERIA:

(ii), (iv)

SEE ALSO:

Halimeda Banks

Phytoplankton

DISCUSSION:

The major types of algae in the Great Barrier Reef World Heritage Area are phytoplankton, zooxanthellae, and benthic macroalgae such as seaweeds (e.g. *Halimeda*), turf algae and crustose coralline algae. Approximately 400–500 species of macroalgae are found in the Great Barrier Reef World Heritage Area (Price, I. 1996, pers. comm.). It is likely that most species of macroalgae in the Great Barrier Reef World Heritage Area have already been recorded, but additional species will almost certainly be found. The red algae (Rhodophyta) are the most diverse macroalgae in the Great Barrier Reef World Heritage Area, with approximately twice as many species as there are brown algae (Phaeophyta) or green algae (Chlorophyta). More than 155 species of red algae from more than 25 families have been recorded from the Capricorn–Bunker region of the Great Barrier Reef World Heritage Area alone (Cribb 1983). Furthermore a number of primitive red algae have been recorded in the Great Barrier Reef World Heritage Area (Larkum et al. 1977). The macroalgae of the Great Barrier Reef World Heritage Area is typical of that found throughout the tropical Indo-West Pacific region, and consequently levels of endemism are low (Price, I. 1996, pers. comm.).

It would be difficult to argue on grounds of algae diversity or endemism alone that the Great Barrier Reef World Heritage Area is of greater value than other areas in the Indo-West Pacific region. However, the value of the region stems from its wide variety of reef types and environmental regimes, giving rise to a range of diverse habitats over a wide latitudinal range. This value is enhanced by the potential for adequate conservation management in this region as compared to other areas of the Indo-West Pacific (Price, I. 1996, pers. comm.).

Algae perform a number of fundamental roles in coral reef ecosystems. They are the major, if not the only primary producers in reefal systems, as free living benthic macroalgae and phytoplankton, but also importantly as zooxanthellae, the symbiotic unicellular algae in the tissues of corals (Larkum 1983). Studies over a variety of reefs have found that despite differences in reef structure and biota, in general the levels of primary production are remarkably similar (Barnes et al. 1986). Some algae are also important fixers of nitrogen, e.g. *Trichodesmium*. The benthic algae are the major food source for grazing animals, particularly fishes and molluscs. However, the turf-forming algae are the most important food source for herbivorous reef animals (Price & Scott 1992).

Calcareous algae are major contributions to the production of sediments in both reefal and inter-reefal environments (see *Halimeda* Banks) (Borowitzka 1983). Analysis of the composition of reef rock and surface reef sediments has shown their origins to be a mixture of coral (28%), coralline algae (30%), *Halimeda* (30%), and foraminifera (10%) (Maxwell 1972). Thus 60% of reef sediments and reef rock were found to be algal in origin.

In addition to being important producers of sediment, algae are also important cementing agents in coral reef systems. The crustose coralline algae of the red algal family Corallinaceae are particularly important in this respect (Borowitzka 1983). These algae encrust and cement the carbonate deposits adding considerable strength to reefal structures, particularly on the high energy windward margins of reefs. Other benthic macroalgae contribute to the bio-erosion of reef structures by dissolving away calcium carbonate substrata.

Latitudinal and cross-shelf gradients in algal abundance and distribution have been observed in the Great Barrier Reef World Heritage Area, although these have not been reported in detail. However, a series of large scale surveys of algal distributions and abundance have been recently conducted in the Central and Cairns Sections of the Great Barrier Reef Marine Park, and the results are presently being analysed (McCook, L.J. & Price, I.R. in prep.). Within reef zonation is also apparent with different taxa occupying different zones of a single reef, and a high degree of uniformity in species composition when similar zones between reefs are compared (Cribb 1993; Morrissey 1980).

The understanding of the algae of the Great Barrier Reef World Heritage Area is restricted by the poor resolution in algal taxonomy. This, and the paucity of information on the distribution of algae in the Great Barrier Reef World Heritage Area are two areas that need considerable effort to better understand the contribution of algae to the 'outstanding universal value' of the Great Barrier Reef World Heritage Area.

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Natural Heritage Attribute: Ascidians

SOURCE:

Dr P. Kott, Queensland Museum, Brisbane

CONCLUSIONS:

- at least 330 species of ascidians are likely to occur in the Great Barrier Reef World Heritage Area; and a further 100 or more indigenous Australian temperate species appear to have been derived from the tropical fauna that flourishes in the reefal habitats of the Great Barrier Reef World Heritage Area;
- most species occurring in the Great Barrier Reef World Heritage Area occupy a vast geographic range covering its latitudinal length;
- the Great Barrier Reef World Heritage Area acts as a bridge for ascidians between tropical and temperate waters, providing the reefal habitats that accommodate the extension of the range of tropical species to the south, at least to the Tropic of Capricorn, and by providing candidates for speciation in the temperate waters of Australia, contributes to the species diversity of the continent;
- The Great Barrier Reef World Heritage Area is an avenue for gene flow which contributes to the genetic diversity of the Indo-West Pacific tropical fauna by accommodating populations of tropical species well to the south of their usual range.

MOST RELEVANT CRITERIA:

(iv)

DISCUSSION:

The following discussion of ascidians was written by Dr P. Kott.

Natural Heritage Attribute: Ascidians

Dr P. Kott, Queensland Museum

Approximately 600 species of the Ascidiacea (of about 2000 known worldwide) are recorded from Australian waters. Of these only 10 have a range that suggests they are relicts of a Gondwanaland fauna. Some of the 200 species (approximately) recorded only from temperate waters, appear to be indigenous Australian species, some of which may have affinities with the southern fauna. The remainder together with species exclusively from tropical waters or with a continuous range from tropical to temperate waters can be regarded as having their origin in the tropics.

Only one genus, *Sycozoa,* is well represented in the southern oceans, is not generally known from the tropics and can, with confidence be regarded as having an origin in the Southern Ocean. The genera *Pyura, Synoicum, Polyclinum* and *Aplidium* are also more diverse in the Southern Ocean than in the tropics. However, there are more genera that appear to have radiated into temperate waters from the tropics than the reverse. Especially, the genera not recorded from south of the subtropical convergence can be said to be those that are most likely to have tropical affinities. These are *Pseudodiazona, Rhopalaea, Clavelina, Pycnoclavella, Sigillina, Hypodistoma, Polydistoma, Eucoelium, Polycitor, Eudistoma, Stomozoa, Exostoma, Brevicollus, Pseudodistoma, Monniotus, Euherdmania, Ritterella, Condominium, Phallusia, Perophora, Ecteinascidia, Plurella, Microgastra, Polycarpa, Polyandrocarpa, Oculinaria, Symplegma, Stolonica, Chorizocarpa, Botryllus, Botrylloides, Microcosmus, Ctenyura, Ctenicella, Halocynthia, Hartmeyeria, Herdmania.* The family Didemnidae is generally not well represented in the Southern Ocean. In tropical waters it is the most diverse family and most of the Australian species probably arise in the tropics.

Accordingly, by applying these considerations to the data set out in Kott (1985, 1990a, 1990b, 1992a, 1992b and unpublished) at least half of the 200 ascidian species reported exclusively from Australian temperate waters, the indigenous forms recorded only from tropical waters (about 150 species) and 180 species with a range from Australian temperate or tropical waters into the tropical Indian and/or West Pacific Oceans comprise the 430 species of the Ascidiacea from Australian waters that confidently can be said to have tropical affinities.

One of the characteristics of the components of the tropical ascidian fauna (for which most of the records come from reefal habitats) are the vast geographic ranges of so many of the species, not only into the Indian Ocean and/or Indonesia, the Philippines and west Pacific, but also down the length of the Great Barrier Reef, south to the Capricorn Group and sometimes beyond to the coastal locations off Moreton Bay and northern New South Wales (*Lissoclinium bistratum* see Kott 1982b). Few species recorded from the northern Great Barrier Reef do not also occur at Heron Island, one of the restraints possibly being a too high diurnal change for species occupying reef flat habitats (*Lissoclinium voeltzkowi* see Kott 1980).

Ascidians are fixed organisms, and gene flow and spread of populations can occur only through dispersal of gametes and larvae. Selective pressures restricting dispersal probably operate to ensure sufficiently crowded populations for internal (colonial habit) or external (solitary habit) fertilisation. Nevertheless, free-swimming larvae are invariably a part of the life history, although usually they are free-swimming for only very short periods (Kott 1982a). In view of the short time that larvae are free-swimming, it is probable that gene flow occurs by a complex web of recruitment between the crowded populations occupying the profusion of habitats in the vast Indo-West Pacific coralline region. In the very centre of this region is the Great Barrier Reef, its communities drawing their components and their genetic strength from the region to the north of the Australian continent and constituting a framework for the extension of tropical species into southern latitudes, even into temperate waters across the southern coast of the continent. Sometimes they speciate in these coastal habitats, where possibly the agents of gene flow are dispersed and are not recruited into existing populations, resulting in their isolation, and contributing to the marked diversity of the southern Australian ascidian fauna.

The Great Barrier Reef not only contributes to the genetic diversity of the tropical fauna of the Indo-West Pacific, but also acts as a bridge between the tropics and the temperate waters of the Australian continental shelf, contributing to the species diversity of the whole Australian continent and to the diversity of the class Ascidiacea throughout the world.

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Natural Heritage Attribute: Birds

SOURCE:

Mr T. Stokes, Great Barrier Reef Marine Park Authority, Townsville

Dr K. Hulsman, Australian Environmental Studies, Griffith University

Mr P. O'Neill, Queensland Department of Environment, Rockhampton

Mr M. Short, Queensland Department of Environment, Cairns

CONCLUSIONS:

- Great Barrier Reef World Heritage Area contains globally important area for seabirds, including breeding colonies for 22 species;
- Great Barrier Reef World Heritage Area is at the extremity of distribution for some species;
- areas that are of international importance to migratory shorebirds are adjacent to or included within the Great Barrier Reef World Heritage Area;
- Great Barrier Reef World Heritage Area contains populations of threatened species;
- birds play important roles in nutrient addition to cays, and the establishment of terrestrial flora;
- significant aesthetic value derived from large breeding colonies.

MOST RELEVANT CRITERIA:

(ii), (iii), (iv).

DISCUSSION:

One hundred and seventy-five species of birds, excluding those only recorded on continental islands, have been recorded from the Great Barrier Reef World Heritage Area (Kikkawa & Hulsman 1993). This fauna can be divided into seabirds, shorebirds (waders) and land birds.

Seabirds:

Australia's seabird fauna is represented by 110 species in 12 families, of which 76 species breed in Australia, and 34 are regular visitors in non-breeding seasons to Australia (Ross et al. 1995). The Great Barrier Reef World Heritage Area supports breeding colonies of 22[40] species of seabirds (Table 2), nesting on approximately 25% of Great Barrier Reef islands (Walker 1994). It is estimated that between 1.4 and 1.7 million seabirds breed annually in the Great Barrier Reef World Heritage Area, while non-breeding seabirds may add a further 425 000 to give a total in excess of 2 million seabirds within the Great Barrier Reef World Heritage Area (Walker 1994; Hulsman, K. 1996, pers. comm.).

King (1993) identified 58 significant islands with seabird colonies in Queensland, and a further 27 were considered to be important but of less significance. Of the 58 significant island sites, 54 are within the Great Barrier Reef World Heritage Area. The addition of Riptide Cay (O'Neill & Heatwole 1996) gives a total of 55 significant seabird islands in the Great Barrier Reef World Heritage Area (Table 3). The total number of significant and minor islands is being re-assessed and is likely to increase (Stokes et al. 1996; Hulsman, K. 1996, pers. comm.).

The Far Northern Section of the Great Barrier Reef Marine Park has the highest species diversity of seabirds with 22 species breeding in that Section (QDEH 1994). King (1993) identified 22 islands significant for seabirds in this Section. Frazer Muir in Stokes et al. (in press) considers there are more. Seabirds nest on about 34% of all islands in the Cairns and Far Northern Sections (Short, M. 1996, pers. comm.).

Raine Island supports the most diverse group of breeding tropical seabirds in the Great Barrier Reef World Heritage Area with 15 breeding species (Ogilvie & King 1993). It is situated at the far western extremity of the southern Pacific distribution of the Herald Petrel, and it is the only location within Australia where this species nests (Walker 1994). In addition to the Herald Petrel, Raine Island supports four other species that are uncommon elsewhere in the Great Barrier Reef World Heritage Area; the Red-footed Booby which apart from Raine Island has many pairs on Moulter Cay and Sandbank No. 7 (Short, M. 1996, pers. comm.); the Red-tailed Tropicbird which only occurs upon Raine and Lady Elliot Islands; the Great and Lesser Frigatebirds (Ogilvie & King 1993; Walker 1994; WBM Oceanics Australia 1995). Furthermore the largest colonies in the Great

[40] In some cases the number of breeding seabirds in the Great Barrier Reef is given as 24 (e.g. King 1993), including two species normally considered as shorebirds, namely the Eastern Reef Egret and the Nankeen Night Heron.

Barrier Reef World Heritage Area of the Masked Booby are found on Raine Island (Walker 1994), and of Lesser Frigatebirds on Quoin Island with 500 pairs, about 2.5% of the Australian population (Short, M. 1996, pers. comm.). The Roseate Tern is threatened in the northern hemisphere and the Great Barrier Reef population is thought to be 15% of the remaining world population (Walker 1994). The principal breeding areas for this tern are a group of inner-shelf cays off northern Cape York Peninsula and in the Capricorn–Bunker group of islands (Walker 1994).

In the Cairns Section, 4 islands are recognised as being significant, namely Eagle Island, Rocky Islet, Michaelmas Cay and the South Barnard Islands (King 1993). Michaelmas Cay is considered to be the second most important site for seabird breeding in the Great Barrier Reef World Heritage Area (Hulsman, K. 1996, pers. comm.). However, over the past decade there have been significant declines in the breeding populations of the Sooty Tern (25% decline), Common Noddy (45% decline), and the Crested Tern (De'ath 1994). Human activity is the likely cause of the population decline, with over 70 000 people visiting the Cay annually (Hulsman, K. 1996, pers. comm.). However, this may not be the sole cause of the decline (Stokes, T. 1996, pers. comm.).

Five significant islands are located in the Central Section, including Eshelby Island which has the largest known colony of Bridled Terns in the Great Barrier Reef World Heritage Area (Ogilvie & King 1993).

The Mackay/Capricorn Section has 22 islands with significant colonies of seabirds (King 1993), supporting 18 of the 24 species that breed in the Great Barrier Reef World Heritage Area (Ogilvie & King 1993). In particular the 12 cays of the Capricorn–Bunker Group support 73–75% of all seabird biomass in the Great Barrier Reef World Heritage Area, due to the presence of the most numerous species, the Wedge-tailed Shearwater and the Black Noddy (Walker 1994). Approximately 90% of the eastern Australia population of Wedge-tailed Shearwaters breed on the Capricorn–Bunker Islands, with North West Island as the nesting site for 50% of the number of seabirds of the Great Barrier Reef World Heritage Area (Walker 1994).

Of the seabird fauna of the Great Barrier Reef World Heritage Area, the Little Tern (*Sterna albifrons*) has been listed as vulnerable by the Queensland Government under the *Nature Conservation Act 1992*. Since 1980, 34 breeding events have been observed in Queensland, 26 within or adjacent to the Great Barrier Reef World Heritage Area (O'Neill 1995). These events suggest that breeding activity is concentrated in the Townsville/Whitsunday region. However, this is likely to be an artefact of increased survey effort in these areas. It is likely that far greater numbers breed in the Cairns and Far Northern Sections. It appears that in any one year 30 to 50 breeding pairs are likely to be found in the State (O'Neill 1995).

Two species of seabird, the Black Noddy (*Anous minutus*) and the Bridled Tern (*Sterna anaethetus*), are particularly important for the dispersal and establishment of *Pisonia grandis* on Great Barrier Reef cays. This is particularly evident in the Capricorn–Bunker group of islands (Walker 1991). Fourteen other species of seabird may also contribute to the dispersal of *Pisonia grandis* fruits and seeds (Walker 1991). Furthermore, avian guano from nesting Black Noddies and Bridled Terns may provide a competitive edge to the establishment and domination of *Pisonia grandis*, which has a unique mycorrhizal association that enables it to utilise guano at levels poisonous to other flora (Walker 1991).

Shorebirds:

The Great Barrier Reef World Heritage Area contains areas that are internationally important for the conservation of shorebirds. An area will be considered to be of international importance for migratory shorebirds under the Ramsar Convention if it regularly supports 20 000 or more shorebirds, or regularly supports 1% or more of the individuals in a population (Watkins 1993). Using these criteria Watkins (1993) identified 7 areas that are of international significance for shorebirds in or adjacent to the Great Barrier Reef World Heritage Area (Table 4). Bowling Green Bay and Shoalwater Bay have been listed as Ramsar sites. A December 1995 survey of shorebirds in Shoalwater Bay found that it supports internationally important numbers of 7 species, that is, more than 1% of the East-Asian–Australasian population, including the largest number of Whimbrel and second largest number of Terek Sandpipers in Australia (O'Neill, P. & Driscoll, P. 1996, pers. comm.). In December 1995, Moulter Cay supported 270 breeding pairs of Nankeen Night Herons (Short, M. 1996, pers. comm.).

The Beach Stone-curlew (*Esacus neglectus*) has been classified as vulnerable to extinction, with an Australian population estimated to be less than 1000 individuals (Garnett 1992b). It has been recorded from 134 islands in both the northern and southern Great Barrier Reef World Heritage Area (Garnett 1992a). Shoalwater Bay and the northern Great Barrier Reef are important areas for this species (QDEH 1994; Watkins 1993), with the Shoalwater Bay and Port Clinton area supporting the largest number in Australia – 90 individuals in 1995 surveys (O'Neill, P. & Driscoll, P. 1996, pers. comm.).

Land birds:

The avifauna of the continental islands of the Great Barrier Reef World Heritage Area is similar to the fauna of comparable habitats of the adjacent mainland (Kikkawa & Hulsman 1993). However, the Great Barrier Reef World Heritage Area is important to a number of land birds, including the Torresian Imperial Pigeon (*Ducula spilorrhoa*), and the Silvereye (*Zosterops lateralis*), which is the only species of bird which has been differentiated into a distinct morphological race on the Great Barrier Reef (Kikkawa & Hulsman 1993). The Torresian Imperial Pigeon migrates from Papua New Guinea to the Great Barrier Reef World Heritage Area where it breeds. The area between Cooktown and Cape York is the most important region for breeding, though breeding colonies extend to its southern limit at Aquila Island in Broad Sound (King 1990). Very large colonies of more than 10 000 pairs each occur on 6 low wooded islands, namely Hannibal, Night, Lowrie, Hay, Hannah, Pipon and Warham (King 1990). Large colonies of between 1000 and 10 000 breeding pairs occur primarily upon continental islands (King 1990). The pigeon feeds upon lowland rainforest and movement of the flocks take place in the morning and afternoon to feed on the mainland (King 1990). The pigeon is significant in introducing rainforest flora to the northern islands of the Great Barrier Reef World Heritage Area. A subspecies of the Silvereye (*Zosterops lateralis chlorocephala*) is an endemic to the islands of the Capricorn–Bunker group, where a small population exists (Garnett 1992a).

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Table 2. Breeding Seabirds of the Great Barrier Reef World Heritage Area

Procellariidae:	
Puffinus pacificus	Wedge-tailed Shearwater
Pterodroma arminjoniana	Herald Petrel
Pelecanidae:	
Pelecanus conspicillatu	Australian Pelican
Sulidae:	
Sula sula	Red-footed Booby
Sula dactylatra	Masked Booby
Sula leucogaster	Brown Booby
Phalacrocoracidae:	
Phalacrocorax varius	Pied Cormorant
Phalacrocorax melanoleucos	Little Pied Cormorant
Fregatidae:	
Fregata ariel	Lesser Frigatebird
Fregata minor	Great Frigatebird
Phaethontidae:	
Phaethon rubricauda	Red-tailed Tropicbird
Laridae:	
Larus novaehollandiae	Silver Gull
Hydroprogne caspia	Caspian Tern
Sterna dougallii	Roseate Tern
Sterna sumatrana	Black-naped Tern
Sterna fuscata	Sooty Tern
Sterna anaethetus	Bridled Tern
Sterna albifrons	Little Tern
Sterna bergii	Crested Tern
Sterna bengalensis	Lesser Crested Tern
Anous stolidus	Common Noddy
Anous minutus	Black Noddy

(Source: Ogilvie & King 1993)

Table 3. Significant Seabird Islands and Number of Breeding Species Recorded

Far Northern Section:	
Maclennan Cay	4
Cholmondeley Island	3
Moulter Cay	7
Wallace Island	9
Raine Island	15
Saunders Island	5
Bird Islands	7
Magra Island	2
Ashmore Banks	4
Piper Islands	4
Quoin Island	7
Chapman Island	4
Sherrard Island	6
Sandbank No.8	9
Sandbank No.7	6
Fife Island	6
Pelican Island	9
Stainer Island	7
Davie Cay	5
Tydeman Cay	8
Sandbank No.1	3
Stapleton Island	10
Combe Island	7

Cairns Section:	
Eagle Island	6
Rocky Islet	6
Michaelmas Cay	7
South Barnard Islands	6

Central Section:	
Purtaboi Island	4
Brook Islands	4
Holbourne Island	3
Eshelby Island	4
East Rock	4

Mackay/Capricorn Section:		
Redbill Island		2
Pelican Rock & Akens Island		7
Bacchi Cay		7*
Thomas Cay		6
Frigate Cay		10
Bylund Cay		6%
Price Cay		7
Bell Cay		9
Riptide Cay		3
Gannet Cay		3
North Reef Island		3
Tryon Island		7
North West Island		3
Wilson Island		6
Wreck Island		8
Heron Island		3
Erskine Island		7
One Tree Island		8
Masthead Island		8
Hoskyn Island	East	6
	West	6
Fairfax Island	East	6
	West	7
Lady Musgrave Island		6
Lady Elliot Island		9

(* currently 3; % currently 4)

(Source: King 1993; O'Neill & Heatwole in press; Stokes et al. in press; Walker 1994; O'Neill, P. 1996, pers. comm.; Short, M. 1996, pers. comm.)

Table 4. Areas of International Importance for Shorebirds in the Great Barrier Reef World Heritage Area

Armstrong Beach:	
	Pied Oystercatcher
Broad Sound–Shoalwater Bay:	
	Beach Stone-curlew
	Eastern Curlew
	Grey Knot
	Grey-tailed Tattler
	Pied Oystercatcher
	Terek Sandpiper
	Whimbrel
Bushland Beach:	
	Mongolian Plover
	Whimbrel
Finlaysons Point:	
	Pied Oystercatcher
Mackay area:	
	Bar-tailed Godwit
	Eastern Curlew
	Great Knot
	Mongolian Plover
	Ruddy Turnstone
	Sooty Oystercatcher
	Terek Sandpiper
Northern Great Barrier Reef:	
	Beach Stone-curlew
	Grey-tailed Tattler
	Mongolian Plover
	Pacific Golden Plover
	Pied Oystercatcher
	Ruddy Turnstone
	Sooty Oystercatcher
	Whimbrel
Ross River mouth:	
	Eastern Curlew
	Mongolian Plover
	Whimbrel

(Source: Watkins 1993; QDoE & Qld Wader Study Group, December 1995, Survey of Shoalwater Bay Shorebirds, unpub. data)

Natural Heritage Attribute: Bryozoans

SOURCE:

Dr P. Arnold, Museum of Tropical Queensland, Townsville

CONCLUSIONS:

- Indo-West Pacific region contains the highest diversity of bryozoans;
- Great Barrier Reef World Heritage Area contains an estimated 300–500 species of bryozoans (8–12% of world fauna);
- bryozoans along with sponges and ascidians form 'natural isolates' that provide important structure and habitats for other invertebrate species in areas of soft sediments;
- likely that the bryozoan fauna of reefal and shelf environments are distinct;
- some species particularly noted for their beauty.

RELEVANT CRITERIA:

(ii), (iii), (iv)

DISCUSSION:

The following discussion of the bryozoans was written by Dr P. Arnold.

Natural Heritage Attribute: Bryozoans

Dr P. Arnold, Museum of Tropical Queensland

Bryozoans (= Ectoprocta, Polyzoa) are colonial benthic (bottom-dwelling) animals, which are usually attached to hard, stable substratum. Hyman (1959) gave an estimate of 4000 living species, a figure generally accepted by subsequent authors (e.g. Ryland 1982; Nielsen 1995).

Bryozoans on coral reefs form relatively small colonies (millimetres to tens of centimetres in diameter) and occur in cryptic environments such as caves and under coral plates. They are thus generally inconspicuous although members of the family Phidoloporidae (= Reteporidae, Sertellidae), popularly known as lace corals, are often photographed by divers. Bryozoans have a good fossil record, which allows studies of speciation using both paleontological techniques and genetic analyses (e.g. Jackson & Cheetham 1994). They also provide good models for the study of life history patterns in colonial marine benthic invertebrates (as reviewed in McKinney & Jackson 1991). Only a few of these studies (e.g. Osborne 1984) have been carried out on coral associated species in the Great Barrier Reef region.

Bryozoans, sponges and ascidians form multispecies 'natural isolates' in the soft sediment environments of the Great Barrier Reef shelf (Birtles & Arnold 1988); these isolates provide much of the three dimensional structure of the bottom on the middle-shelf at depths greater than 22–23 metres. The natural isolates provide a stable substratum for other invertebrates (crustaceans, molluscs, echinoderms) and contribute to the high species diversity on the middle-shelf. The natural isolates may also act as food for certain omnivorous, grazing echinoderms and molluscs (Birtles & Arnold 1988). There have been important studies on adaptations of bryozoans to life in soft sediment, based on species from the Great Barrier Reef shelf (e.g. Cook & Chimonides 1978, 1981, 1985).

The taxonomy of Great Barrier Reef bryozoans is still poorly documented. The classic studies on Indonesian bryozoans by Harmer (1915, 1926, 1934, 1957) also included Australian material. The latter was mostly collected last century by dredging, and hence represented shelf rather than reef fauna. The bryozoans from the 1928–1929 Great Barrier Reef Expedition , reported on by Hastings (1932), were also collected by dredge and thus were mainly shelf species. Dr J.P. Ross collected bryozoans from reefs off Townsville, but only preliminary results were published (Ross 1974). Collections by Dr J.S. Ryland at Heron Island in the 1970s have only recently been documented (Ryland & Hayward 1992; Hayward & Ryland 1995). These very useful papers by Drs Hayward and Ryland represent the only modern taxonomic studies on coral reef associated bryozoans in the Great Barrier Reef region.

As with many other marine taxa, the Indo-West Pacific region contains the highest diversity of bryozoans. Harmer (1915, 1926, 1934, 1957) recorded 510 species and subspecies from the Indonesian archipelago. A combination of Harmer's species list and the compendium by Okada and Mawatari (1958) totalled 725 species for the Indonesia–Philippines region (Gordon 1984). These are undoubtedly underestimates. Ross (1974) noted that 208 species had been recorded from the Great Barrier Reef region, but with few from coral reef habitats. 124 species were recorded from Heron Island (Ryland & Hayward 1992; Hayward & Ryland 1995), 34 of which were newly described. The high percentage (27%) of new species almost certainly reflects the poor knowledge of this group in the Great Barrier Reef region, rather than a high degree of endemism. It also reflects more recent attention to detail in describing bryozoans, with regular use of the scanning electron microscope to document features. This has revealed a greater species diversity than recognised by earlier workers such as Harmer. I believe an estimate of 300–500 species would not be unrealistic for the Great Barrier Reef World Heritage area.

Jackson, Winston and Coates (1985) suggested that coral associated bryozoans had wide environmental tolerances, with the majority also occurring in non-reef habitats. This was based on distribution patterns of 65 species from the Caribbean. There may be a greater habitat specificity in the Indo-Pacific fauna. Hayward and Ryland (1995) noted that their coral reef collections contained few of the species previously reported from the Great Barrier Reef. As indicated previously, most of the early samples were from soft sediment habitats of the shelf. Present sampling of the Great Barrier Reef shelf off Townsville, as reported in Birtles and Arnold (1988), shows a greater overlap with the published species lists, which may indicate a distinct shelf fauna. Until results of ongoing detailed taxonomic studies on these shelf bryozoans are available, the extent of habitat specificity in bryozoans of the Great Barrier Reef region can not be accurately assessed. Work in progress on the shelf epifaunal invertebrates in general, however, strongly suggests that the fauna of reef and soft sediment shelf areas are distinct, and must be considered separately for management purposes.

There is no indication of a relict fauna among the bryozoans of the Great Barrier Reef World Heritage area, although some of the extant species have close relatives among the Tertiary fossils of Victoria and South Australia.

There is insufficient work to document any regional (north-south, cross-shelf) variation in reef associated bryozoans. Studies on the shelf bryozoans of the central Great Barrier Reef by Birtles and Arnold indicate a distinct cross-shelf variation. The inner shelf, less than 22–23 metres depth and dominated by terrigenous mud, has a depauperate, specialised fauna, including anchored colonies, e.g. *Retiflustra* Arnold 1987, *Sphaeropora*: Cook and Chimonides 1981, *Parmularia*: Cook and Chimonides 1985, as well as mobile epifaunal species in the genus *Selenaria*: Cook and Chimonides 1978. The middle-shelf (22–23 metres to about 45 metres depth) has a diverse encrusting fauna found on biogenic rubble and natural isolates, as well as erect, flexible algae. The true inter-reef fauna at depths of 45–100 metres is not known well enough to characterise this habitat. The upper slope (100 to 500 m) , however, contains a quite distinctive assemblage of free living, soft sediment bryozoans, many of which are similar to or identical with species on the south-eastern Australian slope (Arnold, unpub. data).

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Natural Heritage Attribute: Butterflies

SOURCE:

Mr P.S. Valentine, Department of Tropical Environment Studies and Geography, James Cook University, Townsville

CONCLUSIONS:

- 118 species have been identified within the Great Barrier Reef World Heritage Area, representing 30% of all known Australian butterflies;
- two endemic subspecies have been described;
- limited study of the Great Barrier Reef World Heritage Area butterflies has taken place;
- rapid speciation processes may be at work on some of the islands following the post-glacial sea-level rise, however studies are required;
- several rare and little-known species occur within the Great Barrier Reef World Heritage Area;
- remarkable migratory and aggregation records occur for some Great Barrier Reef World Heritage Area butterflies;
- the butterfly fauna have strong links with the coastal fauna and islands may provide relatively secure populations in the face of coastal development pressures;
- the addition of the Torres Strait area to the Great Barrier Reef World Heritage Area would add greatly to the butterfly richness and significance.

MOST RELEVANT CRITERIA:

(ii), (iii), (iv)

DISCUSSION:

The butterfly fauna of the Great Barrier Reef World Heritage Area have been subject to very limited study and systematic surveys have been completed for only a few islands, most of which have been summarised by Duckworth and McClean (1986). Incidental records do exist for some additional areas. For example there is a listing of species at Carlisle Island (Reeves 1988), and Scawfell Island (Moss 1995) and for some sites in the Whitsunday Islands (Valentine 1985:39). Occasional reference to species which are known from specific locations do add marginally to the information (e.g. Valentine 1988, 1993). It is possible therefore to give a partial list of species although there are certain to be large gaps in present knowledge.

Almost all butterfly sightings are confined to resident populations on the larger islands and it is clear that given the island ecosystem characteristics, especially the larger islands such as Hinchinbrook and the Whitsunday group, species richness might be similar to adjacent mainland areas. Occasional sightings occur of migratory behaviour some distance offshore (e.g. Valentine 1988; Moulds 1976). As pointed out by Common and Waterhouse (1981), the earliest observation of Australian butterflies known to science was the account in Joseph Banks' Endeavour journal of an encounter, on 29th May, 1770, with masses of a Danainae butterfly at Thirsty Sound (between Long Island and Quail Island offshore from St Lawrence). From the description provided (Beaglehole 1962) it is unclear which species was involved but it is likely to have been *Tirumala hamata*, the Blue Tiger, or *Euploea core*, the Common Australian Crow. Recently a massive aggregation of *Tirumala hamata* was recorded from Scawfell Island, involving an estimated tens of thousands of individuals. Such aggregations rival the famous Monarch Butterfly (*Danaus plexippus*) behaviour in north America (to which the Blue Tiger is closely related) and have already attracted attention for the spectacular aesthetic values involved. Other locations where overwintering aggregations occur within the Great Barrier Reef include Magnetic Island and Hinchinbrook Island. Additional migratory records relate to the skipper *Badamia exclamationis* which has an astonishing annual migration from the Torres Strait, Cape York Peninsula area south along the coast to Rockhampton during November and December with the returning generation heading north from March or April.

There are two subspecies of butterflies described which are known only from within the World Heritage Area. The large Lycaenidae from the Whitsunday Islands, described as *Ogyris zosine zolivia* Waterhouse (known as the Whitsunday Azure) was recorded from Hayman, Whitsunday and Lindeman Island (Common & Waterhouse 1981). I have recently (1992) confirmed its continued presence on Lindeman

Island despite some development pressures on its habitat. In its larval stage it requires a combination of mistletoe and a specific ant. Another subspecies occurs on the mainland. The second endemic subspecies within the Great Barrier Reef is the recently described skipper butterfly *Hesperilla malindeva dagoomba* Johnson & Valentine, so far known only from Magnetic Island (Johnson & Valentine 1994). The subspecific name is a local Aboriginal language name for Magnetic Island. More recently this species has been recorded from Scawfell Island in the Cumberland Group about 50 km offshore (Moss 1995). Individuals in this new sample of the species seem to display similar reduced maculation but may be more variable than the Magnetic Island subspecies and include characteristics shared with some mainland populations. There is a need for formal comparison with *H. m. dagoomba* to ascertain their subspecific status. No genetic work has yet been attempted on this species.

Elsewhere there are some important habitat areas which are may be significant for butterflies. There are extensive unexplored mangrove areas which are likely to be important habitat for several species of butterflies including one recognised as facing habitat reduction problems (*Hypochrysops apollo apollo* – the Apollo Jewel). There is an historical record of *Libythea geoffroy* on Magnetic Island. This is a relatively rare species, and the life history has only recently been described (Johnson & Valentine 1989). The confirmation and formal description of the carnivorous larvae of *Liphyra brassolis* Westwood was made on Great Palm Island (Johnson & Valentine 1986).

The total number of species so far recorded on the offshore islands of the Great Barrier Reef is 118, a figure comparable to adjacent mainland species richness for much of the coastline. This already represents 30% of all described species in Australia. Recent records from limited collecting at larger islands suggest that further additions will be made from future surveys. For example the fauna of Hinchinbrook Island and of Whitsunday Island are poorly known. A current listing is in Table 5.

Despite the limited current research it is clear that there are some highly interesting aspects of butterfly diversity within the islands of the Great Barrier Reef World Heritage Area. Such values apply primarily to the large islands produced by recent sea level changes including Magnetic Island and the Whitsundays. The limited research to date has produced evidence of some active speciation amongst butterflies on the larger islands. In this sense the Great Barrier Reef islands provide a fascinating laboratory for future research.

One comment should be made about the exclusion of Torres Strait from the World Heritage Area. The islands of the Torres Strait provide a fascinating interchange area between the butterfly fauna of Papua New Guinea and that of Australia. The World Heritage value for the Area would be greatly enhanced by including Torres Strait islands.

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Table 5. The Butterflies of the Great Barrier Reef World Heritage Area

HESPERIIDAE	**NYMPHALIDAE (cont.)**	**LYCAENIDAE**
Allora doleschallii doleschallii	*Phalanta phalantha araca*	*Liphyra brassolis major*
Hasora discolor mastusia	*Cupha prosope prosope*	*Hypochrysops ignitus chrysonotus*
Hasora hurama hurama	*Acraea andromacha andromacha*	*Hypochrysops apelles apelles*
Badamia exclamationis	*Tellervo zoilus gelo*	*Hypochrysops polycletus rovena*
Tagiades japetus janetta	*Melanitus leda bankia*	*Arhopala centaurus centaurus*
Trapezites eliena	*Mycalesis sirius sirius*	*Arhopala madytus*
Trapezites iacchus	*Mycalesis terminus terminus*	*Arhopala micale amphis*
Trapezites petalia	*Hypocysta irius*	*Ogyris zosine zolivia*
Toxidia thyrrus	*Hypocysta metirius*	*Ogyris olane ocela*
Hesperilla sexguttata	*Hypocysta pseudirius*	*Hypolycaena phorbas phorbas*
Hesperilla malindeva dagoomba	*Hypocysta adiante adiante*	*Deudorix epijarbas diovis*
Taractrocera ina	*Heteronympha merope merope*	*Anthene seltuttus affinis*
Ocybadistes flavovittatus flavovittatus	*Xois arctoa arctoa*	*Candalides margarita margarita*
Ocybadistes walkeri sonia	*Polyura sempronius sempronius*	*Candalides erinus erinus*
Suniana sunias rectivitta	*Phaedyma shepherdi shepherdi*	*Candalides acastus*
Arrhenes dschilus iris	*Pantoporia consimilis consimilis*	*Nacaduba berenice berenice*
Telicota colon argeus	*Mynes geoffroyi guerini*	*Nacaduba kurava parma*
Telicota augias krefftii	*Doleschallia bisaltide australis*	*Nacaduba biocellata biocellata*
Telicota ancilla ancilla	*Hypolimnas bolina nerina*	*Prosotas dubiosa dubiosa*
Cephrenes trichopepla	*Hypolimnas misippus*	*Catopyrops florinda halys*
Sabera dobboe autoleon	*Hypolimnas alimena lamina*	*Catopyrops florinda estrella*
Parnara amalia	*Vanessa kershawi*	*Theclinesthes onycha onycha*
Pelopidas agna dingo	*Junonia villida calybe*	*Theclinesthes miskini eucalypti*
PAPILIONIDAE	*Junonia orithya albicincta*	*Theclinesthes sulpitius sulpitius*
Protographium leosthenes leosthenes	*Cethosia cydippe chrysippe*	*Danis danis serapis*
Graphium macleayanum wilsoni	*Vindula arsinoe ada*	*Danis cyanea arinia*
Graphium sarpedon choredon	*Tirumala hamata hamata*	*Lampides boeticus*
Graphium eurypylus lycaon	**PIERIDAE**	*Syntarucus plinius pseudocassius*
Graphium agamemnon ligatum	*Appias paulina ega*	*Zizeeria karsandra*
Eloppene anactus	*Pieris rapae rapae*	*Zizina labradus labradus*
Papilio aegeus aegeus	*Catopsilia pyranthe crokera*	*Famegana alsulus alsulus*
Papilio fuscus capaneus	*Catopsilia pomona pomona*	*Euchrysops cnejus cnidus*
Papilio demoleus sthenelus	*Catopsilia gorgophone gorgophone*	
Papilio ulysses joesa	*Eurema hecabe phoebus*	
Cressida cressida cressida	*Eurema smilax*	
Atrophaneura polydorus queenslandicus	*Eurema herla*	
Ornithoptera priamus euphorion	*Elodina parthia*	
LIBYTHEIDAE	*Elodina queenslandica kuranda*	
Libythea geoffroy nicevillei	*Elodina padusa*	
NYMPHALIDAE	*Elodina perdita perdita*	
Danaus plexippus plexippus	*Delias argenthona argenthona*	
Danaus chrysippus petilia	*Delias mysis mysis*	
Danaus affinis affinis	*Delias aganippe*	
Euploea tulliolus tulliolus	*Anaphaeis java teutonia*	
Euploea core corinna	*Cepora perimale scyllara*	
Euploea sylvester sylvester		

(Source: based upon published accounts and field records to December 1995)

Natural Heritage Attribute: Crocodiles and Terrestrial Reptiles

SOURCE:

Dr J. Miller, Queensland Department of Environment, Townsville

CONCLUSIONS:

- estuarine crocodiles occur in the Great Barrier Reef World Heritage Area, but these individuals are marginal to the mainland population;
- reefal island crocodiles are unlikely to have any significant contribution back to the main populations, however they form part of the reefal ecosystem;
- at least 9 snakes and 31 lizards occur on the islands of the Great Barrier Reef World Heritage Area;
- one threatened lizard occurs on Magnetic Island.

MOST RELEVANT CRITERIA:

(ii), (iv)

DISCUSSION:

Estuarine Crocodile (*Crocodylus porosus*):

The estuarine crocodile is listed as vulnerable to extinction by the IUCN (IUCN 1994). Within Australia, the Northern Territory contains the largest area of suitable crocodile habitat, and is the stronghold of the species in this country. In Queensland crocodiles occur in coastal waterways north of Rockhampton. The strength of Queensland's crocodile population is found in north-western Cape York Peninsula (Taplin 1987), with the Jardine Swamps area being particularly important (Miller, J. 1996, pers. comm.). The north-western Cape York Peninsula is considered to be of high conservation value for the estuarine crocodile (Taplin 1987). On the eastern coast of Queensland, the north-eastern Cape York Peninsula (particularly the Jardine River National Park and Lockhart River region), Princess Charlotte Bay (particularly Lakefield National Park) and the eastern coastal plains from Cape Melville to Cooktown are considered to be of moderate conservation value (Taplin 1987). Additionally, specific regions such as the Daintree and Pascoe Rivers, provide important areas of crocodile habitat (Miller, J. 1996, pers. comm.). The management of crocodiles in Queensland has largely focused upon the removal 'problem' animals away from locations of human settlement. Consequently the majority of large breeding crocodiles have been removed from the south eastern corner of the species' range. Thus the highest numbers of crocodiles in Queensland are to be found north of Cooktown with decreasing numbers moving south from Cooktown (Miller, J. 1996, pers. comm.).

Breeding populations of estuarine crocodiles are found in a number of coastal river systems north of the Tropic of Capricorn. They utilise a variety of habitats from river mouths through to freshwater swamps well inland. Breeding is restricted to 'suitable habitat', where appropriate materials to make a nest are available. Crocodiles are selective in choosing nesting materials and nest location. Freshwater swamps, ephemeral swamps, and the tidal reaches of rivers often provide good nesting habitat. However, nest site selection is not fully understood, though with current surveys it is hoped that a characterisation of suitable nesting habitats may be determined (Miller, J. 1996, pers. comm.).

Whilst the primary habitat for crocodiles occurs outside the Great Barrier Reef World Heritage Area, its proximity ensures that crocodiles do occur on islands within the Area (e.g. see Limpus 1980). Large numbers of crocodiles do not occur in the Great Barrier Reef World Heritage Area. However, crocodiles have been recorded from approximately 25% of the islands north of Cairns, on both continental and reefal islands (Miller & Bell 1995). They have been recorded from inner-, mid- and outer-shelf locations. Those recorded from mid- to outer-shelf islands are typically small to medium sized animals, while records from inner-shelf islands include larger animals (Miller & Bell 1995). It is likely that larger individuals and a greater number of individuals will occur on islands closer to major population epicentres. At this stage crocodile breeding hasn't been recorded from Great Barrier Reef islands (Miller & Bell 1995).

Following a major rain, crocodiles have been known to move out of rivers and along the coast. Some of these may also move further out to the islands of the Great Barrier Reef World Heritage Area. At this stage there is no understanding of why some crocodiles move out of the rivers into other areas. However, anecdotal evidence supports the idea that small to medium sized crocodiles, that do not compete well within the hierarchy of river populations, may decide to move to other territory, using flood waters to their best advantage in dispersal (Miller, J. 1996, pers. comm.).

The crocodiles on reefal islands are clearly outliers to the main population, and their contribution back to that population is unknown. However, if crocodiles have left rivers because they were not competing well, then it is unlikely that they could easily survive back in the rivers (Miller & Bell 1995). Indeed for small to medium sized crocodiles on mid- and outer-shelf reef islands there is likely to be little chance of making it back to the mainland. Some of the near shore islands, for example Bird Island and those of the Sir Charles Hardy Group, contain complex habitat that could support larger crocodiles. Such crocodiles may well move back into river systems. In either case, the crocodiles of the reefal islands are not important to the survival of the crocodiles in Queensland, though the near shore islands may serve as a refugia for some individuals (Miller, J. 1996, pers. comm.).

If the eastern Queensland crocodile populations were decimated, the reefal island crocodiles are unlikely to re-invade the rivers. However, the reefal crocodiles are part of the Great Barrier Reef system and the system should be managed to maintain their presence. Such management should reduce anthropogenic disturbance to crocodiles, while informing people of the possibility of encountering crocodiles in the reefal environment (Miller & Bell 1995). Management of ecosystems to maintain relatively 'pristine' conditions will not only serve crocodiles but also other biota (Miller, J. 1996, pers. comm.).

Terrestrial Reptiles:

At least nine snakes and 31 lizards are found on the islands of the Great Barrier Reef World Heritage Area (Heatwole 1993). However, this count is likely to be incomplete, and the species list will increase with further systematic investigation. Furthermore it would increase considerably if the Great Barrier Reef islands of the Torres Strait were also included, as a result of the presence of a number of extra limital Papua New Guinean species (Heatwole 1993).

The lizards of the islands include six species of geckos (Gekkonidae), one legless lizard (Pygopodidae), two goannas (Varanidae) and 22 species of skinks (Scincidae) (Heatwole 1993). The nine snakes include a blind-snake (Typhlopidae), a python (Boidae), three colubrids (Colubridae) and four elapids (Elapidae) (Heatwole 1993).

The snakes and some of the lizards are found on continental islands occupying habitats similar to that which they would occupy on the mainland. A number of lizards are characteristic of coral cays, particularly those of the northern and central parts of the Great Barrier Reef (Heatwole 1993). Species richness in terrestrial reptiles decreases with both increasing latitude and increasing distance from mainland shore (Miller, J. 1996, pers. comm.).

The striped-tailed delma (*Delma labialis*) has a restricted distribution, being found only from Magnetic Island. It is considered to be vulnerable (Cogger et al. 1993).

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Natural Heritage Attribute: Crustaceans

SOURCE:

Mr P. Davie, Queensland Museum, Brisbane

Dr A.J. Bruce, Research Associate, Queensland Museum, Brisbane

CONCLUSIONS:

- many of the groups have been poorly studied;
- the Great Barrier Reef World Heritage Area is likely to be highly diverse for most groups with a cosmopolitan Indo-West Pacific fauna;
- endemism of reef fauna is low, but other habitats may have greater endemism;
- the extensive range of habitats in the Great Barrier Reef World Heritage Area is important for crustacean diversity.

MOST RELEVANT CRITERIA:

(iv)

DISCUSSION:

The crustaceans are a ubiquitous group living within all habitats of the Great Barrier Reef World Heritage Area, from the reefal environments to the inshore intertidal mangrove and seagrass habitats. They play important roles in ecological processes, taking on both parasitic and free-living forms, and being important food resources, while in other instances they are also important predators. However, only a few groups of the Great Barrier Reef World Heritage Area crustaceans have been studied in any detail, and a large majority of the fauna is unknown (Bruce 1993; Davie 1993).

Over 100 species from more than 50 genera of barnacles (Class Maxillopoda, Subclass Cirripedia) have been recorded from the Great Barrier Reef World Heritage Area (Jones et al. 1990). This comprises 43 species in 23 genera from the reef, and 55 species in 32 genera from lagoonal waters, while in the oceanic waters on the eastern side of the outer barrier reefs 25 species in 17 genera have been recorded (Jones et al. 1990).

The Great Barrier Reef World Heritage Area has a large peracarid fauna (Class Malacostraca, Subclass Peracarida), with isopods and amphipods being the most abundant (Bruce 1993). Currently more than 150 species of isopods have been recorded from the Great Barrier Reef, but many more are likely to be found, similarly 50 species of mysids have been documented (Bruce 1993). The amphipods are the largest of the peracarid orders with over 1100 genera and more than 6000 known species (Bruce 1993), however they have been poorly studied in the Great Barrier Reef World Heritage Area. In one study, of a single family only, Berents (1983) recorded 17 species from Lizard Island including 7 new species.

The decapod crustaceans (Class Malacostraca, Order Decapoda) are one of the better known groups of the Great Barrier Reef World Heritage Area, the area having one of the most diverse decapod faunas of Australia. For the combined orders of Decapoda, Stomatopoda and Euphausiacea records for 1030 species in 358 genera from 81 families exist for the Great Barrier Reef World Heritage Area. It is estimated that this fauna is about 75% known. In comparison, the total Australian fauna has 2172 species in 686 genera from 109 families (Davie, P. 1996, unpub. data). Thus the fauna of the Great Barrier Reef World Heritage Area in these three orders represents about 50% of the Australian fauna. Typically endemism is low with 62 species (6%) from these three orders being restricted to the Great Barrier Reef World Heritage Area (Davie, P. 1996, unpub. data). However, endemism is higher in the estuarine fauna than the reef fauna (Davie, P. & Bruce, A.J. 1996, pers. comm.).

The decapod crustaceans, particularly of the family Grapsidae, play important roles in mangrove ecosystems. Up to 80% of the annual leaf litter in tropical mangrove ecosystems is buried or consumed by decapod crustaceans. In doing so they have significant effects on the retention of litter nutrients within mangrove ecosystems (Robertson & Alongi 1995). Mangroves and seagrass meadows offer important nursery habitat for a variety of crustacean species, in particular a number of commercially important species of penaeid prawn (Robertson & Duke 1987; Robertson & Blaber 1992).

The high diversity in the Great Barrier Reef World Heritage Area is a consequence of the great diversity of habitats within the regions. Looking at individual habitats, the reef environments would present the highest species diversity followed by seagrass, mangrove and then soft-sediment communities. Whilst these latter habitats are less diverse than reefal systems, they are none the less highly diverse. For example the estuarine systems of the Wet Tropics region (e.g. Trinity Inlet, Murray River) are some of the most diverse in Australia for decapod crustaceans (Davie 1994; Davie, P. 1996, pers. comm.).

There are no recognised threatened crustaceans from the Great Barrier Reef World Heritage Area, nor are any considered to be relicts (Davie, P & Bruce, A.J. 1996, pers. comm.). There has been insufficient research to give details on any cross-shelf and latitudinal trends in crustacean abundance or diversity. However anecdotal evidence suggests that inner-shelf reefs are likely to have greater crustacean diversity than outer-shelf reefs. Furthermore lagoonal inter-reefal diversity is likely to be higher than east of the outer barrier. There is likely to be a steady attrition in species diversity from north to south (Davie, P. & Bruce, A.J. 1996, pers. comm.).

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Natural Heritage Attribute: Echinoderms

SOURCE:

Dr A. Birtles, Department of Tourism, James Cook University, Townsville

CONCLUSIONS:

- an estimated 800 extant species of echinoderms occur in the Great Barrier Reef World Heritage Area, representing about 13% of the world's taxa;
- many rare taxa occur in the Great Barrier Reef World Heritage Area;
- higher phylogenetic diversity of echinoderms is well expressed in the Great Barrier Reef World Heritage Area;
- Great Barrier Reef World Heritage Area is likely to have the greatest species diversity of echinoderms for any marine protected area in the world;
- distinct reefal and non-reefal suites of species exist with very strong zonation observable in both assemblages.

MOST RELEVANT CRITERIA:

(ii), (iii), (iv)

DISCUSSION:

There are approximately 6000 extant echinoderms in the world, of these almost 1200 (approximately 20%) have been recorded from Australia. Approximately two-thirds of these would be tropical species, giving an estimated 800+ species for the Great Barrier Reef World Heritage Area (Birtles, A. 1996, pers. comm.). Records exist for approximately 500 species from the Great Barrier Reef World Heritage Area, with the remaining few hundred species likely to be found in deep waters over the shelf break. In global terms, the Australian echinoderms are relatively well known, with approximately 790 species being recognised by 1946 (Clark 1946).

The echinoderms are an ancient group of animals with ancestors being recognisable 500 million years ago. It is a particularly diverse phylum, with taxa from all five extant classes being found in the Great Barrier Reef World Heritage Area. The classes are Crinoidea (feather stars), Asteroidea (sea stars and pin-cushion stars), Ophiuroidea (brittlestars and basketstars), Echinoidea (urchins) and Holothurioidea (sea cucumbers). The echinoderm fauna of the Great Barrier Reef World Heritage Area expresses much of the higher phylogenetic diversity of the phylum, exhibiting the classical features that divide the phylum into its classes and families.

Echinoderms are ubiquitous in their distribution, occupying all habitats, including coral reefs, mangroves, seagrass and soft bottom areas, from the intertidal zone through to the abyssal depths off the continental shelf, on soft and hard substrates. Of the macro-epibenthic fauna the echinoderms are amongst the most abundant, and on occasions dominate communities in terms of biomass and number of individuals. They exhibit a wide range of feeding strategies, and include suspension feeders, deposit feeders, carnivores, browsers and parasites (Birtles & Arnold 1988).

The centre of tropical echinoderm diversity is likely to be the Indo-West Pacific region centred around Sulawesi. However, as a marine protected area the Great Barrier Reef World Heritage Area, is likely to be unmatched anywhere else in the world for echinoderm diversity (Birtles, A. 1996, pers. comm.).

There are no good estimates of endemism for the phylum. However, many species appear to be very rare, and some may have highly restricted distributions. Of 155 species Birtles (1989) investigated, 44 (28%) were represented by just one or two individuals from a total of 31 400 specimens. This rarity is particularly noticeable in some of the groups that have undergone recent radiation and speciation, for example several of the 17 or so species of the seastar genus *Anthenea* are known only from type material and have not been collected since they were first described (Birtles, A. 1996, pers. comm.). There are no threatened echinoderm taxa in the Great Barrier Reef World Heritage Area. However, this may change in future for some large intertidal and just subtidal species that are particularly vulnerable to collection.

Distinct reef and soft bottom faunas are recognisable. Of the approximately 200 common soft-bottom species less than 10% are found on reefs, and when they are present abundances are typically very low (Birtles, A. 1996, pers. comm.). The reef echinoderm fauna is well known, while the soft-bottom and deepwater taxa still require taxonomic resolution. The soft bottom inshore fauna has strong affinities with the fauna of the East Indies, while the reef fauna has affinities with both Western Pacific and East Indies (Birtles 1989).

Strong zonation occurs both within reefal communities and across the soft bottom communities. Soft bottom zonation is primarily associated with physical characteristics, particularly nutrient levels, wave action and the re-suspension of sediments, and the nature of sediments (e.g. reefal or terrigenous in origin, extent of clay, silt etc.). The major separation in the soft bottom echinoderm (and also molluscs, crustaceans, bryozoans, demersal fishes, ascidians, and algae) community occurs in the Central Section of the Great Barrier Reef between inner- and mid-shelf areas (Birtles & Arnold 1988). The inner-shelf echinoderm community is dominated by carnivores and has very low abundance of browsers, in contrast the mid-shelf echinoderm communities have a significantly lower abundance of carnivores and increased abundances of suspension feeders and browsers (Birtles & Arnold 1988). Species diversity is significantly higher at mid-shelf locations. The discontinuity occurs at around the depth of 22–23 m, past this depth the occurrence of 'natural isolates' (Birtles & Arnold 1988) creates areas of hard substrate that suspension feeding echinoderms (particularly crinoids and dendrochirote holothurians) can settle upon, and also provides food resources for browsers (see Soft Bottom Habitat). On the shelf break very strong zonation occurs corresponding to rapidly increasing depths (Arnold & Birtles 1985). There is a north-south attenuation in species diversity for the echinoderms, and discontinuities in this trend may be associated with major oceanographic processes (Birtles, A. 1996, pers. comm.).

Collection and documentation of echinoderms has been neither systematic nor extensive enough to enable localities of particular importance to be identified. However, the strong zonation across the soft bottom habitats highlights the importance of managing for distinct communities along the continuum of the shelf rather than assume the shelf communities are uniform.

The echinoderms play a significant role in structuring particular communities. For example in some subtidal soft bottom areas, the carnivorous asteroids of the genera *Astropecten* and *Luidia* occur in large concentrations. They play an important role in structuring infuanal communities, feeding primarily upon small crustaceans and molluscs. The crown-of-thorns starfish, *Acanthaster planci*, is a vivid example of the structuring effects of echinoderms. Feeding upon sessile animals, primarily corals, the crown-of-thorns starfish has been responsible for substantial mortalities in coral communities. It is likely that in smaller numbers and relatively infrequently, this is an entirely natural process, however anthropogenic influences may have exacerbated crown-of-thorns starfish outbreaks. In some areas masses of crinoids are the dominant suspension feeders. Similarly, in soft bottom areas on the inner shelf, huge aggregations of the deposit feeding sand dollars (*Leganum* spp.) will have profound effects upon interstitial communities.

Echinoderms contribute to the aesthetic qualities of the Great Barrier Reef World Heritage Area. Following corals and fishes, tourists notice the echinoderms the most (Birtles, A. 1996, pers. comm.). In particular the rheophilic suspension feeders, for example the dendrochirote holothurians, and the diverse and vividly coloured crinoids that can form aggregates of several hundred in a few square metres, make a visually stunning display.

During the 1890s bêche-de-mer was commercially exploited in large quantities, and remains the only commercial exploited echinoderm fishery in the Great Barrier Reef World Heritage Area. Eight species are commercially exploited. The current knowledge and understanding of these species is at a rudimentary level, and considered to be only barely enough to manage the fishery, assuming that the precautionary principle is actively applied (Birtles, A. 1996, pers. comm.). Furthermore the phylum may produce novel and useful natural products, in particular the epidermal surface of many species are remarkably un-fouled, this could lead to the development of efficient anti-fouling substances for marine structures.

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Natural Heritage Attribute: Fishes

SOURCE:

Mr M. Cappo, Australian Institute of Marine Science, Townsville

Dr D. Williams, Australian Institute of Marine Science, Townsville

CONCLUSIONS:

- species diversity of Great Barrier Reef World Heritage Area is high but is less diverse than for the Indo-West Pacific centre;
- endemism is low as most fish are distributed through the Indo-West Pacific;
- heterogeneity of the Great Barrier Reef World Heritage Area at a range of spatial scales offers an extensive range of habitats for fish;
- life histories of some species demonstrate the connectivity of the range of nearshore and offshore habitats within the Great Barrier Reef World Heritage Area;
- abundance and diversity of fishes changes over a range of spatial and temporal scales;
- abundance and huge diversity in fishes shape, size and colour contributes to the aesthetic value of the Great Barrier Reef World Heritage Area.

MOST RELEVANT CRITERIA:

(ii), (iii), (iv)

DISCUSSION:

Much of the research into the fishes of the Great Barrier Reef World Heritage Area has focused upon coral reef fishes. However the area contains a range of other habitat types, for example mangroves, seagrasses, and hard and soft bottom areas between reefs, which are important to the fish fauna of the Great Barrier Reef World Heritage Area. These areas contribute to fish diversity, and often provide crucial habitats for some juvenile taxa, or essential food resources. Indeed the latitudinal extent of the Great Barrier Reef World Heritage Area coupled with regional variations in environmental regimes provides an extensive range of habitats for fish.

Estimates for the number of species in the Great Barrier Reef World Heritage Area range from 1200 to 2000, with 1500 often being taken as a reasonable estimate (Williams, D. 1996, pers. comm.). Russell (1993) suggests that the total may eventually exceed 2000. More than 130 families of fishes are currently known from the Great Barrier Reef World Heritage Area (see Table 6). The Capricorn–Bunker group have recorded more than 960 species alone (Russell 1993). The species list is likely to grow the greatest in the northern region of the Great Barrier Reef World Heritage Area, being the region least subject to systematic collection and documentation. Coral reef habitats exhibit the greatest species richness, followed by mangrove and estuarine environments. Seagrass and inter-reefal areas are likely to exhibit lower levels of species richness than coral reef environments, but the fishes of these habitats are poorly known (Williams, D. 1996, pers. comm.).

The Great Barrier Reef World Heritage Area is close to the centre of coral fish diversity, namely the Indo-West Pacific region centred upon the Philippine archipelago (with 2700+ species), the islands of Indonesia (with 3000+ species) and Papua New Guinea (Russell 1993). The majority of coral reef fishes are cosmopolitan species distributed throughout this region, accordingly endemism is low. Russell (1983) estimates endemism at 3% for the Capricorn–Bunker group, and this is not likely to be different for other areas.

The Great Barrier Reef World Heritage Area fish fauna exhibits a huge range of diversity in form, shape, colour and size. The behaviour of fishes individually, and in schools, adds a further dimension of diversity. This diversity adds considerably to the aesthetic value of the Great Barrier Reef World Heritage Area, particularly in reefal environments.

The Great Barrier Reef World Heritage Area contains some noteworthy fishes, including species of billfish and the whale-shark (*Rhincodon typus*). The Lizard Island region and Ribbon Reef shelf-break contains the major spawning ground in the world for black marlin. The inshore shelf waters of the Barrier Reef Lagoon are the major nursery and feeding areas for the black marlin, especially areas near major mangrove lined bays such as Dunk Island, Cairns and Bowling Green Bay. The Great Barrier Reef World Heritage Area provides habitat for the largest fish in the world, the whale-shark which reaches a size of 18 m and can weigh over 15 tonnes. Furthermore aggregates of large fishes such as potato cod, Queensland grouper and sharks at various localities, such as the Yongala wreck and Cod Hole, provide considerable attraction to the Great Barrier Reef World Heritage Area for tourists.

The Great Barrier Reef World Heritage Area provides one of the most pristine coral reef environments in the Indo-West Pacific region. Compared with may other regions fishing effort is low, though there is local impact upon some targeted species (e.g. coral trout, red throated emperor). Currently there are no Great Barrier Reef World Heritage Area fishes recognised as threatened (Williams, D. 1996, pers. comm.).

Trends in coral reef fish abundance and diversity are observable over a range of spatial and temporal scales. For example changes are observable within the various zones of one reef, between reefs across the shelf, and between reefs at similar shelf locations along the length of the Great Barrier Reef World Heritage Area.

There are significant changes in both species composition and abundance between reefs at inner-, middle- and outer-shelf locations. Williams (1982) notes that some families, particularly the Pomacentridae and Chaetodontidae are particularly useful for distinguishing position across the shelf. Species richness is greatest on mid-shelf reefs, and lowest on inshore reefs, while outer-shelf reefs display intermediate levels of diversity (Williams & Hatcher 1983). Significant changes in trophic structure in fish communities at various shelf locations are also apparent. mid-shelf reefs have a high biomass of planktivores; on inshore reefs algal grazers are significantly lower in biomass than on other shelf positions. The changes in invertebrate feeders and piscivores are much less pronounced across the shelf (Williams & Hatcher 1983). The cross shelf changes in abundance and diversity are much greater than changes observed between reefs at similar shelf locations (Williams 1982).

There is latitudinal variation in cross-shelf patterns of fish distribution. In the region south of Townsville the outer-shelf reefs support a mix of mid- and outer-shelf communities and the mid-shelf communities become a mix of inshore and mid-shelf reef communities. It appears that fish communities undergo a general move offshore in the south when compared to the northern region. This may be related to the greater distance of the southern reefs from the edge of the continental shelf than the northern reefs (Williams, D. 1996, pers. comm.). The latitudinal change is small compared to those observed across the shelf (Williams 1982).

Changes in abundance and composition also occur over time (Williams 1986). The magnitude of temporal variability within a reef is similar to the variability between reefs at the same shelf position, but much smaller than the cross shelf variation (Williams 1986). The Great Barrier Reef World Heritage Area, in covering the entire shelf from intertidal zone to past the edge of the shelf, and the latitudinal range from Cape York to north of Fraser Island, provides a unique opportunity to investigate the trends in fish communities across numerous environmental and physical gradients.

Mangrove habitats are important in providing essential nursery sites for a range of fishes (Robertson & Duke 1987; Robertson & Blaber 1992). Similarly seagrass meadows provide important habitats for some fish species. Surveys of seagrass meadows using beam trawls have found 65 species of fish from 35 families (Coles et al. 1992). Such estimates of diversity, however, are likely to be under estimates, as the sampling techniques used are limited. For example, beam trawls tend to sample only slow demersal fish, missing other important components of the fish fauna (Cappo, M. 1996, pers. comm.).

The connectivity of various habitats is demonstrated by the example of juvenile baitfish (e.g. golden lined sardine and northern pilchard) dependence on copepods and crab larvae washed out from mangroves and estuaries into shallow bays. From these areas, the bait fish migrate into deeper waters and become the food of pelagic billfish (Cappo 1995), seabirds (e.g. frigates and boobies) and dolphins, as well as many other predatory fish.

Specific locations of importance for the fishes of the Great Barrier Reef World Heritage Area are difficult to identify. Rather the value of the region for fish is derived from the heterogeneity of the Great Barrier Reef World Heritage Area in spatial scales and environmental regimes that gives rise to high fish diversity. Furthermore the current conservation status of fishes of the Great Barrier Reef World Heritage Area, and the presence of a regime to manage the fish are important features of the value of the Great Barrier Reef World Heritage Area to fishes. It should be noted however that most work has focused upon coral reef environments in the Great Barrier Reef World Heritage Area, and greater attention could be placed upon the range of other habitats.

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Table 6. Families of Fishes from the Great Barrier Reef World Heritage Area

Class Elasmobranchii		Class Actinopterygii	
Hexanchidae	Cow Sharks	Serranidae	Rock Cods, Groupers, Coral Trout
Heterodontidae	Bullhead and Horn Sharks	Pseudochromidae	Dottybacks
Rhincodontidae	Whale-sharks	Plesiopidae	Roundheads
Brachaeluridae	Blind Sharks	Acanthoclinidae	Banded Longfins
Orectolobidae	Catsharks, Carpetsharks	Teraponidae	Grunters
Hemiscyllidae	Bamboo Sharks	Kuhliidae	Flagtails
Stegostomatidae	Leopard Sharks	Priacanthidae	Bullseyes
Ginglymostomatidae	Nurse Sharks	Apogonidae	Cardinalfish
Odontaspididae	Sand Tiger Sharks	Sillaginidae	Whiting
Alopiidae	Thresher Sharks	Malacanthidae	Tilefishes
Lamnidae	Mako Sharks	Rachycentridae	Black Kingfish, Cobia
Scyliorhinidae	Catsharks	Echeneidae	Suckerfishes, Remoras
Carcharhinidae	Whaler Sharks	Carangidae	Trevallies, Jacks
Hemigaleidae	Weasel Sharks	Trachinotidae	Dart, Oystercrushers
Sphyrnidae	Hammerhead Sharks	Coryphaenidae	Dolphinfish
Squalidae	Dogfishes	Lutjanidae	Sea Perch, Hussars, Snappers
Torpedinidae	Electric Rays	Caesionidae	Fusiliers, Banana Fish
Rhinobatidae	Guitarfishes and Shovelnose Rays	Lobotidae	Tripletails
Rajidae	Skates	Gerreidae	SilverBiddies

Class Elasmobranchii		**Class Actinopterygii**	
Dasyatididae	Stingrays	Haemulidae	Grunters, Javelinfish, Sweetlips
Gymnuridae	Rat-tailed Rays	Sparidae	Silver Bream
Myliobatidae	Eagle Rays	Lethrinidae	Emperors, Sweetlips
Mobulidae	Manta Rays	Nemipteridae	Monocle Bream, Threadfin Bream
Class Holocephali		Mullidae	Goatfishes
Chimaeridae	Ghost Sharks	Pempheridae	Sweepers
Class Actinopterygii		Kyphosidae	Drummers
Albulidae	Bonefishes	Leiognathidae	Ponyfishes
Elopidae	Ladyfish, Giant Herring	Ephippidae	Batfishes
Megalopidae	Tarpon	Chaetodontidae	Coralfishes, Butterflyfishes
Moringuidae	Worm Eels	Pomacanthidae	Angelfishes
Chlopsidae	Reef Eels	Pomacentridae	Damselfishes
Muraenidae	Moray Eels	Cirrhitidae	Hawkfishes
Ophichthidae	Snake Eels	Cheilodactylidae	Morwongs
Congridae	Conger Eels	Opistognathidae	Jawfishes
Nettastomatidae	Wire Eels	Mugilidae	Mullet
Clupeidae	Round Herrings, Sprats	Polynemidae	Threadfin
Engraulididae	Anchovies	Labridae	Turkfish, Wrasses
Chanidae	Milkfishes	Scaridae	Parrotfishes
Gonorhynchidae	Rat Fishes	Champsodontidae	Sabre Gills
Plotosidae	Eeltail Catfishes	Uranoscopidae	Stargazers
Synodontidae	Lizardfishes, Grinners	Trichonotidae	Sand-Divers
Euclichthyidae	Euclicthyid Cods	Creediidae	Sand Eels
Ophidiidae	Blindfishes	Pinguipedidae	Grubfishes
Carapidae	Pearlfishes	Tripterygiidae	Triplefins
Bythitidae	Cusk Eels	Clinidae	Weedfishes
Batrachoididae	Frogfishes	Blenniidae	Blennies
Antennariidae	Anglerfishes	Callionymidae	Dragonets
Ogcocephalidae	Handfishes	Schindleriidae	Floaters
Gobiesocidae	Clingfishes	Eleotridae	Gudgeons
Atherinidae	Hardyheads	Gobiidae	Gobies Gudgeons
Belonidae	Neddlefishes, Longtoms	Microdesmidae	Wormfishes
Hemiramphidae	Garfishes	Siganidae	Spine Feet, Happy Moments
Exocoetidae	Flyingfishes	Zanclidae	Moorish Idols
Monocentridae	Pineapplefishes	Acanthuridae	Surgeonfishes, Unicornfishes
Holocentridae	Squirrelfishes, Soldierfishes	Sphyraenidae	Barracudas, Sea Pike
Caproididae	Boarfishes	Trichiuridae	Hairtails
Pegasidae	Seamoths	Xiphiidae	Swordfishes
Aulostomidae	Trumpetfishes	Istiophoridae	Billfishes
Fistulariidae	Cornetfish, Hair-tailed Flutemouths	Scombridae	Spanish Mackeral, Tunas
Centriscidae	Razorfishes	Bothidae	Lefteye Flounders
Solenostomidae	Ghost Pipefishes	Pleuronectidae	Righteye Flounders
Syngnathidae	Pipefishes, Seahorses	Soleidae	Soles
Scorpaenidae	Scorpionfishes	Cynoglossidae	Tongue Soles
Caracanthidae	Orbicular Velvetfishes	Triacanthidae	Tripodfishes
Aploactinidae	Velvetfishes	Balistidae	Triggerfishes
Triglidae	Gurnards	Monacanthidae	Leatherjackets
Dactylopteridae	Flying Gurnards	Ostraciidae	Boxfishes
Platycephalidae	Flatheads	Tetraodontidae	Pufferfish
Centropomidae	Barramundi	Diodontidae	Porcupinefishes
Acropomatidae	Split Fins		

(Source: Randall et al. 1990; Russell 1993; Cappo, M. 1996, pers. comm.)

Natural Heritage Attribute: Flatworms

SOURCE:

Dr L. Cannon, Queensland Museum, Brisbane

CONCLUSIONS:

- platyhelminth fauna of the Great Barrier Reef World Heritage Area is largely Indo-West Pacific in distribution with correspondingly low levels of endemism;
- flatworm fauna exhibits high diversity in free-living macro and meiofaunal forms, and very high diversity in parasitic forms;
- the polyclad turbellarians are a conspicuous animal on the reef with vivid colours and patterns contributing to the aesthetic value of the Great Barrier Reef World Heritage Area.

MOST RELEVANT CRITERIA:

(iii), (iv)

DISCUSSION:

The phylum Platyhelminthes (flatworms) is divided into two groups, the largely free-living turbellarian, and the wholly parasitic Neodermata[41]. Taxa from all groups can be found within the Great Barrier Reef World Heritage Area. Turbellarians can also be divided into macrofaunal flatworms (large free-living species), meiofaunal worms (small free-living interstitial species (less than 1 mm)), and symbiotic worms (Cannon 1993).

With the exception of recent work on the polyclad turbellarian worms (Newman & Cannon 1994a; 1994b), there has been little investigation into the free-living flatworm fauna of the Great Barrier Reef World Heritage Area. However, when groups have been studied the taxa of the Great Barrier Reef World Heritage Area typically displays a cosmopolitan fauna with an Indo-West Pacific distribution (Cannon, L. 1996, pers. comm.). Accordingly endemism is low for the Great Barrier Reef World Heritage Area, but species diversity is high. In this respect the Great Barrier Reef World Heritage Area does not offer anything unique in comparison to other Indo-West Pacific environments. However, the size of the Great Barrier Reef World Heritage Area, and its latitudinal extent ensures that the area offers an extensive range of habitats and environmental regimes in which flatworm diversity is expressed.

No specific locations or general habitat types can be identified as being particularly important for the flatworm fauna of the Great Barrier Reef World Heritage Area, however the high diversity of microhabitats is very important in facilitating and maintaining a high species diversity.

Trends in abundance and distribution across the shelf or along latitudinal gradients are difficult to observe due to the paucity of systematic collection and the need for more taxonomic work. However, there are likely to be distinct reefal and inter-reefal faunas across the shelf (Cannon, L. 1996, pers. comm.). Furthermore an attenuation in species richness as you move from the northern end to the southern end of the Great Barrier Reef World Heritage Area is apparent (Cannon, L. 1996, pers. comm.).

Polyclad Turbellaria:

Approximately 200 species of polyclad turbellarian worms from the Great Barrier Reef World Heritage Area have been recorded. However, descriptions for only a small portion of these have been published (Cannon, L. 1996, pers. comm.). It is likely that the species list for the polyclad turbellarian worm fauna of the Great Barrier Reef World Heritage Area will reach at least 300 species (Cannon, L. 1996, pers. comm.). Based upon published and unpublished data the Great Barrier Reef World Heritage Area would be the most diverse area in the world for polyclad turbellarian worms, however this is clearly an artefact of collection. It is expected that most species will have a general Indo-West Pacific distribution. Furthermore research has focused upon reefal environments and there is a greater paucity of information regarding the inter-reefal taxa.

The most diverse and abundant polyclad flatworms from the southern region of the Great Barrier Reef World Heritage Area belong to the family Pseudocerotidae (Newman & Cannon 1994b). Species from this family are often 'the most flamboyantly coloured flatworms' (Newman & Cannon 1994a:160), with vibrant

[41] The Neodermata comprise five groups, Aspidogastrea, Cestodaria, Digenea and Monogenea (flukes or trematodes) and the Cestoda (tapeworms).

and vivid patterns, adding considerable aesthetic value to their environments. The Pseudocerotid polyclads are known to feed upon colonial ascidians (Newman & Cannon 1994b).

Other Free-living Platyhelminthes:

For the meiofaunal turbellarians diversity is likely to be high (Dittman 1991), but again little work has been carried out. The other orders of free-living flatworms are represented by occasional records from the Great Barrier Reef World Heritage Area in the literature (e.g. for Acoela Class Turbellaria), however for the remaining orders no work has been published. However, it is expected that diversity for these orders will be at levels similar to that of the Polycladida. Unpublished data on the interstitial Proseriata and Kalyptorhynchia indicate a rich fauna (Cannon, L. 1996, pers. comm.).

Parasitic Platyhelminthes:

The parasitic platyhelminthes have an exceptionally high diversity. Species numbers are likely to be in the magnitude of thousands, rather than hundreds (Rohde 1976; Cannon, L. 1996, pers. comm.). A workshop held on Heron Island produced 580 parasite records, of these nearly 200 were platyhelminthes (Lester & Sewell 1989).

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Natural Heritage Attribute: Fringing Reefs

SOURCE:

Dr L. DeVantier, Australian Institute of Marine Science, Townsville

CONCLUSIONS:

- fringing reefs cover 667 km^2 of the Great Barrier Reef World Heritage Area with the majority being adjacent to continental islands;
- they can exhibit high species diversity, and often high coral cover;
- Great Barrier Reef World Heritage Area contains some of the largest and oldest coral colonies;
- the genotype of some colonies may have been present on the reef for several thousand years;
- inshore coral communities in the southern regions of the Great Barrier Reef World Heritage Area may offer new insights into coral reef formation and evolution;
- fringing reefs can exhibit very high aesthetic value.

MOST RELEVANT CRITERIA:

(i), (ii), (iii), (iv)

DISCUSSION:

There are 758 fringing reefs (231 incipient fringing[42]; 545 fringing) occurring in the Great Barrier Reef World Heritage Area. This corresponds to approximately 26% of the total number of reefs in the Great Barrier Reef World Heritage Area (2904) (Hopley et al. 1989). The area of the fringing reefs totals 667 km^2, corresponding to approximately 3% of total reefal area, and about 0.2% of the area of the Great Barrier Reef World Heritage Area (Hopley et al. 1989). Of the two main types of fringing reefs, mainland fringing reefs and continental island fringing reefs, the vast majority, approximately 700, surround continental islands (DeVantier, L. 1996, pers. comm.).

There are several areas that exhibit exceptional mainland fringing reefs: Dingo Beach, Bowen Beach and Cape Tribulation. The Dingo Beach area exhibits exceptional species richness for an area growing right on the mainland coast, with about 150 species recorded. At a single site diversity falls in the range of 50–80 species (DeVantier et al. 1996). The high coral cover and high species diversity of the Dingo Beach fringing reefs gives considerable aesthetic appeal when compared with other nearshore reefs of this region (van Woesik & DeVantier 1992). Furthermore the area has a high diversity of molluscs and is known as a collecting site for shells (van Woesik & DeVantier 1992). Anecdotal evidence suggests that the Bowen Beach fringing reefs also have very high coral cover. However, little is known about their species richness (DeVantier, L. 1996, pers. comm.).

In the northern region of the Great Barrier Reef World Heritage Area, the fringing reefs of Cape Tribulation have a very high coral species diversity. Over a three-day period Veron (1987) recorded 141 species from 50 genera. At that time, some of these species had not been recorded from the Great Barrier Reef World Heritage Area. It is likely that other exceptional sites of mainland fringing reefs occur further north, particularly around Princess Charlotte Bay. However, these have not been documented as most systematic research has been carried out in the southern regions of the Great Barrier Reef World Heritage Area.

Important sites for continental island fringing reefs typically occur around complex island archipelagos, such as the Brook Islands, the Palm Island group, the Whitsunday Island group, and the Keppel group of islands.

The Brook Islands fringing reefs exhibit high coral diversity and high coral cover, it is likely that there has been no major disturbance of the reefs for many years (DeVantier & Endean 1989). They are considered to be a near pristine example of near shore fringing reefs (DeVantier 1995). Over 150 species of hard corals have been recorded, and the reefs are known for their very large coral colonies of great age. Indeed the reef contains several of the largest and presumably oldest massive corals yet discovered (DeVantier 1995). In the Palm Group, the fringing reefs of Orpheus Island are among those with some of the highest species diversity in the Great Barrier Reef World Heritage Area (DeVantier, L. 1996, pers. comm.).

[42] Incipient fringing reefs are those with no extensive reef flat, but with corals growing over rocky foundations largely below low tide level (Hopley et al. 1989).

Within the Whitsunday region coral cover and species diversity are most extensive in Shute Harbour and locations in the north of the island group (van Woesik & DeVantier 1992). In a recent survey approximately 33% of sites had coral cover greater than 30% (DeVantier & Turak 1995). Maximum coral cover, greater than 75%, was recorded at Little Grassy Island, and greater than 50% cover was recorded at South Double Cone Island (DeVantier & Turak 1995). Of the 68 sites surveyed 61 had more than 30 species of hard coral, with one site at South Double Cone Island having 87 species (DeVantier & Turak 1995).

The fringing reefs of the Keppel Island group are important as they are the southern most fringing reefs in the Great Barrier Reef World Heritage Area. They exhibit high coral cover, on average being greater than 50%. At one site Middle Island coral cover was recorded at 94% (van Woesik et al. 1995). The fringing reefs of Magnetic Island are interesting as they spawn earlier than offshore reefs (DeVantier, L. 1996, pers. comm.).

At the southern end of the Great Barrier Reef World Heritage Area there is little fringing reef development except for that in the Keppel Island group. In part this is due to the lack of suitable substrates for their development and also the effects of Broad Sound, with its large tidal range and high levels of suspended sediments. However there are a few areas where fringing coral communities, rather than reefs, have developed. For example at Pine and Wild Duck Islands, and also off mainland at Gladstone. These sites have particular importance as they have much to tell about the conditions that preclude reef development, including the effects of high sediment loads, the lack of hard substrates, and shading effects. Sites such as these are very important to gain a thorough scientific understanding of coral reef development (DeVantier, L. 1996, pers. comm.). Indeed fringing reefs and these coral communities offer the greatest range of microhabitats and disturbance regimes in which to study the responses of coral reefs and coral communities. The Great Barrier Reef World Heritage Area thus offers unique opportunities for advancing understanding of ecological and evolutionary processes in these systems (DeVantier, L. 1996, pers. comm.).

Prior to the last sea-level rise the locations of contemporary fringing reefs would have been aerially exposed. Thus the modern-day fringing reefs have a recent history of about 6000–10 000 years old. These reefs contain some of the largest coral colonies and may be 500–700 years old; they are some of the oldest living marine animals in the world. Furthermore the fission and fragmentation of some coral colonies facilitates the perpetuation of the same genotypes over periods well in excess of the ages of individual colonies (DeVantier & Endean 1989).

Recently a unique coral community was found in about three metres of muddy water not far from a mangrove area in the Whitsunday group of islands. Within this community a new species of massive coral was found, *Goniastrea* spp. A similar coral had been known from Western Australia, but never from the Pacific Ocean. This example serves to demonstrate that despite the extensive study that has occurred in some areas, in this case the Whitsunday region, significant discoveries are still being made (van Woesik & DeVantier 1992).

The aesthetic value and natural beauty of fringing reefs can be very high. In evaluations made by experienced observers those sites with a high degree of heterogeneity, high coral diversity and high coral cover were considered to be of great aesthetic value (DeVantier, L. 1996, pers. comm.).

Unfortunately the close proximity of fringing reefs to the mainland, and anthropogenic activities, makes them particularly susceptible to land based outputs such as sediments and nutrients. Furthermore the attractiveness of the continental islands for boating, and the increasing emphasis upon large scale tourism makes the fringing reefs of the Whitsunday and Brook Island groups particularly susceptible to damage by increased visitation by tourists.

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Natural Heritage Attribute: Geological and Geomorphological Aspects

SOURCE:

Prof. D. Hopley, Director Sir George Fisher Centre, James Cook University, Townsville

CONCLUSIONS:

- Great Barrier Reef World Heritage Area contains the largest reef system the world has ever known;
- the size and morphological diversity of the Great Barrier Reef makes the Great Barrier Reef World Heritage Area unique;
- Great Barrier Reef World Heritage Area contains 2904 coral reefs covering 20 055 km^2;
- geological evolution of continental islands, reefs and cays is intimately connected with sea-level change;
- major changes in sea-level are recorded in the reef's structure;
- cross-shelf gradient in many parameters are particularly evident in the Great Barrier Reef World Heritage Area;
- as a consequence of its young age, the total history of the reef's evolution is available offering a unique opportunity for greater understanding of coral reef evolution;
- Great Barrier Reef World Heritage Area contains examples covering nearly all stages of reef development;
- Great Barrier Reef World Heritage Area contains exceptional examples of blue holes;
- the Great Barrier Reef World Heritage Area contains more than 300 coral islands displaying a range of morphologies;
- coastal attributes of world importance include: rock types and morphologies, sand barriers, deltas, and dune systems;

MOST RELEVANT CRITERIA:

(i)

DISCUSSION:

The following discussion of the geological and geomorphological aspects of the Great Barrier Reef World Heritage Area was written by Prof. D. Hopley.

Natural Heritage Attribute: Geological and Geomorphological Aspects

Prof. D. Hopley, Sir George Fisher Centre, James Cook University, Townsville

INTRODUCTION

Physical size and morphological diversity make the Great Barrier Reef unique amongst the world's coral reefs (Hopley et al. 1989). Within the Great Barrier Reef Marine Park area alone are some 20 055 km^2 of coral reefs and although this makes up only 3.25% of the world's reefs (total 617 000 km^2) the latitudinal spread over a distance 2300 km or 14° means that it is generally regarded as the largest reef system the world has ever known.

IDENTIFIED NATURAL HERITAGE ATTRIBUTES

1. Evolution of the Queensland Coastline

The Great Barrier Reef is a continental shelf reef system which by definition means that it is part of the continent protecting a mainland coastline. At the mainland coast the offshore continental islands and the reefs and island of the Great Barrier Reef proper are an integrated system, the geological evolution of which has been intimately connected with sea-level change.

Whilst is a very young reef system (Davies 1992), probably no more than 500 000 years old, along most of its length, this period of earth history has been characterised by major rises and falls of sea-level with amplitudes of more than 125 m. Thus the mainland coastline of north-east Queensland has moved across the continental shelf and at lowest sea-level stages has been located on the shoulder of the continental shelf outside the Great Barrier Reef. Mainland influences have and still do play a very important role in the processes which determine the morphology and development of the Great Barrier Reef (Hopley 1995).

Sea-level has been at or near its present position along the Great Barrier Reef for more than 6000 years, allowing the build-up of terrigenous sediments and other mainland influences adjacent to the coastline. Indeed there is a very distinctive cross-shelf gradient in many of the parameters which control coral growth (Hopley 1989). These include sediments, turbidity, nutrients and temperature extremes. The distinctive differences between innermost and outermost continental shelf produce distinctive and separate communities, the overlapping of which mid-shelf gives this area the greatest species diversity. Whilst other reef systems may follow similar trends, only on the Great Barrier Reef, because of its size, is this so well illustrated.

The coastal attributes are therefore an integral part of the total Great Barrier Reef system, Table 7 illustrates the make-up of the coastline divided into three sectors between Torres Strait at the northern end of the Great Barrier Reef Marine Park to Hervey Bay at the southern end (Hopley 1985). Major attributes include:

a. Hard rock headlands and high continental islands:

The variety of rock types along the Queensland coast give a variety of morphologies which can match those anywhere in the world e.g. sedimentary rocks, Cape Bedford and the Flinders Islands; massive granites e.g. Hinchinbrook Island, Cape Cleveland and Cape Upstart; volcanic rocks, Palm Islands, Whitsunday Islands.

b. Sand barriers:

Over a period of more than 6000 years of stable sea-level and on a coastline which receives large amounts of fluvial sediment, sand barriers form a very large portion of the coastline. Although generally not unique features there are some special areas e.g. south of Cape Cleveland and fed by the Burdekin River is a sequence of more than 125 beach ridges made entirely over the past 6000 years (Hopley 1970).

c. Deltas:

Because of the protection given by the Great Barrier Reef high sediment yield and (apart from cyclones) normally low energy conditions, wave deltas have built up at the mouths of many of the major rivers e.g. Barron, Herbert, Fitzroy. Probably the most prominent is the Burdekin Delta (Hopley 1970). This is often used as a world class example of a wave influenced delta with dynamic deltaic spits (including Cape Bowling Green) (Hopley 1970).

d. Dunes:

Large dunes are not normally part of the tropical coastal geomorphological scene. However, for special geological and climatic reasons the Queensland coast has a number of world significant dune areas. In the south these are the large sand islands of which only Fraser Island, the largest sand island in the world, enters into the southern most part of the Great Barrier Reef region. However, it is in the north where some of the dune systems are best displayed (Pye 1982). They are formed of a very pure quartz sand; largest areas are in Shelburne Bay and near Cape Flattery. However, there are many other examples e.g. Whitehaven Bay, Whitsunday Island.

e. Mangrove and salt pans:

Coastland wetlands form one of the most important parts of the Queensland shoreline. Approximately 35 species of mangroves are found varying from woodland in the south to fully developed mangrove forests in the north (Bunt et al. 1982; Stoddart 1980). Extensive areas are found at the mouths of most rivers and in the lee of headlands. Probably the best sequences are found in the sheltered channels behind near shore continental islands e.g. Hinchinbrook Channel and the Narrows behind Curtis Island. Along the dominant dry sectors of the Queensland coast, mangroves form only a fringe in the intertidal area and large extents of apparently bare salt pan exist above mean sea-level. The result of high evaporation rates and low rainfall, these areas are best developed where annual rainfall totals are below 1200 mm. Extensive areas are found around Princess Charlotte Bay and in the Fitzroy River delta.

2. Geological and Geomorphological Evolution of the Reef Structure

In spite of its size, the Great Barrier Reef is one of the youngest major reef structures in the world (Davies 1992), now regarded as less than half million years since its initial evolution on a continental shelf which had previously been dominated by terrigenous sedimentation (Symonds et al. 1983). The total history of a major reef system is therefore available and is currently being investigated because of its youth and the knowledge which is available, and environmental factors such as sea-level change, this opportunity for a full undertaking of a major reef province's evolution cannot be matched by older and more complex systems.

Sea-level change is one of the most dominant determining environmental factors in reef evolution and major changes associated with glaciation and deglaciation are recorded by the Great Barrier Reef (Hopley 1982; Davies & Hopley 1983; Davies et al. 1985). During major glacials, sea-levels may have been as much as 125 m or more below their present position, thus exposing the entire Great Barrier Reef region. At these times subaerial processes have operated on the exposed reefs, in some places at least, forming karstic landforms, such as steep sided gorges and blue holes, interpreted as collapsed dolines (Backshall et al. 1979). Examples of these features include steep sided gorges now drowned, between Darley Reef, Gould and Cobham Reefs, and between Hook and Hardy Reefs and numerous channels through the Pompey Complex. Examples of blue holes are few and far between, as they are world wide. However, there are three excellent examples in the Pompey Complex in Molar Reef, Cockatoo Reef and in another reef to the south at latitude 20°57'S, longitude 151°27'E. This latter example is probably one of the best in the world having an explored depth of 90 m (Byron, undated).

During high sea-levels the reefs have been recolonised and in each interglacial phase up to 30 m or more of new reefal limestone has been added. As the shelf is generally subsiding the resultant structure of the Great Barrier Reef reefs is in the form of a layer cake system. The majority of continental shelf reefs and also open ocean atolls appear to have developed in much the same way and the Great Barrier Reef provides an excellent example for reef development at a world wide scale.

Because reef form is largely controlled by depth of antecedent platform from which the modern reef is forming; and because there is a great variation in this depth over the Great Barrier Reef province, nearly all stages of reef from can be seen in the Great Barrier Reef (Hopley 1982). This includes the shelf edge ribbon reefs of the Northern Great Barrier Reef. Most recently, submerged and extinct equivalents of the ribbon reefs have been found on the shelf-edge along many parts of the Great Barrier Reef. Particularly prominent submerged shelf-edge reefs are found between Cairns and Hinchinbrook Island in the North Central Great Barrier Reef, and outside the Pompey Reef Complex on the South Central Great Barrier Reef.

In their growth towards sea-level coral reefs are strongly affected by wind and tidal currents, hardline Reef on the Great Barrier Reef being established mainly along the windward south-eastern side. However, a further determining factor is tidal range which ubiquitously on the Great Barrier Reef is greater than 2.5 m and in places (Pompey Complex and adjacent reefs) can be more than 5 m. On the adjacent mainland tidal ranges may reach 10 m. This semidiurnal oscillation of water levels produces tidal currents which are equalled in the far north, to the east of Torres Strait, where the constriction provided by Torres Strait and the unusual conditions produced by highly complex tides from both the Gulf of Carpentaria and the northern Coral Sea produces similar tidal currents of high velocity.

The end result is a reef complexity which is based on a tidal deltaic morphology not matched elsewhere in the world (Backshall et al. 1979). For example, studies of the Pompey Complex have indicated that they developed as a ribbon reef structure with narrow intervening passes, but stepped back from the shelf-edge. However, the velocity of both incoming flood tides and outgoing ebb tides, through each of the channels, has produced delta-like structures of reefal sediments which have subsequently been colonised by corals to produce the deltaic patterns currently seen in the reefs. In the north the deltaic reefs opposite Torres Strait are similar (Veron 1978). However, they only show a flood delta as the reefs themselves, also developed as small ribbon reefs on the very edge of the continental shelf, are too close to deep water on their eastern sides for deltaic forms to develop.

3. Morphological Diversity of the Reef

The morphology of the present reef is a response to the post-glacial rise in sea-level and the colonisation and upward growth from the older reefal foundations which had previously been exposed. Depth to the older (Pleistocene) foundations varies from 0 m to more than 30 m. This is the result of regional variations in the late Pleistocene subsidence of the continental shelf, together with climatic variations during periods of exposure which have resulted in differences in the amount of erosion which has taken place.

Classification of reefs of the Great Barrier Reef (Hopley 1982) has been based on the depth of the antecedent surface from which the modern reefs grow. Where this is deep, reefs may have only just reached sea-level; where shallow the reefs have not only reached sea-level but also extended laterally to form crescentic, lagoonal and planar reefs (Tables 8 and 9). No other reef province in the world provides such a range of reef morphology.

A wide range of reefal forms are found on a cross-shelf transect across the Great Barrier Reef. Inshore reefs have responded to strong terrigenous influences. Whilst the outermost reefs have oceanic features. For example, off Myrmidon Reef, opposite Townsville, corals have been found at 115 m, *Halimeda* at 125 m, and 100% coral cover between 70 m and 80 m depth because of water clarity (Hopley 1989). Smaller scale zonation is also well developed on the Great Barrier Reefs due to distinctive windward (south-east) and leeward sides.

***Halimeda* reefs** (e.g. Orme 1985; Phipps et al. 1985; Marshall & Davies 1988; Drew & Abel 1988).

Features which appear to be unique to the Great Barrier Reef are the *Halimeda* Banks found inside the ribbon reefs on the northern Great Barrier Reef. Large banks at depths of 20–40 m are formed almost entirely of *Halimeda* which appears to have built structures equal in size to many of the coral reefs. These algal bioherms commenced to grow more than 10 000 years ago i.e. more than 2000 years before reef growth was initiated during the post-glacial transgression. It has been hypothesised that growth began at a time when the mainland coastline, because of lower sea-level, was closer to the outer shelf and water quality in this area precluded coral growth but encouraged algal growth (Hopley 1995).

4. Evolution of Coral Cays (Hopley 1982; in press)

The Great Barrier Reef has more than 300 coral islands, the great range of morphology and distribution of which is helpful in determining the major environmental influences on island development. Island types lie on a continuum from coarse shingle deposits of windward margins to sand cays on the lee side of reefs. Complex islands containing elements of both shingle and sand cays, in which cementation processes have played an important part have a unique range on the Great Barrier Reef. Cays also range from unvegetated to forested with complex terrestrial vegetation. The most complex of all are the low wooded islands, which are found on the northern Great Barrier Reef, north of Cairns. These comprise not only coarse windward deposits and leeward sand cays but also extensive areas of reef top mangroves in the lee of the windward coarse deposits, particularly where cemented. Forty-four islands of this type have been recognised. The most studied examples are first and foremost Low Isles, near Port Douglas, and secondly, Three Isles north of Cooktown. Both were the focus of attention of the 1928–29 Royal Society Expedition and the 1973 Royal Society – Universities of Queensland Expedition to the Great Barrier Reef.

The variety and form of Great Barrier Reef cays results from the range of factors that affect island building. The range of controlling variables cannot be matched in any other single reef province. Variations in reef top ages, reef shape and sea-level history, combined with the differences in energy conditions and tidal ranges, produce this diverse morphology.

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Table 7. Major Characteristics of the Queensland Coast adjacent to the Great Barrier Reef

	Torres Strait – Cooktown		Cooktown – Hinchinbrook Island		Hinchinbrook – Hervey Bay	
Bedrock	651	(16.2)	861	(44.4)	1782	(20.4)
Regolith and laterite	198	(4.9)	6	(0.3)	267	(3.1)
Terraces and fans	399	(9.9)	222	(11.5)	1023	(11.7)
Beach ridges	225	(5.6)	159	(8.2)	612	(7.0)
Parabolic dunes	303	(7.5)	18	(0.9)	234	(2.7)
Transverse and other dunes	684	(17.0)	51	(2.6)	408	(4.7)
Mangroves	531	(13.2)	468	(24.2)	1602	(18.3)
Salt pan and halophytes	351	(8.7)	36	(1.9)	1002	(11.5)
Saline coastal grassland	312	(7.7)	6	(0.3)	978	(11.2)
Swamps, channels etc.	729	(18.1)	111	(5.7)	825	(9.5)

(Source: Data from CSIRO Division of Land Use Research (Galloway 1981))

Note: Figures are in km^2
Figures in parentheses show % for each region

Table 8. Evolutionary Classification of Reefs of the Great Barrier Reef

1. **JUVENILE** (enhancement of Pleistocene relief)
   - (i) *Unmodified antecedent platform:* Pleistocene foundations without modern growth. These cannot be differentiated from submerged reefs on aerial photographs, and are not included in Table 9.
   - (ii) *Submerged reefs:* reefs not at modern sea level but with some growth over the older foundations, usually most prolific on the highest parts of these Pleistocene foundations.
   - (iii) *Irregular reefs:* patchy reef flat development as the growth from the Pleistocene highs reaches modern sea level.
2. **MATURE** (horizontal extension of modern reef flats)
   - (iv) *Crescentic reefs:* coalescence of patch reefs on the most productive windward margins, to produce a crescent shaped reef with open back reef area.
   - (v) *Lagoonal reef:* extension of the reef flat around the margins of the foundations to enclose or partially enclose one or more lagoons.
3. **SENILE** (masking of original relief)
   - (vi) *Planar reef:* infilling of lagoons by internal patch reef growth and sediment transport from windward margins to produce extensive reef flat, eventually with widespread sediment blanket.

To these basic forms are added one further outer-reef type:

- (vii) *Ribbon reefs:* linear reefs growing from structurally or morphologically determined linear foundations (see Hopley 1982 for further discussion).

Fringing reefs are also incorporated in the mapping and gazetting program, differentiation being made between:

- (viii) *Incipient fringing reef:* with no extensive reef flat, but with corals growing over rocky foundations largely below low tide level, attached to mainland or continental island.
- (ix) *Fringing reef:* identifiable reef flat development, attached to mainland or continental island.

(Source: Hopley 1982)

Table 9. Numbers and Areas of the Reef Types on the Great Barrier Reef

	Number	Total Area (km^2)	Mean Size (km2)
Submerged	566	3514	6.2
Patch	446	4061	9.1
Crescentic	254	4266	16.8
Lagoonal	270	4252	15.7
Planar	544	2214	4.1
Ribbon	66	1081	16.4
Incipient fringing	213	120	0.6
Fringing	545	547	1.0
TOTAL	**2904**	**20055**	**6.91**

Natural Heritage Attribute: Geological Aspects of Continental Islands

SOURCE:

Prof. R. Henderson, Department of Earth Sciences, James Cook University, Townsville

CONCLUSIONS:

- a majority of the 600 continental (high) islands are composed of massive granites or silicic volcanics with two significant age groups, Late Palaeozoic (330–270 Ma) and Cretaceous (120–100 Ma);
- the Great Barrier Reef World Heritage Area contains some exceptional sites for studying particular geological assemblages;
- the Great Barrier Reef World Heritage Area contains some assemblages, including the serpentinite rocks of South Percy Island, not commonly found elsewhere.

MOST RELEVANT CRITERIA:

(i), (iii)

SEE ALSO:

Geological and Geomorphological Aspects

DISCUSSION:

There are more than 600 continental (high) islands in the Great Barrier Reef World Heritage Area. These are primarily made of ancient igneous rocks similar to the uplands of the adjacent mainland. In addition around 300 coral cays composed of reef derived materials occur in the Great Barrier Reef World Heritage Area (Hopley et al. 1989; Maxwell 1972).

The continental islands are mountainous regions representing erosional residuals upon the now submerged continental shelf. The rocks of which they are comprised represent a range of ages, from Devonian to Quaternary. Most (some 70%) of the continental islands are composed of granites or their volcanic equivalents (rhyolites or acid volcanics), or mixtures of granites or acid volcanics and other materials (some 20%). The remaining 10% of continental islands are constituted from other rock types (Henderson, R. 1996, pers. comm.). Examples of granite islands include Magnetic and Hinchinbrook Islands. Palm Island is composed of a mixture of granites and rhyolites, while Dunk Island contains tracts of basement metamorphics as well as granite. The age of the granites fall within the range of 270–330 million years. However, in some areas they are younger, for example in the Whitsunday Island group, the granites are of Cretaceous age having been formed around 110 Ma (Henderson, R. 1996, pers. comm.).

Several continental island are particularly interesting from a geological point of view. South Repulse Island contains a package of basic volcanics and fossiliferous limestones that are unique and cannot be matched on adjacent mainland assemblages (Fergusson et al. 1994). South Percy Island contains ultramafic rocks, largely serpentinised, and pillow basalts found in no other locations in the Great Barrier Reef World Heritage Area (Leitch et al. 1994). This assemblage has lead to the development of a serpentine flora with characteristic lifeform, and a serpentine endemic taxa (see Terrestrial Flora) (Batianoff & Specht 1992). Wild Duck Island is known for its Cretaceous sediments, while the Whitsunday Islands are the best site on the east coast of Australia to study of Cretaceous volcanics (Ewart et al. 1992), which are of broad significance to the geological context of Australia at this time (Henderson, R. 1996, pers. comm.). The Flinders Island Group, in Princess Charlotte Bay are excellent examples of sandstone islands in the Great Barrier Reef World Heritage Area (Maxwell 1972).

In addition to the geological make-up of the continental islands their form and structure gives rise to considerable aesthetic value. For example 'the spectacular mountain complex of Hinchinbrook I., with its steep cliffs, gorges, youthful deeply incised valleys, and waterfalls' (Ewart 1978:25). Mt Bowen at a height of 1121 m is one of the highest peaks in Queensland, and one of the highest peaks on any Australian continental island excluding Tasmania. Furthermore the complex archipelagos of some island groups, for example the Palm and the Whitsunday groups, provide a considerable diversity of habitats and environmental regimes which facilitate and maintain high species richness in these localities.

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Natural Heritage Attribute: *Halimeda* Banks

SOURCE:

Dr E. Drew, Australian Institute of Marine Science, Townsville

CONCLUSIONS:

- 20 species of *Halimeda* occur in the Great Barrier Reef World Heritage Area;
- significant sediment contributors to reefal and inter-reefal environments;
- the Great Barrier Reef World Heritage Area contains the most extensive actively accumulating *Halimeda* beds in the world;
- actively accumulating for up to 10 000 years;
- primarily located in the northern region with unique deepwater *Halimeda* beds in the central region of the Great Barrier Reef World Heritage Area;
- may provide important nursery habitat for a range of taxa.

MOST RELEVANT CRITERIA:

(i), (ii), (iv)

DISCUSSION:

Halimeda is an important genus of calcareous green algae found primarily around and upon coral reefs in tropical waters (Drew 1993). Thirty species of *Halimeda* have been recorded worldwide, with twenty growing within the Great Barrier Reef World Heritage Area (Drew 1993). *Halimeda* species are important primary producers in reefal environments (Hillis-Colinvaux 1980), and make significant contributions to reefal sediments as they quickly disintegrate after death leaving a coarse gravel of the plant's calcified segments.

In the inter-reefal areas on the landward side of the ribbon reefs in the northern Great Barrier Reef, an extensive area of *Halimeda* sediment supporting a luxuriant growth of *Halimeda* meadows has developed. These *Halimeda* deposits cover an extensive area, up to 2000 km^2 in the northern Great Barrier Reef. These deposits form discrete patches, often several kilometres long behind each ribbon reef with a distinct break associated with the passages in the outer barrier (Drew 1993). Within each of these *Halimeda* banks, numerous mounds may be discerned, typically a few hundred metres in diameter and up to 20 metres high (Phipps et al. 1985). Often between mounds are the remnant pinnacles of coral rock of Pleistocene age (Drew 1993).

The mounds are not consolidated sediments but rather a loose muddy matrix, whose structure would be easily disturbed by activities such as trawling (Drew, E. 1996, pers. comm.). Seismic studies have shown that at least 15 m of sediment overlay the Pleistocene discontinuity (Orme et al. 1978). Accordingly the maximum age of the banks is 10 000 years (Drew & Abel 1985). The mounds have been formed in situ from the meadows of living algae, which are prolific generators of the sediment. Drew (1983) found that 1 kg per $metre^2$ of *Halimeda* could generate at least 2 kg per year of sediment. Vertical accumulation of sediments in the mounds has been estimated at rates of up to 1 m every 1000 years (Drew 1993). Structures analogous to contemporary *Halimeda* mounds can be traced back to the Late Paleozoic (300 Ma) where phylloid algae formed similar bioherms (Drew 1993).

Halimeda species from the genus sections *Halimeda*, Micronesicae and Rhipalis are present at both reef and bank sites (Drew & Abel 1985), however as a contributor to the total biomass of calcareous green algae, those from the section Opuntia dominate both reefal and bank environments. *H. hederacea* is significant in both bank and reef environments, contributing 45.1% and 28.4% to total biomass respectively. The other main contributor to biomass on the meadows is *H. copiosa* (33.9%). Combined *H. hederacea* and *H. copiosa* contribute on average 81% to total biomass of calcareous algae on northern Great Barrier Reef *Halimeda* meadows (Drew & Abel 1988). Other species of calcareous algae found within meadows include *Udotea* sp. and *Penicillus* sp. (Drew & Abel 1985). In reefal environments *H. opuntia* (40.2%) and *H. hederacea* (38.3%) are significant contributors to calcareous algae biomass (Drew & Abel 1988).

The location of *Halimeda* banks is linked to the availability of essential nutrients that the species requires. It is hypothesised that the high tidal range in the northern Great Barrier Reef combined with the deep breaks in the barrier reef, result in an upwelling of colder nutrient rich water, which is forced through the reef break and across to the meadows. The plume of cooler water has been tracked from the reef break to the meadow (Wolanski et al. 1988). However, across this distance the level of nutrients decreases, being utilised by numerous phytoplankton also washed through the reef break on the tide. It is suggested that consumption of phytoplankton by zooplankton and subsequent decay and re-mineralisation of organic nutrients provides the *Halimeda* meadows with essential nutrients (Drew 1993). The lack of *Halimeda* beds adjacent to sections of the reef where reef breaks are less deep, and thus unable to facilitate upwelling of deep nutrient rich water, and the lack of *Halimeda* meadows in areas where reefs are more distant from the edge of the continental shelf support this theory. The existence of *Halimeda* banks clearly demonstrate the connectivity of components of the inter-reefal, reefal and oceanic environments.

Within the Great Barrier Reef World Heritage Area the most extensive *Halimeda* beds are found in the northern sections commencing from the start of the ribbon reefs just north of Port Douglas and continuing to just below Pandora entrance. However, *Halimeda* is absent in the Princess Charlotte Bay area, where it is suggested that turbid waters may reduce light too much or directly smother plants (Drew & Abel 1988). The largest continual extent of *Halimeda* bed occurs from about Second Three Mile Entrance to the Quoin Island Entrance (Drew, E. 1996, pers. comm.).

Further south, *Halimeda* beds are known from only two locations. In the Swain Reefs *Halimeda* meadows occur on the top of a few shallow carbonate (reefal) platforms. While in behind Myrmidon Reef and in front of Bowl Reef, meadows have been found at a depths greater than 50 m, with the deepest recorded at 96 m (Drew & Abel 1988). These deepwater meadows display a distinct species composition to both the northern and southern Swains Reef shallower meadows, with *H. frails* contributing around 50% of the biomass of total calcareous algae (Drew & Abel 1988). These southern meadows are important to the understanding of *Halimeda*, providing the opportunity to investigate active *Halimeda* beds in considerably different environments to those of the northern Great Barrier Reef (Drew, E. 1996, pers. comm.).

Several other species of green algae, and red and brown algae have been recorded from *Halimeda* meadows. Similarly seagrasses have also been recorded (Drew & Abel 1988). No quantitative studies concerning the fauna of *Halimeda* meadows have yet been carried out, thus there is limited information concerning the meadows' role as habitat (Drew, E. 1996, pers. comm.). However the non-*Halimeda* component of meadow sediment, originating from foraminifera (35%), mollusc (33%) and bryozoan (11%) indicates their presence (Drew & Abel 1988). A number of small reefal fish occupy the meadows while larger fish reside around the coral pinnacles between mounds, perhaps contributing through grazing to the local depletion of *Halimeda* in those areas. A number of invertebrates, such as sponges and echinoderms, particularly crinoids have been observed. Furthermore it is likely that the meadows serve a nursery role to a number of species (Drew, E. 1996, pers. comm.).

Halimeda banks occur in a number of other regions, including the Nicaraguan Rise in the Caribbean (Hine et al. 1988); the east Java Sea in Indonesia (Phipps & Roberts 1988); in the Timor Sea north-west of Australia (Marshall et al. 1994); and upon the continental shelf off Bombay in India (Rao et al. 1994). However, of these banks, only those in the east Java Sea are actively accreting significant amounts of sediment at the present time. Thus the northern Great Barrier Reef is the greatest extent of active *Halimeda* meadows in the world. Furthermore the unusual habitats of the southern deepwater meadows and the Swain Reef meadows contributes to the universal importance of the *Halimeda* banks of the Great Barrier Reef World Heritage Area.

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Natural Heritage Attribute: Hard Corals

SOURCE:

Dr J.E.N. Veron, Australian Institute of Marine Science, Townsville

CONCLUSIONS:

- the Great Barrier Reef World Heritage Area contains the largest coral reef system in the world;
- 2904 coral reefs cover 5.6% of the Great Barrier Reef World Heritage Area;
- the Great Barrier Reef World Heritage Area contains an extensive diversity of reef morphologies, including deltaic, dissected and detached reefs;
- high heterogeneity at a range of spatial scales gives rise to high habitat diversity;
- 359 species of hard corals recorded from the Great Barrier Reef World Heritage Area;
- Great Barrier Reef World Heritage Area exhibits low endemism, with most species distributed through the Indo-West Pacific;
- long lived massive corals can provide historical information regarding environmental conditions over several hundreds of years;
- Great Barrier Reef World Heritage Area occurs within a jurisdiction that has a higher potential for effective conservation management than other reefal areas of the Indo-West Pacific region.

MOST RELEVANT CRITERIA:

(ii), (iii), (iv)

DISCUSSION:

The Great Barrier Reef is the single largest coral reef in the world (Veron 1995). Whilst not being the most species diverse reefal system in the world, it is exceptionally diverse in terms of reef morphologies, habitats and environmental regimes (Veron 1995). Using Hopley's (1982) classification of reefs, (see Geological and Geomorphological Aspects), submerged reefs are numerically dominant (566), while juvenile patch reefs, and mature crescentic and lagoonal reefs dominate in terms of extent (4061 km^2; 4266 km^2; and 4252 km^2 respectively). In total the 2904 reefs of the Great Barrier Reef World Heritage Area cover an extent of 20 055 km^2 (Hopley et al. 1989). The total reefal area covers 5.9% of the Great Barrier Reef World Heritage Area, which corresponds to about 9% of the continental shelf as defined by a depth of 200 m (Hopley et al. 1989).

The reef framework is provided by Scleractinian corals in combination with the cementing abilities of a number of species of coralline algae, upon the eroded carbonate platforms of earlier extinct reefs. Globally more than 800 species of hard coral have been recorded (Veron 1995). While the global centre of species diversity is situated in the Indo-West Pacific region centred upon the islands of Borneo, Sulawesi and the Philippine archipelago, with 410 species from the latter location, the diversity of coral species in the Great Barrier Reef World Heritage Area is high. Three hundred and fifty-nine species, or about 88% of all central Indo-Pacific species have been recorded from the Great Barrier Reef World Heritage Area (Veron 1993).

Table 10 shows the number of species recorded from regions of the Great Barrier Reef World Heritage Area. The central region of the Great Barrier Reef World Heritage Area, with complex archipelagos of the Whitsunday and Palm groups of islands, is the most diverse with 343 recorded species, followed by the northern region. Given the majority of intensive research and documentation has occurred in the more readily accessible southern regions of the Great Barrier Reef World Heritage Area, new records and new species are likely to be found in the northern region of the Great Barrier Reef World Heritage Area (Veron, J. 1996, pers. comm.). Endemism in the Scleractinia is low for the Great Barrier Reef World Heritage Area and those species restricted to the World Heritage Area may well be an artefact of limited collection of Scleractinia in other regions rather than a true indication of endemism (see Table 11).

The diversity of corals is largely related to the diversity of habitats within an area. It is not surprising then that the complex high island archipelagos of the Whitsunday, Palm and Keppel groups of islands offering a range of habitats from high energy north-east facing substrates through to muddy low energy mangrove environments give the highest species diversity of hard corals in the Great

Barrier Reef World Heritage Area. In contrast species diversity drops off significantly around the Capricorn–Bunker group where reef and cay formation are considerably more uniform. Despite their reduced diversity, approximately 68% of Great Barrier Reef World Heritage Area corals have been recorded from the Capricorn–Bunker Group. Indeed, at sites on other Pacific Ocean reefs no more than 10% of their coral species would not be found within the Great Barrier Reef World Heritage Area (Veron, J. 1996, pers. comm.).

The Great Barrier Reef is an ecologically contained unit which operates as a source for other reefal regions to the north via the East Australia Current. This is in contrast to other reefs such as those of north-west Australia which receive inputs from reef systems to the north in Indonesia.

The huge latitudinal extent of the Great Barrier Reef World Heritage Area ensures that it includes a diverse range of habitats and environmental regimes. In particular, the high tidal range experienced in the southern section of the Great Barrier Reef World Heritage Area, and fast currents through the Torres Strait have produced reef types not seen elsewhere in the Indo-West Pacific region. Examples are the deltaic reefs of the Pompey Complex in the south, and those just beyond the northern boundary of the Great Barrier Reef World Heritage Area (Veron 1978). These deltaic reefs consist of a complex of interwoven narrow channels through which high tides and high velocity currents flow. At either end of the channels, a delta-like formation of sediments has formed. In the northern deltaic reefs the delta only forms on the western end of the channels. A further result of the high tidal range upon the southern reefs is the formation of terraced algal rims that isolate the lagoons at heights of 3 m above low tide. While outside the Great Barrier Reef World Heritage Area, the dissected reefs of the Torres Strait are also unique reef types whose morphology in part is due to the strong currents flowing through Torres Strait (Veron 1978).

No true atolls exist in the Great Barrier Reef. However, the Great Detached Reef in the Far Northern Section of the Great Barrier Reef Marine Park and Ashmore Reef further north are exceptional examples 'shelf-edged atolls': that is, reefs surrounded by very deep water, in this case the Queensland Trough. Other important hard coral communities and reefs can be found inshore, which often contain unique combinations of species not elsewhere found (Veron, J. 1996, pers. comm.) (see Fringing Reefs). An example is a new record for the Pacific of the undescribed massive faviid *Goniastrea* spp. (van Woesik & DeVantier 1992).

Some hard corals are exceptional in being able to provide a history of themselves and their environment that reaches back several centuries (Lough & Barnes 1996). X-rays have been used to reveal the annual banding in cores from Porites sp. The longest record began in AD 1479, while a large number have covered the period 1746–1982 and serve to provide important baseline information otherwise unavailable (Lough & Barnes 1996). Parameters of coral growth (density, extension and calcification) can be related over time and, where similar patterns emerge across reef sites conclusions about regional or reef wide environmental variables may be drawn (Lough & Barnes 1996).

One of the most important factors giving rise to the universal importance of the Great Barrier Reef World Heritage Area comes from the potential for the area to be well managed. In contrast, many of the remaining Indo-West Pacific coral reef systems fall within the territories of less developed countries that have limited opportunities and resources for effective management.

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Table 10. Species Diversity in the Great Barrier Reef World Heritage Area

Region	Corresponding GBRMP Section	Recorded Species
Northern Great Barrier Reef	Far Northern and Cairns Sections	324
Central Great Barrier Reef	Central Section	343
Capricorn–Bunker	Mackay/Capricorn Section	244
Pompey and Swain Reefs	Mackay/Capricorn Section	163

(Source: Veron 1993)

Table 11. Endemic Scleractinia Species of the Great Barrier Reef World Heritage Area

Acropora azurea
Acropora cardenae
Acropora sp.1 E Australia
Acropora sp.2 E Australia
Acropora sp.3 E Australia
Montipora sp.3 E Australia

(Source: Veron 1993)

Natural Heritage Attribute: Mangroves

SOURCE:

Dr N.C. Duke, Townsville

CONCLUSIONS:

- 2069 km^2 of mangroves occur in or directly adjacent to the Great Barrier Reef World Heritage Area;
- 37 species recorded in the Great Barrier Reef World Heritage Area, being 54% of world flora;
- Great Barrier Reef World Heritage Area has a comparable and complementary diversity to other areas of high diversity;
- important trends at a range of spatial scales makes the Great Barrier Reef World Heritage Area the prime location for research into mangrove ecology and evolution;
- habitat for a range of taxa, in particular the juveniles of some species;
- important contributors to ecological processes.

MOST RELEVANT CRITERIA:

(ii), (iii), (iv)

DISCUSSION:

Mangroves are a diverse group of predominantly tropical trees and shrubs occupying the area above mean sea level in the marine intertidal zone (Robertson & Alongi 1995). The boundary of the Great Barrier Reef World Heritage Area is thus problematic when considering mangroves. Apart from those on offshore islands the boundary of the Great Barrier Reef World Heritage Area is likely to slice mangrove communities in two. However, the importance of mangroves to the integrity of neighbouring marine ecosystems cannot be understated. Mangroves offer feeding grounds and nurseries for a range of fauna, and contribute to a number of other important processes, such as bank and shore stabilisation, and primary production. The area of mangrove within or neighbouring the Great Barrier Reef World Heritage Area is approximately 2069 km^2 (Galloway 1982). This represents approximately 18% of Australia's mangrove areas.

Worldwide, 69 species of mangrove from 21 plant families have been recorded (Duke 1992). Within or immediately adjacent to the Great Barrier Reef World Heritage Area, 37 species from 20 families have been recorded (see Table 12). This makes the Great Barrier Reef World Heritage Area one of the most diverse areas in the world for mangrove habitat, with a similar, but complementary, level of diversity being expressed in the nearby Indo-Malesia region (Duke 1992). Other regions of mangrove in the world have a much smaller suite of species, between one-quarter and one-half that of the Great Barrier Reef World Heritage Area region. When combined with the pressures upon mangrove areas in the rapidly advancing Indo-Malesia region the Great Barrier Reef World Heritage Area mangroves clearly stand out as being of world significance. There are no species of mangrove endemic to the Great Barrier Reef World Heritage Area, however one hybrid variety, *Lumnitzera X rosea* has only been recorded from Missionary Bay (Duke, N. 1996, pers. comm.).

Two trends can be observed in the distribution of mangroves in the Great Barrier Reef World Heritage Area. A cross-shelf trend shows decreasing diversity as you move away from the mainland coast to islands with mangrove communities. Thus at Halfway Islet only three species of mangrove are recorded, while at a nearby mainland location, Captain Billy Creek 12 have been recorded (Duke, N. 1996, unpub. data). These species-diverse coastal regions typically have higher nutrient inputs from larger watersheds and less saline conditions compared to island locations of similar latitude. The other important trend is a general decrease in diversity with increasing latitude. Thus at Escape River in the north 26 species have been recorded, while at St Lawrence Creek in the south only three species have been recorded (Duke, N. 1996, unpub. data).

While these trends are broadly observable at the scale of the whole Great Barrier Reef World Heritage Area, at a finer scale, local conditions – for example the size of the watershed, the size and shape of the watercourse, the average level of rainfall, and the dispersal properties of particular species – will create local and regional differences that overlay the broadscale trends identified above. Furthermore, within the one river system distinct patterns of upstream and downstream communities may develop. Some mangroves are restricted to these local environments. Temperature, salinity and dispersal distance are the three main factors affecting distribution patterns.

As a consequence of the wide variety of environmental variables, in part through its latitudinal extent, the Great Barrier Reef World Heritage Area is an important region where changes in the genetic base of individual species can be studied. This may lead to important insights in to the evolution of contemporary mangrove flora. One example is the case of Avicennia marina, which displays a marked morphological change from its northern populations to those in the south of the Great Barrier Reef World Heritage Area. The genetic base for this change has been identified (Duke 1990, 1991, 1995); no where else in the world has the genetic base for such differentiation in mangrove plants been identified. The Great Barrier Reef World Heritage Area offers a unique opportunity to investigate the evolution of mangroves.

The mangrove trees form a structure upon which a whole range of biota is dependent. Importantly also, mangroves need to be seen as a system that is a part of a much larger estuarine system along the coast. They form an important link between the rainforest and the reef; the structure relating to rainforest flora, and many dependent organisms having direct links to the reefal and seagrass environments. Accordingly upstream changes that affect mangroves may affect neighbouring systems. The interlinks between mangroves and other systems are exemplified when looking at black marlin and sailfish. These billfish feed upon baitfish which migrate out to deeper waters as they grow. In their early life history stages they occupy shallow bays especially near the mouth of mangrove systems where they feed upon a variety of zooplankton flushed out from the mangroves (Cappo 1995a, 1995b).

The invertebrate fauna of mangroves can be divided into that associated with the forest canopy, primarily spiders and insects, and the aquatic animals occupying the intertidal areas (Hutchings & Recher 1982). Decapod crustaceans are usually the numerically dominant macrobenthos in mangrove communities (Robertson & Alongi 1995). Of these, the crabs of the family Sesarminae play an important role in burying leaf and reproductive-part litter within mangrove forests, thus retaining nutrients within the system. Other dominant groups include the polychaetes and molluscs particularly the gastropods. However, ascidians, echinoderms, coelenterates and sponges are also present (Hutchings and Recher 1982).

A number of fish families numerically dominate the waters of mangroves. These include Ambassidae, Clupeidae, Engraulididae, Gobiidae and Leiognathidae. Species of the families Sparidae, Haemulidae, Lutjanidae, Carcharhinidae, Centropomidae and Carangidae also contribute to the biomass of mangrove fish communities (Robertson & Alongi 1995). Furthermore, mangroves play an important role as nursery sites to many fishes and crustaceans (Roberston & Duke 1987; Robertson & Blaber 1992). A number of bird species are considered to be mangrove specialists, including some that are considered to be endemic to mangrove habitat. The flying foxes, *Pteropus poliocephales* and *P. alecto,* camp and feed in the mangrove canopy as do a number of other bats. Several reptiles also utilise mangrove habitats, including the mangrove monitor (*Varanus indicus*) and several pythons (Hutchings & Recher 1982). Mangrove habitats along the east coast of Cape York Peninsula provide important habitat for estuarine crocodiles (GBRMPA 1994).

Mangroves play a fundamental role in the stabilisation of sediments along coastlines and estuarine banks, preventing erosion from periodic cyclonic events and wave action. Pioneer forms of mangrove are able to quickly capitalise upon sediments washed down from upstream, binding it with their roots, in turn allowing mature forest forms of mangrove to take hold.

Given the limited extent of mangroves (less than 1% of the Great Barrier Reef World Heritage Area), and the important roles they play it is difficult to identify specific regions or areas of special or more noteworthy importance. Indeed the local variations in mangrove distribution ensure that each system is unique and is worthy in itself. Despite this, some examples can be drawn out.

The offshore islands that support mangrove communities are all particularly important. These relate directly back to the mainland at the same latitude, and express the cross-shelf trend. Three extensive areas of mangrove habitat, from north to south are the Jackey Jackey Creek/Newcastle Bay region (approximately 220 km^2), the Hinchinbrook Island region including Hinchinbrook Channel and Missionary Bay (approximately 250 km^2), and in the south, Shoalwater Bay (approximately 300 km^2).

In terms of species diversity the Olive River in the north is arguably the most diverse in Australia for mangrove flora with 27 species having been recorded (Duke, N., unpub. data). The Olive River is also the only area in Australia that contains *Dolichandrone spathacea*, a species normally found in Malaysia and Papua New Guinea. The next closest recorded site of the species is in Papua New Guinea, a distance of some 100 nautical miles. With genetic work this species may turn out to be a new species. (Duke, N. 1996, pers. comm.). In the middle section of the Great Barrier Reef World Heritage Area the Murray River is highly diverse with 27 species (Duke, N., unpub. data). While at the southern end, near Shoalwater Bay, Port Clinton is very diverse with 13 species recorded (Duke, N., unpub. data).

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Table 12. Mangroves Occurring in the Great Barrier Reef World Heritage Area

Pteridaceae:	*Acrostichum speciosum*
Plumbaginaceae:	*Aegialitis annulata*
Bombacaceae:	*Camptostemon schultzii*
Sterculiaceae:	*Heritiera littoralis*
Ebenaceae:	*Diospyros littoralis*
Myrsinaceae:	*Aegiceras corniculatum*
Caesalpiniaceae:	*Cynometra iripa*
Combretaceae:	*Lumnitzera littorea*
	Lumnitzera racemosa
	Lumnitzera X rosea
Lythraceae:	*Pemphis acidula*
Myrtaceae:	*Osbornia octodonta*
Sonneratiaceae:	*Sonneratia alba*
	Sonneratia caseolaris
	Sonneratia lanceolata
	Sonneratia X gulngai
Rhizophoraceae:	*Bruguiera cylindrica*
	Bruguiera exaristata
	Bruguiera gymnorrhiza
	Bruguiera parviflora
	Bruguiera sexangula
	Ceriops australis
	Ceriops decandra
	Ceriops tagal
	Rhizophora apiculata
	Rhizophora mucronata
	Rhizophora stylosa
	Rhizophora X lamarckii
Euphorbiaceae:	*Excoecaria agallocha*
Meliaceae:	*Xylocarpus granatum*
	Xylocarpus mekongensis
Avicenniaceae:	*Avicennia marina*
Acanthaceae:	*Acanthus ebracteatus*
	Acanthus ilicifolius
Bignoniaceae:	*Dolichandrone spathacea*
Rubiaceae:	*Scyphiphora hydrophyllacea*
Arecaceae:	*Nypa fruticans*

(Source: Duke 1992)

Natural Heritage Attribute: Marine Mammals

SOURCE:

Prof. H. Marsh, Department of Tropical Environment Studies and Geography, James Cook University, Townsville

Dr P. Corkeron, Department of Tropical Environment Studies and Geography, James Cook University, Townsville

CONCLUSIONS:

- The Great Barrier Reef World Heritage Area is a significant refuge for cetacean biodiversity in the tropical Indo-Pacific as coastal species such as the Irrawaddy dolphin and the Indo-West Pacific humpback dolphin are unlikely to survive outside Australia. It is also a breeding ground for the threatened humpback whale.
- The Great Barrier Reef World Heritage Area supports an estimated 15% of the dugongs that have been recorded in Australian waters to date. The dugong is the only extant species of the family Dugongidae and one of only four species in the mammalian order Sirenia. The dugong is classified as vulnerable to extinction by the IUCN with poor long-term survival prospects outside Australia.

MOST RELEVANT CRITERIA:

(ii), (iv)

DISCUSSION:

Members of two major groups of marine mammals, the orders Cetacea (whales and dolphins) and Sirenia (sea cows) occur in or are regular visitors to the Great Barrier Reef World Heritage Area.

Cetaceans

The mammalian order Cetacea includes two modern sub-orders, the Mysticeti or whale-bone whales and the Odonotceti or toothed whales, porpoises and dolphins. There are about 80 species of cetaceans in 40 genera and 13 families. At least 26 species in 18 genera and five families visit or are resident in the Great Barrier Reef World Heritage Area, a level of diversity which is probably typical of other coastal regions in the Indo-West Pacific.

Most species of cetaceans are classified by the IUCN as insufficiently known, reflecting the paucity of knowledge of the order generally (Klinowska 1991). The species which visit the Great Barrier Reef World Heritage Area regularly include the humpback whale (*Megaptera novaeangliae*) which is classified as vulnerable by the IUCN (IUCN 1995).

Four features make the Great Barrier Reef World Heritage Area important for cetaceans:

(1) Two of the three species of dolphin resident in the inshore waters of the Great Barrier Reef World Heritage Area, the Irrawaddy River dolphin (*Orcaella brevirostris*) (Marsh et al. 1989) and the Indo-Pacific humpbacked dolphin (*Sousa chinensis*) are restricted to tropical and warm temperate coastal waters in the Indo-West Pacific region and have very poor prospects of survival outside northern Australia.

(2) The region is a breeding area and northern terminus for humpback whales travelling along the eastern Australian coastline each year during their breeding migrations from the Antarctic to tropical waters (Simmons & Marsh 1986). This population of humpbacks is increasing by at least 10% per annum after being seriously depleted by whaling earlier this century (Bryden et al. 1990).

(4) The region is an important habitat for the dwarf minke whale (Arnold et al. 1987) which are regularly sighted on the Ribbon Reefs between Cairns and Lizard Island in June and July. The dwarf minke is probably an undescribed subspecies of the minke whale (*Balaenoptera acutorostrata*) (Arnold, P. 1996, pers. comm.).

(4) Longman's beaked whale (*Mesoplodon pacificus*), considered to be the rarest whale in the world, has been recorded in the Great Barrier Reef World Heritage Area. The species is known from only two specimens (both skulls and jaws): one found near Mackay, the other on the coast of the Somali Republic in north-east Africa. A live specimen has never been positively identified (Klinowska 1991).

Dugong

The dugong, *Dugong dugon*, the only herbivorous mammal which is strictly marine, has high biodiversity value as one of only four extant members of the mammalian Order Sirenia (sea cows), all of which are listed as vulnerable to extinction by the IUCN (1995). The dugong is the only extant member of the family Dugongidae. The other modern member of the family Dugongidae, the giant Steller's sea cow, *Hydrodamilis gigas*, was exterminated by humans in the 18th century (Marsh & Lefebvre 1994).

The dugong's range extends throughout the tropical and sub-tropical coastal and island waters of the Indo-West Pacific east to the Solomon Islands and Vanuatu, and between about 26° to 27° north and south of the equator (Nishiwaki & Marsh 1985). Over much of this range, dugongs are now believed to be reduced to relict populations which are separated by large areas where they are close to extinction or extinct. The dugong's prospects of survival are poor throughout most of its range outside Australia (Bertram 1981).

Northern Australia is regarded as the dugong's stronghold and a significant proportion of dugong stocks is believed to occur in northern Australian waters between Moreton Bay (near Brisbane) in the east, and Shark Bay in the west. Quantitative information on dugong distribution and abundance comes from dedicated aerial surveys. These surveys indicate that dugongs are the most abundant marine mammal in the inshore waters of northern Australia (Marsh, unpub. data). Even though not all areas of suitable habitat have been surveyed, the population estimates for northern Australia sum to more than 80 000 (Marsh et al. 1994; in press) of which some 12 000 (15%) occur in the Great Barrier Reef World Heritage Area.

Seagrasses are the staple food of dugongs (Lanyon et al. 1989) and most sightings of dugongs on aerial surveys and most locations of dugongs fitted with satellite transmitters have been in the vicinity of seagrass beds (Marsh & Rathbun 1990; Marsh et al. in press). Dugongs occur all along the coast of the Great Barrier Reef World Heritage Area and have been sighted more than 50 km offshore associated with deepwater and reefal seagrass beds in the Far Northern Section.

Within the Great Barrier Reef World Heritage Area, more than 80% of dugongs occur in the region north of Cooktown, more than a third of these occur in the Princess Charlotte Bay region another quarter between Lookout Point and Cape Melville (Marsh & Saalfeld 1989, 1990; Marsh et al. in press). Numbers appear to be stable in this region apart from a possible localised depletion close to Lockhart River community.

In contrast, in the region south of Cooktown, the number of dugongs has declined by approximately 50% over the past eight years from an estimated 3479 ± s.e. 459 to 1682 ± s.e. 236. Over a large section of the region, this decline is over 80%. This change is most likely to be due to unsustainable dugong mortality within the region. Important sites in the southern Great Barrier Reef World Heritage Area include the Hinchinbrook Island area, Cleveland Bay, Upstart Bay and Shoalwater Bay.

Dugongs have a life-span of more than 70 years and bear only one calf at a time at intervals of three years or more (Marsh et al. 1984; Marsh 1995). Population models indicate that a dugong population reproducing optimally will increase at only about 5% per year. Thus dugong populations can sustain only a very low level of anthropogenic mortality (1–2% of females). Dugongs in the southern Great Barrier Reef World Heritage Area are threatened by habitat loss, traditional hunting and incidental mortality in commercial gill-nets and in shark nets set for bather protection (Marsh et al. in press). These impacts are unquantified and their relative importance probably varies in different parts of the World Heritage Area.

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Natural Heritage Attribute: Marine Turtles

SOURCE:

Dr C. Limpus, Queensland Department of Environment, Brisbane

CONCLUSIONS:

- Great Barrier Reef World Heritage Area contains globally important nesting and feeding grounds for loggerhead, green, hawksbill and flatback turtles;
- southern Great Barrier Reef World Heritage Area loggerhead turtle breeding population is approximately 70% of the South Pacific population;
- Raine Island accommodates the largest green turtle breeding population in the world;
- Great Barrier Reef World Heritage Area contains one of the last significant breeding population of the hawksbill turtle in the world;
- approximately 10% of the endemic flatback turtles breed on a few islands in the southern region of the Great Barrier Reef World Heritage Area;
- olive ridley and leatherback turtles also utilise the resources of the Great Barrier Reef World Heritage Area.

MOST RELEVANT CRITERIA:

(iv)

DISCUSSION:

Six of the world's seven extant species of marine turtle are found in the Great Barrier Reef World Heritage Area. For four of these species, the loggerhead, green, hawksbill and flatback turtles, the Great Barrier Reef World Heritage Area provides feeding and nesting sites that are of universal importance to their continued survival. Furthermore the Great Barrier Reef World Heritage Area provides important habitat and food resources for both the olive ridley and leatherback turtles. Each of these will be dealt with individually.

Loggerhead Turtle (*Caretta caretta*):

The loggerhead turtle is listed as vulnerable by the IUCN (IUCN 1994), and endangered by both the Queensland (*Nature Conservation (Wildlife) Regulation 1994*) and Australian Governments (ANZECC 1991). Whilst a number of loggerhead populations are stable, for example the Greece/Turkey population, or even increasing as is the case of the South African population, the global population of loggerhead turtles has decreased significantly in recent times. Within Australia it is estimated that a decline in the population in the range of 50–80% has occurred since the mid-1970s (Limpus & Reimer 1994). The Marine Turtle Specialist group of the IUCN's Species Survival Commission has recommend that the classification of the loggerhead turtle should be changed from vulnerable to endangered (Limpus, C. 1996, pers. comm.).

Within the Pacific two genetically distinct populations of loggerhead turtles exists. One is centred in the northern hemisphere with important breeding areas in Japan, and the other based in the Coral Sea, with important breeding areas in south-east Queensland, and small populations in Vanuatu and New Caledonia. An additional Australian breeding area occurs in Western Australia. The south east Queensland breeding area is concentrated in the Capricorn–Bunker Group, the Swain Reefs, and the Bundaberg to Wreck Rock area. In 1977 about 3500 females nested in south-east Queensland region, currently only about 1000 females nest annually. The breeding aggregations in Vanuatu and New Caledonia contribute less, with about 100 females nesting annually.

Approximately 70% of the Australian population nests at five locations, namely Mon Repos, Wreck Island, Tyron Island, Erskine Island and the Wreck Rock beaches (Limpus & Reimer 1994). Together these sites account for 60% of the South Pacific population of loggerhead turtles highlighting the importance of the Great Barrier Reef World Heritage Area to loggerhead turtle conservation. Furthermore the population dynamics of the eastern Australia loggerhead turtle population is the best understood in the world (Limpus, C. 1996, pers. comm.).

Following their emergence the hatchlings undergo a pelagic dispersal phase, where they are taken by the East Australia Current south to about Coffs Harbour and then east into the open ocean. After 15–20 years the loggerhead turtles return to within 2000–2500 km of their hatching location, and then drop out onto the shallow continental shelf feeding upon benthic fauna, primarily molluscs and crabs. The Great Barrier Reef World Heritage Area, with its broad continental shelf provides one of the largest areas of suitable feeding habitat for mature loggerhead turtles. Through provision of both suitable nesting locations and food resources the Great Barrier Reef World Heritage Area is clearly of universal importance for the continued survival of this threatened species (Limpus, C. 1996, pers. comm.).

Green Turtle (*Chelonia mydas*):

The green turtle is listed as endangered by the IUCN (IUCN 1994), and vulnerable by both the Queensland (*Nature Conservation (Wildlife) Regulation 1994*) and Commonwealth Governments (ANZECC 1991). Despite significant reductions in global populations over the past 100 years, Australia's populations have not suffered a comparable decline and are considered to be the best remaining populations in the world. Four independent breeding aggregations of green turtles occur in Australia; two of which are located within the Great Barrier Reef World Heritage Area. Raine Island and Moulter Cay constitute the northern Great Barrier Reef breeding aggregation with 30 000–40 000 females nesting each year (Limpus 1994). The Raine Island breeding aggregation is the biggest in the world. At the southern end of the Great Barrier Reef World Heritage Area the Capricorn–Bunker group provides nesting sites for a further 8000 females each year (Limpus 1994). The remaining two aggregations are upon the North West Shelf in Western Australia and in the Gulf of Carpentaria, with 18 000 and 5000 nesting females each year respectively.

Following a pelagic dispersal phase of young hatchlings, the turtles return to within 2500 km of their nesting place. Tag returns from turtles suggests that the turtles from the southern Great Barrier Reef aggregation disperse over much of the Great Barrier Reef region, while those from the northern Great Barrier Reef aggregation tend to disperse north west into the Torres Strait and the Gulf of Carpentaria. The green turtle is a herbivore feeding upon seagrasses and algae. The Great Barrier Reef World Heritage Area provides important nesting sites for the largest breeding aggregation of green turtles in the world. Furthermore the shallow and recently discovered deeper seagrass meadows and algae within the Great Barrier Reef World Heritage Area provide the essential resources for the southern Great Barrier Reef population.

Hawksbill Turtle (*Eretmochelys imbricata*):

The hawksbill turtle is classified as vulnerable by both the Queensland (*Nature Conservation (Wildlife) Regulation 1994*) and Commonwealth Governments (ANZECC 1991), and is classified as endangered by the IUCN (IUCN 1994). The global populations of this species have been severely reduced primarily through the hunting of the species for tortoiseshell. The impact upon the species has been so great that the Marine Turtle Specialist group of the IUCN's Species Survival Commission has recommend that the species be classified as critically endangered (Limpus, C. 1996, pers. comm.).

The Great Barrier Reef World Heritage Area is fundamental to the continued survival of this species as it contains one of the few remaining significant populations. The northern Great Barrier Reef population nests on inner-shelf high islands and cays north from Princess Charlotte Bay into Torres Strait (Miller 1994). The total Great Barrier Reef World Heritage Area nesting population is several thousand females (Limpus 1994). Other major Australian breeding aggregations occur in north-east Arnhem Land and upon the North West Shelf in Western Australia. Significant nesting locations in the Great Barrier Reef World Heritage Area include Millman Island, Boydong Island and Hannibal Island. Hawksbill turtles feed almost exclusively on sponges and can be found on almost all reefs in the Great Barrier Reef World Heritage Area. The Great Barrier Reef World Heritage Area supports the biggest aggregate of feeding hawksbill turtles in the world (Limpus, C. 1996, pers. comm.).

Flatback Turtle (*Natator depressus*):

The flatback turtle has been classified as vulnerable by the IUCN (IUCN 1994), and as vulnerable by the Queensland Government (*Nature Conservation (Wildlife) Regulation 1994*). It is endemic to the continental shelf of Australia, and occupies the shallow waters in the lagoon of the Great Barrier Reef, through Torres Strait and into the Arafura Sea and along the northern section of the Western Australia coast. All nesting of the flatback turtle occurs on Australian lands, where approximately 10 000 females nest annually. Nesting focuses upon the islands of west Torres Strait, the bottom of the Gulf of Carpentaria, western Arnhem Land, the north-west shelf of Western Australia, and within the Great Barrier Reef World Heritage Area between Mackay and Rockhampton. The Great Barrier Reef World Heritage Area including Peak Island and Wild Duck Island supports about 1000 females annually, that is about 10% of the world stock of the flatback turtle (Limpus, C. 1996, pers. comm.). The species does not have an oceanic pelagic dispersal phase, and it migrates within continental shelf waters, accordingly the management of this species is less complicated than other marine turtles. It avoids hard substrates such as coral reefs and rocky shores, spending most time in soft bottom areas of the Great Barrier Reef World Heritage Area. It feeds primarily upon soft bodied invertebrates.

Leatherback Turtle (*Dermochelys coriacea*):

The leatherback turtle is classified as endangered by both the IUCN (IUCN 1994) and the Queensland Government (*Nature Conservation (Wildlife) Regulation 1994*), while the Commonwealth Government has classified the species as vulnerable (ANZECC 1991). It has very limited occurrence in the Great Barrier Reef World Heritage Area, with most records coming from the Wreck Rock to Battle Creek Area at the southern extremity of the Great Barrier Reef World Heritage Area. These populations are very small with three individuals or less nesting each year. The leatherback is an oceanic turtle, feeding primarily upon jellyfish on the ocean side of the outer reefs.

Olive Ridley (*Lepidochelys olivacea*):

The olive ridley turtle is considered to be endangered by both the IUCN (IUCN 1994) and Queensland Government (*Nature Conservation (Wildlife) Regulation 1994*), and vulnerable by the Commonwealth Government (ANZECC 1991). No breeding of the olive ridley turtle occurs in the Great Barrier Reef World Heritage Area, although some feed in the lagoonal area on molluscs and crabs. The bulk of the population is not found within the Great Barrier Reef World Heritage Area, and it is most likely that the Gulf of Carpentaria provides the most important feeding locations.

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Natural Heritage Attribute: Molluscs

SOURCE:

Dr W.F. Ponder, Australian Museum, Sydney

Mr I. Loch, Australian Museum, Sydney

CONCLUSIONS:

- the number of mollusc species occurring in the Great Barrier Reef World Heritage Area is estimated to range from a minimum of 5000, to possibly as many as 8000;
- Great Barrier Reef World Heritage Area molluscan fauna represents a significant proportion of world molluscan diversity;
- there are four main components to the Great Barrier Reef World Heritage Area molluscan fauna, with the most speciose being the shallow reefal fauna, with tropical Indo-West Pacific affinities and very low levels of endemism;
- the other three main components are the shallow coastal molluscan fauna and the shelf fauna both which are shared with southern Queensland and New South Wales, and a tropical coastal component that is shared, in large part, with northern Australia;
- endemism is highest in the components that are shared with southern Queensland and New South Wales;
- the gastropod family Volutidae exhibits the highest degree of endemism in the Great Barrier Reef World Heritage Area;
- many species have large colourful shells prized by shell collectors, and adding to the aesthetic qualities of the Great Barrier Reef World Heritage Area;
- some species of bivalves are important in bioerosion of coral substrates;
- larval molluscs and other planktonic molluscs, are important components of the Great Barrier Reef plankton;
- much of the molluscan fauna of the Great Barrier Reef World Heritage Area is poorly known, in particular the smaller sized taxa.

MOST RELEVANT CRITERIA:

(iii), (iv)

DISCUSSION:

The following discussion of molluscs was written by Dr W.F. Ponder and Mr I. Loch.

Natural Heritage Attribute: Molluscs

W.F. Ponder and I. Loch, Australian Museum, Sydney

Molluscs are the second largest phylum of animals, next to arthropods. They are predominantly marine and benthic, although many marine taxa have a pelagic larval stage. A few molluscs (some cephalopods and some gastropods, including all pteropods and heteropods) are pelagic as adults.

All molluscs have an unsegmented body and most have a calcareous shell, a single, ventral motile organ (foot), a feeding tooth-studded ribbon (radula) and a mantle cavity enclosing the gills and into which the anus, kidney and reproductive system opens. There are three large classes of molluscs, by far the largest being the Gastropoda (snails, slugs, limpets) which typically have a single shell (absent in slugs). Gastropods have undergone a major radiation to occupy most niches and take up a wide variety of feeding strategies (deposit feeding, herbivory, carnivory, parasitism). The Bivalvia (scallops, oysters, clams) is also a very diverse group which are predominantly filter feeders, and are characterised by having a pair of shells. They have lost the radula and a distinct head and many are infaunal burrowers or attach to the substrate. In contrast, the Cephalopoda have streamlined bodies, most are predators and very efficient swimmers with the foot modified to form a funnel used in jet propulsion. They have arms surrounding the mouth, a large brain and well-developed and complex eyes, and have a single shell (nautilus), shell rudiment (cuttlefish, squids) or no shell (octopuses). There are also four small classes, the Polyplacophora (chitons), Scaphopoda (tusk shells), Aplacophora (spicule worms, often treated as two classes) and Monoplacophora, a deepwater group of limpet-like molluscs not yet not recorded from Australia.

The documentation of molluscan diversity on the Great Barrier Reef began early in Australian European history with the piecemeal description from exploration expeditions, culminating in the broad ecological description of Forbes (1851). Subsequently, Australian based specialist collectors produced a series of expedition based reports, including Brazier (1875) from the 1871 Australasian Eclipse Expedition, Brazier (1876–1878) from the 1875 "Chevert" Expedition, Watson (1886), Smith (1885), Haddon (1886) (from the Challenger Expedition, 1873–76, which sampled off the northern east coast in deep and shallow water off Raine Island); Hedley (1906, 1907) from Masthead Island, and Hedley (1909) from the Hope Islands, Iredale (1929, 1930) from the 1926 G.B.R. Boring Expedition to Michaelmas Cay. The lower bivalves from the Great Barrier Reef Expedition to Low Isles in 1928–1929 were described by T. Iredale (1939) but the remainder of the molluscs collected by this expedition were never described. However, Iredale's notes and the collections, are housed in the Australian Museum, as are most of the collections cited above. Contemporary with and subsequent to this locality based approach, are many taxonomic group papers including many Great Barrier Reef species. Many of the numerous taxa named by Iredale and Laseron (1956–1959) as Queensland endemics are now considered to be synonyms of more widely distributed species.

Boss (1970) estimated 47 000 living species, but subsequent authors have elevated this to 200 000 species (see review in Van Bruggen 1995). Hedley (1909) recorded about 1700 species from Queensland in the only attempt to list the state's molluscan fauna. There are no accurate estimates of the number of species found within the Great Barrier Reef, but we conservatively estimate that there are a minimum of 5000 species, with possibly as many as 8000, including shore and nearshore faunas as well as those on the continental shelf and slope. Most of these are small, many (perhaps 80%) are less than 5 mm in maximum dimension and some less than 1 mm. One sublittoral sample from the Swains Reef produced the shells of over 1000 species of molluscs, a little less than half the total molluscan fauna of NSW. This also compares with only 3000 marine species from the whole of western Europe, including the Mediterranean and 4400 from the western Atlantic (Platts 1996). Thus the molluscan fauna of the Great Barrier Reef represents a significant proportion of total molluscan diversity.

The molluscan fauna comprises several components. Most speciose is the shallow reefal fauna, which has tropical Indo-West Pacific affinities. There is a very low level of endemism in this component, which attenuates with increasing latitude. A further tropical component is that found in coastal waters with largest terrigenous inputs. This component is shared in large part with northern Australia, also attenuates with increasing latitude, and has a small endemic element. A third component is a shallow coastal fauna shared with southern Queensland and New South Wales. This component attenuates with decreasing latitude, and virtually all is endemic to eastern Australia. The fourth major component is that shared in common with the continental shelf of New South Wales and southern Queensland, although elements of this fauna are found on the upper slope, or within the Capricorn Channel, rather than the shelf on the Great Barrier Reef. Again, there is a high degree of endemism in this component, and a close relationship to the Tertiary fauna of Victoria and South Australia (e.g. Darragh 1971, 1979).

Many of the very diverse groups contain predominantly small-sized taxa and are poorly known in and outside the Great Barrier Reef. In these groups the degree of endemism is difficult or impossible to assess because no revisions have been undertaken (e.g. Galeommatoidea, Eulimoidea, Columbellidae, Cephalaspidea etc.). In some other diverse groups, reviews are available, but extensive revision is required before the data can be used with confidence. These include Triphoroidea (Laseron 1956a, 1958), Turridae (Hedley 1922) (some genera and subfamilies subsequently revised), Pyramidelloidea (Laseron 1959), Marginellidae (Laseron 1957). In some cases more modern treatments have resulted in profound changes to classification. For example, included in what Laseron (1956b) regarded as a single family, Rissoidae, there are several families scattered through several major groups of gastropods (Ponder 1983a, 1984, 1985, 1988, 1991, 1994; Ponder & Yoo 1976, 1977, 1978, 1980; Ponder & DeKeyzer 1992). In addition, some groups that have undergone recent revisions are so poorly known through the rest of the Indo-West Pacific that species known only known from the Great Barrier Reef region cannot definitely be stated to be endemics (e.g. Scaphopoda, Lamprell & Healy in press).

Many of the families containing larger-sized shelled taxa are much better known taxonomically and the Queensland species are dealt with, in part, in several semipopular reference works (McMichael & Rippingale 1961; Wilson & Gillett 1971; Short & Potter 1987; Lamprell & Whitehead 1992; Wilson 1993, 1994). Some of the families of large-sized gastropods, especially those exhibiting direct development, contain some endemic species, or even genera, but the family exhibiting the highest degree of endemism is the Volutidae. These gastropods have large, colourful shells and are prized by shell collectors and tourists. They also exhibit marked regional variation and speciation (McMichael 1963; Weaver & DuPont 1970; Darragh 1971; Wilson 1994) and include the very large Baler Shells (*Melo* spp.). Some of the endemic volutes are in shallow water (less than 20 m) but others are confined to deeper water of the outer-shelf or slope (Darragh 1979, 1983; Willan 1995). Very few additional shallow water endemics are also known amongst the larger-sized molluscs, some exceptions being *Nassarius whiteheadae* (Nassariidae) (Cernohorsky 1984) and some muricids (Ponder 1972), including two species of *Murex* (Ponder & Vokes 1988). Most of the other endemic taxa in the large-sized families are found in deeper water in the Capricorn Channel or on the slope outside the reef. These include some Columbariinae (Turbinellidae) (Darragh 1987; Harasewych 1983); Cassidae (Ponder 1983) and Conidae (Röckel & Korn 1990). There are also a few apparently endemic octopuses (Octopodidae) (Norman 1992b). Other notable molluscan groups include the Conidae (Walls 1979; Wilson 1994), the most conspicuous of several toxoglossan groups that have harpoon-shaped teeth through which poison can be injected. Most species of cones prey on polychaetes or other molluscs, but a few hunt small fish and some of these have long been known to be responsible for human deaths (Kohn 1958). Cone shells and another group, the cowries (Cypraeidae) (Burgess 1985; Wilson 1993) are extremely popular with shell collectors. Both groups are very diverse, having about 90 and 64 species respectively on the Great Barrier Reef. Other conspicuous groups include the strombs (Strombidae) (*Strombus, Lambis*) (Abbott 1960, 1961, 1967; Walls 1980), giant clams (Tridacnidae) (Rosewater 1965), pearl oysters (Pteriidae) (Hynd 1954), oysters (Thomson 1954), tellinoideans (Willan 1993), creepers (Cerithiidae) (Houbrick 1978, 1985, 1992), Planaxidae (Houbrick 1987), Littorinidae (Rosewater 1970; Reid 1986), mitres (Mitridae and Costellariidae) (Cernohorsky 1973, 1991; Pechar et al. 1980; Wilson 1994), augers (Terebridae) (Bratcher & Cernohorsky 1987; Wilson 1994), muricids (Emerson 1973; Radwin & D'Attilio 1976; Ponder & Vokes 1988; Houart 1992; Wilson 1994) as well as families such as Isognomidae, Lucinidae, Veneridae, Trochidae, Turbinidae, Muricidae, Turbinellidae, Fasciolariidae and many others.

Opisthobranchs are a diverse group of often shell-less gastropods and the colourful slug-like nudibranchs are particularly conspicuous in shallow water (Willan & Coleman 1984). Recent revisions of some of these groups have shown greater diversity than previously realised (e.g. Brunckhorst 1993; Rudman 1981a, 1981b, 1982, 1984, 1986, 1991; Rudman & Avern 1989).

Squids and cuttlefish are common in the waters of the Great Barrier Reef and planktonic gastropods (heteropods and pteropods) (Spoel 1967, 1976; Newman & Greenwood 1988; Newman & Spoel 1989; Newman 1990) as well as larval molluscs, are important components of the plankton. Violet snails (Janthinidae) and sea lizards (Glaucidae) float on the surface feeding on siphonophores. Cuttle bones (Sepiidae, Cephalopoda) (Iredale 1926; Roper & Hochberg 1987) are commonly washed ashore and are one of the most diverse faunas in the world. Octopods are also diverse and currently being revised (e.g. Norman 1992a, 1992b, 1992c) and several species are as yet unnamed.

Two bivalve groups, the date mussels (*Lithophaga*, Mytilidae) and members of the Gastrochaenidae burrow into coral and are important in bioerosion (Otter 1937; Wilson 1979; Kleemann 1979, 1984; Evseev 1981). Other bivalves (Teredinidae (Turner 1966) and Xylophagidae) burrow into wood, being significant recycling (although destructive to man-made wooden objects such as wharf piles and boats) agents, especially in estuaries. Some snails (a few members of the Coralliophilidae) also burrow into coral and possibly feed on the coral polyps or steal food from the polyps, as do other coralliophilids which live externally on corals. Species of the muricid whelk *Drupella* (Muricidae) feed on corals, sometimes causing damage (Turner 1992).

Some molluscs are parasites on other invertebrates. Two gastropod groups are very diverse and exclusively parasitic. The eulimids are parasites on echinoderms and the pyramidellids attack various invertebrates. Other groups are larger sized and are more properly considered predators. Some gastropods (Architectonicidae (Bieler 1993), Epitoniidae, Ovulidae, Cuthonidae and Pinufiidae) feed on coelenterates, including corals, and many other carnivorous families prey on a wide range of animals. For example, the large triton, *Charonia tritonis* (Ranellidae) feeds on the crown-of-thorns starfish (Wilson 1993; I.L., pers. observ.), although not exclusively, and other ranellids feed on various invertebrates. Some families are very specialised, for example it appears as though all members of the Cassidae feed on urchins and all mitrids on sipunculids (see review by Taylor et al. 1980).

These larger molluscs are probably the best documented part of the Great Barrier Reef invertebrate fauna, although much of the information is unpublished, being contained in private and state museum collections, particularly the Australian Museum. Once databased, these data could be utilised as a powerful management tool as they have a well documented historical component.

Recreational shell collecting has traditionally been a popular pastime on the Great Barrier Reef, both by tourists and locals. If done sensitively, this activity represents little threat to the environment and past activities have resulted in the accumulation of valuable data in private collections, many of which end up in state museums.

Commercial harvesting of molluscs in the past was largely based on pearl oysters (*Pinctada* spp., Pteriidae), trochus shell (*Trochus*; Trochidae) and scallops (*Amusium*; Pectinidae), although squid and giant clams (Tridacnidae) have also been exploited. Some of the shelled molluscs found in the Great Barrier Reef are commercially important in the specimen shell trade, but the vast majority of species have no commercial value.

The terrestrial molluscan fauna of the islands of the Great Barrier Reef contains a number of endemics, primarily of Camaenidae (Smith 1992). The relationships, taxonomy and distributions of the smaller species are not well known. There are also a few freshwater molluscs on some high islands but they are poorly documented and none are known to be endemics. A rich fauna of estuarine molluscs is found in mangroves on the islands and, particularly, along the coast. As far as is known there are no endemic taxa associated with mangroves on the islands but they are poorly investigated for small sized taxa and families such as Assiminidae and Stenothyridae may possibly contain endemics.

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Natural Heritage Attribute: Octocorals

SOURCE:

Dr P. Alderslade, Northern Territory Museum and Art Gallery, Darwin

Dr Z. Dinesen, Great Barrier Reef Marine Park Authority, Townsville

CONCLUSIONS:

- from 270 genera of octocorals worldwide, an estimated 80 genera are likely to occur in the Great Barrier Reef World Heritage Area;
- octocorals occur in all habitats, across all shelf positions and throughout the latitudinal extent of the Great Barrier Reef World Heritage Area;
- soft corals are a major component of the sessile benthic reef fauna of the Great Barrier Reef World Heritage Area;
- form and colour of octocorals contribute to the aesthetic value of the Great Barrier Reef World Heritage Area.

MOST RELEVANT CRITERIA:

(ii), (iii), (iv)

DISCUSSION:

Octocorals are a ubiquitous group of animals with species occurring in all oceans from polar to tropical waters and at all depths from the intertidal to the abyssal (Alderslade 1993). They are characterised by polyps with 8 pinnate tentacles. The octocorals include the soft corals and gorgonians (Order Alcyonacea) and the sea pens (Pennatulacea). Within tropical reefal environments the soft corals and gorgonians may make up a large part of reef fauna, though the soft corals are virtually absent from the reefs of the West Indies compared to those of the Indo-West Pacific (Alderslade, P. 1996, pers. comm.).

The octocoral fauna of tropical reefs has been very poorly investigated, unlike the hard corals (Scleractinia), few monographs have been devoted to the octocorals. Identification to species level is very difficult, often requiring extensive microscope work to confirm identifications (Dinesen, Z. 1996, pers. comm.). Accordingly, it is not possible to give any accurate estimate of the number of species that occur in the Great Barrier Reef World Heritage Area. Of approximately 270 genera of octocorals worldwide, 80 genera (10 sea pens, 70 soft corals and gorgonians) are estimated to occur within the Great Barrier Reef World Heritage Area (Alderslade, P. 1996, pers. comm.). Hundreds of species are likely to be unreported (Dinesen, Z. 1996, pers. comm.).

Similarly, as little investigation of the octocorals of other regions in the tropical Indo-West Pacific has occurred, it is difficult to make any conclusive comments regarding the endemism of the Great Barrier Reef World Heritage Area fauna. However like many other marine fauna with planktonic larvae endemism is likely to be low, with most species distributed throughout the tropical Indo-West Pacific region (Dinesen, Z. 1996, pers. comm.).

The soft corals and gorgonians contribute significant aesthetic value to the reefal environment as a consequence of their shape, form and colour. For example in clear deep waters (20–30 metres or greater) of the mid- and outer-shelf reefs very large (1.5–2 metres tall) 'coral trees' of the soft coral genus *Dendronephthya* occur. These often have bright orange or purple polyps (Dinesen, Z. 1996, pers. comm.). Similarly, gorgonians of the genus *Subergorgia* form large fans often coloured yellow (Alderslade, P. 1996, pers. comm.).

Octocorals produce a number of secondary metabolites that appear to play important roles in octocoral ecology. These natural products have generated interest because of their potential applications as pharmaceutical agents (Coll & Sammarco 1986). They may serve ecological roles such as a defence mechanism against predators by making the octocoral toxic or distasteful to potential predators (Bowden & Coll 1983; Coll & Sammarco 1986), or as allelopathic agents, killing some neighbouring hard corals, thereby increasing space available for the octocoral colony (Sammarco et al. 1983).

Octocorals occupy both reefal and inter-reefal habitats in the Great Barrier Reef World Heritage Area. However little work has specifically investigated the octocorals of inter-reefal areas. Within reefal environments the composition of soft coral assemblages, and their abundance change across reef zones, and with shelf position (Dinesen 1983). Dinesen (1983) found that, in the central Great Barrier Reef, total living soft coral cover was very high on some outer-shelf reef slopes. The most diverse assemblages of soft corals occurred on reef slopes at both mid- and outer-shelf positions; the soft coral fauna of inner-shelf reefs was significantly different from that of the mid- and outer-shelf reefs.

Dinesen (1983) showed that soft corals are not restricted to turbid inner-shelf environments, but rather are distributed across the shelf. While soft coral cover is lower than that of hard corals, they are a major component of sessile reef benthos (Dinesen 1983). Generally on outer reefs, soft coral cover increased with increasing depths, while hard coral cover decreased, however the reverse may occur (Dinesen 1983).

In addition to cross shelf changes in soft coral assemblages, latitudinal changes are also likely to occur. In the Capricorn–Bunker group of islands of the southern Great Barrier Reef octocorals may be less conspicuous than in the northern Great Barrier Reef (Dinesen, Z. 1996, pers. comm.), however systematic surveys are yet to be carried out. The octocoral fauna of the Great Barrier Reef World Heritage Area will most likely mirror other tropical marine fauna with decreased species diversity at higher latitudes.

Unlike hard corals, soft corals do not have a solid limestone skeleton and are not generally reefal framework builders. However their tissue contains calcareous sclerites, which contribute to sediment generation in reefal environments, in particular species from the genus *Sinularia* produce '*Sinularia* rock', which in some areas forms a major part of the reef structure (Alderslade, P. 1996, pers. comm.). They are both heterotrophic and autotrophic, feeding upon zooplankton (Lewis 1982) and phytoplankton (Fabricius et al. 1995), and fixing carbon through photosynthesis via their zooxanthellae. Furthermore while chemical defences may deter feeding upon soft corals, some fauna are able to safely ingest some soft corals (e.g. the aeolid nudibranch *Phyllodesmium longicirra* (Bowden & Coll 1983)).

The ability of some octocorals to grow rapidly and out-compete hard corals has led to their characterisation as a 'weed' in reefal environments, quickly colonising disturbed areas such as that following a crown-of-thorns starfish outbreak or a cyclone. While this has probably occurred at some sites, the high soft coral cover on many reefs makes it difficult to connect their presence to major disturbance events, further indicating that soft corals are clearly an integral component of the reefal ecosystem (Dinesen, Z. 1996, pers. comm.).

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Natural Heritage Attribute: Phytoplankton

SOURCE:

Dr M. Furnas, Australian Institute of Marine Science, Townsville

CONCLUSIONS:

- phytoplankton are the principal primary producers in the open shelf waters of the Great Barrier Reef World Heritage Area (approximately 95% of the World Heritage Area);
- includes a diverse group of algae ranging in size from 0.5 microns to 200+ microns;
- two broad communities exist: an offshore oceanic community and a lagoonal community;
- phytoplankton biomass is highest is shallow nearshore waters;
- upwelling of nutrients along the shelf break, cyclonic disturbances of shelf sediments and flood waters may locally increase phytoplankton biomass;
- *Trichodesmium* is a significant contributor of nitrogen to the Great Barrier Reef World Heritage Area.

MOST RELEVANT CRITERIA:

(ii), (iv)

DISCUSSION:

Phytoplankton are microscopic planktonic algae that range in size from 0.5 microns to 200 microns, with a few forms reaching larger sizes (Hallegraeff 1995). They are an exceptionally diverse group of organisms, including the diatoms, dinoflagellates, golden-brown flagellates, green flagellates, and a diverse range of smaller coccoid picoplankton (less than 2 microns in diameter) which includes cyanobacteria and prochlorophytes (Hallegraeff 1995). Phytoplankton are the principal primary producers for the 95% of the Great Barrier Reef World Heritage Area that is open water, forming the basis of the food chain in these waters.

Two broad communities of phytoplankton occur in the Great Barrier Reef World Heritage Area. One is an oligotrophic oceanic community that is dominated by picoplankton (cyanobacteria and prochlorophytes), though other groups are also present. This assemblage is pan-tropical. The second community assemblage of diatom and dinoflagellate species predominantly occurs in the lagoonal waters of the shelf where nutrient inputs from terrestrial sources are more important. This 'coastal' assemblage is not restricted to the tropics (Furnas, M. 1996, pers. comm.). Revelante and Gilmartin (1982) suggest that while forming a continuum three assemblages are present in the Great Barrier Reef lagoonal waters: an assemblage characteristic of the lagoonal waters *per se*; an assemblage associated with patch reef lagoons towards the outer edge of the lagoon; and an assemblage associated with shallow mangrove dominated inshore coastal channels. In terms of composition there is nothing special or unique about the phytoplankton community of the Great Barrier Reef World Heritage Area per se. There are no known endemic species.

Conspicuous surface blooms of the nitrogen fixing cyanobacterium *Trichodesmium* occur throughout the year in the Great Barrier Reef World Heritage Area. These blooms may be very large and persistent. One such bloom was observed along 1600 km of the Queensland coastline, stretching from the shore to the outer barrier occupying about 51 200 km^2 (Wood 1965 in Revelante & Gilmartin 1982). Preliminary calculations suggest that *Trichodesmium* is a very important source of nitrogen for the Great Barrier Reef ecosystem. However at this stage there are no reliable estimates of its contribution due to the lack of information regarding *Trichodesmium* abundance and distribution (Furnas, M. 1996, pers. comm.).

Phytoplankton primary production in open waters of the Great Barrier Reef is approximately 0.6 g C m^{-2} day^{-1} (Furnas & Mitchell 1988). There is some evidence of a latitudinal gradient. The northern region (0.385 g C m^{-2} day^{-1}) having lower levels of primary production than that of the southern region (1.149 g C m^{-2} day^{-1}) (Furnas & Mitchell 1988). Picoplankton accounted for 60–80% of the primary production on shelf areas (Furnas & Mitchell 1988). A first order estimate of the primary productivity of the whole Great Barrier Reef suggests that phytoplankton are responsible for 58–65%, while reefs contribute 24–35% (Furnas & Mitchell 1988).

Phytoplankton biomass as indicated by chlorophyll concentration is not distributed uniformly throughout the Great Barrier Reef

World Heritage Area. While latitudinal gradients are not pronounced, significant cross-shelf gradients in chlorophyll concentration occur. Typically, chlorophyll concentrations are highest in the shallow nearshore zone where terrestrial inputs and resuspension of sediments are concentrated (Furnas, M. 1996, pers. comm.). Plankton biomass tends to be lower offshore, however this is affected by the physical nature of the outer barrier reef. Upwelling along the shelf break is known to bring significant amounts of cold deep nutrient rich water up onto the continental shelf (Furnas 1995). Enhanced concentrations of phytoplankton may develop in these regions (Furnas, M. 1996, pers. comm.).

The highest biomass of phytoplankton on the outer shelf was recorded in the Pompey Reefs of the southern Great Barrier Reef (Furnas, M. 1996, pers. comm.). At this stage however, upwelling has not been detected in this region as strong mixing of oceanic and shelf waters prevents detection of any cooled upwelled water.

Phytoplankton abundance in Great Barrier Reef World Heritage Area waters is limited by the availability of inorganic nutrients, in particular nitrogen. Without substantial external inputs of nutrients, resident phytoplankton populations have little scope for biomass increase (Furnas et al. 1995). Shelf-scale budgets for nitrogen and phosphorous have been developed for the central Great Barrier Reef (Cape Tribulation to Dunk Island: Furnas et al. 1995). External sources of nutrients include rivers (7000 metric tonnes N per annum, 700 metric tonnes P per annum), rainfall (2700 m.t. N p.a. and 160 m.t. P p.a.), sewage (400 m.t. N p.a. and 110 m.t. P p.a.), and upwelling (1200–4000 m.t. N p.a. and 400–1000 m.t. P p.a.). Additional inputs of nitrogen come from Trichodesmium (4600–213 000 m.t. p.a.) and reefal fixation (1400 m.t. p.a.) of atmospheric nitrogen (Furnas et al. 1995). These external inputs of nitrogen and phosphorous are small relative to natural recycling processes (Furnas et al. 1995).

Despite the low levels of anthropogenic nutrient inputs into the Great Barrier Reef system relative to natural processes, the assimilative capacity of the system is unknown. Low nutrient concentrations and inputs are characteristic of coral reef ecosystems. Accordingly Furnas et al. (1995) advise caution in the management of nutrient inputs into the Great Barrier Reef to ensure its continued conservation.

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Natural Heritage Attribute: Polychaete Worms

SOURCE:

Dr P. Hutchings, Australian Museum, Sydney

CONCLUSIONS:

- polychaetes are an old group extending back to Cambrian times (500 Ma);
- dominant macrofauna (in numbers of species and individuals) in reefal sediments and coral substrates;
- currently 80 species are recorded for the reefs of the Great Barrier Reef World Heritage Area, however total species diversity could exceed 500;
- diversity is a product of latitudinal extent, habitat diversity and good condition of the Great Barrier Reef;
- polychaetes play important roles in ecosystems;
- the tropical polychaete fauna is very poorly known.

MOST RELEVANT CRITERIA:

(ii), (iv)

DISCUSSION:

The following discussion of polychaete worms was written by Dr P. Hutchings.

Natural Heritage Attribute: Polychaete Worms

Dr P. Hutchings, Australia Museum, Sydney

Polychaetes are predominantly marine or estuarine segmented worms. They are an old group extending as far back as the Cambrian Period (500 Ma). Certainly the relatively few fossil records of polychaetes, or parts of them, (remembering that polychaetes are predominantly soft bodied worms) indicate that polychaetes radiated early on and therefore most of the 80 odd currently recognised families are also very old. This explains, at least in part, why most polychaete families and many polychaete genera are worldwide in their distribution, although species within these genera may have very restricted distributions.

As an aside, although all text books currently refer to polychaetes as a class (Polychaeta) of the phylum Annelida with the other members of the phylum being the Hirudinae (leeches) and the Oligochaetes (earthworms), a recent paper in 1995 by Rouse and Fauchald suggests that the Annelida are not monophyletic and use the term Articulata, which includes the Arthropoda, Clitellata, Polychaeta and the Pogonophora[43]. Thus the term 'Annelida' should be avoided, and the status or rather the terminology for Polychaeta is also currently problematical, and the term 'Class Polychaeta' should be avoided.

Currently about 15 000 species of polychaetes have been described worldwide, and over 800 from Australian waters (Day & Hutchings 1979). The majority of these records are from temperate areas. However it must be stressed that these 800 records are based upon the literature. As detailed family revisions occur in Australia, two points become clear: a) a substantial part of the fauna is undescribed; and b) many of the names present in the literature when examined are found to be mis-identifications and represent undescribed species. For example Day and Hutchings (1979) list 32 species of Terebellidae, since then Hutchings and her associates have found that of these 32 species only 18 occur in Australia, and now after a revision of the family, the terebellid fauna consists of at least 101 species (55 Amphitritinae, 22 Thelepodinae and 24 Polycirrinae), many of which have been described as new species. Many areas are poorly represented in collections, including deeper water, reefal areas and tropical regions in general.

The above example of the terebellid has been found to be true of all polychaete families looked at in detail. This preamble is necessary in order to put my comments below on the status of Great Barrier Reef World Heritage Area polychaetes into some sort of context. Even where extensive collections have been made on the reef especially from inter-reefal areas by Arnold, Birtles and Pichon, and Riddle (1988a, 1988b), they have not been fully identified and incorporated into Museum collections. Arnold (pers. comm.) recorded 185 species in 45 families in the sediment in the three bays around Townsville, and Paxton (pers. comm.) recorded 200 infaunal species in the Bay of Halifax, both

[43] Although this latter group will almost certainly be found to be included in the Polychaeta.

these areas are on the edge of the Great Barrier Reef Province and presumably similar numbers would occur in nearby inter-reefal sediments.

All museum polychaete collections in Australian museums are heavily biased towards temperate regions, and only the museums in Sydney and Melbourne currently have people working on polychaetes. Thus the figures below are guesstimates and largely based upon my own extensive experience at One Tree and Lizard Islands, and not necessarily based upon published records.

Polychaetes occur in all the habitats within the Great Barrier Reef World Heritage Area, from the mangroves through the seagrass beds, inter-reefal sediments, and within the reef structure itself as borers, nestlers and encrusters. In addition species which are pelagic throughout their life occur in reefal waters (probably widely distributed species), and various reproductive stages of polychaetes are found in reefal plankton at various times of the year (Hutchings 1977, 1986).

In reefal sediments and within coral substrates polychaetes dominate the macrofauna both in terms of numbers of individuals and numbers of species. Polychaetes are also an important component of the meiofauna, but this has hardly been sampled on the reef. I have found within a small head of dead coral (say 750 grams wet weight) over 75 species present, not including species less than 1–2 mm in length. I would predict that the total polychaete fauna for the Great Barrier Reef World Heritage Area could exceed 500 species. This is mainly because of the diversity of habitat, and the geographical extent of the region. It is likely that reefal sediments will be the richest habitat in terms of number of species and individuals, however considerable variation in species composition is expected between inshore and offshore sites. Inshore sites, especially those associated with mangroves, may have a fairly specialised fauna and include species which can tolerate low oxygen levels. Species composition and abundances will be determined by such factors as sediment characteristics, water movement, stability of sediments. The next most diverse habitat is probably the fauna living within the reef matrix and again these may well show latitudinal and cross shelf variations. Probably the most homogenous habitat is the pelagic one, although the composition of this will vary seasonally as the sexual stages of typically 'sedentary' species enter the water column for reproduction. Each of the major habitats will have a very characteristic fauna and within each of these habitats variations across and down the reef will occur.

Probably only about 80 species have been recorded from the reefal area. However as discussed above many of these names may not be valid, and undescribed species may be included. Around the turn of the century and up until about 1970, people working on polychaetes from the Great Barrier Reef were often from Europe, or used keys and descriptions from Europe. Accordingly many species were recorded as European species in Great Barrier Reef waters without even considering the biological implications of this. The lack of keys and reference works for Australian polychaetes, and particularly for tropical regions, has hampered the documentation of polychaete fauna.

Within Australia several patterns of polychaete distributions seem to occur, species with very restricted distributions, species occurring just in southern waters, species restricted to the east or west coast and those restricted to tropical waters. There are species which occur throughout the Great Barrier Reef and others which seem to be restricted to southern or northern areas. It appears that the fauna at Lizard is richer than the fauna at One Tree – whether this is a real latitudinal effect or a reflection of the greater range of habitats around Lizard is not certain. At this stage we lack the knowledge to determine if some areas are more important than others for particular species of polychaetes. The majority of polychaetes recruit via pelagic larvae, it may be that a species may be common in an area for many years and then disappear for several years, this just being a reflection of the vagaries of larval recruitment.

While some published records suggest that some of the species recorded from the Great Barrier Reef are Indo-Pacific species, and certainly some species do have wide distributions, a detailed analyses of species distributions is hampered by very limited information from other reefal areas in the Indo-Pacific. For many areas virtually nothing is known. I recently looked at a collection of seamice (family Aphroditidae) from Indonesian waters and only one of these species occurred in

Australian waters, and that occurred off the Northern Territory coast. The species occurring in the Great Barrier Reef region were predominantly restricted to that region. Certainly there are some genera in several families which are restricted to the Indo-Pacific. Amongst the family Terebellidae, there appears to be no overlap of species between the Great Barrier Reef, Papua New Guinea, Hong Kong and the Solomon Islands, although we do have a species of Nereididae which occurs in both the Northern Territory and the Solomons, and I suspect that it will be found to occur in far north Queensland. Several genera of terebellids which were originally thought to be endemic to Australia, and in some cases to the Great Barrier Reef, have now been found elsewhere in the Indo-Pacific.

Attempting to compare the polychaete fauna of the Great Barrier Reef with other regions is difficult. Certainly the reefs off the Kimberleys are very rich and different in species composition. Lagoonal sediments in Tahiti are less speciose than found in the Great Barrier Reef, and it appears that the fauna of dead coral substrate is also less rich in French Polynesia than in the Great Barrier Reef World Heritage Area. This suggests that the diversity of polychaetes follows the same pattern as found in other invertebrate groups across the Pacific. There is no data to say whether the fauna of, say the Philippines, is richer than the Great Barrier Reef or not. This was most likely the case and may still be. However, continued species richness will depend on the amount of habitat degradation which has occurred.

I would contend that the polychaete fauna is a major component of the Great Barrier Reef, both in terms of number of species and individuals, and also in terms of productivity. They exhibit a tremendous range of reproductive strategies, including brooders, and broadcast spawners, exhibiting both sexual and asexual reproduction. Life cycles may be completed in a few weeks or take several years. Because of the extent and diversity of the Great Barrier Reef, and as the reef is primarily in good condition, there is likely to be a large number of species present. In contrast, throughout the Indo-Pacific many reefs have been degraded, and presumably some loss of species has occurred. Furthermore few people are working on the polychaetes in these areas, so the fauna is likely to remain undocumented, even though it is well documented that polychaetes are a major component of the food chain.

The level of knowledge about the Great Barrier Reef World Heritage Area polychaetes is not at a stage where comments can be made regarding rare or threatened fauna. However, the maintenance of all reefal habitats in good condition will ensure that polychaete diversity remains high. I know of no commercial collecting of polychaetes in the area, except perhaps on some muddy beaches for *Marphysa* for bait, which could lead to some local extinctions.

The polychaetes are an important component of the food chain. They exhibit a wide range of feeding strategies: deposit, herbivores, filter feeders, surface deposit feeders, carnivores, suspension feeders, omnivores and probably a lot are opportunistic feeders. They may be selective or non-selective feeders. They therefore feed on all sorts of organisms from bacteria, algae, detritus, other invertebrates and carrion. In addition polychaetes are eaten by a wide range of organisms. Some species of *Conus* molluscs are highly selective as to which species they feed on. Those species which breed by mass spawning are often preyed upon by many organisms at that time.

Polychaetes also play other important roles in the Great Barrier Reef World Heritage Area ecosystems through bioturbation of sediments by the actions of burrowing and feeding, and bioerosion of coral substrates. After a coral colony dies, polychaetes are one of the first groups of macroinvertebrates to colonise this newly available substrate, both by boring into the substrate and as nestlers occupying small crevices created by other borers. They appear to facilitate the settlement of other invertebrates, and gradually this substrate may be completely reworked creating a new three-dimensional habitat, some being eroded completely to form new sediment. Densities of such boring communities increases with increased organic loads, for example sewage discharges, or after a crown-of-thorns starfish plague (Hutchings 1986). Densities and species composition of polychaetes may also provide an indication of stress levels, and act as pollution indicators.

Polychaetes are abundant in all reefal and inter-reefal habitats, and play a major role in the functioning of these ecosystems, although precise details are not available.

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Natural Heritage Attribute: Proserpine Rock Wallaby

SOURCE:

Ms P. Winkel, Department of Zoology, James Cook University, Townsville

CONCLUSIONS:

- Proserpine rock-wallaby is classified internationally as endangered;
- restricted to a very small range, including one continental island in the Great Barrier Reef World Heritage Area;

MOST RELEVANT CRITERIA:

(ii), (iv)

DISCUSSION:

The Proserpine rock-wallaby (*Petrogale persephone*) was only brought to scientific attention in 1976, though it had been known by members of the Proserpine branch of the Wildlife Preservation Society of Queensland, and no doubt other local peoples for some time (Sharman et al. 1995). It is known from a small number of localities around the Proserpine area including some offshore islands. Accordingly it has a presence in the Great Barrier Reef World Heritage Area. Acknowledging its restricted range and the high level of anthropogenic impact within that range the IUCN has classified the species as endangered (IUCN 1994).

It is the second largest rock-wallaby, with males up to 9.0 kg and females up to 6.0 kg. It has an overall dark grey appearance with black feet and black dorsal surface of the tail. Most individuals have a short yellow to white tail tip of variable length (Maynes 1982; Sharman et al. 1995; Winkel, P. 1996, pers. comm.). Typically it occupies rocky hills and mountains covered with semi-deciduous notophyll vine thicket or forest, and will venture to a limited degree out from the canopy to forage. It is the only rock-wallaby to live within tropical rainforests on a permanent basis. It is thought to be a relict of an apparently more widespread species, prior to the smaller and more successful unadorned rock-wallaby (*Petrogale inornata*) becoming more common (Sharman et al. 1995).

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Natural Heritage Attribute: Seagrasses

SOURCE:

Ms J. E. Mellors, Department of Tropical Environment Studies and Geography, James Cook University, Townsville

Mr W. J. Lee Long, Northern Fisheries Centre, Queensland Department of Primary Industries, Cairns

CONCLUSIONS:

- 15 species of seagrass are recorded from the Great Barrier Reef World Heritage Area and other species may yet be described;
- Great Barrier Reef World Heritage Area flora is typical of the Indo-West Pacific flora;
- several species reach their latitudinal limits in the Great Barrier Reef World Heritage Area, and at least two species appear endemic;
- more than 3000 km^2 of seagrass habitat within the Great Barrier Reef World Heritage Area;
- extensive meadows of deepwater seagrass recently found;
- important nursery for many fishes and penaeid prawns;
- important food resource for threatened dugong and green turtle;
- important roles in sediment stabilisation and nutrient capture.

APPLICABLE CRITERIA:

(ii), (iv)

SUPPORTING DOCUMENTATION:

Seagrasses are widespread marine angiosperms found in most regions of the world. High levels of endemism and speciation characterise the Australian seagrasses. However, this is more apparent in temperate regions (Poiner & Peterken 1995). Of more than 30 species found within Australia, 15 species from 8 genera are recorded from the Great Barrier Reef World Heritage Area (see Table 13) (Kuo et al. 1996; Lee Long et al. 1993; Poiner & Peterken 1995). The species list is likely to increase following revision of the genus *Halophila* (Lee Long & Coles 1995).

Most of the species found in the Great Barrier Reef World Heritage Area are typical of seagrasses from the Indo-West Pacific region. However, several species (*Cymodocea rotundata, Enhalus acoroides, Halophila tricostata*) reach latitudinal limits within the Great Barrier Reef World Heritage Area, and at least one species (e.g. *Halophila tricostata)* is likely to be endemic to the region (Kuo et al. 1993). The species diversity of seagrass has been found to decrease with increasing latitude (Lee Long et al. 1993).

Seagrasses grow on a range of substrates, generally in localities that are sheltered from prevailing south-easterly trade winds, such as estuaries, coastal bays and inlets, on fringing and barrier reef platforms and behind islands (Lee Long et al. 1993). Seagrasses have been found in both intertidal and subtidal locations, from 2.2 m above to 28 m below mean sea level (Lee Long et al. 1993). The discovery of extensive deepwater seagrass meadows followed discrepancies between dugong population estimates and estimated seagrass cover in the northern section of the Great Barrier Reef Marine Park (Lee Long et al. 1989). Extensive deepwater seagrass meadows have been found in the Barrow Point–Lookout Point and Hervey Bay regions (Lee Long et al. 1993). Three general depth zones for seagrasses are recognised: less than 6 m, where all species have been regularly recorded; between 6 and 11 m where *Halophila* and *Halodule* species are the most common; and at depths greater than 11 m where the ability to grow with low light intensities gives *Halophila* species a competitive advantage (Lee Long et al. 1993). The deepwater seagrass meadows have been recorded in few other localities in the Indo-Pacific region (Lee Long et al. 1993). They are particularly important feeding areas for dugong (*Dugong dugon).*

Sites where 5 or more species of seagrass have been recorded are listed in Table 14; of these, 18 sites contained 8 or more species. The richest sites with 12 species recorded at each were the Barrow Point to Lookout Point area, and the Dunk Island and coast region (Lee Long et al. 1993).

The reported extent of seagrass from Cape York to Hervey Bay, approximately 4000 km^2, is comparable to the total cover of mangrove habitat in Queensland (Lee Long et al. 1993). Approximately 3000 km^2 of this occurs within the Great Barrier Reef World Heritage Area. However, this is likely to be an underestimate of the total extent of seagrass as much of the area has not been surveyed for deepwater meadows (Lee Long et al. 1993). Localities within the Great Barrier Reef World Heritage Area that contain extensive areas of seagrass habitat include Cape Direction, Roberts Point, Bathurst Bay, Barrow Point to Lookout Point and Port Clinton each containing greater than 100 km^2 (Lee Long et al. 1993).

Seagrass meadows provide an essential food resource for the dugong and the green sea turtle (*Chelonia mydas*) which are listed respectively as vulnerable and endangered by the IUCN (IUCN 1994). Numerous dugong feeding trails in the deepwater *Halophila* meadows between Barrow Point and Point Lookout demonstrated for the first time the importance of deepwater meadows to dugong (Lee Long et al. 1989; Lee Long et al. 1993). The deepest feeding trail was recorded at a depth of 23.7 m (Lee Long et al. 1989).

Whilst some species are residents of seagrass habitats for their whole life, seagrass meadows are particularly important as nursery grounds for a range of penaeid prawns and fish (Coles et al. 1987; Coles et al. 1992). Surveys in the area from Cairns to Bowen found 19 species of penaeid prawn in 5 genera (see Table 15), 65 species of fish from 35 families (see Table 16), and 17 species of crab from five families (see Table 16) (Coles et al. 1992). In this region, fish species numbers and diversities were highest in Hinchinbrook Channel, Bowling Green Bay and Upstart Bay (Coles et al. 1992). Similarly, Hinchinbrook Channel and Upstart Bay exhibited high crab species diversity (Coles et al. 1992).

The commercial interest in exploitable fisheries has influenced much of the early research into seagrass habitats. More recently, conservation interest in the dugong has re-directed research into seagrass, in particular the deepwater seagrasses which are important as dugong feeding grounds (Lee Long et al. 1989) but less so as habitats for juvenile prawn (Derbyshire et al. 1995). There is, however little known about the importance of seagrass habitats for other non-commercial species, and consequently it is difficult to give any estimate for the total species diversity inhabiting or utilising seagrass meadows, though it is high (McKenzie, L. 1996, unpub. data). The fauna associated with seagrass meadows has a strong connection with other proximate habitats; for example, mangrove type species are prevalent in seagrass habitats adjacent to mangrove habitats and coral reef species are common in meadows on reefs (Ogden & Gledfelter 1983). Primary and secondary productivity in seagrass meadows provide support for extended food chains and links to other ecosystems. Intertidal seagrass meadows are important habitats for the food of shorebirds and support fish and prawn populations which migrate to other habitats.

Seagrasses play an important role in sediment trapping and stabilisation. Robust species with strong root structures (for example *Thalassia hemprichii, Thalassodendron ciliatum, Cymodocea rotundata*) are able to bind the sediment, while the leaves buffer and attenuate water flow causing sediments to drop out (Fonseca et al. 1982). Sediment profiles of seagrass meadows and adjacent bare-bottom substrates have shown that seagrass meadows are successful in trapping fine sediments (Mellors, J. 1996, unpub. data). It is likely that the success in trapping sediments will explain the function of seagrass meadows as nutrient sinks in this region (Mellors, J. 1996, pers. comm.). Furthermore, seagrass meadows make important regional contributions to net primary production (Lee Long et al. 1993).

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Table 13. Seagrass Species Recorded from the Great Barrier Reef World Heritage Area

Cymodocea rotundata
Cymodocea serrulata
Enhalus acoroides
Halodule pinifolia
Halodule uninervis
Halophila decipiens
Halophila capricorni
Halophila ovalis
Halophila ovata
Halophila spinulosa
Halophila tricostata
Syringodium isoetifolium
Thalassia hemprichii
Thalassodendron ciliatum
Zostera capricorni

(Source: Lee Long et al. 1993; Kuo et al. 1996)

Table 14. Localities of High Seagrass Diversity
(showing species number recorded)

Escape River	7
Orford Ness	5
Shelburne Bay	6
Margaret Bay	7
Temple Bay	6
Weymouth Bay	8
Lloyd Bay	6
Cape Direction	8
Roberts Point	5
Flinders Group	9
Princess Charlotte Bay	9
Bathurst Bay	7
Ninian Bay	7
Barrow Point–Lookout Point	12
Cape Flattery	7
Bedford Bay–Cape Tribulation	8
Cairns Harbour	10
Barnard Island	5
Dunk Island and coast	12
Hinchinbrook Island and Channel	9
Palm Island	7
Halifax Bay	6
Cape Pallarenda	7
Magnetic Island	11
Cleveland Bay	8
Upstart Bay	10
Abbot Bay	7
Edgecumbe Bay	10
Whitsunday coast	8
Whitsunday Group	9
Shaw Island	8
Repulse Bay	7
Port Newry	7
Shoalwater Bay	10
Gladstone Harbour	8
Rodds Harbour	5

(Source: Lee Long et al. 1993)

Table 15. Penaeid Prawn Species Found in Great Barrier Reef World Heritage Area Seagrass Habitats

Metapenaeopsis mogiensis
Metapenaeopsis novaeguineae
Metapenaeopsis palmensis
Metapenaeopsis rosea
Metapenaeopsis wellsi
Metapenaeus bennettae
Metapenaeus eboracensis
Metapenaeus endeavouri
Metapenaeus ensis
Parapenaeopsis cornuta
Parapenaeopsis tenella
Penaeus esculentus
Penaeus latisulcatus
Penaeus longistylus
Penaeus monodon
Penaeus semisulcatus
Trachypenaeus anchoralis
Trachypenaeus curvirostris
Trachypenaeus fulvus

(Source: Coles et al. 1992)

Table 16. Fish and Crab Families Found in Great Barrier Reef World Heritage Area Seagrass Habitats

Fish Families:	
	Ambassidae
	Antennariidae
	Apogonidae
	Atherinidae
	Belonidae
	Blenniidae
	Callionymidae
	Chaetodontidae
	Cynoglossidae
	Engraulididae
	Gerreidae
	Gobiidae
	Haemulidae
	Hemiramphidae
	Labridae
	Leiognathidae
	Lethrinidae
	Monacanthidae
	Mugiloididae
	Mullidae
	Ostraciidae
	Paralichthyidae
	Platycephalidae
	Scorpaenidae
	Serranidae
	Siganidae
	Sillaginidae
	Soleidae
	Sphyraenidae
	Syngnathidae
	Synodontidae
	Taeniodidae
	Teraponidae
	Tetraodontidae
	Triacanthidae
Crab Families:	
	Calappidae
	Dorippidae
	Majidae
	Parthenopidae
	Portunidae

(Source: Coles et al. 1992)

Natural Heritage Attribute: Sea Snakes

SOURCE:

Mr T. Ward, Department of Tropical Environment Studies and Geography, James Cook University, Townsville

CONCLUSIONS:

- 17 species of sea snakes occur in the Great Barrier Reef World Heritage Area;
- distinct reefal and soft bottom assemblages are apparent;
- patterns of abundance and distribution poorly known;
- trawling is the major anthropogenic impact on sea snakes in the Great Barrier Reef World Heritage Area.

MOST RELEVANT CRITERIA:

(iv)

DISCUSSION:

The world's 51+ species from 10 genera of sea snakes are restricted to the Indian and Pacific Oceans. They can be divided into five functional groups, namely the Hydrophines, Aipysurines, Laticaudines, the genus *Pelamis*, and the mud snakes of the genera *Ephalophis*, *Parhydrophis* and *Hydrelaps* (Marsh et al. 1993; Ward, T. 1996, pers. comm.). Sea snakes are typically benthic animals, except for the genus *Pelamis*, which has one pelagic species, *P. platurus* (Marsh et al. 1993).

Seventeen species are known to occur in the Great Barrier Reef World Heritage Area. This includes twelve species of Hydrophines from six of the world's ten genera, namely, *Acalyptophis* (1 species), *Astrotia* (1), *Disteira* (2), *Enhydrina* (1), *Hydrophis* (6+), and *Lapemis* (1) (Ward, T. 1996, pers. comm.). The Aipysurines contain two genera and seven species worldwide (Marsh et al. 1993). Both genera are represented in the Great Barrier Reef World Heritage Area, with three species from *Aipysurus* and one from *Emydocephalus* (Ward, T. 1996, pers. comm.). The yellow-bellied sea snake, *Pelamis platurus*, is also found in the Great Barrier Reef World Heritage Area (Marsh et al. 1993).

In comparison to other tropical marine fauna there is a high degree of endemism at the species level of sea snakes. Approximately 48% of the 31 species occurring in northern Australian waters are considered to be endemic to these waters (Heatwole & Cogger 1993), however no species are endemic solely to the Great Barrier Reef. Furthermore, no species of sea snakes are considered to be threatened (Marsh et al. 1993).

Distinct reefal and soft bottom communities are observable in the Great Barrier Reef World Heritage Area sea snakes. The reefal assemblage is dominated by three main species, *Aipysurus laevis*, *Emydocephalus annulatus*, and *Astrotia stokesii*. The latter also being common in inshore soft bottom habitats. Typically there are small populations (100s of individuals, mostly the olive sea snake, *A. laevis*) of sea snakes on fringing reefs, e.g. around the Keppel Islands. Additionally some large populations are scattered through the Far Northern Section of the reef, and outside the Great Barrier Reef World Heritage Area on the Coral Sea reefs. The Swain Reefs have large multispecies (3–4) populations (1000 per reef). Typically large populations occur on offshore reefs that have large shallow lagoons. It is suggested that some predation by raptors may prevent populations on inshore reefs and reefs with cays from reaching the levels found in the Swains (Ward, T. 1996, pers. comm.). In general patterns of abundance and distribution for reefal assemblages are poorly known. The reefal assemblages are considered to be generally well protected within the Great Barrier Reef Marine Park, however some illegal collection for the aquarium trade of the olive sea snake has occurred (Marsh et al. 1993).

The soft bottom community is dominated by the Hydrophines and *Aipysurus eydouxii*. Unlike the site attached reef species, which are amenable to mark–recapture techniques, it is difficult to estimate their abundance (Marsh et al. 1993). Similarly there is sparse information regarding the distribution of soft-bottom sea snakes. Species composition varies across the shelf. In estuarine waters *Enhydrina schistosa* is numerically abundant; in inshore waters to about 100 m, *Lapemis hardwickii* and *Hydrophis elegans* are dominant, while in deeper waters *Hydrophis ornatus* is dominant (Ward, T. 1996, pers. comm.). The soft bottom sea snakes are heavily impacted by prawn trawling, where they are a significant by-catch (Marsh et al. 1993).

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Natural Heritage Attribute: Soft Bottom Habitats

SOURCE:

Dr A. Birtles, Department of Tourism, James Cook University, Townsville

CONCLUSIONS:

- soft bottom habitats occupy the majority (approx. 94%) of the Great Barrier Reef World Heritage Area;
- species diversity of soft bottom habitats is high, but poorly documented;
- strong cross shelf zonation is apparent, with at least four discernible zones;
- lagoonal and inter-reefal diversity is associated with the presence of 'natural isolates' that create small areas of hard substrate in the soft bottom environment;
- 'natural isolates' are particularly vulnerable to periodic disturbance such as trawling.

MOST RELEVANT CRITERIA:

(ii), (iv)

DISCUSSION:

Soft bottom habitats are the most extensive habitat type within the Great Barrier Reef World Heritage Area, covering approximately 94% of the Great Barrier Reef World Heritage Area, or approximately 91% of the shelf, as defined by a depth of 200 m (Hopley et al. 1989). Macrobenthic fauna occupying these habitats is typically distinct from that occupying reefal environments. Furthermore surveys along a cross shelf transect have identified strong cross shelf zonation in community composition and abundance. Four zones can be identified, inshore, lagoonal, inter-reefal and upper slope zones (Arnold & Birtles 1985). Unfortunately the soft bottom communities are little studied and the full diversity of this habitat is unknown.

Despite the lack of extensive investigation, that which has been carried out shows that soft bottom communities are very diverse (Birtles 1989). Over 2000 taxa were recorded across a transect in the Townsville region, however many of these are yet to be described (Birtles, A. 1996, pers. comm.). The echinoderms are the most abundant, and amongst the most diverse, of the macrobenthic organism of soft bottom communities (Birtles & Arnold 1988).

The most obvious change in soft bottom community structure occurs in the Central Section between an inshore zone and a lagoonal zone, corresponding to a depth of 22–23 m (Birtles & Arnold 1988). This discontinuity is exhibited in echinoderms, molluscs, crustaceans, demersal fishes, bryozoans, ascidians, sponges, cnidarians, seagrasses and algae (Arnold & Birtles 1985). Species diversity typically increases significantly beyond this depth. Similarly the trophic structure of the community changes. For example, the dominant echinoderm taxa in inshore areas are carnivorous, while browsers and suspension feeders dominate at mid-shelf locations. In some cases the discontinuity is sharp, with a transition between inshore and lagoonal zones occurring in as little as 500 m, in other cases the transition is much more gradual (Arnold & Birtles 1985).

Within the lagoonal zone the presence of calcareous rubble of biological origin provides settlement sites for colonial and solitary organisms. Some of these organisms may produce calcareous skeletons themselves and build a large stable surface for the settlement of other organisms (Birtles & Arnold 1988). These 'natural isolates' of biological origin 'form islands of hard substrate in a "sea" of otherwise unstable soft sediments' (Birtles & Arnold 1988:330). The main builders are bryozoans, ascidians, sponges, some corals and crustose coralline algae. At least for the echinoderms the presence of the 'natural isolates', and their associated taxa are largely responsible for the increased diversity observed at depths greater than 22–23 m and this almost certainly applies to many of the other taxa on the shelf. At shallower depths 'natural isolates' are unable to form as wave action regularly reaches the bottom and disturbance prevents their formation.

Sampling out to the shelf edge indicated a third zone, which Arnold & Birtles (1985) have called an inter-reefal zone. This region has a diverse fauna with many taxa not found in either the lagoonal or inshore zones. Their distribution is characterised by small scale patchiness. The transition from lagoonal to inter-reefal zones is much more gradual than the change from inshore to lagoonal (Arnold & Birtles 1985). Solitary corals dominated the fauna of the fourth zone, the upper slope, and appear to be sharply zoned by depth (Arnold & Birtles 1985).

There has been little study of these soft bottom communities.

There is little information regarding latitudinal variations in soft bottom communities, however the limited evidence, e.g. comparisons of fauna off Townsville with that off Lizard Island suggests that there are major differences (Arnold & Birtles 1985).

The natural isolates, responsible for much of the lagoonal and inter-reefal shelf diversity are particularly vulnerable to disturbance. It is likely that large cyclones could disturb the structure. However, periodic trawling concentrated in areas of soft bottom habitats may destroy the 'natural isolates'. Accordingly management of the Great Barrier Reef World Heritage Area needs to be cognisant of the strong zonation in the soft-bottom community and not assume that it is a uniform habitat. Clearly areas within each of the inshore, lagoonal, inter-reefal and slope zones, need to be protected from anthropogenic impacts if the biodiversity of all soft-bottom habitats is to be maintained.

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Natural Heritage Attribute: Sponges

SOURCE:

Dr J. Fromont, Department of Zoology, James Cook University, Townsville

CONCLUSIONS:

- 1500 species estimated to occur in the Great Barrier Reef World Heritage Area, being equivalent to approximately 30% of the extant Australian sponge fauna;
- sponge fauna tends to be Indo-West Pacific in distribution;
- endemism likely to be low but lack of taxonomic studies limits quantification;
- relicts of reef-building sponges prominent during the Ordovician Period have been recorded in the Great Barrier Reef World Heritage Area;
- cross-shelf trends in sponge abundance and diversity exhibited;
- play significant roles in ecosystem processes.

MOST RELEVANT CRITERIA:

(ii), (iv)

DISCUSSION:

Sponges are benthic animals living in marine and fresh waters, ranging from polar to tropical environments. Within Australian waters it is estimated that up to 5000 species exist (Hooper & Wiedenmayer 1994). However any discussion of the Porifera of Australia, including those of the Great Barrier Reef World Heritage Area must be prefaced with the qualification that very little is known about the taxa. Despite this, Australia is renowned by scientists worldwide to have a wonderful sponge fauna (Fromont, J. 1996, pers. comm.). This general paucity of information is unlikely to change in the near future as only a handful of people are currently working on the Australian sponges.

Taxonomically three classes of sponges are recognised: Demospongiae, Calcarea and Hexactinellida. The largest class, Demospongiae, accounts for an estimated 95% of extant species (Hooper 1993). Of the 500 nominal species recorded in the Solandarian biogeographic province, 374 are considered to be valid (Hooper & Lévi 1994). Much of the described fauna has focused upon the macrobenthos of reef habitats. When cryptic species such as boring sponges and those that often encrust under ledges and within caves, and the fauna of inter-reefal and coastal areas is included, Hooper and Lévi (1994) estimate up to 1500 species of sponge may exist in the Solandarian province.

Comments concerning endemism of the sponges must be treated with caution given the general paucity of tropical sponge research. Of 27 most recently described species of the Great Barrier Reef region 7 (26%) appear to be endemic (Bergquist et al. 1988; Fromont 1991, 1993). The majority of Great Barrier Reef species have Indo-West Pacific distributions.

Hooper and Lévi (1994) suggests that sponge diversity may be highest in the central region of the Great Barrier Reef[44], particularly around the Whitsunday Islands where the abundance of continental islands may contribute. Anecdotal evidence suggests the areas around Cape Tribulation, Pandora Reef and Orpheus Island are also pockets of great sponge diversity (Fromont, J. 1996, pers. comm.). However these 'pockets' of diversity may merely be artefacts of study site location rather than a true indication of the locations of high sponge diversity.

Though responsible for extensive barrier and fringing reefs, commencing during the Ordovician Period and lasting for around 100 million years, today sponges play only a minor structural role in living coral reefs (Hooper 1993). The sclerosponges are considered to be living relicts of these ancient reef-building sponges. Such species, for example, *Acanthochaetetes wellsii, Astrosclera willeyana*, have been found within the Great Barrier Reef World Heritage Area, on mid-shelf and outer-shelf reefs in caves or the continental slope. These species have solid calcareous skeletons analogous to hard corals (Hooper 1993; Fromont, J. 1996, pers. comm.). Recently a new species of the well known fossil group 'Sphinctozoa', *Vacelettia* n.sp., was found at Osprey Reef. This is the second only living species of this once thought extinct phylum of major reef builders (Hooper, J., unpub. data).

An increased flexibility in sponge morphology and the evolution of autotrophic species has

[44] This roughly corresponds to the Central Section of the Great Barrier Reef Marine Park.

ensured the sponges ability to compete effectively in tropical environments (Fromont, J. 1996, pers. comm.). These autotrophic sponges are significant contributors to the net primary production of reef ecosystems (Hooper 1994). The heterotrophic sponges are important for accreting calcium carbonate skeletons in deep water where light is limiting (Hooper 1994). Furthermore boring and burrowing species of sponges are important contributors to the bioerosion of calcium carbonate structures.

Wilkinson and Cheshire (1989) have documented longitudinal trends in fore-reef slope sponge biomass and diversity across the shelf. They found an overall decrease in species richness and biomass with increasing distance from the shore, with significantly more diverse sponge communities on inner- and middle-shelf reefs (88 and 90 species respectively) than on outer-shelf and Coral Sea reefs (75 and 65 species respectively). Furthermore they found that inner-shelf reef sponge communities were taxonomically very different from middle- to outer-shelf reef communities, and consisted primarily of heterotrophic species. In contrast outer-shelf reefs were characterised by a greater proportion of phototrophic species. The high diversity of heterotrophic species upon the inner-shelf reefs is likely to be the result of land based inputs of nutrients and sediments, while the 'clean' waters of the middle- and outer-shelf reefs support the greater numbers of phototrophic species (Wilkinson & Cheshire 1989).

Sponges provide important habitat for other taxa, including echinoderms, particularly brittle-stars (Ophiuroidea) and feather stars (Crinoidea), molluscs and fishes. Within the inter-reefal areas sponges along with bryozoans and ascidians form multi-species complexes providing habitat for a range of invertebrates (Birtles & Arnold 1988). Sponges are particularly important for some species of nudibranchs where co-evolution between the two has been found with a specificity to the genus, and in some cases, the species levels (Fromont, J. 1996, pers. comm.). Sponges provide a source of food for grazing fish and invertebrates (Hooper 1993). Sponges provide the major food resource for the hawksbill turtle (*Eretmochelys imbricata*) (Limpus, C. 1996, pers. comm.).

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Natural Heritage Attribute: Terrestrial Flora

SOURCE:

Dr G. Batianoff, Queensland Herbarium, Brisbane

CONCLUSIONS:

- over 2100 plant species occur on the Great Barrier Reef World Heritage Area islands, representing about 25% of Queensland's floral diversity in just 0.1% of its area;
- over 75 species are rare or threatened, with a number of endemic species;
- the southern limits of world distribution for a number of pantropic plants are reached in the Great Barrier Reef World Heritage Area;
- the Great Barrier Reef World Heritage Area provides a unique opportunity to investigate theories of island biogeography through the continuing processes of rainforest species invasion;
- birds are important for the dispersal, colonisation and establishment of some plants;
- five floristic regions on continental islands can be delineated, and an additional two for coral cays;
- distinct latitudinal trends in community composition are expressed.

MOST RELEVANT CRITERIA:

(ii), (iii), (iv)

SEE ALSO:

Mangroves

DISCUSSION:

This discussion of the terrestrial flora of the Great Barrier Reef World Heritage Area is divided into the continental island flora and the coral cay flora.

Continental Islands:

The flora of the continental islands, consisting of 2195 species from 911 genera and 195 families, corresponds to about 25% of the total Queensland flora (Batianoff & Dillewaard 1995). This high diversity largely depends upon speciation in ten large plant families (Batianoff & Dillewaard 1995). This flora shows a large degree of similarity with that of other Pacific Islands, however the diversity in some families (in particular the Mimosaceae and Convolvulaceae) is better represented in the Great Barrier Reef World Heritage Area (Batianoff & Dillewaard 1995). Of these 2195 species, 79 are considered to be threatened or rare (see Table 17), corresponding to about 6% of Queensland's known rare and threatened flora (Batianoff & Dillewaard 1995).

Floristic analysis of continental island flora gives five floristic regions. These are:

1. Northern Region (Cape York to Dunk Island)
2. Wet Tropics Region (from Dunk Island to north of Magnetic Island including Hinchinbrook Island)
3. Dry Tropics Region (from Magnetic Island to Gloucester Island)
4. Whitsunday Region (Whitsunday Islands, Northumberland Islands and Percy Islands)
5. Capricorn Region (Keppel Bay Islands and Curtis Island) (Batianoff & Dillewaard 1995).

The most diverse region is the Whitsunday Region with 1141 species followed by the Northern Region (976 species), Capricorn Region (846 species), Dry Tropics Region (735 species) and finally the Wet Tropics Region (656 species) (Batianoff & Dillewaard 1995). Hinchinbrook Island with 600 species and Curtis Island with 590 species are the most species diverse islands in the Great Barrier Reef World Heritage Area. The Northern Region has the largest concentration of rare and threatened species with 27 species, followed by the Wet Tropics Region with 24, the Whitsunday Region with 20, the Dry Tropics Region with 18, while only one species occurring in the Capricorn Region is classified as rare or threatened (Batianoff & Dillewaard 1995).

In general, from north to south there is an increase in herbaceous plants and a decrease in woody plants. This trend is closely related to the presence of woody rainforest species recolonising the northern islands from the close mainland tropical forests (Batianoff & Dillewaard 1996). The distribution of littoral margin flora is similar from north to south.

Batianoff and Dillewaard (1995) found that species diversity increases linearly with island size up to 5000 ha. Following this the relationship is no longer linear and other factors, such as habitat diversity, remoteness, palaeoclimates and fire, begin to play important roles in determining species richness. The considerable range of island sizes and environmental regimes provides a unique area for research into theories of island biogeography.

At the time of island formation, due to sea-level rise, some 6000 years ago, the continental island flora consisted largely of dry sclerophyll formations. Remnants of rainforest flora still exist in some places, for example a small patch of hoop pine on Lizard Island, indicating a more widespread rainforest flora prior to eucalyptus invasion some 8–9000 years ago (Batianoff & Dillewaard 1995). The managers of island flora need to be cognisant of these remnants, particularly when considering burning regimes. Furthermore, Batianoff and Dillewaard (1995) suggest there is a tendency to overestimate the importance of Aboriginal fire regimes on islands, whilst recognising that on some large inshore groups, such as the Whitsunday Islands, Aboriginal fire regimes have played important roles. Within contemporary times there has been a re-invasion of rainforest species into large areas of sclerophyll forest, particularly within the wet tropical sections of the Great Barrier Reef World Heritage Area. This re-invasion of rainforest species contributes greatly to the high species richness of some islands (Batianoff & Dillewaard 1995).

Three endemic taxa have been recorded on the continental islands: *Albizia* sp.; *Berrya rotundifolia* (Halford 1993); and *Habenaria divaricata*, an orchid endemic to Dunk Island (Jones 1988).

Of particular interest is the flora of serpentine areas, of which South Percy Island is the only example in the Great Barrier Reef World Heritage Area. Typically serpentine flora is characterised by stunted trees in an open woodland formation over a grassy ground stratum, often with a number of serpentine endemics (Batianoff & Specht 1992). *Stackhousia tryonii* is an endemic to the serpentine soils of central Queensland, including South Percy Island. It is one of only two nickel hyper-accumulators recorded in Australia, accumulating up to 1–2% of its dry weight in nickel, compared with other serpentine plants accumulating 0.05–0.5% (Batianoff et al. 1990). Nickel hyper-accumulation is known to occur in about 150 species worldwide; about 50 occur from New Caledonia, and around 70 from temperate regions from the northern hemisphere (Batianoff et al. 1990). *Stackhousia tryonii* was first described from material collected from South Percy Island. Later *S. tryonii* was placed in synonymy with *S. monogyna*, however, Batianoff et al. (1990) argue that they are distinct taxa with *S. tryonii* showing distinct characters. It is thought they have a common ancestor, with *S. tryonii* evolving to tolerate serpentine soils. South Percy Island provides an important site in which the evolution of serpentine flora can be investigated under seashore conditions.

Some of the Great Barrier Reef World Heritage Area continental islands (Lizards Island, Hinchinbrook Island, Northumberland Islands, Percy Islands) have considerable heritage value as they are the type localities of a number of taxa being collected by botanists (e.g. Banks, Solander, Brown, Cunningham) in the first hundred years (1770–1880) of Australia's colonisation by Europeans (Batianoff, G. 1996, pers. comm.). In addition they represent unique reference sites less influenced by modern anthropogenic forces than mainland equivalents, upon which greater understanding of evolution and speciation can be obtained.

Coral Cays:

It is likely that floristic analysis of the coral cay flora will discriminate two floristic regions: northern and southern. The northern region has a rich flora with 300–350 species. This includes a high occurrence of rainforest species and low levels of exotics. In contrast the southern cay flora is depauperate with about 120 species, and a large number of these being exotics (Batianoff, G. 1996, pers. comm.). In the northern region two endemic species are known: *Spermacoce buckleyi* (Sinclair Island) and *Lepturus stoddartii.*

The *Pisonia grandis* flora of the Capricorn–Bunker group is of world importance, however only 160 ha of this vegetation type exists in the Great Barrier Reef World Heritage Area. Lady Elliot Island (9 mature trees) is the world's most southerly limit of the taxon (Batianoff, G. 1996, pers. comm.). Indeed the Capricorn–Bunker group of islands, extending to latitudes further south than either New Caledonia or Vanuatu, provides important localities for pantropic plants at Australian, and world, southern limits of distribution, including *Scaevola taccada* (Lady Elliot), *Suriana maritima*

(Hoskyn), *Stenotaphrum micranthum* (Masthead) and *Trachymene cussonii* (Lady Elliot) (Batianoff, G. 1996, pers. comm.).

Birds are particularly important for the dispersal of some species on both continental island and coral cay floras. The Black Noddy and the Bridled Tern are significant dispersal agents for *P. grandis* (Walker 1991), while the invasion of rainforest species into northern coral cays and continental islands is largely assisted by the mainland rainforest feeding of the Torresian Imperial Pigeon (also see Birds).

The flora of the continental islands and the coral cays of the Great Barrier Reef World Heritage Area is exceptionally diverse given the small land area involved. A number of rare, threatened and endemic species occur on the islands, while some islands provide the most southerly populations for some taxa. Furthermore the Great Barrier Reef World Heritage Area due to its size and latitudinal extent provides a unique opportunity to investigate theories of island biogeography and plant evolution.

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Table 17. Rare and Threatened Flora of the Continental Islands in the Great Barrier Reef World Heritage Area

Taxon	Status	Taxon	Status
Acacia homaloclada	R	*Elaeocarpus carolinae*	R
Acacia jackesiana	R	*Eucalyptus xanthope*	V
Acacia polyadenia	R	*Gahnia insignis*	R
Acmenosperma pringlei	R	*Grewia graniticola*	R
Actephila sessilifolia	R	*Gymnema brevifolium*	V
Albizia retusa subsp. *retusa*	R	*Gymnostoma australianum*	R
Albizia sp. (South Percy Island G.N. Batianoff+ 14444)	P	*Habenaria divaricata*	E
Amaranthus pallidiflorus	R	*Habenaria xanthantha*	R
Aphyllorchis queenslandica	P	*Homalium* sp. (South Molle Island J.A. Gresty AQ208995)	P
Archidendron hirsutum	P	*Huperzia phlegmaria*	R
Arenga australasica	V	*Ipomoea saintronanensis*	R
Argyrodendron sp. (Whitsunday McDonald+ 5831)	P	*Kunzea graniticola*	R
Aristolochia chalmersii	R	*Larsenaikia jardinei*	R
Atalaya rigida	R	*Leucopogon cuspidatus*	V
Austromyrtus lucida	R	*Livistona drudei*	V
Austromyrtus pubiflora	R	*Macaranga polyadenia*	V
Banksia plagiocarpa	R	*Macropteranthes fitzalanii*	R
Berrya rotundifolia	R	*Muellerargia timorensis*	E
Bonamia dietichiana	R	*Myrmecodia beccarii*	V
Brachychiton compactus	R	*Omphalea celata*	V
Buchanania mangoides	P	*Ozothamnus eriocephalus*	V
Canthium sp. (Thornton Peak H. Flecker NQNC76110)	P	*Peripleura scabra*	R
Capparis sp. (Gloucester Island Batianoff 920912)	R	*Peristylu banfieldii*	R
Cassia sp. (Paluma Range G. Sankoswky+ 450)	R	*Psychotria coelospermum*	R
Cassia queenslandica	R	*Psychotria lorentzii*	P
Cerbera dumicola	R	*Quassia bidwillii*	R
Cerbera inflata	R	*Rhodamnia pauciovulata*	R
Cleistanthus myrtianthus	R	*Solanum sporadotrichum*	R
Combretum trifoliatum	R	*Spathoglottis plicata*	V
Comesperma praecelsum	R	*Stackhousia tryonii*	R
Corchorus hygrophilus	P	*Stenocarpus cryptocarpus*	R
Croton magneticus	V	*Syzygium alatoramulum*	R
Ctenopteris blechnoides	R	*Tephrosia savannicola*	R
Dendrobium johannis	V	*Tetramolopium* sp. (Mt Bowen G.D. Fell 1224)	P
Dendrobium phalaenopsis	V	*Tiliacora australiana*	R
Dipodium ensifolium	R	*Tinospora angusta*	R
Dischidia littoralis	V	*Wrightia versicolor*	R
Drosera adelae	R	*Xylosma ovatum*	R
Didymoplexu pallens	P	*Zanthoxylum rhetsa*	P
Ehretia grahamii	R		

(Source: Batianoff & Dillewaard 1995)

(E=endangered; V=vulnerable; R=rare as per schedules 2, 3 and 4 of the *Nature Conservation Act 1992* (Qld); P=species proposed for inclusion in schedules.)

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