

# Marine tourism impacts and their management on the Great Barrier Reef

VJ Harriott

CRC Reef Research Centre  
&  
James Cook University

[www.reef.crc.org.au](http://www.reef.crc.org.au)



*Established and supported under the  
Australian Government's  
Cooperative Research Centres Program*

## CRC REEF RESEARCH CENTRE TECHNICAL REPORT NO 46

CRC Reef Research Centre Ltd is a joint venture between: Association of Marine Park Tourism Operators, Australian Institute of Marine Science, Great Barrier Reef Marine Park Authority, Great Barrier Reef Research Foundation, James Cook University, Queensland Department of Primary Industries, Queensland Seafood Industry Association and Sunfish Queensland Inc.

# MARINE TOURISM IMPACTS AND THEIR MANAGEMENT ON THE GREAT BARRIER REEF

Vicki J. Harriott

CRC Reef Research Centre  
and  
School of Tropical Environmental Science and Geography,  
James Cook University.

A report funded by the CRC Reef Research Centre.

The CRC Reef Research Centre was established under the Australian Government's Cooperative Research Centres Program. It is a knowledge-based partnership of coral reef managers, researchers and industry. Its mission is to plan, fund and manage world-leading science for the sustainable use of the Great Barrier Reef World Heritage Area. Partner organisations are:

- Association of Marine Park Tourism Operators
- Australian Institute of Marine Science
- Great Barrier Reef Marine Park Authority
- Great Barrier Reef Research Foundation
- James Cook University
- Queensland Department of Primary Industries
- Queensland Seafood Industry Association
- SUNFISH Queensland Inc.

CRC Reef Research Centre  
PO Box 772  
Townsville QLD 4810 Australia  
Phone: 07 4729 8400  
Fax: 07 4729 8499  
Email: [info@crcreef.com](mailto:info@crcreef.com)  
Web: [www.reef.crc.org.au](http://www.reef.crc.org.au)

©CRC Reef Research Centre Ltd.

National Library of Australia Cataloguing-in-Publication entry

Harriott, V. J. (Vicki J.), 1955-.  
Marine tourism impacts and their management on  
the Great Barrier Reef.

Bibliography.  
Includes index.  
ISBN 1 876054 47 6.

1. Tourism – Environmental aspects – Queensland – Great Barrier Reef. 2. Marine parks and reserves – Queensland – Great Barrier Reef. 3. Tourism – Social aspects – Queensland – Great Barrier Reef. 4. Great Barrier Reef Marine Park (Qld.) – Management. I. CRC Reef Research Centre. II Title. (Series : CRC Reef Research Centre technical report ; no. 46).

338.4791943

This publication should be cited as:

Harriott, VJ. 2002. *Marine tourism impacts and their management on the Great Barrier Reef*. CRC Reef Research Centre Technical Report No 46. CRC Reef Research Centre, Townsville.

This work is copyright. The Copyright Act 1968 permits fair dealing for study, research, news reporting, criticism or review. Selected passages, tables or diagrams may be reproduced for such purposes provided the source is acknowledged. Major extracts of the entire document may not be reproduced by any process without written permission of the Chief Executive Officer, CRC Reef Research Centre.

While every effort has been made to ensure the accuracy and completeness of information presented in this report, CRC Reef Research Centre Ltd accepts no responsibility for losses, damage, costs and other consequences resulting directly or indirectly from its use.

In some cases, the material may incorporate or summaries views, standards or recommendations of third parties. Such material is assembled in good faith but does not necessarily reflect the considered views of CRC Reef Research Centre Ltd or indicate a commitment to a particular course of action.

Published by CRC Reef Research Centre Ltd, PO Box 772, Townsville, QLD 4810.

## **TABLE OF CONTENTS**

<b>ACKNOWLEDGEMENTS .....</b>	<b>5</b>
<b>EXECUTIVE SUMMARY .....</b>	<b>6</b>
<b>1. INTRODUCTION .....</b>	<b>9</b>
<b>2. BENEFITS OF MARINE TOURISM.....</b>	<b>12</b>
<b>3. THE INTERNATIONAL CONTEXT .....</b>	<b>14</b>
<b>4. PERCEPTIONS OF MARINE TOURISM IMPACTS.....</b>	<b>17</b>
<b>5. OTHER IMPACTS ON REEFS.....</b>	<b>18</b>
<b>6. IMPACTS OF MARINE TOURISM ON THE GREAT BARRIER REEF .....</b>	<b>20</b>
<b>7. MANAGEMENT OF TOURISM IMPACTS.....</b>	<b>34</b>
<b>8. CONCLUSIONS.....</b>	<b>35</b>
<b>9. REFERENCES .....</b>	<b>36</b>

## ACKNOWLEDGEMENTS

I thank Bryony Barnett, Gianna Moscardo, Tony Stokes, Annie Illett, David Windsor, Ed Green and Louise Goggin for comments on the manuscript, and for access to published and unpublished material.

## EXECUTIVE SUMMARY

Tourism has been identified as a critical issue in the management of the Great Barrier Reef Marine Park (GBRMP). About 1.6 million tourists visit the Great Barrier Reef (GBR) region each year, and generate an income of over \$1 billion per year in direct value. A further estimated one million visitor nights per year are spent in accommodation on island resorts within the boundaries of the GBRMP. The rapid increase in numbers of tourists and development of tourism infrastructure development on the GBR which caused great concern in the 1980s has stabilised since 1995. Recreational use of the GBR region by coastal residents is also high, and in many circumstances, the impacts of recreational users can be impossible to separate from those of commercial tourism activities.

Tourism on the GBR is geographically concentrated, with 85% of tourist visitation taking place in the Cairns and Whitsundays Areas, which cover about 7% of the area of the Marine Park and are the focus for tourism management. As a result, impacts of tourism are low and diffuse over the remaining Park area. Advances in transport technology may result in greater access by mass tourism operations to currently inaccessible regions of the reef and could affect the distribution and management of tourism impacts in the future.

Impacts of marine tourism can be broadly categorised as ecological, social and cultural. The major types of marine tourism impacts include:

- coastal tourism development (population pressures, construction activities);
- island-based tourism infrastructure (marinas, sewage discharge, construction);
- marine-based tourism infrastructure (pontoons, moorings, fish feeding);
- boat-induced damage (anchoring, ship grounding, litter, waste discharge);
- water based activities (diving, snorkelling, reef walking, fishing);
- wildlife interactions (seabirds, turtle-watching, whale-watching).

Activities associated with construction activity and structures are regulated under permit requirements. Planning should take into account cumulative impacts but these can be difficult to assess and management tools to contain such impacts can be contentious and difficult to implement. Legislation requires monitoring of waste water discharges, and tertiary treatment is required of any sewage effluent released into the GBRMP.

The best studied of tourism impacts are those associated with pontoons, anchoring and diving. A series of extensive impact assessments has found that impacts of pontoons on the surrounding reef areas are minimal, apart from the 'footprint' under the pontoon and its moorings. Anchoring of both tourist and recreational boats is a significant issue in heavily visited sites in the Marine Park. Anchors and anchor chains are capable of breaking multiple coral colonies at each drop. Management of anchoring impacts includes installation of both private and public moorings, 'no-anchor' areas in heavily used places such as some of the Whitsunday Islands, and an education program for boaters, promoting codes-of-practice.

The impacts of diving and snorkelling have been well studied both in Australia and overseas. Most divers do not break corals, but a small percentage of divers who swim too close to the coral may break many coral branches on each dive. Fragile branching corals are the most susceptible to breakage. Internationally, the carrying capacity of coral reefs has been determined to be about 5,000 divers per site per year. Above this level of dive intensity, environmental deterioration has been noted. Because of the large choice of dive sites available, no GBR sites currently appear to approach this level of diving activity. Some studies of snorkellers have detected larger numbers of broken corals in active snorkel areas, including snorkel trails, but the level of breakage levelled off quickly and did not increase over time. Recommendations for reducing diver and snorkeller impacts, such as dive briefings and careful selection of sites have been taken up by the diving industry.

Because tourism is an important commercial activity on the GBR and involves millions of visitors each year, it requires careful management by the Great Barrier Reef Marine Park Authority (GBRMPA) and Queensland Parks and Wildlife Service (QPWS). Tourism is managed on the GBR by a combination of zoning plans, plans of management of intensively used sites, codes-of-practice, and permits. Changes in the volume and profile of tourism on the GBR in the last 20 years mean that tourism management is presently under revision. The new approach being considered is based on a reef-wide strategic framework that promotes mandatory performance standards rather than proscriptive permits. Education and training remains an important component of tourism management. An Environmental Management Charge, introduced in 1993, is collected for each reef visitor and contributes to the funding of research, education and Marine Park management.

Surveys of tourists and the east Australian community have reported a perception that tourism activity is one of the three greatest threats to the GBR. Of the people surveyed, 53%

perceived that tourism activities and tourism infrastructure had a large or very large impact on the GBR. In comparison, reports from scientists and conservationists on threats to the GBR rate inshore water quality, overfishing, predation by crown of thorns starfish and coral bleaching as of greatest concern. It may be necessary to provide the community and tourists with better information about the GBR and its management to ensure public perception of threats to the GBR is based on the best available information.



## 1. INTRODUCTION

Tourism is the activity with the highest commercial value within the Great Barrier Reef Marine Park (GBRMP) (GBRMPA 2000a). Approximately 1.6 million visitors travel to or through the GBRMP on commercial tourism operations each year (Figure 1). In addition, more than one million visitor nights per year are spent in accommodation on island resorts within the boundaries of GBRMP (extrapolated from Driml 1987, Zann 1996). The direct value of marine tourism is over \$1 billion per year (Zann 1996, Dinesen and Oliver 1997, GBRMPA 2000a), approximately four times that of the next most valuable commercial activity, i.e. commercial fishing.

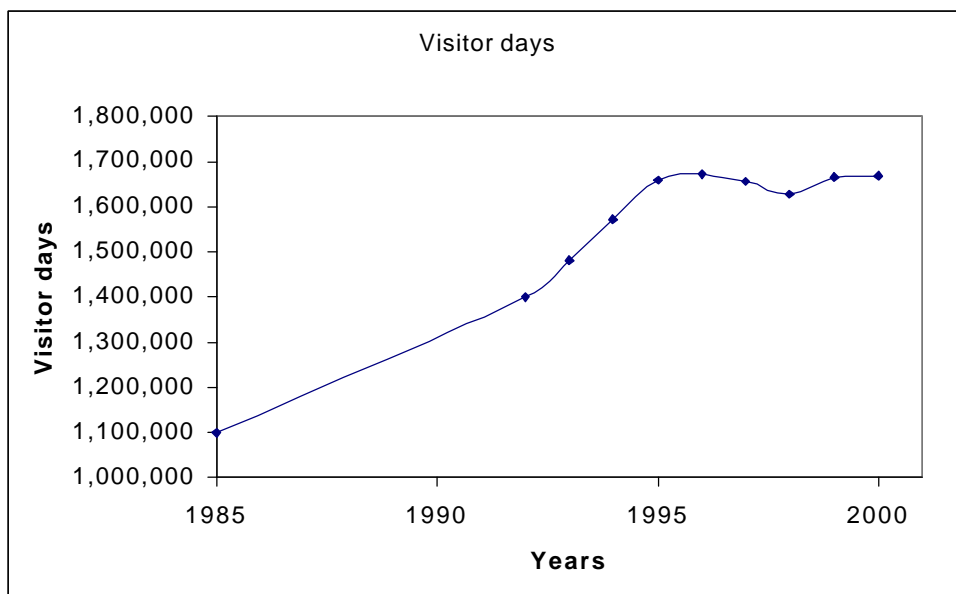


Figure 1. Patterns of tourist visitor days in the GBR region. Data for 1984 – 85 from Driml (1987- excluding passenger ferries), 1992-3 data from Kelleher and Craik (in Aiello 1997), 1993-4 data from Williams 1996; 1995-2000 data from EMC returns, GBRMPA.

The impacts of marine tourism on the GBRMP, and marine tourism management were extensively reviewed by Aiello (1997), Dinesen and Oliver (1997), Edwards (1997) and Wachenfeld *et al* (1998). This report briefly reviews information on tourism impacts covered in those reports, but focuses on knowledge accumulated since 1997, marine tourism impacts in an international context, and concentrates on information sources provided in the published literature.

Tourism on the Great Barrier Reef (GBR) has followed a general pattern of low visitation in the post-war period, followed by rapid expansion through the 1970s and 1980s. More

accurate data on numbers collected since the introduction of the Environmental Management Charge (EMC) in 1993 show a period of stable visitor numbers in the late 1990s (Figure 1). However figures on numbers of tourists before 1994, with the exception of the Driml (1987) study, are largely unreliable (Valentine *et al* 1997). For example, published figures of the annual numbers of tourist days for the early 1980s of 150,000 (Williams 1996, Vanderzee 1996, Wachenfeld *et al* 1998) are inconsistent with the detailed study of Driml (1987), which showed > 1 million visitor days, and seem to be too low to be realistic.

Tourism has been recognised as a 'critical issue' by the Great Barrier Reef Marine Park Authority (GBRMPA). It has attracted increasing attention from park managers, and there has been considerable debate over a long period about the best way to manage tourism within a multi-use marine park. Part of the concern about management of tourism has been related to its rapid expansion in the face of relatively little information about the acute and cumulative impacts of tourism on the environment. There were fears concerning continued rapid growth in the industry, and its implications for management of the Marine Park, with predictions of continued annual growth in numbers of 10% per annum (Dinesen and Oliver 1997, Wachenfeld *et al* 1998). There were periods of demand for new tourism infrastructure to support the escalating industry. In some cases, the expansion included technologies that were little studied at the time, such as the floating hotel and large pontoon structures to support day visitors.

Marine tourism in the GBRMP is geographically focussed on two major accessible reef areas off Cairns and in the Whitsunday Islands region. Since 1993, EMC figures have shown that 85% of visitation occurs in these two small parts of the GBR (Figure 2). These regions represent just 7 % of the area of the Marine Park (GBRMPA 2000a). These figures, while supporting the same general pattern, appear to be more accurate than the previously reported ones that 95% of tourists visit 4% of the reef area (Williams 1996, Vanderzee 1996, Wachenfeld *et al* 1998). This focus for tourism activity means that the other 85% of the Marine Park area is accessed by 15% of the tourists, resulting in a very low level of tourism impacts over the majority of the park. Data since 1994 indicate a small decline in visitor numbers in the Cairns Planning Area, and a small increase in visitor numbers in the Whitsundays Planning area, indicating that the forecasts of continued 10% annual increases in tourist numbers have not eventuated.

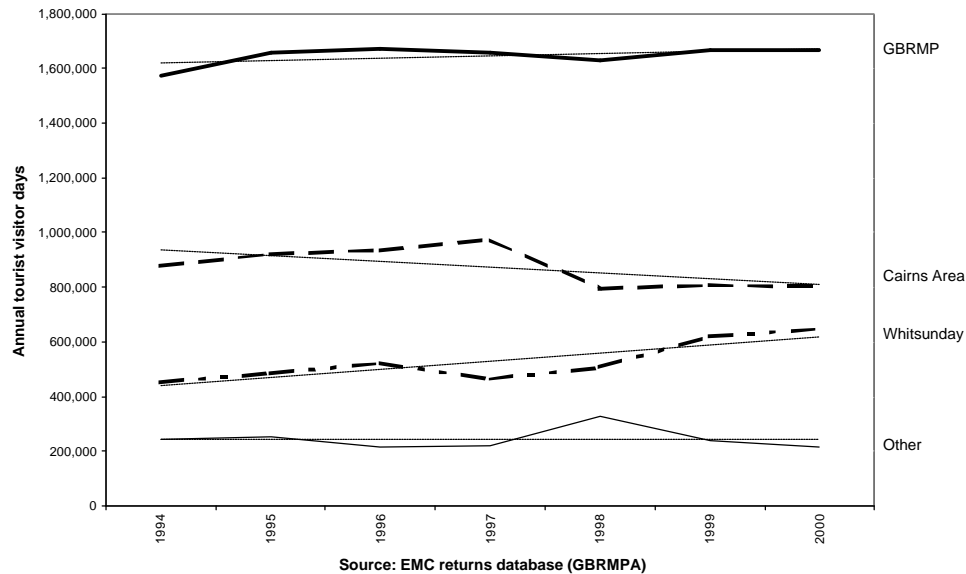


Figure 2. Trend in number of reef visitor days in the Cairns and Whitsundays Planning Areas, and in the remainder of the GBRMP for the period since statistics were collected in conjunction with the Environmental Management Charge in 1993.

Major sectors of the GBR marine tourism industry are (after Vanderzee 1996):

- Structure-based tourism operations. Tourist pontoons are used as a base for day passengers. Other structures include underwater observatories, and a floating hotel that operated briefly in the 1980s. Larger day trip operations to pontoons represent the largest single component of the industry.
- Vessel-based tourism operations. These carry from < 10 to > 400 passengers, and may be site-specific or roving, and may operate to islands or moorings.
- Extended vessel-based tourism operations. Vessels carry 6 – 160 passengers on trips of several days to weeks, generally stopping at more than one destination.
- Bareboat charter. Primarily based in the Whitsunday Islands, yachts are available for charter with or without crew for operation within a restricted area.
- Cruise ships. Large (> 10,000 tonnes) cruise ships pass through and anchor overnight in the Marine Park.
- Aircraft-based operations. Conventional aircraft, seaplanes and helicopters are used for sightseeing and transfers.
- Resort and shore-based operations. There are several island-based resorts within the Marine Park, and a number of mainland resorts adjacent to the Marine Park.

## 2. BENEFITS OF MARINE TOURISM

The marine tourism industry is a major contributor to the Australian economy, with an estimated direct value in excess of \$1 billion (Wachenfeld *et al* 1998, GBRMPA 2000a). About 1.6 million visitor days are spent on commercial marine-based activities in the Great Barrier Reef Marine Park (GBRMP) each year. A further one million visitor nights are spent at Great Barrier Reef (GBR) island resorts, with more than nine million visitor nights on the reef and adjacent coast (Zann 1996). In 1998, 742 tourism operations were permitted within the GBRMP, including 1674 individual craft (Wachenfeld *et al* 1998). Total employment was estimated at 120,000 people (Zann 1996).

The GBR was designated a World Heritage Area in 1981. One requirement of World Heritage status is presentation of the WHA. Marine tourism has been viewed by the Great Barrier Reef Marine Park Authority (GBRMPA) and the tourism industry as a principal mechanism for presentation for the Great Barrier Reef World Heritage Area (GBRWHA) to the community. By enhancing people's understanding and enjoyment of the GBR, tourism can ensure continued public support for its conservation and management (Dinesen and Oliver 1997).

Relative to other extractive uses of the Marine Park, marine tourism has great potential to be ecologically sustainable. In many parts of the world, tourism is promoted as an environmentally sustainable industry which can replace extractive industries while at the same time providing financial support for local economies (Agardy 1995, Moscardo 1997, White 2000).

### Marine tourism and conservation

In countries outside Australia, there is strong pressure to expand the network of marine protected areas to enhance reef conservation. A major mechanism to fund conservation and marine park efforts is via the tourism industry (Moscardo 1997, Hawkins 1998). The economic value of coral reef tourism plays an important role in making a case for improved management and conservation (Dixon 1998). The following contributions of tourism to environmental conservation have been identified (UNEP 2002)

- Direct financial contributions e.g. fees for park entry.
- Contributions to government revenues via taxes, rates, license fees.

- Improved environmental management and planning. Motivation to plan for tourism can assist in choices between conflicting uses and prevent deterioration of environmental assets valuable to tourism.
- Environmental awareness training. Tourism can increase public appreciation of the environment and enhance environmental awareness, which increases the community's desire to preserve the environment.
- Protection and preservation. Increases the value of attractive, and pristine sites and enhances support for marine protected areas.
- Alternative employment. Tourism can provide employment for people displaced from less environmentally sensitive activities (eg. logging in rainforests).

In Australia, the Environmental Management Charge of (currently) \$4 per visitor per day to the GBRMP (GBRMPA 2000a) is used to support education, research and the cost of management of the Park.

The tourism industry is reliant on a healthy attractive environment for its sales. Research by Shafer *et al* (1998) and Shafer and Inglis (2000) has found that the most significant factors influencing the enjoyment of day visitors to the GBR are staff interactions, and the quality of the corals and fish. Thus, there is strong motivation to protect and conserve reefs that are the subject of tourism interest.

This has been increasingly recognised in reef management by moves by GBRMPA to work closely with the tourism industry in developing management policies. An example of an effort to preserve reefs for tourism has been the large industry investment by Cairns-based marine tourism industry in crown of thorns starfish controls to preserve areas of living reef around their tourist facilities. Efforts driven by the tourism industry to support sustainable tourism include the projects developed under the Reef 2005 program (eg. Aiello 1997, Edwards 1997), one component of a major effort towards industry self-regulation.

### 3. THE INTERNATIONAL CONTEXT

Travel and tourism drove more than 10% of the global Gross Domestic Product (GDP), consumer spending and capital investment in 1997 (Hawkins 1998). The development and management of marine tourism and nature-based tourism are important issues for international coral reefs. Outside Australia, the USA and Japan, most coral reefs are in developing countries. The benefits of sustainable reef-based tourism include foreign and investment income, increased employment, increased infrastructure, motivation for the establishment of marine protected areas, and displacement of environmentally destructive practices (eg. Vogt 1997). Management practices in several international coral reef marine protected areas were reviewed by Aiello (1997), who concluded that success was mixed and highly dependent on the resources available for park management and on the support of the local communities.

Significant financial benefits are seen as a major motivation to protect and manage coral reefs in many countries. Muthiga and McClanahan (1997) reported that damage to a Kenyan coral reef was lower under intensive tourist visitation than where fishing pressures were high. White *et al* (2000) report that the economic benefits from a managed marine area in the Philippines due to higher fisheries catches and revenue from tourism exceed the cost of management. They also suggest that increased income from park entrance fees from dive tourism would also support reef management.

Disadvantages of major tourism development in these regions include uncontrolled development in areas with little environmental legislation or recognition of cumulative impacts, displacement of locals from sites of tourism interest, little flow-on benefit from large resorts to the local communities, and undesirable social impacts on indigenous culture (Moscardo 1997, Hill 1998). In many cases, a major cause of concern relates to uncontrolled coastal development of large resorts close to the reefs that are a major focus of the tourism market (Ormond *et al* 1997). In the Caribbean, social dislocation can occur when 100 million visitors each year join 170 million residents (Hill 1998). In the Egyptian section of the Red Sea, a 10-fold increase in dive tourism over a decade has produced major impacts from reef infilling for resort construction, as well as concerns over the direct effects of large numbers of divers on the coral reefs (Hawkins and Roberts 1994, Ormond *et al* 1997).

For marine tourism on the Great Barrier Reef (GBR), many of these concerns do not apply. The great majority of reefs in the Great Barrier Reef World Heritage Area are a considerable distance offshore, relative to most reefs overseas. Most reefs which are the basis of the tourism industry are 10 - 60 km offshore of the mainland. Most tourists are accommodated on mainland hotels and resorts, and travel by boat, often for many hours to reach these reefs. While coastal development is a real issue in Australia (see Section 5), there are well-established legislation and controls on development, relative to many overseas countries, including legislation which covers mainland development likely to impact on the GBR Marine Park. Social and cultural impacts on local communities are significant in Australia, but less so than in other countries where Eurocentric culture is not the norm. The interests of Aboriginal people in the GBR region has received increased attention in recent years. Concerns that rapidly increasing tourist numbers will alienate local residents from use of reefs close to population centres has also been a concern (see Section 6).

The GBR has two factors which distinguish it from any other reef in the world with regard to tourism and its impacts: its large size and well-established management regime. The GBR is the largest reef system in the world. It is 2,500 km long, covers an area of 344,000 km<sup>2</sup>, and consists of 2,900 separate reefs, and 940 islands, of which 27 support resorts (Zann 1996). Each reef is on average around 10 km<sup>2</sup> in area and about 10 km in perimeter. The geographical scale of the reef system which supports marine tourism on the GBR is vast, for example in contrast with the reefs of Florida which are relatively small in area and are accessed by very large numbers of tourists. The focus of tourism activity in the Cairns and the Whitsunday Island regions mean that the remaining 93% of the Marine Park has very low level of tourism impacts. The coastal region adjacent to the Great Barrier Reef Marine Park (GBRMP) also supports low population numbers reducing environmental pressures, particularly in comparison with the reefs of South East Asia (Burke *et al* 2002).

The second factor is that management of the GBRMP has been in place since 1975. Management of the Marine Park has been acknowledged as pioneering and its management systems including the multiple-use zoning schemes have been used as a model for development of marine parks elsewhere (Aiello 1997). Tourism has been recognised as one of the critical issues in marine park management, and many systems are in place to regulate and control tourism activities and their impacts. These include the requirement for environmental impact assessment for any construction or infrastructure activities, requirements for permits for tourism activities, the establishment of an Environmental

Management Charge in 1993 to support research and management of the Marine Park, and the existence of Marine Park staff to enforce regulations. Few other coral reef marine parks are as intensively managed.

In combination, these two factors mean that the impact of tourism on about 93% of the GBR is very low, and intensive and well-resourced management systems are in place to manage tourism and its impacts in the geographically confined, intensely-used areas.



#### 4. PERCEPTIONS OF MARINE TOURISM IMPACTS

There is strong public support for the Great Barrier Reef Marine Park (GBRMP), and a strong desire by the community to protect the park from adverse impacts (Green *et al* 1999, Moscardo *et al* 2001). A 1997 survey of more than 1000 Australian residents collected responses on the perceived state of the Great Barrier Reef (GBR), threats to the reef and attitudes towards reef protection. The majority of the survey sample had concerns about the future of the health of the GBR. Of those who responded to the survey, 31% identified tourism as a major threat to the GBR. This was the third highest response, behind pollution (50%) and general human impact, but was higher than crown of thorns starfish (30%), oil spills/ shipping (23%), overfishing (21%), and agricultural run-off (9%) (Green *et al* 1999).

When questioned specifically about tourism effects (amongst a list of other potential impacts), 53% of respondents believed that activities of tourists and tourism infrastructure have a large or very large negative impact on the GBR. Only 12- 13% thought that the impacts were slight or that there was no impact. By contrast, more respondents believed the following would have a large or very large impact: agricultural run-off 66%; crown-of-thorns starfish (65%); commercial fishing (65%); urban and industrial run-off (67%).

In a paper comparing these surveys with a second survey of mainly international visitors, Moscardo *et al* (2001) concluded that while there was recognition that tourism has the potential for negative impacts on the GBR, there was little understanding of the ways in which tourism might be a problem. The study also concluded that there was only a low level of awareness of other potential long-term and widespread impact on the reef, such as coastal development. They suggested that providing more information about the reef, its management and long-term threats might allow a more informed evaluation of threats and how they could be reduced.

This research indicated strongly that there are concerns in the community about marine tourism impacts on the GBR. Tourism is extensively managed on the GBR, and the aim of management is to ensure that impacts from tourism impacts are minimal. It may be that the public perception of tourism impacts is disproportionate to reality.

## 5. OTHER IMPACTS ON REEFS

While marine tourism impacts rank highly in public perceptions relative to many other types of impact (Moscardo *et al* 2001), most of the impacts of marine tourism are generally localised and often minor (Dinesen and Oliver, 1997). It is difficult to objectively rank other threats to the Great Barrier Reef (GBR), to evaluate whether the severity of tourism impacts has been overestimated in the surveys (Moscardo *et al* 2001). Dinesen and Oliver (1997) identified the greatest threat to the GBR as the use and development of adjacent mainland areas. They argued that the indirect effects of urban expansion, including in some cases for tourism infrastructure development, may produce greater impacts than the direct effects of tourism activities located within the boundaries of the GBR Marine Park.

In the State of the Marine Environment report (Zann 1996), tourism is listed as a major management issue on the GBR, because of the large number of tourists and value to the economy. However, the major environmental issues were listed as: declining inshore water quality; outbreaks of crown-of-thorns starfish, effects of trawling on reef benthos, effects of line fishing and threat of oil spills from shipping. These all represent potentially widespread and long-term impacts.

In 1998, a major coral bleaching episode occurred on the GBR (Berkelmans and Oliver 1999) and internationally. Many reports have linked increased frequency of bleaching of corals with global climate change, and have suggested that the condition of the GBR will deteriorate within decades (Hoegh-Guldberg 1999). In addition, damage as a result of storm events and cyclones can severely impact reefs, breaking large numbers of corals and greatly reducing coral cover (Connell *et al* 1997). These are natural events that are part of the risk framework for the GBR tourism industry and for Park management, and there is little that can be done to minimise the risk, rectify damage or mitigate effects on tourist operations.

The World Wide Fund for Nature (WWF), in its major campaign to address issues related to the GBR, lists the major threats as: unsustainable fishing, pollution including coastal runoff and the threat of oil spills, climate change and coral bleaching and coastal development (WWF 2002). Growth of the coastal population, including growth triggered by tourism, is included as one aspect of coastal development. Similarly, in an evaluation of international coral reefs at risk, Burke *et al* (2002) identify major threats as coastal development, marine-based pollution, sedimentation from island sources, overfishing and destructive fishing.

Tourism was included only as a potential driving force for poorly regulated coastal development.

There seems to be a mismatch between public perceptions of tourism as a threat to the GBR, relative to other broad scale impacts. These impacts can be locally significant, when tourism triggers large infrastructure developments on islands and coastal communities. More recent surveys in 2001 by Moscardo and co-workers (personal communication) have demonstrated a reduction in the number of survey participants identifying tourism as a major threat to the GBR, relative to the comparable 1997 surveys. This may represent increasingly sophisticated public understanding of reef-related issues. However community awareness of issues such as coastal development, global climate change, overfishing and water quality remained low.

## 6. IMPACTS OF MARINE TOURISM ON THE GREAT BARRIER REEF

According to Moscardo (1997), the goals of sustainable tourism are to:

- improve the quality of life of host communities;
- preserve intra- and intergenerational equity;
- protect the quality of the environment by maintaining biological diversity and ecological systems;
- ensure cultural integrity and social cohesion of communities and;
- provide a high quality experience for tourists.

Clearly, the ideal of sustainable tourism involves minimising any adverse ecological, social or cultural impacts of tourism. The major types of marine tourism impact are (Table 1)

- Coastal tourism development;
- Tourism infrastructure (island-based);
- Tourism infrastructure (marine-based);
- Boat-induced damage;
- Water-based activities;
- Wildlife interactions.

In evaluating tourism impacts, it is often impossible to separate the effects of commercial tourism from recreational activities of coastal residents. This is particularly the case for the final three impact types in the list above. Recreational activities generally take place from small boats and are concentrated around coastal population centres. Moscardo (personal communication) has estimated that recreational visitors to the Great Barrier Reef (GBR) number about 2.1 million per year, compared with 1.6 million tourist visitor days. The discussion below encompasses both tourism and recreational impacts.

While social and cultural impacts have long been recognised as important (Dinesen and Oliver 1997), there have been relatively few studies of social and cultural impacts relative to the studies of ecological impacts (Moscardo 1999). Such social impacts include negative effects of tourism on the experiences of other users, sometimes leading to displacement of traditional and recreational users through disturbance and overcrowding (Wachenfeld *et al* 1998). The Great Barrier Reef Marine Park Authority (GBRMPA) policy has been to manage the GBR to provide a range of recreational opportunities for all users, not just high-density commercial tourism (Wachenfeld *et al* 1998).

A framework to manage social impacts often incorporates the Limits of Acceptable Change (LAC) planning model (reviewed in Shafer and Inglis 2000). In such analyses, an understanding of the interactions between the quality of the natural resource and the expectations of visitors and other stakeholders is required. Indicators can be derived which reflect the acceptable state of the biophysical or social environment eg. the degree of crowding that is acceptable. Such planning tools require analysis of visitor experience and expectations to determine which social, biophysical and management conditions affect user perceptions (Moscardo 1999, Shafer and Inglis 2000).

An example of such a study on the GBR includes the work by Shafer and Inglis (2000), who surveyed reef visitors and found a range of perceptions related to the preferences of reef visitors. They report that repeat visitors were more sensitive to the presence of high-density tourism and reef infrastructure. They argue that this is evidence to support a policy which ensures that a range of visitor opportunities is available, and that indicators for desired settings can be developed.

In the following sections, marine tourism impacts on the GBR are discussed under the broad categories listed in Table 1. Most information is available in ecological impacts, because they have been best studied (Dinesen and Oliver 1997), but information on social impacts is included where it is available.

Table 1. Summary of tourism impacts on the GBR.

<b>Activity</b>	<b>Impacts</b>	<b>Management and mitigation</b>
<b>Coastal tourism development</b>		
Population pressures	Increased pressure on services such as sewage, transport, electricity Impacts on social values and amenity	Regional planning taking into account cumulative impacts
Construction of tourism developments	Effects on catchment water quality	Environmental impact assessment; Best-practice construction techniques; Monitoring
<b>Tourism infrastructure (island-based)</b>		
Marina/ harbour development	Local, on affected reefal area Water quality (antifoulants) Introduced pests Impacts on social values and amenity	Environmental impact assessment; Engineering design Reactive monitoring; Water quality monitoring
Sewage discharge	Depends on treatment level Elevated nutrients and turbidity Freshwater input	Requirements for discharge levels; Water quality monitoring; Tertiary treatment; Land irrigation
Construction	Vegetation damage Loss of wildlife habitat Sediment runoff	Environmental impact assessment; Best-practice construction techniques; Water quality monitoring
Tourism activities	Focus for motorised and non-motorised vessels and marine activities	As discussed below

### **Tourism infrastructure (marine-based)**

Pontoons	Shading of benthos Dragging of moorings Focus for tourist activities	Permit required; Appropriate design; Careful selection of location; Transplant susceptible biota away from site
Moorings	Local damage to benthos Reduce impacts from anchors	Encouraged to reduce anchor damage; Appropriate design; Liability and safety issues
Fish feeding	Focus of fish aggregations Research shows no negative impacts	Activity limited by permit; Best-practice for fish feeding

### **Boat-induced damage**

Anchoring	Local coral damage Cumulative impacts	Installation of private and public moorings; Codes of practice in other areas; Anchor over sand; Education program
Ship groundings	Damage to reef structure Local benthos damaged Anti-fouling paint on reef Risk of oil or chemical spills	Education of private and charter users
Litter	Potential harm to wildlife Aesthetics	Education program; Penalties
Waste discharge	Local nutrient enhancement Potential water pollution	Education program; Penalties; Storage tanks in boats
Vessel strike/ disturbance to wildlife	Injury/death and/or disruption to social bonds	Education program; Penalties; Speeds limits, especially in shallow seagrass areas

### **Water-based activities**

Diving	Local damage to fragile corals	Education program; Industry code-of-practice; Dive briefings; Site selection for inexperienced divers
Snorkelling	Local damage to fragile corals	Education program; Industry code-of-practice; Provision of resting buoys and flotation; Briefings
Reef walking	Coral breakage	Education program; Industry code-of-practice; Walking trails to focus damage
Fishing	Small relative to recreational and commercial	Zoning requirements; Industry code-of-practice

### **Wildlife interactions**

Seabirds	Close contact can damage nesting sites and breeding	Legislation; Education program; Industry code-of-practice; Limited access to breeding sites; Briefings
Turtle-watching	Uncontrolled access can affect breeding success	Education program; Industry code-of-practice; Briefings Trained guides; Limit access to key breeding sites
Whale-watching	Potential for whales to be disturbed by uncontrolled contacts	Legislation; Education program; Industry code-of-practice; Trained guides; Limit entry for 'dedicated' operators
Fish feeding by divers	Wrong diet; disease & enhanced capture risk; fish dependency; human danger;	Education program; Legislation; Guidelines; Briefings; Permit conditions

### Coastal tourism development

Large numbers of visitors require considerable infrastructure in the form of accommodation, transport, shopping, entertainment and services like electricity and sewage. Most developments in coastal Queensland are managed by the local and state government, along with residential development, and detailed discussion of these diffused impacts is beyond the scope of this report (but see Wachenfeld *et al* 1998). Construction of tourism facilities will trigger an environmental impact assessment, which should account for the impacts of the development, including any in Marine Park waters, and how they are to be controlled. Tourism development on the coastal strip of Queensland has been recognised as a planning issue, and must take into account social impacts and cumulative impacts of developments. In the absence of strategic planning, large-scale tourism development has the potential to impact on social and amenity values within a community.

### Tourism infrastructure (island-based)

Of the 940 islands on the GBR, 27 support resorts, primarily on high rocky islands in the Whitsunday Islands region (Zann 1996). Green Island off Cairns, and Heron Island, and Lady Elliott Island in the Capricorn-Bunker Group in the south are the only sand cays with resorts, with other based on rocky continental islands. GBR island resorts have been estimated to support about \$300 million worth of tourism business per year (Zann 1996).

Some of the impacts of island resorts are related to the construction of buildings and other infrastructure such as marinas. These have been controversial in some cases in the last decade. For example, dredging of the boat harbour at Heron Island and deposition of the material in a spoil dump triggered extensive environmental monitoring (Gourley and Jell 1993). The development of the harbour had resulted in changes in the water level over the reef flat. These were repaired during the harbour reconstruction, again altering draining and tidal levels on the reef flat.

Such construction activities require permits that may be conditional, an environmental impact assessment and an environmental monitoring program. Over the last 15 years, GBRMPA has developed a relatively sophisticated system for managing impact assessment within the Marine Park. The features of the environmental monitoring programs were

reviewed in Nelson and Mapstone (1998), and feature independent environmental consultants paid by the proponent who answer directly to GBRMPA, guidelines about what constitutes appropriate monitoring design, development of 'reactive monitoring' to assess ongoing small impacts, and an external review process. Management of all construction activities with the Marine Park includes a contract between developers and the Authority, and includes a security bond against possible future site remediation.

A further consideration on island resorts is of the disposal of sewage effluent (Gallagher and Volker in press). Current GBRMPA policy requires that all point source sewage discharges within the GBRMP are tertiary treated with nutrient reduction, or have land reuse of secondary or tertiary effluent with minimal marine discharge (Edwards 1997, Volker *et al* 1997, Wachenfeld *et al* 1998). This has greatly reduced previous concerns about eutrophication of reef waters from sewage release. A research program on waste water management on island resorts on the GBR (Volker *et al* 1997, Gallagher and Volker in press) has shown that the use of effluent in irrigation eg. of golf courses, as an alternative to ocean discharges, has the potential to reduce the amount of nutrient discharged into the surrounding marine waters.

Island-based tourism operations provide a focus for other activities such as seaplanes and helicopters, small boats, jet skis, surf skis, wind-surfers and canoes, water skiing, and snorkel and diving activities. Impacts of these activities are discussed in later sections.

#### Tourism infrastructure (marine-based)

Pontoons are moored offshore up to 60 km from the coast in areas of the reef with few coral cays to provide a base for up to 400 day visitors each day. They were intended in part to relieve tourist pressure on the few accessible coral cays (Inglis 1997). Tourist pontoons were first installed in the 1980s and were simple low-cost structures with improvised mooring systems comprising chains attached to miscellaneous concrete and steel anchors (Inglis 1997, Kapitze 1999). Vandreeze (1996) estimated that 50% of tourists to the GBR travel on day trips to a moored pontoon. Following escalating demand for pontoons and other structures in the Marine Park, a 'no-structures' subzone covering 22% of the Cairns section of the Marine Park was declared in 1992 to limit the number of sites at which pontoons were permitted (Dinesen and Oliver 1997).



Several accidents, including the sinking of the 'Fantasy Island' structure in 1988 and the breaking of a pontoon from its moorings during Cyclone Justin in 1997 have intensified pressure to optimise pontoon mooring design (Kapitze 1999). Ongoing collaboration between researchers, marine park management and engineering industry has seen the development of draft reef infrastructure guidelines which could be adopted as a model for new developments (Kapitze 1999, Kapitze *et al* in press). The guidelines include recommendations on design of moorings, anchor and pontoon body, as well as procedures for siting pontoons, and their installation and maintenance.

Concerns about the impacts on the reef communities of pontoon structures resulted in a series of environmental monitoring programs which have been a required condition of pontoon permit approval since 1989 (reviewed by Inglis 1997, Nelson and Mapstone 1998). The development of pontoon monitoring systems by a number of consultants coincided with the requirement for more comprehensive impact assessment within the GBRMPA. Some of the monitoring has lacked sufficient rigour in survey design to detect any other than major impacts (Nelson and Mapstone 1998). Their detailed analysis of 11 pontoon monitoring studies reported that early pontoons had an impact on benthic communities under the pontoons as a result of shading and movement of the mooring chains (Nelson and Mapstone 1998). The response to these early studies was to site pontoons over sandy areas and away from living corals, and to improve the technology of mooring systems. More recent monitoring has demonstrated few significant impacts on coral or fish communities by operating pontoons (see sections on snorkelling and fish feeding) (Nelson and Mapstone 1998). There is strong motivation for tourism operators to implement practices to protect the environment near pontoons, because of the limited number of suitable sites and the high cost of moving the pontoons should the reef be damaged.

Sweatman (1996) comprehensively reviewed information about fish feeding associated with tourist pontoons, following concerns that aggregation of predatory fish would deplete local fish populations. The study found that the fish species studied aggregate under natural conditions, and could find no evidence of any impacts of the fish on prey or competitor species. The study also found that fish respond to human signals, with fish dispersed away from the pontoons outside the times when the tourist boats are present. The fish are apparently attracted to the pontoon by feeding, and the primary management concern that

the amount of food is limited that the quality of the food is appropriate for the species. There is also potential for aggression by the fish and as a result all marine wildlife feeding has been banned in Florida, USA. A permit is now required for fish feeding activities within the GBRMP. The practice of feeding food scraps has been discontinued, and a limit on the amount of 1 kg per site per day of raw marine product or fish pellets has been applied (GBRMPA 2000a).

In a special case of a tourism infrastructure, a floating hotel was installed at John Brewer Reef in 1988 and removed following a financial failure of the operation less than 18 months later (reviewed in Harriott and Saenger 1995, Inglis 1997). The major impacts of the resort development were the destruction of the top 1 – 2 m of coral bommies that were removed to allow the passage of the floating hotel into the lagoon, and breaching of effluent limits on several occasions because of malfunction of the wastewater treatment plant.

The impact assessment study was one of few to include a component on the social impact of the hotel (Harriott and Saenger 1995). One social impact of tourism is the displacement by large-scale tourism of local users of reefs. The study reported about equal numbers of positive and negative responses to the presence of the hotel. Some people chose to visit the reef for its novelty value, or used the hotel as a navigation aid. The reef was not particularly popular with locals and several alternative destinations were available, possibly reducing social impacts.

Installation of moorings has the potential to cause minor damage to the surrounding areas. The presence of moorings also concentrates divers and other activities to a restricted area. Studies have shown higher diver damage around moorings than in control sites. However, there is agreement that the presence of moorings greatly reduced anchor damage (Dinesen and Oliver 1997), and the GBRMPA management policy is to provide public moorings and require private moorings as part of permit conditions in heavily used sites. The number of application for mooring permits increased from 4 in 1995/96 to 113 in 2000/2001 (GBRMPA Annual Reports).

## Boat-induced damage

Boating impacts are particularly difficult to separate as relating to tourism or recreational activity. Large boats, with the exception of bare-boat charters, are more likely to carry tourists, while small boats are more likely to be privately owned by coastal residents. Private boats are likely to range more widely than commercial boats, because they are often more flexible.

Anchor damage has been an issue of great significance within the GBRMP for more than a decade. While recognising that anchor damage was of local significance and would not impact on the broad regional scale, anchoring of large numbers of recreational and charter vessels was recognised as causing damage, particularly to the fringing reefs in the Whitsunday Islands and offshore from Cairns (Dinesen and Oliver 1997). Anchoring damages corals and other benthic organisms both directly as a result of the anchor dropping on corals, and as a result of the movement of the anchor chain across the substrate (Wachenfeld *et al* 1998).

Management of anchor damage in the GBRMP has been addressed by designation of some 'no anchoring' or 'limited anchoring' areas; the establishment of the Reef Protection Areas in the Whitsunday Islands, which limits anchoring to areas away from coral; and by implementing an intensive education, training and extension program. A draft moorings policy was released by GBRMPA in 2001 (GBRMPA 2001) and will be finalised in May 2002. Managers have worked closely with industry in developing and implementing these plans.

In the Cairns section of the Marine Park, more than 300 privately owned mooring had been installed by 2001. Demand for private mooring had been low in the Whitsundays, where there was more demand for public moorings where there are approx 50 public moorings (GBRMPA 2001)

Other boating impacts relate to release of sullage and other waste water, and littering. Discharge of waste from ships has been regulated by requirements for storage tanks in ships over 10m, and limits to areas where boats can discharge wastes (Dinesen and Oliver 1997; Edwards 1997). Littering in the marine park is illegal and is considered to be a relatively minor problem, best addressed by public education (Edwards 1997).

Speeding vessels also kill, injure and/or disturb the social bonding of wildlife. The risk for GBR dugongs appears to be most acute in shallow-water seagrass areas such as the Hinchinbrook Region (Preen 2001). Many turtles are also killed and/or injured (Haines and Limpus 2001) and Cleveland Bay near Townsville is a particular hotspot (K. Dobbs, personal communication). Boat strikes and/or disturbance to cetaceans are also well known (Haley and Read 1993, Van Parijs and Corkeron 2001). The GBRMPA is working to increase awareness in the GBR of the risk that speeding boats pose to wildlife. Boat ramp signage, posters, leaflets, and television advertisements comprise part of a multi-faceted education campaign. In addition, voluntary vessel restrictions and lanes have been instituted in the Hinchinbrook Region in collaboration with local people.

### Water-based activities

Of all tourist activities, diving has received the greatest attention in recent years. In the early 1990s very little research had been done on the environmental impacts of diving, but the topic has been well researched since then. Studies have concluded that high levels of diving activity at a single site can cause detectable changes to the coral communities, and eventually, a change to the aesthetics of the reef if diving intensity is high enough (Hawkins and Roberts 1992). The damage occurs primarily to fragile branching corals, and site selection to avoid more sensitive sites should be considered when establishing locations where large numbers of divers will visit (Hawkins and Roberts 1992, Roupheal and Inglis 1995, 1997). The number of divers per site at which damage becomes apparent was found to be around 5,000 divers per site per year (the carrying capacity) in two locations - in the Red Sea (Hawkins and Roberts 1997) and in Bonaire in the Caribbean (Hawkins *et al* 1999).

On the Great Barrier Reef, an estimated 178,000 dive p.a. took place in the mid-1990 (Zann 1996), over hundreds of dive sites. At the diving-oriented resort of Heron Island, approx. 16,000 dives were fairly evenly spread over 23 dive sites (Harriott *et al* 1997). Few sites on the GBR approach the carrying capacity of 5,000 divers per site established in other studies at more intensively dived locations. In Sharm-el-Sheikh in the Red Sea, up to 50,000 dives per site per year have been recorded and cause visible damage to coral communities, and growth in diver numbers was expected to continue (Hawkins and Roberts 1997).

In most studies, few divers damaged any corals, but a couple of divers who lacked buoyancy control, or were focused on underwater photographs were responsible for most of the damage (Harriott *et al* 1997, Roupael and Inglis 1997). Male divers were also more destructive than female divers in one study (Roupael and Inglis 2001). It has been noted that anchoring of dive boats caused much more damage than the divers if mooring were not used. Recommendations of the studies were that divers should be made aware of the sensitive nature of the corals and of diving practices such as good buoyancy control. A study by Medio *et al* (1997) demonstrated the success of dive briefings in reducing damage by divers on coral reefs. The GBRMPA has adopted a code-of-practice for industry that stresses environmentally sensitive practices (GBRMPA 2000a). Other recommendations were that divers enter the water and establish buoyancy over sandy areas rather than corals, and that learner and inexperienced divers should dive mainly over sandy areas. Where shore diving is customary, impacts can be minimised by use of boardwalks for approaching the dive area and floating pontoons for diver access, a system that has been developed in the Red Sea (Ormond *et al* 1997).

Snorkelling has been less studied than scuba diving, but because most tourists stay on the surface of the water when snorkelling, they are less likely to impact on the reef. However, Allison (1996) reports that most damage in the Maldives occurred when snorkellers kicked or stood on coral colonies. Management of snorkelling so that sites were deep enough that people could not stand (ie. > 2 m deep) would reduce damage from this effect.

In an examination of seven studies of snorkeller damage at reef pontoons on the GBR, Nelson and Mapstone (1998) report that there were no statistically significant changes in coral cover in a study of seven snorkelling sites. At five of the seven snorkel sites, coral cover increased during the study (3% to 13% cover per year). Only one of four sites analysed demonstrated a significant difference between control and impact sites in the amount of damaged corals.

On the intensively used pontoon sites on the GBR, snorkellers are generally restricted to sites within close distance to the pontoon, partly for the safety of the visitors. These areas are generally around 50m X 50 m and marked with ropes and floats. Even on the most heavily visited reefs, any damage which occurred is likely to be restricted to a very small proportion of the reef.

Snorkel trails have been proposed as a way to promote interpretation of the marine environment to tourists and to restrict impacts of snorkellers to small areas. Plathong *et al* (2000) have examined the effects of snorkel trails and found that even at low levels of use (15 snorkellers per week), a difference could be detected in the number of broken corals between the trails and control sites. They report that the change occurred within a month of the opening of the trail to snorkellers, and that after the initial period, the amount of damage stabilised. They raise the interesting question of whether it is best to concentrate snorkellers and their damage to a small area, as occurs with trails, or whether it is best to spread the impacts over a wider area. The authors suggest that short briefings, careful site selection, establishment of floating rest stations, and periodic rotation of trails might be useful management strategies.

Snorkelling is one of the few areas of tourist behaviour where social impacts have been examined. Shafer *et al* (1998, 2000) reported that most people surveyed on day trips to the reef were not negatively affected by the number of others in the water with them. They suggested that visitors with little prior experience had few expectations, so were not disturbed by the presence of other people. More experienced snorkellers are able to swim further from the boat and large groups. In a related study, Inglis *et al* (1999) analysed perceptions of crowding during snorkelling in a study using manipulated photographs of snorkellers taken above and below the water. In general, more experienced divers preferred a less crowded setting. Most people surveyed preferred scenes with fewer than six other snorkellers in underwater scenes.

Reef walking by significant number of tourist is practiced at few locations, including Heron Island, Low Islands and Hardy Reef (Dinesen and Oliver 1997). Studies of the impact of reef walking have concluded that repeated passes break a significant number of corals, but that there is no detectable difference in coral cover in areas subject to reef walking than in control sites (Liddle and Kay 1987, Kay and Liddle 1989, Hawkin and Roberts 1993). Corals recover from the breakage of fragments by regrowing branches, and some fragments are capable of establishing new colonies. On a reef-wide scale, impacts of reef walking are negligible. Management of reef-walking included providing information on coral fragility to tourists, avoiding areas with fragile branching corals, and keeping to clear tracks where possible (GBRMPA 2000a).

Fishing is an ancillary activity with most tourism activities. The level of fishing activity by most tourists is minimal relative to the effort of recreational and commercial fishers. Fishing is regulated within the GBRMP by the zoning schemes which prohibit fishing within Marine Park B areas. In addition, most large-scale tourism operations are more oriented to non-extractive activities such as snorkelling, diving and glass-bottom boats and would discourage fishing close to their primary sites so that large fish are available for other tourists to see. The small but financially significant game-fishing industry has close links with tourism in the area offshore from Cairns. The industry is considered to have small environmental impacts because it focuses on pelagic species (Edwards 1997). The fishery is primarily catch, tag and release, though there are different views on the probable survival of released fish.

### Wildlife interactions

Breeding populations of seabirds are common in the northern and southern regions of the GBRWHA where islands suitable for nesting are most common, with up to 75% of seabird biomass in the Capricorn-Bunker group (Wachenfeld *et al* 1998). Declines in populations of some bird species have been identified in monitoring studies at the Swains Reefs (Heatwole *et al*, 1996) and Michaelmas Cay (King *et al* 1992), but links to humans can be difficult to separate from natural variation. Disturbance of nesting seabirds by island visitors is a major concern at Michaelmas Cay off Cairns (Stokes 1996, Edwards 1997).

The status of seabirds in Australia was reviewed by Hulsman *et al* (1997) and Wachenfeld *et al* (1998). Concerns with respect to human impacts relate to direct impacts on breeding success as a result of disturbance, and loss of bird roosting habitat as a result of construction of tourism accommodation. They recognised the impact of tourism and recreation activities as an important impact on seabird populations, particularly as better boats allow visitors to reach previously inaccessible islands. If not managed, the number of breeding islands might be reduced. Differences between species in their susceptibility to disturbance were also recognised. Islands may become dominated by species that are more tolerant of human disturbance activity (Stokes *et al* 1996).

Access to seabird breeding islands is managed by Queensland Parks and Wildlife Service on a site by site basis. Breeding populations are protected by complete closure of some islands

to public access, and seasonal closure of other islands (GBRMPA, 2000a). Guidelines for visiting seabird islands have been developed jointly between GBRMPA and Australian Nature Conservation Agency, now Environment Australia, (WBM Oceanics and Claridge, 1997). The tourism industry has been involved in the development of management plans for sensitive sites such as Michaelmas Cay, including reduction in the number of allowed visitors and limited access to some areas (Stokes *et al* 1996, Edwards 1997, Wachenfeld *et al* 1998).

Whale watching in the GBR region is based on humpback whales east of the Whitsundays watched from charter vessels during their winter migration, and dwarf minke whales east of Cairns (GBRMPA 2000b, Marsh *et al* 1997). There is no evidence of significant impacts on the GBR from whale watching activities, but precautions include adoption of national guidelines and Commonwealth and Queensland legislation controlling various aspects of human-cetacean interactions.

Since 1991, there has been a small but increasing industry based on encounters with dwarf minke whales for a two-month season on the Ribbon Reef area between Port Douglas and Lizard Island (Arnold and Birtles 1999). Visitors on live-aboard charter vessels interact with the whales in the water, with the whales approaching snorkellers who hold a rope tethered to the boat. The whales and the small industry based on them have been studied since 1996 by Arnold and Birtles (1999), who have developed a research program and industry code of practice in collaboration with the GBRMPA and the industry. Recommended practices to minimise any negative impacts on the whales include the requirement for tourists to be well-briefed, and the need for participants to never swim towards the whales. Finalisation and implementation of the code of practice with industry, management and researchers is currently underway. In 2000, the GBRMPA adopted a policy on whale and dolphin conservation that underlines whale-watching and other management practices for cetaceans in the Marine Park (GBRMPA 2000b).

In Australia, marine turtles are considered threatened, and there have been recorded declines in the number of nesting loggerhead turtles in the GBRWHA in recent decades (Wachenfeld *et al* 1998). Turtles are protected in Australia under the (Commonwealth) Environmental Protection and Biodiversity Conservation Act of 1999. Marine turtles encounter tourists in the water when diving, but the interactions of greatest concern are on



the limited number of breeding beaches. Turtles aggregate to breed at a limited number of sites, including Raine Island in the north (Green turtles), and Wreck Island in the south (Loggerhead turtles). Turtle watching is a major activity at Mon Repos near Bundaberg (Marsh *et al* 1997). Nesting turtles can be temporarily disturbed by people, but there is no evidence that production of eggs has been affected (Marsh *et al* 1997). Human activities at the Mon Repos Conservation Park are believed to have saved many turtle eggs from destruction. Turtle watching as a tourist activity is covered by a code-of-practice which encourages practices to minimise disturbance on turtles which come ashore on sandy beaches to lay their eggs (GBRMPA 2000a).

## 7. MANAGEMENT OF TOURISM IMPACTS

An overview of management strategies which minimise tourism impacts is provided by Moscardo (1997). Tourism activities on the Great Barrier Reef (GBR) are managed by the Great Barrier Reef Marine Park Authority (GBRMPA) and the Queensland Parks and Wildlife Service (QPWS) within a statutory framework of zoning plans, plans of management and permits. Permits have been used as the principle tool for management of tourism, with conditions applying to permits granted (Dinesen 1995, Dinesen and Oliver 1996, Wachenfeld *et al* 1998). There has been a perception that over-reliance on permits as a management tool is no longer appropriate. Management Plans are an area-specific tool, and includes strategies for dealing with impacts and activities specific to each region. They include strategies to limit or manage the use of popular high use sites. The tourism management process is presently under revision with a move towards simplification of permits and a move towards site management, greater self-regulation and control of impacts.

The new system features (Wachenfeld *et al* 1998):

- strategic policy planning to establish a clear direction for managing tourism, taking into account cumulative use and cultural and heritage values. This strategy includes Plans of Management for important tourism sites;
- direct management including a revision and simplification of the permit system;
- self-regulation by the industry including codes of conduct and compliance with best environmental practice and a strong education and training program;
- active partnerships with stakeholders including formal consultation with stakeholders.

An Environmental Management Charge introduced in 1993 is collected for each reef visitor and contributes to the funding of research, education and marine park management.

## 8. CONCLUSIONS

The impacts of marine tourism within the Great Barrier Reef Marine Park (GBRMP) are generally localised and of small magnitude compared with those of other environmental concerns (overfishing, inshore water quality, crown of thorns starfish, coral bleaching). Commercial tourism operators have strong motivation to protect the reef resources on which their industry is based. There has been increased emphasis in recent years on involvement of stakeholders including the tourism industry in management of the GBRMP. The status of tourism as one of the 'critical issues' in marine park management is justified by the fact that tourism is the major commercial activity within the GBRMP. It generates significant income, supports a large number of employees, and contributes to the reef's World Heritage Values by presenting the reef to tourists and the community. Apart from the local tourism impacts within the Marine Park, which are generally well managed, there has been concern that rapid expansion of tourism can increase pressure for coastal and urban development, with potential indirect and cumulative effects on the GBRWHA.

## 9. REFERENCES

- Agardy T. 1995. Marine eco-tourism: Fundamental characteristics and links to conservation. In: Hooten AJ, Hatzios ME. (eds) Sustainable financing mechanisms for coral reef conservation: Proceedings of a workshop, World Bank, Washington DC, p 25-26. *Env Sust. Dev. Proc. Ser No 5*.
- Aiello RL. 1997. Successes and failures of global reef management. *Reef Tourism 2005*, Cairns. 167 pp.
- Allison WR. 1996. Snorkeler damage to reef corals in the Maldivian Islands. *Coral Reefs 15*: 215-218.
- Arnold PW, Birtles RA. 1999. Towards sustainable management of the developing dwarf minke whale tourism industry in northern Queensland. CRC Reef Research Centre Technical Report No 27. CRC Reef Research Centre, Townsville. 30 pp.
- Berkelmans R, Oliver JK. 1999. Large-scale bleaching of corals on the Great Barrier Reef. *Coral Reefs 18*: 55-60.
- Burke L, Selig E, Spalding M. 2002. Reefs at risk in South East Asia. World Resources Institute Publ., Washington DC.
- Connell JH, Hughes TP, Wallace CC. 1997. Long-term dynamics of reef crest corals on Heron Island. p 114-123. In Wachenfeld DR, Oliver J, Davis K. (eds) State of the Great Barrier Reef World Heritage Area Workshop, 1995, Townsville, Australia. Great Barrier Reef Marine Park Authority Workshop Series No. 23.
- Dinesen Z, Oliver J. 1997. Tourism impacts. p 414-427 In Wachenfeld DR, Oliver J, Davis K. (eds) State of the Great Barrier Reef World Heritage Area Workshop, 1995, Townsville, Australia. Great Barrier Reef Marine Park Authority Workshop Series No. 23.
- Dixon JA. 1998. Economic values of coral reefs: What are the issues? p 157-162 In Hatzios ME, Hooten AJ, Fodor M. (eds) Coral Reefs. Challenges and Opportunities for Sustainable Management. World Bank, Washington DC.
- Driml S. 1987. Great Barrier Reef Tourism. A review of visitor use. Great Barrier Reef Marine Park Authority Research Publication, Great Barrier Reef Marine Park Authority, Townsville.
- Edwards M. 1997. Concerns and potential threats to the ecologically sustainable use of the Cairns section of the Great Barrier Reef Marine Park by the marine tourism industry. *Reef Tourism 2005*, Cairns. 41pp.

- Gallagher M, Volker R. in press. Numerical studies of nitrogen flows under effluent irrigated lawns on islands in the Great Barrier Reef. CRC Reef Research Centre Technical Report No. 34.
- GBRMPA 2000a. Tourism operator's handbook for the Great Barrier Reef. Publ. Great Barrier Reef Marine Park Authority, Townsville.
- GBRMPA 2000b. Whale and Dolphin Conservation in the Great Barrier Reef Marine Park. Great Barrier Reef Marine Park Authority, Townsville.  
<[http://www.gbrmpa.gov.au/corp\\_site/info\\_services/publications/whale\\_dolphin/index.html](http://www.gbrmpa.gov.au/corp_site/info_services/publications/whale_dolphin/index.html)> April 2002.
- GBRMPA 2001. Moorings in the Great Barrier Reef Marine Park. Background. Unpublished draft policy paper. Great Barrier Reef Marine Park Authority.  
<[http://www.gbrmpa.gov.au/corp\\_site/key\\_issues/tourism/moorings\\_policy.html](http://www.gbrmpa.gov.au/corp_site/key_issues/tourism/moorings_policy.html)> March 2002.
- Gourley MR, Jell JS. 1993. Heron Island spoil dump. Research Publication No 28, Great Barrier Reef Marine park Authority, Townsville.
- Green D, Moscardo G, Greenwood T, Pearce P, Arthur M, Clark A, Woods, B. 1999. Understanding public perceptions of the Great Barrier Reef and its management. CRC Reef Research Centre Technical Report No. 20. 64 pp.
- Haines JA, Limpus CJ. 2001. Marine wildlife stranding and mortality database annual report, 2000, iii. Marine turtles. Report of the Research Coordination Unit, Queensland Parks and Wildlife Service, Brisbane.
- Haley NJ, Read AJ. 1993. Summary of the workshop on harbour porpoise mortalities and human interactions. NOAA Technical Memorandum NMFS-F/NER-5, Massachusetts, USA.
- Harriott V, Saenger P. 1995. The John Brewer Reef Floating Hotel: a case study in marine environmental monitoring. GBRMPA Workshop Series. No. 21, pp 51
- Harriott VJ, Davis D, Banks SA. 1997. Recreational diving and its impact in Marine Protected Areas in Eastern Australia. *Ambio* 26: 173-179
- Hawkins DE. 1998. The relationship of tourism-related revenue generation to coral reef conservation. p 93-95. In Hatzioios ME, Hooten AJ, Fodor M. (eds) Coral Reefs. Challenges and Opportunities for Sustainable Management. World Bank, Washington DC.

- Hawkins JP, Roberts CM, Van't Hof T, DeMeyer K, Tratalos F, Aldam C. 1999. Effects of recreational scuba diving on Caribbean coral and fish communities. *Conservation Biology* 13: 888-897.
- Hawkins JP, Roberts CM. 1994. The growth of coastal tourism in the Red Sea: Present and future effects on coral reefs. *Ambio*. 33: 503-508.
- Hawkins JP, Roberts CM. 1997. Estimating the carrying capacity of coral reefs for scuba diving. *Proc. 8th Int. Coral Reef Symp.* 2: 1923-1926.
- Hawkins JP, Roberts CM 1992. Effects of recreational SCUBA diving on fore-reef slope communities of coral reefs. *Biological Conservation* 62: 171-178.
- Hawkins JP, Roberts CM. 1993. Effects of recreational SCUBA diving on coral reefs. Trampling of reef flats communities. *Journal of Applied Ecology* 30: 25-30.
- Heatwole H, O'Neill PO, Jones M, Preker M. 1996. Long-term population trends of seabirds on the Swains Reefs, Great Barrier Reef. CRC Reef Research Centre Technical Report No 12. CRC Reef Research Centre, Townsville. 50pp.
- Hill C. 1998. Green Globe: the tourism industry and sustainability. p 118-120 In Hatzilios ME, Hooten AJ, Fodor M. (eds) *Coral Reefs. Challenges and Opportunities for Sustainable Management*. World Bank, Washington DC.
- Hoegh-Guldberg O. 1999. Climate change, coral bleaching and the future of the world's coral reefs. *Marine and Freshwater Ecology* 50: 839-66
- Hulsman K, O'Neill PO, Stokes T. 1997. Current status and trends of seabirds on the Great Barrier Reef. p 259 – 282. In Wachenfeld DR, Oliver J, Davis K. (eds) *State of the Great Barrier Reef World Heritage Area Workshop, 1995, Townsville, Australia*. Great Barrier Reef Marine Park Authority Workshop Series No. 23.
- Inglis GJ. 1997. Science and tourism infrastructure on the Great Barrier Reef: learning from experience or just 'muddling through'? *Proceedings, Great Barrier Reef Science Use and Management*. 319-333
- Inglis GJ, Johnson VI, Ponte F. 1999. Crowding norms in marine settings: a case study of snorkeling on the Great Barrier Reef. *Environmental Management* 24: 369-381.
- Kapitze IR. 1999. Sustainable infrastructure development on the Great Barrier Reef. In: *Coasts and Ports'99, Challenges and Directions of the New Century*. Proc. 14th Australasian Coastal and Ocean Engineering Conference and the 7th Australasian Port and harbour Conference, Perth. 323-328.

- Kapitze IR, Matheson MJ, Hardy TA in press. Reef infrastructure guidelines. Tourist pontoons. CRC Reef Research Centre Technical Report No. 39. CRC Reef Research Centre, Townsville.
- Kay A, Liddle M. 1989. Impact of human trampling in different zones of a coral reef flat. *Environmental Management* 13: 509-520.
- King BR, Hicks JT, Cornelius J. 1992. Population changes, breeding cycles and breeding success over six years in a seabird colony at Michaelmas Cay, Queensland. *The Emu* 92: 1-10.
- Liddle M, Kay A. 1987. Resistance, survival and recovery of trampled corals on the Great Barrier Reef. *Biological Conservation* 42: 1-18.
- Marsh H, Arnold PW, Limpus CJ, Birtles A, Breen B, Robins J, Williams R. 1997. Endangered and charismatic megafauna. *Proceedings, Great Barrier Reef Science Use and Management*. 124-138.
- Medio D, Ormond RFG, Pearson M. 1997. Effect of briefings on rates of damage to corals by scuba divers. *Biological Conservation* 79: 91-95.
- Moscardo G. 1997. Sustainable tourism and the environment. Chapter 12 In: Gee CY. (ed) *International tourism: a global perspective*. World Tourism Organization, Madrid. pp 253-276.
- Moscardo G. 1999. Supporting ecologically sustainable tourism on the Great Barrier Reef: the importance of visitor research. In: Molloy J, Davies J. (eds) *Tourism and Hospitality: Delighting the senses*. Bureau of Tourism Research, Canberra. pp 236-253.
- Moscardo G, Green D, Greenwood T. 2000. How great is the Great Barrier Reef! Tourists' knowledge and understanding of the World Heritage status of the Great Barrier Reef. *Tourism Recreation Research* 26: 19-25.
- Muthiga NA, McClanahan TR 1997. The effect of visitor use on the hard coral communities of the Kisite Marine Park, Kenya. *Proc. 8th Int. Coral Reef Symp.* 2: 1879-1882.
- Nelson VM, Mapstone BD. 1998. A review of environmental impact monitoring of pontoon installations in the Great Barrier Reef Marine Park. CRC Reef Research Centre Technical Report No. 13, CRC Reef Research Centre, Townsville. 85 pp.
- Ormond R, Hassan O, Medio D, Pearson M, Salem M. 1997. Effectiveness of coral protection programmes in the Ras Mohammed National Park, Egyptian Red Sea. *Proc. 8th Int. Coral Reef Symp.* 2: 1931-1936.
- Plathong S, Inglis GJ, Huber ME. 2000. Effects of self-guided snorkeling trails in a tropical marine park. *Conservation Biology* 14: 1821-1830.

- Preen T. 2001. Dugongs, boats, dolphins and turtles in the Townsville-Cardwell region and recommendations for a boat traffic management plan for the Hinchinbrook Dugong Protection Area. GBRMPA Research Publication No. 67.
- Rouphael BA, Inglis GJ. 1997. Impacts of recreational scuba diving at sites with different reef topographies. *Biological Conservation* 82: 329-336.
- Rouphael BA, Inglis GJ. 2001. "Take only photographs and leave only footprints?": an experimental study of the impacts of underwater photographers on coral reef dive sites. *Biological Conservation* 100: 281-287.
- Rouphael T, Inglis G. 1995. The effects of qualified recreational scuba divers on coral reefs. CRC Reef Research Centre Technical Report No. 4, CRC Reef Research Centre, Townsville.
- Shafer CS, Inglis GJ, Johnson VY, Marshall NA 1998. Visitor experiences and perceived conditions on day trips to the Great Barrier Reef. CRC Reef Research Centre Technical Report No. 21, CRC Reef Research Centre, Townsville. 76 pp.
- Shafer CS, Inglis GJ. 2000. Influence of social, biophysical, and managerial conditions on tourism experiences within the Great Barrier Reef World Heritage Area. *Environmental Management*. 26: 73-87.
- Stokes T, Hulsman K, Ogilvie P, O'Neil P. 1996. Management of human visitation to seabird islands of the Great Barrier Reef Marine Park. *Corella* 20: 1-13.
- Sweatman H. 1996. Impact of tourist pontoons on fish assemblages on the Great Barrier Reef. CRC Reef Research Centre Technical Report No. 5. CRC Reef Research Centre, Townsville 54pp.
- Valentine PS, Newling D, Wachenfeld D. 1997. The estimation of visitor use from GBRMPA data returns. CRC Reef Research Centre Technical Report No. 19, CRC Reef Research centre, Townsville, pp 54.
- Vanderzee M. 1996. Managing tourism use in Australia's Great Barrier Reef Marine Park. In: *Proceedings the World Congress on Coastal and Marine Tourism, Hawaii. 1996.*
- Van Parijs SM, Corkeron PJ. 2001. Boat traffic affects the acoustic behaviour of Pacific humpback dolphins, *Sousa chinensis*. *J. Mar. Biol. Ass U.K.* 81: 3781/1-6.
- Vogt H. 1997. The economic benefits of tourism in the marine reserve of Apo Island, Philippines. *Proc. 8th Int. Coral Reef Symp.* 2: 2101-2104.
- Volker RE, Gallagher MR, Johnston AJ. 1997. Environmental implications of waste-water management on resort islands of the Great Barrier Reef. *Proceedings of the Great*



- Barrier Reef: Science Use and Management National Conference. Townsville. 1: 152-163.
- Wachenfeld DR, Oliver JK, Morrissey JI. 1998. State of the Great Barrier Reef World Heritage Area. Great Barrier Reef Marine Park Authority, Australia.
- WBM Oceanics, Claridge G. 1997. Guidelines for managing visitation to seabird breeding islands. Great Barrier Reef Marine Park Authority.
- White AT, Vogt HP, Arin T. 2000. Philippine coral reefs under threat: The economic losses caused by reef destruction. *Marine Pollution Bulletin* 40: 598-605.
- Williams A. 1996. Tourism and management of the Great Barrier Reef Marine Park. In: Proceedings of planning sustainable tourism seminar, 1996, Bandung, Indonesia.
- WWF 2002. What's the problem? [www.gbr.wwf.org.au/content/problem/problem.htm](http://www.gbr.wwf.org.au/content/problem/problem.htm).  
March 2002
- Zann LP. 1996. The state of the marine environment report for Australia. Great Barrier Reef Marine Park Authority, Australia.