TOWARDS SUSTAINABLE WILDLIFE TOURISM EXPERIENCES FOR CERTIFIED SCUBA DIVERS ON CORAL REEFS

Thesis submitted by

Dean Kevin Miller B.Sc. (Hons)

15th December 2005

For the degree of Doctor of Philosophy

In the Schools of Business and Tropical Environmental Studies and Geography

James Cook University

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ABSTRACT

The economic opportunities created by SCUBA diving tourism are significant to reef-based communities, as are the potentials for positive outcomes for coral reef environments such as preservation and conservation. These potentials are largely dependent on the quality of the reefs and the marine life that occur there. However, this is rapidly being compromised worldwide by natural (e.g. cyclones, crown-of-thorns), anthropogenic (e.g. extractive fishing and collecting activities, tourism, deteriorating water quality), and global (e.g. coral bleaching) impacts. These impacts have the potential to damage and/or remove the biophysical attributes of coral reef sites most significant to divers' experiences, and are therefore likely to have a negative affect on the demand and visitation for dive sites and locations.

The purpose of this study was to investigate how the biophysical attributes that occur at coral reef dive sites influence certified SCUBA divers' experiences, and whether variations, measured using experience-based theoretical approaches, can be explained by participants' level of Diving and Coral Reef History (DACRH) using the recreational specialization construct. To address the research objectives, a multidisciplinary methodology was developed that described the certified SCUBA diving opportunity in a Recreational Opportunity Spectrum (ROS) and Limits of Acceptable Change (LAC) experience-based framework. This required natural science methodologies to measure, describe, and understand the biophysical attributes that occur at tourism sites, and social science techniques to describe and understand the divers, and the experiences they were having. To achieve this, a four-study research program was designed.

Study One assessed certified SCUBA divers participating in live-aboard diving trips visiting selected Great Barrier Reef (GBR) and Coral Sea dive sites. Based on divers' levels of participation, training and associated skills, and coral reef setting history, they were separated into four recreational specialization groups: 'beginner' (n=46), 'intermediate' (n=236), 'enthusiast' (n=246), and 'specialist' (n=52). Each group was found to be distinct from the others in terms of previous diving and coral reef history measurements, ownership of SCUBA related equipment, and the levels of coral reef interest and knowledge.

Study Two was an assessment of the biophysical attributes that occur on selected coral reef dive sites from the GBR and Coral Sea, and aimed to determine what visiting certified SCUBA divers were most likely to encounter while diving on the specific sites. This study found that differences in the biophysical attribute measurements at each site characterised the main differences between the sites, and thus the diving opportunities.

Study Three analysed the coral reef SCUBA diving experiences for divers on these trips and showed that divers had very high quality experiences on the dive sites, with some sites providing more enjoyable experiences than others. Divers were also having a wide range of experiences, and these were closely linked to the biophysical attributes identified in Study Two. However, some attributes, such as reef sharks and coral quality, were much more important to experiences than other attributes such as small fish life.

Finally, Study Four examined divers' experiences in the context of their degree of recreational specialization. This study found that diving experiences are modified by specialization, with higher specialization resulting in a wider diversity and richness of best experiences, but lower reported levels of enjoyment and evaluations of quality. More specialized divers also perceived a greater number and diversity of environmental impacts than less specialized divers, and these negatively influenced their experiences.

The research presented in this thesis has demonstrated that taking an experience-based approach to understanding the biophysical attributes that occur at tourism sites, as well as understanding the visitors and the experiences they are having, can play a critical role in managing natural areas for their ecologically sustainable use by tourism. This is achieved by identifying those biophysical attributes most significant to a wide range of divers' experiences. This level of understanding will be essential to the maintenance and protection of quality experiences for visitors. This is because many of the attributes significant to divers' experiences identified in this research are also at high risk of being impacted by the activities of extractive users, tourism operators and tourists, and also the affects of natural events and global scale processes. Finally, recommendations are made concerning the management of those biophysical attributes most at risk from damage and/or removal.

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CHAPTER 1

GENERAL INTRODUCTION: CERTIFIED SCUBA DIVING AND THE WILDLIFE TOURISM EXPERIENCE

1.1 Introduction

Wildlife tourism has become a popular activity worldwide. Some forms occur in places like zoos and sanctuaries where viewing wildlife is of a casual nature, locally based, and with minimal investment and skill on behalf of the participant (Kellert, 1996). However, other forms of wildlife tourism focus on viewing wildlife in natural environments, usually driven by the quality of a natural area's living elements (Newsome, Moore, & Dowling, 2002). The demand for these types of wildlife tourism experiences has increased dramatically in the past decade, particularly in the case of marine wildlife tourism (Orams, 1996). Australia's Great Barrier Reef World Heritage Area (GBRWHA) is a prime example, and is world famous for the in-water wildlife tourism opportunities it presents to millions of visitors each year (Williams, 1996). Home to approximately 1500 species of fish, 400 species of coral, 4000 species of molluscs, 500 species of seaweed, 16 species of sea snakes, and six species of marine turtles (GBRMPA, 2000), the GBR Marine Park (GBRMP), and coral reefs in general, are "striking examples of beautiful and fascinating natural environments vulnerable to misuse and abuse by humans" (Kenchington, 1990, p119).

Recent concerns raised by scientists are that coral reefs are being degraded worldwide due to a combination of natural and anthropogenic impacts, and there are calls for urgent reassessments of current management practices (Bellwood, Hughes, Folke, & Nystrom, 2004). This especially includes addressing global issues such as coral bleaching that pose a serious threat to corals and thus coral reefs, reducing or diverting fishing effort to avoid over-exploitation, and specifically stopping destructive fishing practices such as bomb and cyanide fishing (Wilkinson, 2004a). Such threats to the coral reef environment are in direct conflict with wildlife tourism where they co-occur, because they act to damage and/or remove the attributes that visitors pay to see. This scenario is becoming more widespread as the demand for resources increases. However, well-managed wildlife tourism has the potential to assist in reducing over-exploitation by creating alternative uses of resources, and in doing so acts as a tool for the conservation of species and natural areas (Manning & Lime, 1999). Because of this, recent research has focused on developing the most effective framework for representing the value of quality recreation opportunities with wildlife, and protecting that value through management and planning actions (Borrie & Birzell, 2001).

In a coral reef context, well managed wildlife tourism is a more ecologically sustainable option for use of natural resources than virtually all other commercial activities (Harriott, 2002; Miller, 2004). It is non-extractive, and causes minimal damage as compared to collecting, destructive fishing, and coastal development for example. Wildlife tourism can provide positive outcomes for coral reefs and reef-based communities through: encouraging environmental education and awareness (Medio, Ormond, & Pearson, 1997; Townsend, 2000); assist in the establishment and maintenance of Marine Protected Areas (MPAs) (Dixon, 1993; Fenner, 2001); provide sustainable and long term economic rewards to reef-based communities (Chadwick, 2005; Kenchington, Ward, & Hegerl, 2003) for the preservation and conservation of the biodiversity and ecological integrity of coral reefs (Birtles, Valentine, & Curnock, 2001; Kenchington et al., 2003; Valentine, 1992). These outcomes complement the urgent call by the World Summit on Sustainable Development in 2002 for the establishment of networks of larger MPAs, and a major international effort to reduce losses in biodiversity of coral reefs (Wilkinson, 2004a).

Tourism is well recognized as the largest and most important economic industry associated with the GBRMP (Harriott, 2002). To put this into perspective, tourism in the GBR Catchment Area contributes over $5.1(AUD) billion each year to the Australian economy (Access Economics, 2005), with tourism specifically associated with the GBR contributing $1.4 billion (Chadwick, 2005). One of the many activities commonplace to Reef tourism is SCUBA diving. It is estimated that in 1994, there were approximately 2,456,000 SCUBA dives undertaken in the GBRMP from 243 commercial SCUBA diving operators (Windsor, 1996). It is likely that this number is considerably higher now due to known annual increases in reef visitation (Harriott, 2002), with some estimates showing up to 10% increases per year (Wachenfeld, Oliver,

& Morrissey, 1998). With more than 15 million certified SCUBA divers worldwide visiting over 2,000 dive centres located in 19 countries and states, SCUBA diving tourism has been referred to as 'ubiquitous' (Spalding, Ravilious, & Green, 2001). Due to this high rate of participation both in the GBRMP and in other coral reef locations around the world, SCUBA diving tourism is considered one of the economic activities of greatest importance to reef-based economies (Dixon, Fallon Scura, & van't Hof, 1993; Fenton, Young, & Johnson, 1998; Pendleton, 1994; Tratalos & Austin, 2001).

1.1.1 SCUBA diving and marine wildlife tourism

Internationally, SCUBA diving tourism is a rapidly growing component of wildlife tourism, and is a popular activity for people from countries like Australia, the U.S.A, the U.K., and Japan (Birtles, Valentine, Miller, & Curnock, in prep; Curnock, 1998; Davis & Tisdell, 1995; Harriott, Davis, & Banks, 1997). Increasing popularity of the activity might be due to technological advances and lower prices of reliable diving equipment and underwater cameras (Kenchington, 1990). This popularity might also be attributed to relatively affordable training costs making SCUBA diving more accessible to a wider range of travellers such as backpackers. Once certified, divers may travel extensively around the globe to view ship wrecks, coral reefs, caves, walls, and sharks (Tabata, 1992), yet generally coral reefs appear to be the main attraction (Shackley, 1998).

The economic opportunities created by SCUBA diving tourism are well documented, but they are largely dependent on the quality of the reefs and the marine life that occur there (Chadwick, 2005). If the demand for SCUBA diving at a coral reef site is functionally related to the biological and physical (biophysical) attributes that shape the quality of that site, a decrease in their quality is likely to cause a reduction in the visitor demand and economic value of that particular coral reef (Wielgus, Chadwick-Furman, Dubinsky, Shechter, & Zeitouni, 2002). The perception of damage or loss of attributes by visitors may impact financially on economies which are heavily reliant on reef tourism (Dixon et al., 1993; Fenton et al., 1998; Pendleton, 1994; Tratalos & Austin, 2001). In parts of the Philippines and Zanzibar for example, SCUBA diving tourism has sharply decreased because of coral reef degradation caused by coral bleaching (Cesar, 2000; Ngazy, Jiddawi, & Cesar, 2004), and in the Maldives, diving tourism has declined in part due of the removal of reef shark populations by fishers (Anderson & Waheed, 2002). Because of the high demands tourists place on reef quality, the maintenance of sustained reef tourism is often the central element in the justification of MPAs (Dixon et al., 1993).

Wildlife tourism itself is not without its drawbacks, and in many countries it is seen as both an opportunity and a threat. Intuitively, damage caused from activities such as SCUBA diving would seem small when compared to dredging, coral mining, natural disturbance, and coastal development. Until recently, the impact of SCUBA diving was considered low (Harriott et al., 1997; Tagle, 1993). However, the cumulative impact of recreational SCUBA diving at high densities in an area can be substantial (Hawkins & Roberts, 1997). This kind of impact has been referred to as 'loving the reef to death' (Fishman, 1991).

Scientists are in agreement when it comes to diving-related damage on coral reefs, and the numerous studies on this topic show consistent patterns worldwide. These are as follows: many SCUBA dives involve the training of new and uncertified divers (Hawkins & Roberts, 1997); many divers, particularly novice divers, are likely to have poor buoyancy skills and as a result, are more likely to come into contact with corals (Harriott et al., 1997; Rouphael & Inglis, 1997); many popular dive sites have high aesthetic and biological values such as branching corals, which are those most affected by divers (Hawkins & Roberts, 1992b; Rouphael & Inglis, 1995, 1997; Zakai & Chadwick-Furman, 2002); there are no international management strategies or guidelines for minimising diver impacts or promoting environmentally friendly diving practices; and many dive sites attract vast numbers of divers each year (Davis, Harriott, MacNamara, & Roberts, 1995; Hawkins & Roberts, 1992a, 1994; Salm, 1986; Vail & Hoggett, 1997; Valentine, Newling, & Wachenfeld, 1997; Zakai & Chadwick-Furman, 2002). For management purposes, it has been suggested that divers' impacts on coral reef environments are likely to affect the aesthetic value, or the beauty, of a reef well before the biological values are affected (Hawkins & Roberts, 1992b).

The resultant damage to the aesthetic value of coral reefs is now gaining considerable attention among researchers (Hawkins & Roberts, 1997; Shafer, Inglis, Johnson, & Marshall, 1998; Wielgus et al., 2002), as this visible wear and tear on natural sites by previous visitors may affect future experiences (Duffus & Dearden, 1990; Hawkins & Roberts, 1992a, 1997; Manning & Lime, 1999; Watson, 2001). In addition to this is the notion that some visitors may notice these impacts before others, and it has been suggested that the more history a diver has with the activity of SCUBA diving and coral reef settings, the more discerning they might be when it comes to judging the value and quality of coral reef sites (Townsend, 2000). In other words, a beginner SCUBA diver with very low levels of diving and coral reef history might have different experiences and perceptions than a SCUBA diver with very high levels of diving and coral reef history on the same dive site, and even during the same dive. This is because history within an activity and/or setting is likely to modify the way that these environments are experienced and evaluated through previous exposure and knowledge (Ryan, 1995). This idea has not been tested in a SCUBA diving tourism context.

Maintaining the environmental quality and attributes desired for the attraction of a wide range of visitors and the experiences they receive is vital if wildlife tourism is to remain a popular and important activity. However, researchers and managers do not yet fully understand how certified SCUBA divers evaluate site and attribute quality, and which attributes are most important to the diving experience. Given the high demand and growth in SCUBA diving tourism, its significant economic contribution to reef-based communities, its potential to generate positive outcomes for coral reef environments, and the call for more sustainable management practices for coral reef environments, there is an urgent need to understand better: 1) the types of visitors that participate in SCUBA diving tourism; 2) the biophysical attributes that occur at coral reef dive sites; and 3) which of these attributes are most significant to divers' experiences.

1.2 Conceptual framework and literature review

This section explores the conceptual frameworks that allow researchers to measure and describe participants in wildlife tourism and recreation activities, the biophysical attributes that occur at natural sites, and the interaction that takes place between the participants and the biophysical attributes that results in the wildlife tourism experience. First the experience-based theoretical approaches to measuring the certified SCUBA diving wildlife tourism experience are reviewed. These include the Recreational

Opportunity Spectrum (ROS) and Limits of Acceptable Change (LAC) management frameworks. This section concludes with a review of the recreational specialization construct that is used by researchers to segment populations of activity participants based on their levels of activity history.

1.2.1 Experience-based approaches to measuring the certified SCUBA diving wildlife tourism experience

The Recreation Opportunity Spectrum (ROS)

Over the last two decades a number of conceptual frameworks have been developed to address the management of a wide range of recreation and/or tourism activities in natural or wilderness areas. This was done to provide a diversity of recreation users with the high-quality experiences they desired and expected while visiting such places. One of the first and most widely adopted frameworks was the Recreation Opportunity Spectrum (ROS). The ROS, developed by the U.S. Forest Service in the late 1970s, is a planning and management framework for identifying and describing recreation opportunities for a variety of users in a variety of settings (Driver & Brown, 1978). This framework addressed five key issues of recreation planning at the time: 1) how recreation was to be defined; 2) what were the objects of planning and management (does management provide activities, settings, facilities etc); 3) what were the objects demanded by recreationist (activities, settings, facilities etc); 4) could supply and demand be articulated using similar variables; and 5) could a framework by developed to account for the range of recreation demands among the nations recreationists (Driver, Brown, Stankey, & Gregoire, 1987).

The ROS involves specifying recreational goals for users in terms of broad classes of recreation opportunity along a spectrum depending on the range of environmental settings in the planning area (the widest range in terrestrial settings are ‘wilderness’ to ‘urban’). This means identifying specific indicators of these opportunities that permit their operational definition, and defining specific standards for each indicator that make distinctions among the opportunities possible (Driver et al., 1987). Each class is then described in terms of the types of activities allowed, the natural/built setting, and the likely types of experiences that would result from recreation in that area. By incorporating the spectrum into management plans, sensitive areas can be identified and protected and other settings more capable of withstanding heavier levels of use can be earmarked for more intensive forms of recreation. This approach has been successfully applied to a wide range of international, and mostly terrestrial settings. Examples from Australia include: Magnetic Island, Far North Queensland (Cassells, 1989), Rottnest Island, Western Australia (Rottnest Island Authority, 2003), and even in the GBRMP (GBRMPA, 2002b).

One of the basic assumptions of the ROS is that it is able to inform managers about the attributes of an activity in terms of the physical setting (biophysical attributes), the social setting (the types and numbers of users, and their behaviours), and the managerial setting (the level of site development, presence of on site personnel, the services offered such as education and information, and the rules and regulations). All three settings combined provide the recreation opportunity, and thus directly influence the experiences visitors receive (Driver & Brown, 1978; Driver et al., 1987). The ROS provides guidance for a pragmatic approach to managing diverse recreation and tourism interests that align themselves with places in protected areas because of its simple linear relationship among user preferences for physical, social, and managerial characteristics (Shafer & Inglis, 2000). In short, the ROS is a framework designed to understand and manage the opportunity setting that natural areas provide for the purpose of recreation, and identifies the environmental attributes (social and biophysical) that are most significant to visitors' experiences.

Implementing the ROS framework requires: a) defining the characteristics for each setting opportunity (which requires an understanding of the influence of setting characteristics on visitors' experiences); b) defining appropriate activities for each setting opportunity (which requires an understanding of the relationships between activities and impacts); c) defining the visitor experience (which requires an understanding of visitor expectations); and d) developing management plans to reflect and preserve the opportunities (Ormsby, Moscardo, Pearce, & Foxlee, 2004).

In the GBRMP, most SCUBA diving opportunities are offered to visitors via diving vessel tourist operations, mostly due to the large distances that need to be covered to get to suitable reef sites. A spectrum of opportunities for tourists to visit the GBRMP exists *de facto* among these operations (Shafer et al., 1998). Broadly speaking, at one end of the spectrum are day-trip opportunities representing the more developed setting, and at the other end are live-aboard diving trip opportunities representing the wilderness setting. However, it must be acknowledged that the examples provided below represent the extremes of the opportunity spectrum on the GBR, and that there are a wide range of opportunity settings available to visitors along the whole spectrum.

The day-trip SCUBA diving opportunity offers visitors many activities from large and fast vessels, can accommodate large group sizes (up to 450), has a range of facilities and permanent structures, accesses only one or two sites on any one trip usually in close proximity to populated coastal areas, and allows visitors to experience the reef environment for approximately four hours. Because the many activities of large group sizes are concentrated at only one or two sites, the cumulative impacts are likely to be relatively high. The live-aboard SCUBA diving opportunity offers visitors a narrower range of water-based activities from smaller and slower vessels, usually accommodating small group sizes (up to 30), has very few facilities and permanent structures, accesses up to 20 sites in a single trip usually in remote locations far from populated coastal areas, and allows visitors to experience the reef environment for up to ten days. Because the few activities of small group sizes are spread across many sites, the cumulative impacts are likely to be low. A brief description of day-trip SCUBA diving opportunities at one end of the opportunity spectrum, and live-aboard SCUBA diving opportunities at the other end, will now be provided.

Day-trip SCUBA diving opportunities on the GBR

Day-trip operations cater to the more general tourist who wants to experience the reef first hand, and in many instances for the first time (Shafer et al., 1998). Day-trips can provide a broad range of activities and facilities for passengers such as glass bottom boat tours, underwater observatories, helicopter landing pads, pontoons, fish feeding, fishing, and semi-submersibles. Most day-trip operators also offer SCUBA diving activities, either first time ‘Introductory’ SCUBA diving, or dives offered to certified individuals. However, the main activity on day-trips is snorkelling. In a study of four GBR day-trip operators ranging in size from less than 50 to 450 passengers, fewer than 17% of people who travelled to the Reef participated in SCUBA diving activities, while up to 61% of passengers went snorkelling (Shafer et al., 1998). Day-trip operations are not focussed on providing quality SCUBA diving opportunities to visitors, but rather offer the opportunity to ‘try’ SCUBA diving, or allow certified SCUBA divers to dive at sites that are also used for the wide range of activities listed above. In a study on motivations and perceptions of GBR first time and repeat visitors, Moscardo, Saltzer, Galletly, Burke, & Hildebrandt (2003) found that visitors who wish to return to the reef after an initial day-trip were more likely to seek smaller and more specialised Reef operations. In terms of SCUBA diving opportunities, none are more specialised than live-aboard diving trips.

Live-aboard SCUBA diving opportunities on the GBR

Live-aboard diving trips could be defined as dedicated certified SCUBA diving safaris or expeditions, taking participants to see a wide range of sites and species, while living and sleeping on board the vessel for extended days at sea. Live-aboard diving trips provide certified SCUBA divers the opportunity to participate in up to four SCUBA dives per day, with some trips going to sea for as long as ten days. Live-aboard diving trips offer few activities, with their sole purpose being certified SCUBA diving, with up to 98.1% of passengers participating (n=1045) (Birtles et al., in prep). Other activities offered include snorkelling, and in the northern GBRMP during the winter months swimming with dwarf minke whales (Birtles, Valentine, Curnock, Arnold, & Dunstan, 2002b; Valentine, Birtles, Curnock, Arnold, & Dunstan, 2004).

Live-aboard diving trips in the GBRMP can cost over $3,000 (AUD) for a six-day expedition. During this time divers will see a diversity of habitats and species over a large geographical area, visiting remote locations far from populated coastal areas. These trips also have more personalised interpretation programs that provide a greater opportunity for visitors to learn about the Reef and its inhabitants. Participants on live-aboard diving trips have a wide range of diving histories, from the very beginner (just certified) to the more advanced diver (some having dived for up to 38 years) (Birtles et al., in prep). Live-aboard diving trips offer more specialised SCUBA diving opportunities than day-trip operations in terms of the product offered to the visitor. Because of this, it is likely that SCUBA divers that have previous diving histories and a desire to see more remote and pristine coral reef environments than one or even several day-trip or pontoon sites have to offer, would be more likely to travel on a live-aboard diving vessel.

Given the differences in the number of certified SCUBA diving participants between the two types of trips, and the SCUBA diving opportunities offered by each trip, it might be assumed that the biophysical attributes of the physical setting may have different levels of importance to visitors. In this way, visitors partaking in different recreation opportunities along the spectrum might have different expectations and demands of the physical setting, and their evaluations of its quality. Once the biophysical attributes that are most significant to different types of visitors' experiences have been identified, it will be necessary to control the level of impacts to these attributes. This line of thinking paved the way for the Limits Of Acceptable Change (LAC) approach management framework (Stankey, Cole, Lucas, Petersen, & Frissell, 1985).

Limits of Acceptable Change (LAC)

The concept of the LAC framework, which incorporates the ROS framework, is aimed at one of the core areas of responsibility for environmental and natural resource managers, that is predicting and preventing adverse environmental impacts caused by human activities (Oliver, 1995). The foundation for this was the need to develop and implement a process for dealing with the issue of recreational carrying capacity in wilderness, and therefore keeping recreation use levels below saturation point at which minimal environmental impacts were occurring (Cole & Stankey, 1998). The LAC framework therefore manages change due to human use within acceptable levels to maintain a desired level of quality in an area's physical, social, and managerial characteristics. To accomplish this, Stankey et al., (1985) identified a nine-step process (Figure 1.1), based on identifying and monitoring a small number of indicators that specify acceptable levels of naturalness and experiential quality for different environmental settings.

Figure 1.1. Limits of acceptable change planning model (source: Stankey et al., 1985).

Step 1 in the LAC process identifies natural area concerns and issues, specifically, the special features or distinctive qualities within the area that require attention. The LAC process can be particularly useful in guiding management where conflicts between users' 'goals' exist (Cole & McCool, 1998). An example of a goal would be the non-consumptive use of a resource for tourism, while a conflicting goal would be an extractive use of that very same resource. Goals are said to be in conflict whenever it is impossible to simultaneously optimize conditions for all management goals (Cole & McCool, 1998). In the case of certified SCUBA diving tourism this relates to the maintenance of the biophysical attributes that are most important and significant to divers' experiences. This means managing the level of damage and/or removal of these attributes for a wide range of users including tourism operators and tourists, Indigenous communities, local recreation users, recreational and commercial fishing/extracting, coastal developers, and shipping (Shafer et al., 1998).

Managers need to construct a hierarchy of goals for each user group, and thus ultimately decide which goals are more important than others for a given area or resource, and for a given user group. This step promotes a better mutual understanding of the natural resource base (such as the sensitivity of particular environments to recreation use by tourism and other users), a general concept of how the resource could be managed, and a focus on principal management issues (Borrie, McCool, & Stankey, 1998). Major input and consultation is required with users and stakeholders, other management agencies and planners, local interest group members and the general public is required (GBRMPA, 2002a, 2005c; Ormsby et al., 2004).

Step 2 in the process calls for opportunity classes to be defined and described (as does the ROS system) and requires information from users on the range of opportunities or experiences they desire. Opportunity classes describe the subdivisions or zones where different social, physical, or managerial conditions will be maintained (Borrie et al., 1998). For the tourism classes this step requires the measurement of the physical, social, and managerial settings to understand their specific influence on the wildlife tourism experience. In the Tourism Optimization Management Model (TOMM) (Mandis Roberts Consultants, 1997) this is measured as the 'Optimal Conditions', which are defined as 'a desirable yet realistic status for a sustainable future'. In the case of SCUBA diving tourism this will require an understanding of the certified SCUBA diving opportunities provided at specific sites and locations, and must understand the opportunity classes for other users mentioned in Step 1 that also use the resources. Only then can managers decide which conflicting goals will ultimately constrain other goals, and for which users (Cole & McCool, 1998).

An example of where Step 2 has been applied in the GBRMP is the Representative Areas Program (RAP). The objective of the RAP was to increase the protection of biodiversity within the Marine Park through increasing the extent of Marine National Park Zones, (MNPZ), also called Green Zones or 'no-take' zones. To assist the RAP, two independent steering committees were formed to provide expert advice to the GBRMPA about the: biological and physical aspects of the GBR; and the social, economic, cultural and management feasibility aspects of human use of the Marine Park. A wide range of opportunity classes were defined and described. To manage the diversity of users and their activities the Marine Park was divided into eight Zones, each representing a different level of conservation, protection and resource use. These are: a) the General Use Zone; b) the Habitat Protection Zone; c) the Conservation Park Zone; d) the Buffer Zone; e) the Scientific Research Zone; f) the Marine National Park Zone; g) the Preservation Zone (for a detailed description of each of the eight zones see the Great Barrier Reef Marine Park Zoning Plan, 2003). Figure 1.2 details the names of seven of the Zones, the types of activities allowed in each zone, and whether a permit is required to undertake activities in each of zones.

Figure 1.2. Activities guide detailing the allowable use in each seven of the conservation zones used in the GBRMP (source: GBRMPA RAP zoning, Maps, May 18, 2004).

GBRMPA Zoning
(see relevant *Zoning Plans* and *Regulations* for details)

Note: Not all zoning categories necessarily occur in the mapped area shown.

	General Use Zone	Habitat Protection Zone	Conservation Park Zone	Buffer Zone	Scientific Research Zone *	Marine National Park Zone	Preservation Zone
Aquaculture	Permit	Permit	Permit *	✗	✗	✗	✗
Bait netting	✓	✓	✓	✗	✗	✗	✗
Boating, diving, photography	✓	✓	✓	✓	✓ *	✓	✗
Crabbing (trapping)	✓	✓	✓ *	✗	✗	✗	✗
Harvest fishing for aquarium fish, coral and beachworm	Permit	Permit	Permit *	✗	✗	✗	✗
Harvest fishing for sea cucumber, trochus, tropical rock lobster	Permit	Permit	✗	✗	✗	✗	✗
Limited collecting	✓ *	✓ *	✓ *	✗	✗	✗	✗
Limited spearfishing (snorkel only)	✓	✓	✓ *	✗	✗	✗	✗
Line fishing	✓ *	✓ *	✓ *	✗	✗	✗	✗
Netting (other than bait netting)	✓	✓	✗	✗	✗	✗	✗
Research (other than limited impact research)	Permit	Permit	Permit	Permit	Permit	Permit	Permit
Shipping (other than in a designated shipping area)	✓	Permit	Permit	Permit	Permit	Permit	✗
Tourism program	Permit	Permit	Permit	Permit	Permit	Permit	✗
Traditional use of marine resources	✓ *	✓ *	✓ *	✓ *	✓ *	✓ *	✗
Trawling	✓	✗	✗	✗	✗	✗	✗
Trolling	✓ *	✓ *	✓ *	✓ *	✗	✗	✗

PLEASE NOTE: This guide provides an introduction to Zoning in the Great Barrier Reef Marine Park. Relevant Great Barrier Reef Marine Park Zoning Plans should be consulted for confirmation of use or entry requirements.

* Additional restrictions / conditions apply.

ACCESS TO ALL ZONES IS PERMITTED IN AN EMERGENCY.

Step 3 in the LAC process involves the selection of specific and measurable indicators that represent the conditions desired in each opportunity class. Indicators should be a direct measure of the conditions specified by the opportunity classes and, therefore, reflect the unique and important qualities of the visitor experience and environmental resource (Borrie et al., 1998). For SCUBA diving tourism, indicators would represent the biophysical attributes of the coral reef environment most important to quality experiences, the social conditions related to the presence of structures or other people, and the conflicts between different types of users (Shafer et al., 1998). An experience-based approach to designating use and selecting indicators in a LAC process can provide a systematic method for meeting the goals of natural resource managers and tourism operations, as both seek to maintain a diversity of quality opportunities for visitors in a given area (Shafer et al., 1998).

1.2.2 Applying the Limits of Acceptable Change process to measure and describe the certified SCUBA diving wildlife tourism experience

The LAC process provides the theoretical framework to investigate the SCUBA diving wildlife tourism experience, with a focussed approach on identifying the areas and concerns in Step 1, understanding the influence of the physical, social, and managerial settings on the experiences received in Step 2, and selecting indicators of quality experiences in Step 3. This very same process has been investigated for snorkellers on day-trip operations to the GBRMP by Shafer et al., (1998).

These researchers identified in Step 1 of the LAC process that increased day use visitation on the outer GBR tourism sites has been a source of conflict between operators and managers, and between different types of users. Of greatest concern was the potential degradation of coral reef sites by the visitors' and operators' activities, heightened by increased use levels. What the researchers wanted to know was if visitors were having different experiences on the Reef and if different physical and social setting conditions were having differing levels of influence on them. However, it should be noted that the researchers did not measure the physical setting such as the percentage cover of living corals, or the diversity and abundance of fish. The influence of the physical setting was measured using a benefits-based approach.

Of the 1,922 visitors sampled on four different day-trip vessels, nearly half had not visited a coral reef before. Results showed that different 'types' of reef trips, such as large operators (up to 450 passengers) visiting pontoons, and smaller operators (less than 50 passengers) were providing passengers with different experiences. As is the case with wildlife tourism, all operators offered visitors high levels of benefits relating to nature and learning. However, large operators allowed for more passive enjoyment of the Reef through a range of activities in a more developed setting. Visitors travelling with smaller operations were more likely to have received benefits associated with active participation because they had to get into the water if they wanted to experience the Reef, as underwater viewing opportunities from glass-bottom boats and semi-submersibles for example, were not offered.

The influence of the biophysical conditions between the trips was highly consistent, with only slight site-specific variations. This was probably because most of the visitors had very little or no history in coral reef environments. Visitors' perceptions of the influence of 24 conditions on their Reef experience can be seen in Table 1.1. In general most of the conditions were found to positively influence experiences, particularly those concerning the staff, and the natural attributes of the site. This study was essential in providing managers with the first look at the wildlife tourism experience for day-trip visitors to the Reef.

Table 1.1. Day-trip visitor perceptions of the influence of 24 conditions on their coral reef experience while visiting the GBRMP (Source: Shafer et al., 1998).

Condition Item	**Mean**	**Std. deviation**
Helpfulness of staff	6.14	.91
Types of fish I saw	6.12	.95
Size of the coral I saw	6.11	.95
Total amount of coral I saw	6.09	.94
Number of different kinds of coral	6.03	.98
Information provided by the staff	5.98	1.01
Colour of the fish I saw	5.90	1.08
Clarity (visibility) of the ocean water	5.88	1.22
Colour of the corals I saw	5.85	1.17
Appearance of staff	5.81	1.05
Total number of fish I saw	5.80	1.18
Behaviour of the fish	5.64	1.15
Size of the fish I saw	5.62	1.12
Temperature of the air	5.29	1.44
Depth of water	5.28	1.23
Temperature of the water	5.20	1.46
Number of animals other than coral or fish that I saw	5.16	1.39
Sea conditions during the trip from/to shore	5.05	1.60
Number of people on main boat	4.65	1.33
Number of people snorkelling	4.65	1.40
Currents in water around the reef	4.62	1.26
Number of people on the pontoon	4.61	1.35
Amount of wind	4.50	1.45
Number of human-made objects in the water	4.34	1.47

Mean was calculated based on a seven point response format where 1 = very negatively, 2 = negatively, 3 = somewhat negatively, 4 = no influence either way, 5 = somewhat positively, 6 = positively, 7 = very positively.

The greatest difference between trip types was the social setting, particularly the number of other people on board. In general, visitors travelling with smaller operators were more likely to rate the fewer number of people as a positive influence. Because of these differences, the researchers suggested that the most promising indicator condition (Step 3) from this study was the number of people on the trip, as it has the greatest potential to be quantified. They did however acknowledge that the coral and other natural attributes are important to the ecological integrity of the GBR, but this is also what people came to see. They suggested that much work was needed in understanding the visitors' experiences in terms of the biophysical attributes of coral reefs from an ecological and social standpoint. This work has provided an excellent foundation to build on for the assessment of the SCUBA diving wildlife tourism experience on coral reefs.

1.2.3 Measuring the SCUBA diving wildlife tourism experience

SCUBA diving represents a very different way to experience coral reef environments than snorkelling, and especially viewing from glass bottom boats, underwater observatories, or semi-submersibles. SCUBA diving allows the participant to be completely immersed and suspended in a three dimensional underwater environment, and could be compared to the way an astronaut is suspended in zero gravity. This allows divers to linger longer in one area to watch certain types of behaviours, be completely surrounded by schooling fish, allow a full appreciation of the structural complexity of the coral, and actively search and find more cryptic organisms. It also allows divers to experience physical attributes of reef sites like diving along vertical reef walls, entering caves and swim-throughs, or moving along sand filled gullies between towering coral bommies. Therefore, measuring divers' experiences is likely to be completely different to measuring other types of reef activities.

Research focussed on understanding wildlife species, their habitats, and their roles in communities and ecosystems is widespread throughout the history of scientific enquiry. Research focused on the users of such wildlife species and their habitats in both consumptive (e.g. fishing and hunting) and non-consumptive (e.g. viewing handling and photographing) uses is also well covered in the literature (e.g. Heberlein & Kuentzel, 2002; McFarlane & Boxall, 1998; Muloin, 2000). However, disciplinary separation of the natural and social sciences has hampered understandings of the interactions between wildlife and users (Dinsdale, 2004).

Duffus and Dearden (1990) provided a conceptual framework of non-consumptive wildlife use. This framework adopted the notion that the wildlife (the focal species or species groups, and the requirements of the species for survival), and the wildlife user (individuals who engage in encounters with wild species for the purpose of non-consumptive wildlife use), interact with each other to produce non-consumptive use of wildlife, or the wildlife tourism experience. They define this as "a human recreational engagement with the wildlife wherein the focal organism is not purposefully removed or permanently affected by the engagement" (Duffus & Dearden, 1990, p215). They go on to say that to understand this interaction "depends on the biological sciences to understand the nature of the support system that presents the opportunity for contact between the user and the focal species, and the techniques of the social scientist to understand the interrelated concepts of satisfaction that produce recreational benefits" (Duffus & Dearden, 1990, p217). It is recognized that the wildlife tourism experience is a multifaceted phenomenon, and that focusing on only one aspect such as experience will not adequately address the issue (Borrie & Birzell, 2001). To date, a multidisciplinary approach has not been taken to explicitly understand how visitors interact with settings to produce the wildlife tourism experience, especially in a marine tourism context.

Visitors and the wildlife tourism experience

Wildlife users or visitors to wildlife sites are composed of individuals who are engaged in satisfaction seeking behaviour, with the drive being the desire to encounter wildlife under natural conditions (Duffus & Dearden, 1990). To understand what drives the desire, and what leads to satisfaction, managers need to map how environmental attributes are socially constructed (Williams, 1995), which will help recognize the importance of place presentation and meaning in human-wildlife interactions (Fenton et al., 1998). This is crucial as evaluative standards and judgements of environments and ecosystems often differ between managers/researchers and the visitors (Shelby & Harris, 1985). Given this discrepancy, visitors become the premier source of information concerning the attributes of the experience, and their evaluations are an important source of feedback for managers (Borrie & Birzell, 2001). Because of this, the study of the human dimension of the wildlife tourism experience has now emerged as a sub-discipline of natural resource management.

While visitors' cultural and social backgrounds are wide and varied, so are the experiences they have and desire when interacting with wildlife. Some species or attributes are highly sought after and preferred by visitors, and they are usually willing to pay greater amounts of money to see these (Cesar, 2000; Rudd, 2001; Rudd & Tupper, 2002). The desire to have encounters with some species may be so strong that they drive the initial decision to visit certain locations (Tabata, 1992). In many cases this will occur where there are one to two focal species, for example whale sharks at Ningaloo Reef (Davis, Banks, Birtles, Valentine, & Cuthill, 1997) or sea turtles at Mon Repos (Wilson & Tisdell, 2001). What attributes of highly diverse environments such as coral reefs are preferred and why, and which of these lead to high quality experiences is not well understood, partly because coral reefs are complex communities with very high levels of biodiversity. Given the high visitation rates and economic benefits derived from wildlife tourism, it is essential that these factors be defined to enable managers to focus their efforts on maintaining those attributes most significant to visitors' experiences.

Birtles et al., (in prep) examined SCUBA diving tourism on live-aboard diving operations visiting the GBRMP and the Coral Sea. These studies surveyed participants on seven live-aboard diving vessels between 1996 and 1998. Of these participants, 95.5% were certified SCUBA divers, with up to 38 years SCUBA diving history (n=1045). Most visitors had not been to the GBRMP before, and nearly all (98.1%) interacted with the reef environment via SCUBA diving activities, and to a lesser extent snorkelling (51.4%). The benefits of most importance to the divers enjoyment of the trip were related to the natural conditions of the reefs, as well as learning about new things through information and interpretation provided by crews. Of least importance were personal benefits such as being comfortable, eating good food, or having time to themselves. This order of benefits was quite similar to what Shafer et al., (1998) had found for day-trip participants to the GBR, showing that for most participants on trips to the Reef, the physical setting was the greatest focus of the wildlife tourism experience.

In addition to asking visitors to rank a list of benefits that influenced their experiences, Birtles et al., (in prep), and Curnock (1998), began to understand participants' experiences by asking them to list and describe their best experiences in an open-ended question format. In doing this, the researchers were inundated with the diversity and richness of information provided by the visitors, with 103 different responses just for marine organisms. Table 1.2 lists the summary of the results of this enquiry and shows clearly the high diversity of responses provided including marine organisms, locations, diving/snorkelling experiences, and experiences concerning the crew/vessel.

Table 1.2. Live-aboard dive trip participants best experiences on the GBR and Coral Sea dive sites by major themes (Source: Birtles et al., in prep).

Best experiences	Number of respondents	Valid % of respondents	Best experiences	Number of respondents	Valid % of respondents
Marine organisms			**Diving/snorkelling**		
Minke whale	230	23.0	Diving (general)	448	44.7
Fish (non-specific)	173	17.3	Night dives	118	11.8
Corals (non-specific)	146	14.6	Fish feeding	113	11.3
Sharks (non-specific)	146	14.6	Good visibility	57	5.7
Potato cod	133	13.3	Snorkelling	55	5.5
Turtles	81	8.1	Reef wall dives	37	3.7
Animal behaviour	73	7.3	Shark feeding	26	2.6
Marine animals (non-specific)	59	5.9	Drift diving	18	1.8
Whales (non-specific)	46	4.6	Good diving conditions	14	1.4
Interaction with animals	42	4.2	Getting dive certification	14	1.4
Marine life in general	37	3.7	Other diving responses	50	5.0
Dolphins	32	3.2	**TOTAL MARINE LIFE GENERAL**	**950**	
Giant clams	21	2.1	**Dive operations**		
Barracuda	20	2.0	Staff or operations in general	103	10.3
Whitetip reef shark	18	1.8	Being on a boat / the boat	89	8.9
Whale shark	16	1.6	Education and interpretation	78	7.8
Nudibranch	14	1.4	Good food	39	3.9
Manta ray	14	1.4	Other dive operation responses	6	0.6
Cuttlefish	10	1.0	**TOTAL DIVE OPERATIONS**	**315**	31.4
Moray eel	9	0.9	**TOTAL OTHER**	**1761**	44.7
Other marine organisms responses	182	18.2	**TOTAL RESPONSES**	**5611**	
TOTAL MARINE ORGANISMS	**1502**		Left blank (question not completed)	43	
Locations					
Cod Hole	263	26.2			
Steve's Bommie	134	13.4			
Pixie Pinnacle	95	9.5			
Osprey Reef	52	5.2			
Challenger Bay	29	2.9			
North Horn	27	2.7			
Holmes Reef	22	2.2			
Lizard Island	21	2.1			
Clam Beds / Clam Garden	21	2.1			
Cod Hole	263	26.2			
Other location responses	418	41.7			
TOTAL LOCATIONS	**1083**				

Results from the open-ended question "what three best experiences" respondents had received while on their live-aboard diving trip (n=1002). Respondents often provided more than one response. Valid % equals respondents that listed that feature of the total n

This research highlighted the notion that researchers and managers were only just beginning to unravel the true extent of visitors' experiences in coral reef environments, and that the sources of these were as diverse and complex as the reefs themselves. While the information generated in this study provided further insight into certified SCUBA divers wildlife tourism experiences, these data were not site specific, and the results are summed across a large number of sites. This provided little understanding of the specific attributes that were influencing experiences at each site, and how important these were. Birtles et al., (in prep) suggest that to truly understand how specific social and biophysical attributes positively and negatively influence divers' experiences, these attributes have to be measured at a range of sites over time, along with the experiences that visitors are having at each of these sites. Visitors' experiences must be connected to the attributes that actually occur at the sites in a way that provides insight into the interaction that is taking place.

Measuring the environment in the wildlife tourism experience

Essential to providing visitors with quality wildlife tourism experiences, is an understanding of the biophysical attributes that contribute and influence these experiences (Hammitt, Dulin, & Wells, 1993). Yet very few wildlife tourism or recreation studies have attempted to measure and describe these attributes from an ecological standpoint, such as the species and number of organisms available to be seen (Driver, 1985), and how predictable certain species are within a given spatial and temporal scale (Duffus & Dearden, 1990). In many case, the wildlife tourism experience might be focussed on one or two species (e.g. whale sharks or nesting sea turtles), and these encounters usually coincide with critical life history stages such as feeding or reproduction (Birtles et al., 2001). During these times of restricted occurrences and concentration of individuals, the collection of ecological data will be simplified.

However other wildlife tourism experiences will be much less specialised and offer visitors a wide variety of species to be encountered, many of which will be incidental (Birtles et al., 2001). This has been shown to be the case on coral reef dive sites (Birtles et al., in prep; Curnock, 1998) where it is suggested that over 50 species from a wide range of taxa can be seen during a brief snorkel or SCUBA dive (Shafer et al., 1998). Measuring and describing the biophysical attributes to understand how these influence the wildlife tourism experience will be much more difficult in highly diverse settings. This requires a more comprehensive sampling technique to ensure that a much greater range of possible visitor-wildlife interactions are considered.

Interaction between visitors and biophysical attributes

Study of the interactions between visitors and the biophysical attributes has focused primarily on identifying and determining variables important to visitors by asking them to list or rank these in a survey format. Interactions between biophysical attributes and visitors can range from bush walking in the high country, to visiting a national park (terrestrial or marine), to participating in dedicated tours. One of the challenges facing researchers is to demonstrate explicitly the influence of the biophysical attributes on visitors' experiences (Borrie & Birzell, 2001). Much of this work to date has originated from terrestrial settings and has aimed to identify indicators of quality experiences that can be measured and monitored. For example, visitors' preferences for site attributes, crowding and encounters with other visitors, motivations for recreation, and conflict with other types of users are all suggested potential indicators of quality experiences (see Manning & Lime, 1999 for a review of indicators of quality).

Reynolds and Braithwaite (2001) developed a conceptual framework for wildlife tourism interactions, and suggested six quality factors to be intrinsic to the encounter that capture the essence of quality and richness. The first four of these are general to all tourism experiences, and the last two are specific only to wildlife encounters.

> *Authenticity* has been widely used as an estimate of the 'honesty' of the attraction. The degree of natural behaviour exhibited by the fauna, and the environment in which it is viewed
>
> *Intensity* refers to the excitement generated by an experience. Other terms that capture this concept are 'enthrallment' and 'adrenalin rush'
>
> *Uniqueness* of the experience is the sense of the experience being special and unusual and therefore the participant being privileged
>
> *Duration* refers to the length of the exposure to the stimuli. Up to a certain point the experience is heightened. Beyond this point the participant is saturated with the particular experience.
>
> *Species popularity* is driven by a range of factors, which include physical attractiveness, its size, danger and drama associated with the species and the publicity that the species has enjoyed in the public media (Duffus and Dearden (1990) comment that species that provoke the most stimulation are the dangerous predators, lions, tigers, etc).

> *Species status* refers to the rarity of the animal. Species on rare and endangered lists appear to hold a special attraction

Research into the determinants of quality wildlife tourism experiences from a wide range of settings has found a combination of factors that contribute to enjoyable experiences for visitors. In general these can include the enjoyment of watching and viewing animals in their natural environment (Schaenzel & McIntosh, 2000; Valentine et al., 2004; Woods, 2002), the ease and proximity (Birtles et al., 2002b; Pearce & Wilson, 1995) of viewing a large number and variety of wildlife species (Birtles et al., in prep; Curnock, 1998; Hammitt et al., 1993; Woods, 1999), seeing displays of natural behaviour (Davis et al., 1997; Duffus & Dearden, 1990; Reynolds & Braithwaite, 2001; Valentine et al., 2004; Woods, 1999), and the commentary and behaviour of guides (Birtles et al., 2002b; Moscardo, Woods, & Greenwood, 2001; Reynolds & Braithwaite, 2001). In the SCUBA diving wildlife tourism context, the factors contributing to quality experiences are not well understood, mainly due to the small number of studies, and the diversity of species available to be seen.

Hammitt et al (1993) investigated the determinants of quality wildlife viewing in the Great Smokey Mountains National Park, Tennessee using the 'Quality of Wildlife Viewing Model'. This model considers both the quality of the wildlife viewing opportunities, the visitors' expectations and experiences for actual encounters, and the importance of certain species, to understand the interaction that takes place between environment and visitor. The researchers measured the quality of the wildlife viewing as a function of the animals available to be seen from viewing stations and included the number and different types of animals that could be seen. Visitors' visual encounters with animals at the same viewing stations, expectations and beliefs towards encounters, and importance of certain species were also measured (n=325).

The above researchers found that although a wide variety of animals were available for viewing at each of the viewing stations, visitors tended to focus on large mammals including white-tailed deer and black bears. Findings also indicated that what the researchers had seen and measured was quite different from what the visitors saw, possibly due to the difference in the training level between researchers and visitors. Visitors also reported seeing almost as many different kinds and numbers of animals as they had expected, however the number of animals seen by visitors was the most important determinant to a quality wildlife viewing experience, followed by seeing white-tailed deer, black bears, and many different kinds of animals. Finally the researchers found that first time visitors and repeat visitors were having different experiences, which were related to their initial expectations as well as the number and types of animals seen. Repeat visitors reported seeing a greater number and diversity of animals than first time visitors. This result implies that although the biophysical attributes at the site influence the wildlife tourism experience, so might the level of activity and setting history of the visitor. However, the notion of visitor history within an activity or setting explaining variations in the wildlife tourism experience has not been explored for certified SCUBA divers.

1.2.4 Recreational specialization construct

While many forms of wildlife tourism require very little ability or training on behalf of the visitor, some experiences involve considerable expense, knowledge, specialised equipment, and long distance travel (Kellert, 1996). This is partially true of SCUBA diving. Previous research has shown that SCUBA divers can have a wide range of diving histories (Birtles et al., in prep; Cottrell & Meisel, 2004; Curnock, 1998; Meisel & Cottrell, 2004; Mundet & Ribera, 2001), have varying levels of skill and knowledge (Todd, 2000), and can own a considerable number of pieces of specialised SCUBA diving equipment (Todd, 2000). SCUBA divers can also travel extensively to undertake their activity (Tabata, 1992). Given this information it is likely that recreational specialization, or the focussing of behaviour from the general to the specialised, exists for participants in the activity of SCUBA diving.

Recreational specialization was proposed by Bryan (1977), and infers that users in a given recreational activity are able to move along a ‘specialization continuum’ from beginner to specialist, the more they become involved in the given activity. This movement from beginner to specialist may be characterized by frequency of involvement in the activity, participation, the equipment owned, skill, techniques, and setting preferences, and by the end stage, may involve considerable time and money being invested to travel long distances to see particular species (Bryan, 1977).

Bryan (1977) identified four different types of trout fishers based on degree of specialization in his original paper. These were ‘occasional’ fishers (new to the activity), ‘generalists’ (regular participants in the activity), ‘technique specialists’ (anglers who specialise in a particular method of fishing), and ‘technique-setting specialists’ (highly committed anglers who specialise in method and have specific preferences for settings). Manning and Lime (1999) argue that experience preferences not only change between users, but also user preferences change over time. Therefore a generalist with basic preferences for settings and experiences can, over time, become a specialist with specific setting and experience preferences. Although it is well accepted that recreational specialization exists, the prevailing evidence for the construct shows that while some people do progress along the specialization continuum, many people involved in an activity do not (Scott & Shafer, 2001).

Using the recreational specialization framework researchers have been able to segment populations of recreationists into definable units allowing investigations into use of information to make trip decisions, motivations and expected rewards, attitudes toward resource management, preferences for physical and social setting attributes, and other aspects of involvement (Scott & Shafer, 2001). Since the original formation of the recreational specialization construct, various researchers have successfully tested its application in a range of settings and activities such as fishing (Bryan, 1977; Sutton, 2001, 2003), hiking and backpacking (Watson, Niccolucci, & Williams, 1994), rock climbing (Ewert & Hollenhorst, 1997), and bird watching (McFarlane, 1994; Scott, Ditton, Stoll, & Eubanks, 2005). To date the recreational specialization construct has not been used to segment populations of certified SCUBA divers.

Studies on recreational specialization have varied considerably in terms of the ways in which specialization is characterized, and there is still little consensus on how it should be measured. Some have relied solely on behavioural aspects of participants, while others have used attitudes and values exclusively. Most studies have employed both of these variables (Scott & Shafer, 2001). However, Bryan (2001) warns that recreational specialization defined in terms of both behaviours and corresponding attitudes could be problematic, especially given the ease of accessibility to high quality equipment and the learning of skills. More than ever before, new participants can ‘jump start’ into traditional outdoor activities such as fishing and hunting without long term associations with these sports. "While the skills, equipment, and various trappings of specialization are present, the ethical and other attitudinal underpinnings guiding the activity are absent" and may be a prime example of a 'culture lag' (Bryan, 2001, p346). As an example, Bryan (2001) asks "how do we explain equipment-refined, well conditioned backpackers who leave litter at campsites and evidence little concern for the impacts of their activities on delicate ecosystems?" In response, Scott and Shafer (2001) proposed that progression towards specialization can best be understood in terms of (a) focussing of behaviour, (b) the acquiring of new skills and knowledge, and (c) a tendency to become committed to the activity such that it becomes a central life interest.

Support for the conceptual framework of recreational specialization proposed by Bryan (1977), and its ability to provide a means of segmenting populations for further analysis is clear. However, the recreational specialization construct has not been applied to investigate if the level of activity and setting history of visitors can explain variations in the way that the wildlife tourism experience is received and evaluated. Given its wide acceptance among researchers, and its flexibility to cover a wide range of recreational activities and research questions, the recreational specialization construct provides an ideal framework to segment populations of certified SCUBA divers.

1.3 Purpose and objectives

In light of an increasing demand for marine wildlife tourism experiences worldwide, particularly SCUBA diving on coral reefs, there is a need to better understand the visitors who participate in such activities, the social and biophysical attributes that provide the opportunity for marine wildlife tourism to occur, and the specific influence of these attributes on visitors' experiences. It is also unknown if SCUBA divers with varying levels of diving and coral reef history can have different experiences, and if so, how might this occur? The need for such information is further stressed as conflicts between users of coral reef resources have arisen due to extractive industries collecting in areas also used by tourism, and the apparent degradation of coral reef environments worldwide. If attributes of dive sites significant to SCUBA divers' experiences are damaged and/or removed, the overall value of the dive experience might be decreased. Such impacts might cause a downward shift in the demand and visitation to a site. This means that maintaining and protecting the environmental quality and attributes desired for the attraction of visitors and the experiences they receive is vital. This will especially be the case if wildlife tourism is to have potential importance in providing positive outcomes for coral reefs and reef-based communities, especially the preservation and conservation of coral reef environments.

The purpose of this thesis is to analyse certified SCUBA divers' experiences on coral reefs of the GBR and Coral Sea. Live-aboard diving operations where SCUBA diving was the primary activity were selected, as they provide the ideal platform to investigate certified SCUBA divers with a wide range of diving histories, as well as investigate the SCUBA diving wildlife tourism experience in a range of physically and biologically diverse settings during the course of a single trip. The following objectives were designed assess the SCUBA diving wildlife tourism experience for a wide range of diver histories in a ROS and LAC management framework:

1. To provide an assessment of the types of certified SCUBA divers that visit the GBRMP and adjacent Coral Sea reefs on live-aboard diving trips, and how they vary in terms of demographics, and the level of previous diving and coral reef history using the recreational specialization construct;

2. To provide an assessment of the biophysical attributes that occur on a range of selected coral reef dive sites from the GBRMP and Coral Sea using a range of biophysical survey techniques;

3. To describe the types of experiences certified SCUBA divers are having on GBRMP and Coral Sea dive sites in terms of their pre-trip expectations for the biophysical attributes to be encountered during the trip, actual experiences with the biophysical attributes at specific sites, and post-trip perceptions and evaluations of the biophysical attributes encountered during the trip using a series of on-site self-administered questionnaires;

4. To investigate how the biophysical and social attributes that occur at these dive sites influence the SCUBA diving wildlife tourism experience by combining both the biophysical and questionnaire data;

5. To determine whether variations in SCUBA divers' experiences can be explained according to the level of participants' diving and coral reef history using the recreational specialization construct; and

6. To investigate which biophysical and social attributes might best be used as indicators of quality wildlife tourism experiences for certified SCUBA diving in a ROS and LAC management framework.

1.4 Thesis outline

Chapter Two details the selection of the live-aboard diving operators used and a detailed description of the live-aboard diving industry. This chapter also explains the selection of the study sites used and a description of each. The methods employed to investigate the SCUBA diving wildlife tourism experience, placing these in the context of the ROS and LAC management frameworks, are also presented.

Previous research suggested that SCUBA divers come from a wide range of cultural backgrounds, and have varying levels of SCUBA diving history (Birtles et al., in prep, Curnock, 1998). Chapter Three (Study One) is an assessment of the SCUBA divers that participate in live-aboard diving trips to the GBRMP and Coral Sea in terms of demographics, previous diving and coral reef history, ownership of SCUBA related equipment, and the levels of coral reef interest and knowledge. The divers were segmented into four groups using a Multidimensional Recreational Specialization Index (MRSI) based on diver's level of participation, training and associated skills, and coral reef setting history, combined in an index of Diving and Coral Reef History (DACRH) Specialization.

The need to measure and describe the biophysical attributes found at wildlife tourism sites is clear in order to understand the wildlife tourism experience, as prescribed by the ROS construct. Chapter Four (Study Two) is an assessment of the biophysical attributes that occur on selected GBRMP and Coral Sea dive sites. The information collected in this chapter provides an understanding of the attributes of coral reefs that certified SCUBA divers are most likely to encounter during a dive at each site, which will be linked to information that the divers provided on their actual experiences at specific sites in Study Three (Chapter Five). This multidisciplinary approach will aid in understanding the influence of specific coral reef attributes on the wildlife tourism experience. Also explored in Chapter Five are the divers' pre-trip expectations and post-trip perceptions, and their evaluations of the biophysical attributes encountered during their trip.

Chapter Six (Study Four) uses the MRSI developed in Study One to explore if levels of DACRH Specialization can explain variations in the divers' pre-trip expectations, actual experiences at specific sites, and post-trip perceptions and evaluations of the biophysical attributes that occurred on sites. This application of the recreational specialization construct is new, not only to a marine wildlife tourism context, but also in the way it is used to investigate the wildlife tourism experience for different types of users.

Chapter Seven provides a synthesis of the findings of the four studies in this thesis. In addition, the significance of the findings of this research are discussed in terms of the current state of knowledge in the areas of wildlife tourism experiences, and specifically SCUBA diving wildlife tourism. The chapter concludes with management implications and recommendations, and provides an agenda for future research on divers' experiences on coral reefs.

CHAPTER 2

METHODS FOR INVESTIGATING THE CERTIFIED SCUBA DIVING WILDLIFE TOURISM EXPERIENCE

2.1 Selection of SCUBA diving operators

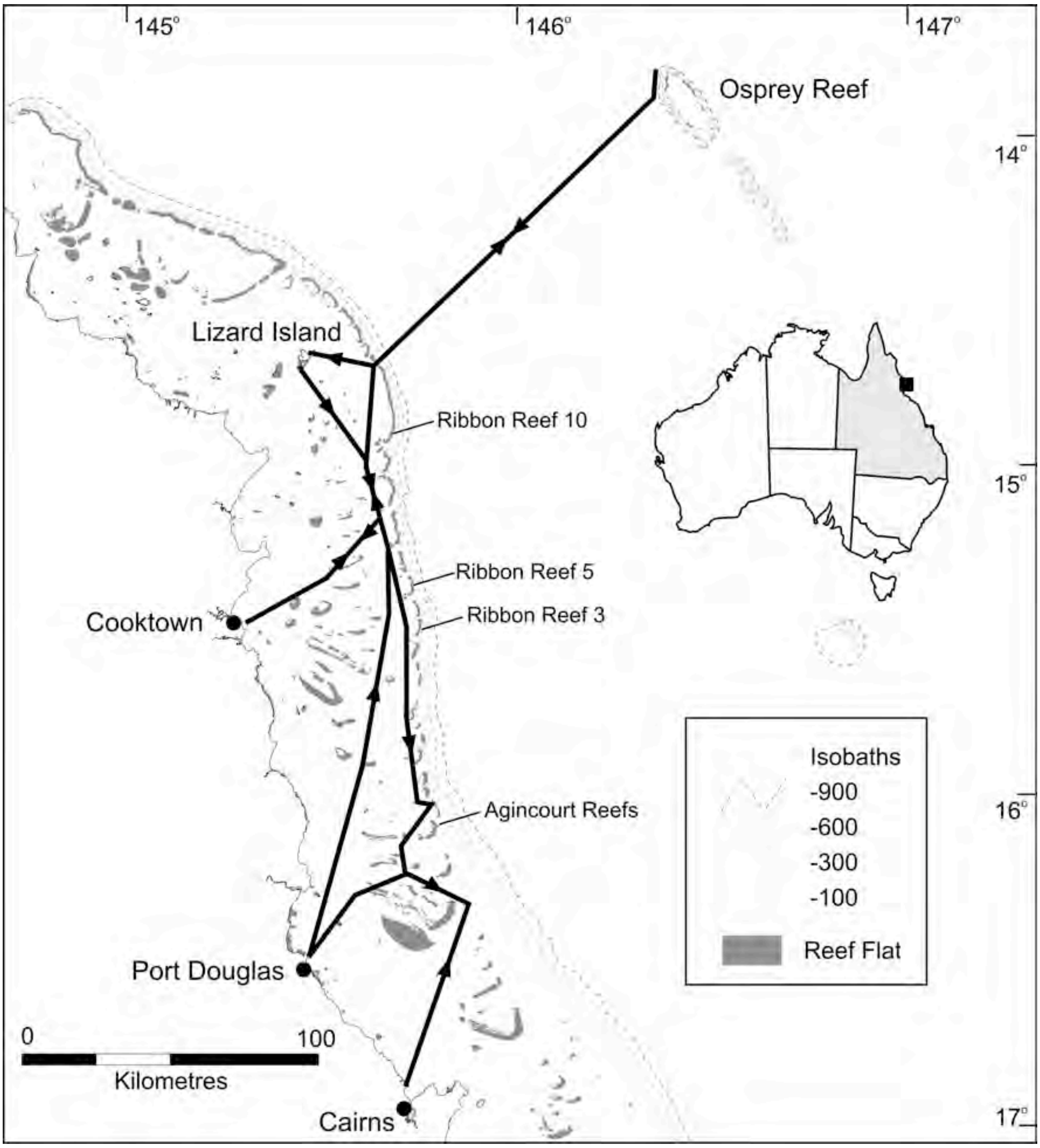
The cooperation and support from the SCUBA diving operators was essential to the successful outcome of this research. Without operator support, the platform to collect data specifically from certified SCUBA divers would not have been available. The live-aboard diving operators used in this research were most suitable to study certified SCUBA divers because they:

- Offer and advertise certified SCUBA diving opportunities as the primary activity;
- Attract a greater percentage of certified SCUBA divers with a wide range of diving histories (Birtles et al., in prep; Curnock, 1998) than day-trip operations (Rouphael & Inglis, 1995; Shafer et al., 1998), the other main alternative for certified SCUBA divers on the Great Barrier Reef (GBR);
- Visit a wide range of reef types and locations (outer reef, pinnacles, oceanic sea mounts), some of which are arguably the best and most pristine sites on offer from the GBR Marine Park (GBRMP) and Coral Sea; and
- Regularly visit the same core set of dive sites in the GBRMP and Coral Sea, allowing for a greater number of respondents to be surveyed on several different vessels over a short period of time.

Six live-aboard diving operators were selected, and all agreed to cooperate by allowing access to their passengers, and to the dive sites themselves via in-kind (free of charge) berth spaces for the researcher. All six operators are members of the Cod Hole and Ribbon Reef Operator Association (CHARROA). CHARROA is an industry association for operators working within the Ribbon Reef location of the GBR, and the Osprey Reef location in the Coral Sea (See Figure 2.1).

CHARROA members pay annual fees in exchange for use and maintenance of mooring systems at some of the most popular dive sites within the GBRMP and Coral Sea. Contact was initially made with the President of CHARROA regarding the aims and scope of the study. CHARROA and its members also have a long history of involvement with James Cook University research projects (see Birtles et al., in prep; Curnock, 1998; Valentine et al., 2004).

Figure 2.1. Map of Cairns to Lizard Island showing the location of the Ribbon Reefs on the Great Barrier Reef and Osprey Reef in the Coral Sea, as well the general trip routes taken by the live-aboard diving operators used in this study.



After an initial presentation of the research objectives and project outline to the each of the operators during a CHARROA meeting in Cairns, CHARROA granted the approval for the research to be undertaken. Operators were then individually approached and information was given regarding what was expected of the passengers and the crew during the study. Each operator was assured that information collected in the study concerning specific boats was strictly confidential, and that this would neither be published nor released to managers or other operators. Ethics approval for the use of human participants was first obtained through the James Cook University Human Ethics committee (approval number H1495).

2.2.1 Description of the live-aboard diving operations used for this study

The six live-aboard diving vessels range in size from 21 to 37m, are ocean going motor vessels, and are either single hull or catamaran in design (Table 2.1). Single hull vessels are better equipped for open-ocean crossings to Osprey Reef, while catamarans have greater deck space and stability in moderate weather conditions that are usually experienced within the GBR lagoon. Regardless of vessel size and design, each is able to operate in heavy seas (>3m), and only severe weather conditions such as tropical cyclones would restrict them from leaving port. The vessels carry between 12 and 28 passengers for four to six days, depending on the operator and locations visited (Table 2.1).

Live-aboard diving trips offer certified SCUBA divers a greater range of travel to remote locations such as the Ribbon Reef and Osprey Reef locations, which are of lower human visitation and infrastructure than day-trip sites (e.g. do not have permanent pontoons). To provide an indication of the distance covered by operators to visit a wide range of sites, from Cairns to the top of Ribbon Reef No.10 is approximately 275km (straight line distance), and from the top of Ribbon Reef No.10 to Osprey Reef is a further 150km (straight line distance). Because of the remoteness of the locations, and the small membership of CHARROA, these six operators are the only vessels to commercially use these sites on a regular basis with the exception of one day-trip operator from Lizard Island. This small boat (capacity of 10 including crew) visits only a few sites at the northern tip of Ribbon Reef No.10, and at most only a few times a week because of variations in demand and weather conditions.

Table 2.1. Description of the six live-aboard diving vessels used in this study and their typical trip itineraries.

Vessel*	Vessel length	Cruising speed	Passenger capacity	No. of crew	Trip Duration (nights)	Typical Itinerary
Nimrod Explorer (Catamaran)	21m	9kn	18	6	3/4	Departs Cairns Saturday 4 pm, steam north, diving along Ribbon Reefs to Cod Hole; Visits Pixie Pinnacle, Steve's Bommie, and Cod Hole. Thursday morning passenger changeover at Cooktown – new passengers fly in from Cairns, Departs Cooktown 4 pm diving Ribbon Reefs and Osprey Reef. Visits Cod Hole, Pixie Pinnacle, North Horn and Admiralty Anchor. Tuesday morning passenger changeover in Cooktown. New Passengers fly in from Cairns: vessel steams south from Cod Hole along Ribbon Reefs; Visits Cod Hole, Pixie Pinnacle, and Steve's Bommie. Returns to Cairns Saturday 7 am.
Spirit Of Freedom	37m	12kn	28	9	3/4	Departs Cairns Saturday 12pm, steam Northeast to Osprey Reef (Weather permitting); Sunday and Monday diving at Osprey Reef; overnight steam to Steve's Bommie. Steam south diving along Ribbon Reefs; Visits Admiralty Anchor, North Horn, Steve's Bommie. Thursday 7am return to Cairns, passenger changeover; Departs Cairns Thursday 12pm, steam northeast to Cod Hole diving along Ribbon Reefs; Visits Steve's Bommie, Pixie Pinnacle, Cod Hole. Monday 7am return to Cairns.
Super Sport (Catamaran)	27m	14kn	26	8	4	Departs Cairns Thursday 11 am, steam north, diving along Ribbon Reefs to Cod Hole; Visits Steve's Bommie, Pixie Pinnacle, Cod Hole. Monday morning passenger change over on Lizard Island – new passengers fly in from Cairns, completing guests fly back to Cairns; vessel steams south, diving along Ribbon Reefs from Cod Hole; Visits Cod Hole, Pixie Pinnacle, Steve's Bommie. Returns to Cairns early Thursday morning.
Taka II	22m	11kn	26	8	3/4	Departs Cairns Tuesday 5 pm, steam north to the Cod Hole overnight; Wednesday begin diving at Cod Hole and steaming south, diving along Ribbon Reefs; Visits Steve's Bommie, Pixie Pinnacle, Cod Hole. Friday 3:30 pm return to Cairns, passenger changeover; Departs Friday 5 pm, steam north to Cod Hole overnight, Saturday begin diving at Cod Hole; overnight steam to Osprey Reef (in Coral Sea; weather permitting); Sunday diving at Osprey Reef; overnight steam to Ribbon Reefs; Monday steaming south, diving along Ribbon Reefs; Visits Cod Hole, Admiralty Anchor, North Horn, Pixie Pinnacle, Steve's Bommie. Tuesday 3:30 pm return to Cairns.
Undersea Explorer	25m	8kn	20	6	6	Departs Port Douglas Saturday 8pm, steam north, diving along Ribbon Reefs to Cod Hole and then to Osprey Reef for 2-3 days (Weather and Itinerary dependent); Visits Pixie Pinnacle, Cod Hole, Admiralty Anchor, North Horn, Steve's Bommie. Returns to Port Douglas Friday 5pm.
Diversity (Catamaran)	21m	18kn	12	5	2/4	Departs Port Douglas Wednesday 8 am, steam north to Agincourt and Ribbon Reefs. Thursday at Cod Hole; Visits Steve's Bommie, Pixie Pinnacle, Cod Hole. Friday 9.30 am return to Port Douglas, passenger changeover; Departs Friday 6pm, steam north to Cod Hole overnight, Saturday begin diving at Cod Hole; overnight steam to Osprey Reef (in Coral Sea; weather permitting); Sunday diving at Osprey Reef; overnight steam to Ribbon Reefs; Monday steaming south, diving along Ribbon Reefs; Visits Cod Hole, Admiralty Anchor, North Horn, Pixie Pinnacle, Steve's Bommie. Tuesday 12 pm return to Port Douglas.

* Vessels presented in alphabetical order. Order not associated with vessels A to F in following results. Itineraries current at August 2003. Table based on Birtles et al., (2002b)

Prices of live-aboard diving trips range from $500 (AUD) (standby rate) to over $3,000 depending on the sites visited, the time spent at sea, and the operator. Accommodation can be basic (4 bunks to a cabin), to luxurious (staterooms with four-post queen size beds and ensuites), and all boats are fully air-conditioned. All meals are prepared by a full time cook/chef and can range from buffet style to individually served meals. Service standards vary between operators, with some likened to that of a quality hotel with warm dry towels handed to passengers after each dive, and beds made daily. Underwater photographers are specifically catered for with fresh water rinsing bins and workspaces for equipment, and in some cases on-board film processing and tuition.

Two of the operators have designated crew positions for marine biologists to interpret the reef environment to their passengers, adding value through education to the tourist experience.

During a live-aboard diving trip, divers will visit up to 20 different dive sites, each differing in physical and biological attributes. The physical topography of the sites visited on the Ribbon Reefs includes coral gardens, back reef slopes, large isolated pinnacles, and coral reef walls. On Osprey Reef, there are clearer oceanic waters and 1000m vertical drop offs. The biological communities at each of the sites can differ remarkably, from large predatory fish and sharks, to swarming clouds of planktivorous fishes, to small and shy marine life from a diverse range of taxa. The coral assemblage at each of the sites also differs from lush coral gardens of branching and plate corals, to isolated bommies interspersed with sandy clearings, to robust brush like corals. Due to extended days at sea, live-aboard diving trips also offer divers night diving opportunities.

The general itinerary for each of the operators is as follows. Each vessel departs from one of four ports: Cairns, Port Douglas, Cooktown, or Lizard Island. For passengers departing from Cooktown or Lizard Island, a low level flight from Cairns is part of the trip because of the remoteness of these ports to major population centres. Vessels departing from all ports except Lizard Island will move north along the Ribbon Reefs, diving at the many dive sites within this location. A roster system of site use has been constructed by the operators to suit each of their itineraries to make sure that they are able to visit some of the more popular sites such as the Cod Hole, Steve's Bommie, and Pixie Pinnacle.

Depending on the operator and the trip duration, these Ribbon Reef dive sites may be the highlight of the trip itinerary. However, five of the six operators offer an overnight steam east across the Coral Sea to visit Osprey Reef (weather permitting – maximum 35 knot winds and/or 4-5m seas, especially if the wind is blowing from a west-south-west direction which is almost side on to the vessels travel path). Once at Osprey Reef, divers are taken to between three and five different sites, again depending on the operator, the weather, and the time spent at this location. One operator spends only one day at Osprey Reef, while the others spend between two and three (weather and itinerary permitting).

Regardless of the operator or the time spent at Osprey Reef there are two sites that are visited more regularly. These are: Admiralty Anchor, and North Horn. Upon completing the dives at Osprey Reef, vessels again undertake an overnight steam back to the Ribbon Reefs. Once back on the Ribbon Reefs, divers get the opportunity to dive additional sites on their way back to port. In doing this round trip, some vessels will travel in excess of 800km, within as little as four days.

A regular day on a live-aboard diving vessel will include four dives, with divers participating in as many of these as they please. The first three dives are undertaken during daylight hours, while the fourth dive of the day is usually a night dive. Each dive is separated by a surface interval, or a period of time that is not spent underwater. Surface intervals are a minimum of two hours long. While these intervals are essential for divers to 'off-gas' excess nitrogen taken up by the body during SCUBA diving activities, the time is spent by passengers reading, watching videos, sleeping, eating, socialising with other passengers, or receiving formal or informal information from the crew. During the trip, boats will move from site to site between daytime dives to provide access to a range of dive sites. However, where large distances need to be covered, vessels will steam overnight (up to 12 hours).

Live-aboard diving trips provide certified SCUBA diving opportunities on some of the most highly regarded dive sites in the GBRMP and Coral Sea. Day-trip operators that focus on providing a Reef experience in a single day simply cannot offer these opportunities with existing technology because of their remoteness.

2.2 Selection of study sites

Six of the operators selected for this research visit a wide range of dive sites from the Ribbon Reef location, and five of the operators also visit the Osprey Reef location. The sites visited are selected by operators as part of their itineraries because of the safe diving and boating conditions they offer, but also because they provide visitors with quality diving experiences (Birtles et al., in prep). Therefore the study sites selected for this research were a subset of those sites that had been pre-selected by the dive operators. Five study sites were selected for this research because they:

- Are well distributed along the general trip itinerary for operators from both the Ribbon Reef and Osprey Reef locations, the two major destinations for the live-aboard diving operators selected for this research;
- Provide certified SCUBA divers a variety of coral reef diving opportunities through differences in the physical and biological attributes that occur at the sites;
- Are key features of live-aboard diving operators' itineraries from both the Ribbon Reef and Osprey Reef locations;
- Are regularly visited by each of the operators selected for this study allowing for a greater number of certified SCUBA divers to be surveyed on several different vessels over a period of time; and
- Were ranked the best dive sites from the Ribbon Reef and Osprey Reef locations in a previous study investigating live-aboard divers experiences (Birtles et al., in prep) (see Table 1.2, Chapter One).

The five study sites selected for this research were found within the two locations visited by the operators. There were three sites from the Ribbon Reef location: Steve's Bommie (SB), Pixie Pinnacle (PP), and the Cod Hole (CH) (Figure 2.2). The two remaining sites, Admiralty Anchor (AA) and North Horn (NH), were from the Osprey Reef location (Figure 2.3). Table 2.2 shows the level of use of the selected study sites by each of the six operators, and also the total use of the study sites by all six operators, expressed as the number of dives undertaken at that site per year. This estimate is based on the actual number of passengers over the sample period on five of the vessels (n=3740; Table 3.2), and the actual number of passenger berths on these vessels over the sample period (4838) providing a 77.3% passenger capacity. This estimate does not include crew dives, and other less frequent users such as charter vessels, more seasonal operators, and private vessels. Therefore the actual numbers are considerably higher.

Table 2.2. The level of use of the five selected study sites by the six live-aboard diving vessels used in this study expressed as the number of dives undertaken by passengers per year.

	Live-aboard diving vessels						
	Diversity	Nimrod Explorer	Spirit of Freedom	Super Sport	Taka	Undersea Explorer	**Total**
Passenger Capacity	12	18	28	26	26	20	**130**
77.3% Passenger Capacity	9	14	22	20	20	15	**100**
Trips Per Week	2	2	2	2	2	1	**11**
Passengers Per Week	18	28	44	40	40	15	**185**
Weeks Per Year	49	49	49	49	49	49	**294**
Passengers Per Year	882	1372	2156	1960	1960	735	**9065**
Ribbon Reef location							
Visits to SB Per Week	2	2	2	2	2	2	**12**
Dives at SB Per Year	882	1344	2156	1960	1960	1470	**9772**
Visits to PP Per Week	2	2	2	2	2	1	**11**
Dives at PP Per Year	882	1344	2156	1960	1960	735	**9037**
Visits to CH Per Week	4	4	4	4	4	2	**22**
Dives at CH Per Year	1764	2688	4312	3920	3920	1470	**18074**
Osprey Reef location							
Visits to AA Per Week	1	2	2	0	1	2	**8**
Dives at AA Per Year	441	1372	2156	0	980	1290	**6239**
Visits to NH Per Week	2	2	2	0	2	4	**12**
Dives at NH Per Year	882	1372	2156	0	1920	2550	**8880**

Estimates are based on all vessels in the study running at 77.3% passenger capacity over a 41-week period (data on actual passenger numbers taken from Table 3.2.). Undersea Explorer does not visit the Osprey Reef location for six weeks during minke whale season, and so the number of dives at the Osprey Reef sites has been adjusted accordingly. Sites are: Steve's Bommie (SB); Pixie Pinnacle (PP); Cod Hole (CH); Admiralty Anchor (AA); North Horn (NH). Vessels presented in alphabetical order. Order not associated with vessels A to F in following results. This estimate does not include crew dives, and other less frequent users such as charter vessels, more seasonal operators, and private vessels. Therefore the actual numbers are considerably higher.

Figure 2.2. Map of the northern Ribbon Reefs showing the position of the three study sites at this location.

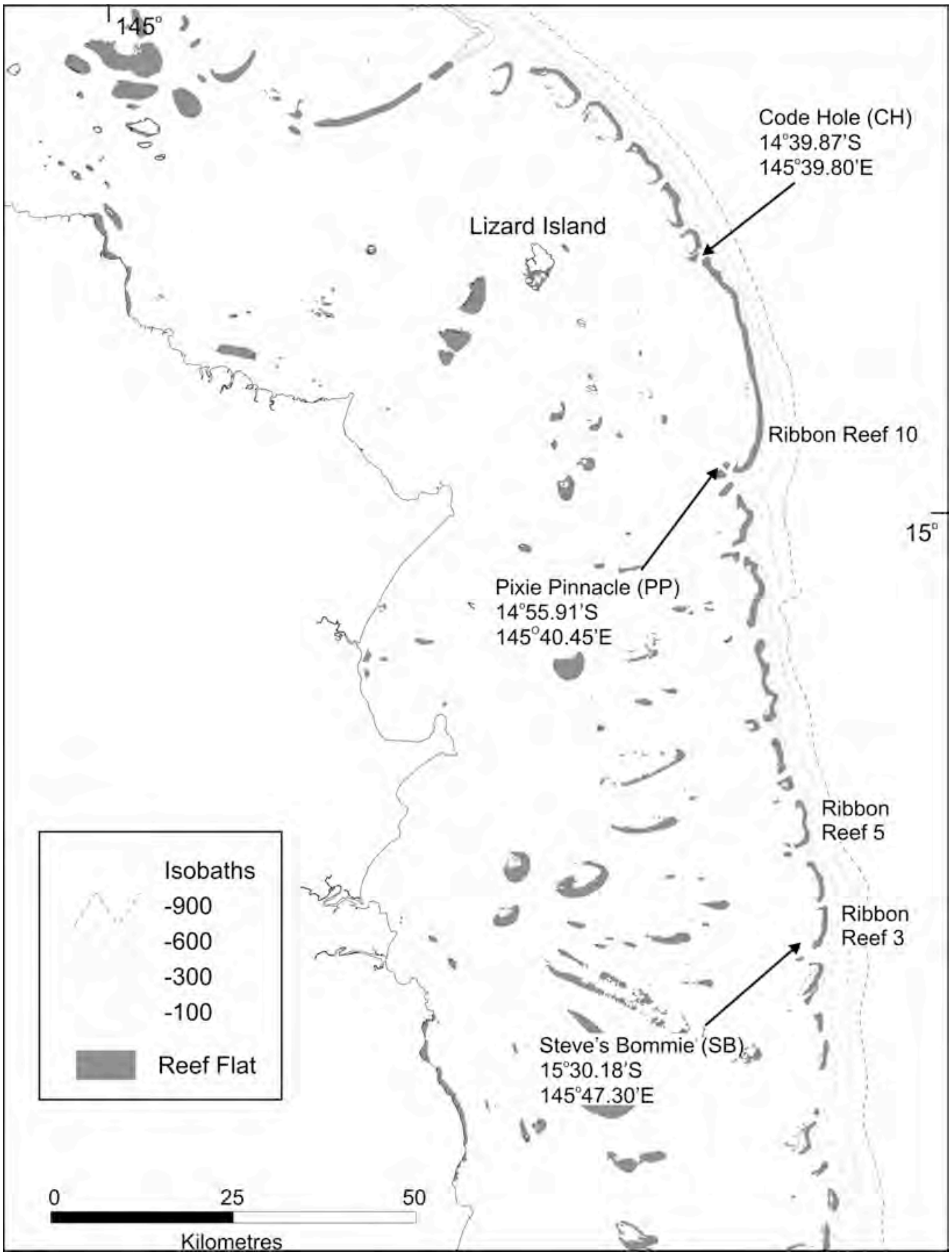
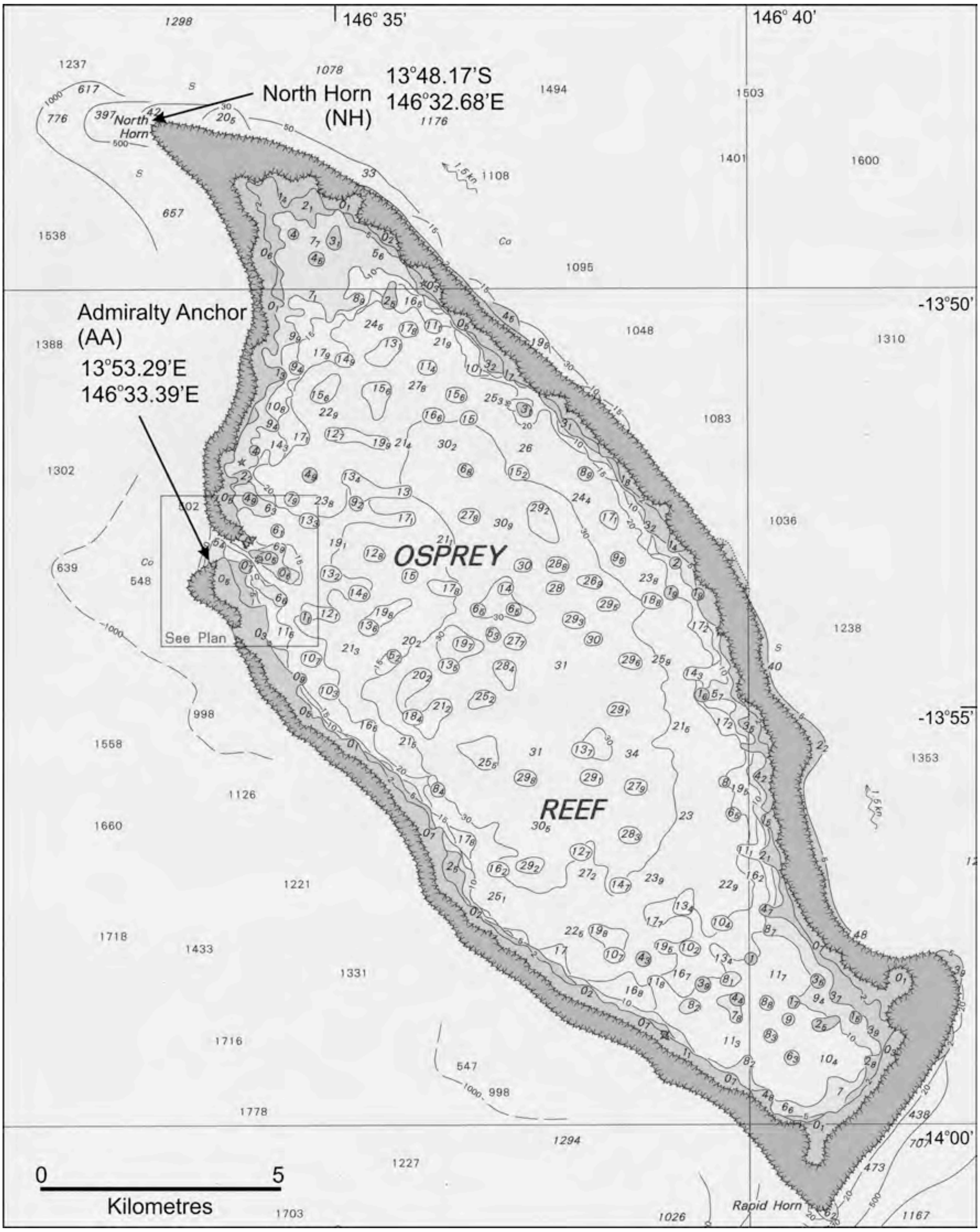


Figure 2.3. Map of Osprey Reef in the Coral Sea highlighting the two study sites at this location (depths are given in metres).



Source: Osprey Reef and Shark Reef [chart] Australian Hydrographic Chart, 1:100000, AUS616 (sub chart 1), Wollongong, N.S.W., Hydrographic Service, Royal Australian Navy, 1996

2.2.1 Brief description of study sites

This section provides a brief description of the Ribbon Reef and Osprey Reef locations, and then each of the five study sites including their position, brief history, site description, level of use, and zoning status. A comprehensive account of each dive site, including the site map, the information presented to the SCUBA divers within the pre-dive briefing, and the typical swim behaviour of the SCUBA divers, is given in Chapter Four.

Ribbon Reef location study sites – Great Barrier Reef

The Ribbon Reefs are a set of ten major reefs on the outer edge of the GBR on the edge of the continental shelf (Figure 2.1). These reefs get their name from their long ribbon like geomorphology. The Ribbon Reefs start at 14°18.26'S, 145°39.00'E, and run down to 15°32.01'S, 146°12.80'E. These reefs fall within GBR bioregion RA2, characterised by distinct geomorphology, coral and fish with Coral Sea influence, and with leeward reef benthos having a mix of clear-water and coastal species (GBRMPA, 2004). The natural attractions of the reefs in the Cairns and Whitsunday's planning areas are the focus of a rapidly expanding tourism industry which accounts for over 85% of the total annual tourism visitation to the GBRMP (Harriott, 2002).

Management of the Ribbon Reef Sector of the Cairns Area Plan of Management falls under the authority of the GBRMP Authority (GBRMPA) and the Queensland Park and Wildlife Service (QPWS). The *Great Barrier Reef Marine Park Act 1975* is the main piece of legislation used to govern the GBRMP. This Act established the GMRMP and the GBRMPA, and provides a framework for planning, management, and ongoing care of the natural assets of the GBR (GBRMPA, 2003). Zoning plans are the primary management tool used by the GBRMPA to separate conflicting activities and outline where specific activities, such as recreational and commercial use, can occur. Zones progress from general use to strict preservation with permits required for particular activities such as commercial tourism and fishing. Before July 1, 2004, the GBRMP had less than 5% of the 350,000km^2 Marine Park area zoned as 'no-take' zones (called Green zones). On July 1, 2004, an increase in the percent of 'no-take' protection to 33.3% of the Marine Park (114,530km^2) became Australian law, an initiative of the

Representative Areas Program (RAP) undertaken by the GBRMPA. This provided a much higher level of protection for the natural resources of the GBRMP from extractive activities.

Ribbon Reef location - Steve's Bommie (SB)

Steve's Bommie (SB) is a large pinnacle rising from a sandy bottom at 32m. Its base is approximately 60m in diameter with the tip at 3m below the surface being approximately 3m in diameter. Its geographic location is close to Ribbon Reef No.3, but is isolated from the reef proper and lies approximately 3km to the west (see Figure 2.2). Coordinates for this site are 15°30.18'S, 145°47.30'E. SB is exposed to the weather conditions, but is somewhat protected by the southern tip of Ribbon Reef No.3 and the northern tip of Ribbon Reef No.2, from the oceanic swell coming in from the Coral Sea. Until 2002, access to this site was via anchor on sandy grounds. Since then a five block mooring system has been installed approximately 50m southeast of the pinnacle. An additional 5-block mooring has also been placed on the western margin of the pinnacle base. Both of these moorings are the initiative of CHARROA. SB gets its name from a deceased crewmember that used to work in the industry in this area. This was his favourite site and has thus been named in his honour, and a plaque has been placed at 25m toward the base of the pinnacle. SB receives the second highest level of use of the five sites selected for this study, and operators usually offer divers one or two dives in a single trip (weather and operator schedule permitting). Use is estimated at 9,772 dives per year (Table 2.2).

Before July 1, 2004, SB was zoned 'General Use Zone' of the GBRMP. The classification of this zone was 'to provide areas of Marine Parks for a diverse range of recreational and commercial activities, consistent with the Region's long-term conservation'. General Use Zones allowed non-extractive (diving, boating, anchoring, photography), extractive (line fishing, trolling, spear fishing (snorkel only), collecting, bait gathering (by hand), crabbing, oyster gathering, commercial netting, trawling, and aircraft activities to take place. Only mining and oil drilling were precluded. All other activities could take place, although many would require a permit. The site itself therefore had very little protection. This was a matter of considerable concern to researchers and the industry and was one of the driving forces behind the initiation of this project. After July 1, 2004, SB was rezoned in the RAP as ‘no-take’ zone. This prevented all of the above activities except boating, diving and photography. However, with a permit from the GBRMPA, research, shipping (other than in a designated shipping area), and tourism program activities are allowed. This has provided a higher level of protection from extractive activities for this site.

Ribbon Reef location - Pixie Pinnacle (PP)

Pixie Pinnacle (PP) is a smaller pinnacle than SB, rising approximately 29m from a sandy bottom with a base diameter of approximately 30m. PP (14°55.91'S, 145°40.45'E) is a separate isolated pinnacle less than 80m from Pixie Reef (Marine Park code 14-152) between Ribbon Reefs No.9 and 10 (Figure 2.2). PP also has two sets of five block moorings, one to the southeast approximately 50m, and one to the west approximately 20m from the base of the pinnacle. These moorings were installed through CHARROA initiatives. PP was rated the second highest coral reef ‘must dive’ for the GBR region due to its high marine biodiversity and abundance (Sawer, 2004). PP receives the third highest level of use of the five sites selected for this study, with operators offering divers one to two dives in a single trip. Use is estimated at 9,037 dives per year (Table 2.2). Before July 1, 2004, PP was zoned as a General Use Zone. After July 1, 2004, PP was also rezoned as a Green or ‘no-take’ zone.

Ribbon Reef location - The Cod Hole (CH)

The Cod Hole (CH) is situated at the north western tip of Ribbon Reef No.10 (Marine Park code 14-146) 14°39.87'S, 145°39.80'E (Figure 2.2). This site is a sheltered back reef site due to the protection from wave action by the reef flat to its east. The CH is flushed with clear oceanic water (providing up to approximately 30m horizontal visibility) every full tide due to its close proximity to the outer edge of the GBR and Coral Sea. However, it is also prone to the effects of the outgoing tide from the GBR lagoon, and visibility at this time can often be quite poor (as little as approximately 5m horizontal visibility). Because the CH runs parallel to a 35m deep and relatively narrow (approximately 1km) channel, the site often exhibits high current flow, the direction depending on the tide. The CH is not a physical hole as the name would suggest but an area some 300m long, and 60m wide (Alder & Haste, 1994). The site is a back reef sandy area ranging between 5m depths near the reef flat to approximately 20m toward the channel, where it gently slopes into a sandy gully 35m deep. Within the back reef, which is the main dive area, are a maze of coral bommies and ridges of all shapes and sizes. There are four moorings at this site (screw moorings that are physically screwed into the reef limestone substrate – two installed by GBRMPA and two installed by CHARROA).

Since the discovery of the resident potato cod (*Epinephelus tukula*) population at this site in 1972, the CH's popularity as an international dive destination has risen rapidly (Alder & Haste, 1994) and it is one of the most famous sites for SCUBA diving activities on the GBR (Vail & Hoggett, 1997; Valentine et al., 1997). In a recent dive magazine article, the CH was rated the highest coral reef 'must dive' site in the GBR region due to its resident population of potato cod and picturesque coral gardens (Sawer, 2004). In the years 1994 and 1995 the CH was estimated to be visited by over 20 different operators, with a monthly average 1000 passengers, most of whom were divers (Valentine et al., 1997). If it is assumed that each of the divers made at least two dives, which most operators offer, then the number of estimated dives undertaken annually between 1994 and 1995 could be taken at 24,000. The number of dives undertaken annually at the CH by the six vessels in this study is estimated at 18,074 (Table 2.2). It should be noted that this site receives additional and substantial use when the day-trip operator from Lizard Island, and the many other charter and private vessels that visit this site annually, are taken into consideration. Therefore, the current total is considerably in excess of 18,074 dives, meaning that this site has the highest level of use of all the Ribbon Reef and Osprey Reef sites selected for this study, and is likely to be one of the most heavily dived sites on the GBR.

The CH was first discovered in the early 1970s by game fishers and dive adventurers (Alder & Haste, 1994). At this time there was concern that the potato cod population and the site might be destroyed by over fishing and site destruction through anchor damage, and until 1975 when the Great Barrier Reef Marine Park Act was passed, there were no mechanisms in place for the management of the CH and its resources. It was only in late 1981 when the Cormorant Pass Section that included the CH, was declared that regulations were developed to prohibit spearfishing and line fishing other than trolling in the area. However potato cod numbers were declining and fishing gear was found in fish’s mouths. Due to high demand of use by tour operators and the declining potato cod population the first Zoning Plan of the GBRMP, the Cairns-Cormorant Pass Zoning plan, was launched in 1983 and was effective until 1991. This provided a higher level of protection of the resources, while also allowing use by tour operators.

In 1991, a revised Cairns Section Zoning Plan was introduced which was aimed at limiting impact and use to the area. The National Park zone at the CH was extended to include the range of the cod and a “No Structures” sub-zone was applied to the entire area. In 1998 the CH was again rezoned in the Cairns Area Plan of Management as a ‘Sensitive Location’. Sensitive locations are identified as having special values (nature conservation, cultural and heritage, scientific or use values). Sensitive areas are managed for low or moderate levels of use, and are no-take zones. Other restrictions also apply, including maximum group size of 60 people per vessel to aircraft (including crew), no anchoring allowed, access for vessels or aircraft via moorings only, no mooring of vessels or aircraft to public moorings for more than four hours in any 24-hour period, and no motorised water sports or hovercraft. Since July 1, 2004, the CH was rezoned as a Green or ‘no-take’ zone.

Osprey Reef location study sites: Coral Sea

Osprey Reef is located at between 13°79'S, 146°54'E and 13°99'S, 146°70'E, within the Coral Sea Islands Territory, about 330 km north east of Cairns (Figure 2.1). It lies some 120 km east of the GBRMP and 550 km north north west of the Coringa-Herald and Lihou Reef National Nature Reserves. However it should be noted that Osprey Reef is not afforded similar protection to the Coringa-Herald and Lihou Reef National Nature Reserves, nor that of the Ribbon Reef dive sites of the GBRMP. Osprey Reef falls within Australian Territorial Waters, under the jurisdiction of the Australian Government, Department of Environment and Heritage.

Separated from Australia's continental shelf by the deep water Queensland Trough, Osprey Reef is the northernmost reef on the Coral Sea (Queensland) plateau. Osprey Reef is an isolated oceanic reef. It is elliptical in shape and covers approximately 195 square kilometres and is about 14 km long and 6 km at its widest point. Rising from a volcanic seamount the reef has steep walls with the water around Osprey Reef shelving to 1000m within one kilometre of the reef edge (Figure 2.3). The lagoon is almost totally enclosed, with only a narrow entrance on the western side of the reef. The maximum water depth within the lagoon is 30m. No regular diving activities are undertaken within the lagoon area. In a recent dive magazine article, Osprey Reef was rated the third highest ‘must dive’ from the GBR (Sawer, 2004).

Osprey Reef is the most highly used of all the Coral Sea reefs for SCUBA diving tourism. While other reefs such as Holmes, Bougainville (accessed from Cairns), and Flinders Reefs (accessed from Townsville) also attract live-aboard diving operators, none are visited as often, or by as many as Osprey Reef. Due to its remote location, only live-aboard operators access this reef. Osprey Reef has been used as a dive location for ten years by diving operators, with two of the operators used in this research visiting there on a weekly basis during this time, and several other operators visiting infrequently. However, in 2001 and 2003 three more of the CHARROA operators also started to visit Osprey Reef more frequently, and it soon became a key feature of their itineraries also. At present five of the six live-aboard diving operators used in this study visit the Osprey Reef location on a weekly basis (weather permitting), with the sixth operator soon to include this location in their itinerary.

Osprey Reef location - Admiralty Anchor (AA)

Admiralty Anchor (AA) is situated on the western midpoint of Osprey Reef 13°53.29'S, 146°33.34'E (Figure 2.3). Although AA is also situated on the reef wall, its main dive area is a plateau between 20 and 30m deep, and consists of a series of winding coral bommie ridges separated by sandy gullies. Once over the reef wall, the depth drops away dramatically to over 1000m. One of the main features of this site, and the reason for its name, is a large coral cave or ‘swim-through’ where divers are able to enter at one end, and exit at the other, virtually a tunnel through the coral. This swim-through is approximately 30m long, and about half way through, wedged deep in the coral, is an admiralty style ships anchor said to be over 100 years old. There is one coral mooring (chain wrapped around coral structure) at this site installed by CHARROA. Although this site has received considerably less attention in the popular press than the other sites selected for this study, it has high importance and value to the industry because it is one of the most dived sites on Osprey Reef. All operators visit here at least once during each trip, with some operators visiting this site up to three times in a single trip because of the safe mooring conditions, and passengers enjoyment of the site (Birtles et al., in prep). Use is estimated at 6,108 dives per year, the least of any of the sites selected for this study (Table 2.2).

Osprey Reef location - **North Horn (NH)**

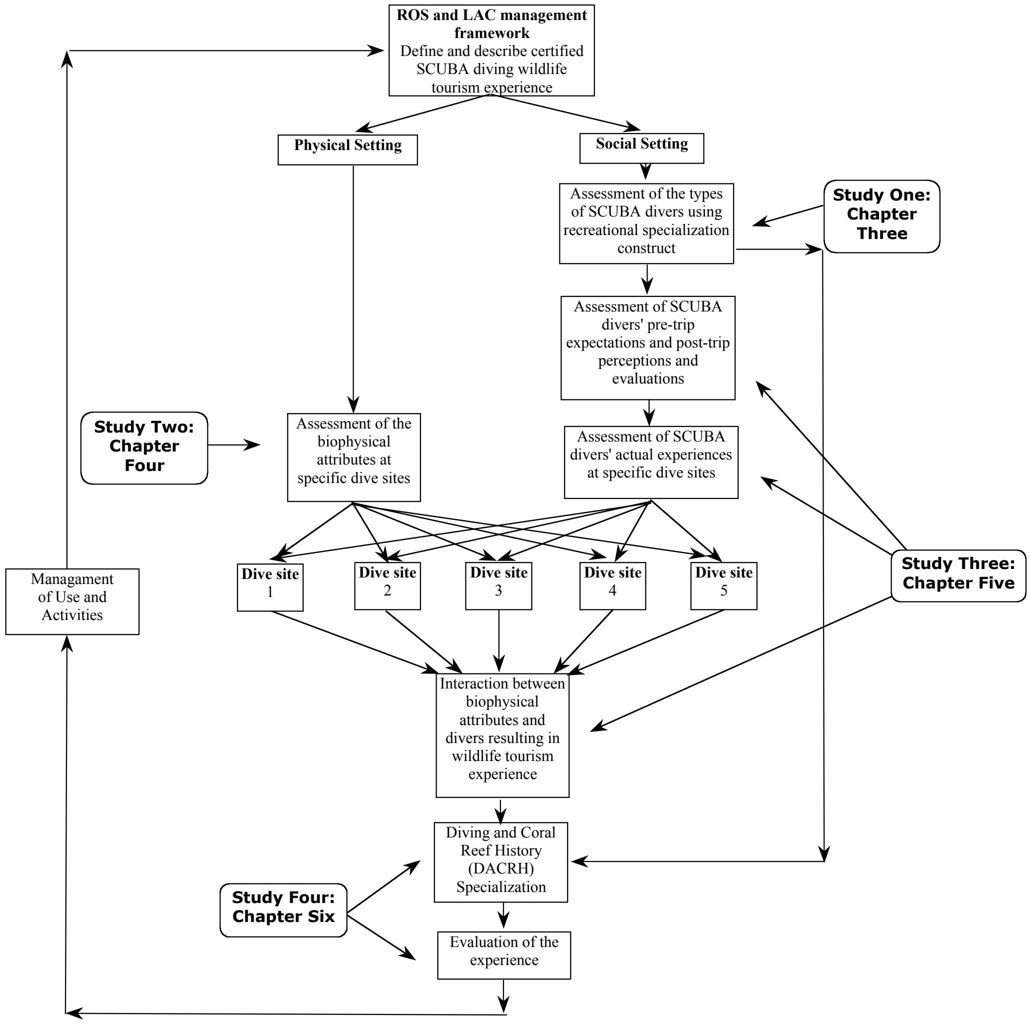
North Horn (NH) at Osprey Reef is the most northern tip of the oceanic reef, 13°48.17'S, 146°32.68'E (Figure 2.3) with several steep walls and drop offs. NH is prone to strong currents that travel along the east or west wall of Osprey Reef, depending on the tide. This is a high-energy site with considerable wave action and surge in the top 5m in winds over 15 knots. There are two reef moorings installed by CHARROA at this site on the northern tip that can only be accessed in south-east and north-east winds. NH is home to a resident population of white tip reef sharks (*Triaenodon obesus*) and grey reef sharks (*Carcharhinus amblyrhincos*), which are the main attraction of the site. This site has been the focus of many magazine and book articles, over ten different documentaries, and was recently listed highly in the world's the 'top 10 best shark dives' (AustralAsia SCUBA Diver, 2003). Use is estimated at 8,880 dives per year, the fourth highest of all the sites selected for this study, but the most heavily dived site at Osprey Reef (Table 2.2).

2.3 Research design

The objectives of this study were: To investigate certified SCUBA divers' wildlife tourism experiences on coral reefs using experience-based theoretical approaches; and to determine whether variations in experiences are related to participant's level of Diving and Coral Reef History (DACRH) Specialization using the recreational specialization construct. To achieve this, the research was set within the context of the Recreation Opportunity Spectrum (ROS) and Limits of Acceptable Change (LAC) management frameworks. To do this, a multidisciplinary approach was taken that required the natural sciences to measure and describe the biophysical attributes that occur at coral reef dive sites, and social sciences to understand the participants and the interactions they were having with the biophysical attributes that results in the wildlife tourism experience.

To define and describe the divers and their experiences, a four-study research program was designed (Figure 2.4). This design needed to: a) understand the types and profiles of the certified SCUBA divers that participate in live-aboard SCUBA diving trips (Study One, Figure 2.4); b) assess the biophysical attributes that are most likely to be encountered by the SCUBA divers on five coral reef sites from the Ribbon Reef and Osprey Reef locations (Study Two, Figure 2.4); c) understand the interaction between the SCUBA divers and the biophysical attributes that results in the wildlife tourism experience (Study Three, Figure 2.4); and d) investigate whether variations in divers' experiences can be explained by their level of DACRH Specialization (Study Four, Figure 2.4).

Figure 2.4. Four-study research design used to define and describe the certified SCUBA diving opportunity class in this thesis.



The following four sections (2.3.1 to 2.3.4) provide a brief description of the research methodology used in this thesis in order to address the research objectives. An introduction, more detailed methodology and analysis, can be found in the four subsequent Chapters for each of the four studies outlined below.

2.3.1 Study One – Understanding certified SCUBA divers: An application of the recreational specialization construct (Chapter Three)

In Step 2 of the LAC planning process, which is an extension of the ROS management framework, the types of participants must be described and defined to understand the certified SCUBA diving experience. Previous research has shown that there is a wide range of certified SCUBA divers that participate in diving tourism activities (Birtles et al., in prep; Curnock, 1998; Rouphael & Inglis, 1995), and that these should range broadly from ‘beginners’ to ‘specialists’, depending on their level of activity and setting history (Bryan, 1977).

Study One is an assessment of the types and profiles of the certified SCUBA divers visiting the Ribbon Reef and Osprey Reef locations, and uses the recreational specialization construct (Bryan, 1977) to provide the tools to segment the certified SCUBA divers into definable units based on their level of diving and coral reef history. This was achieved by conducting a survey of passengers on live-aboard diving trips visiting the Ribbon Reef and Osprey Reef locations, using on-site self-administered questionnaires. Both open-ended and closed type questions were used to collect information regarding demographics, previous diving and coral reef history, ownership of SCUBA related equipment, and the levels of coral reef interest and knowledge. Using the information collected in these questionnaires, the SCUBA divers were then segmented into four groups using a Multidimensional Recreational Specialization Index (MRSI) based on the amount of participation, training and associated skills, and coral reef setting history. Combined, this created an index of Diving and Coral Reef History (DACRH) Specialization. A profile of the SCUBA divers within each of the four groups was then constructed to show separation between each group. The four DACRH specialization groups termed ‘beginner’, ‘intermediate’, ‘enthusiast’, and ‘specialists’, were specifically designed to investigate variations in the certified SCUBA diving experience (Study Four). A detailed account of the methods used for Study One can be found in Chapter Three.

2.3.2 Study Two – Assessment of the biophysical attributes that occur on selected coral reef dive sites (Chapter Four)

In order to understand the experience opportunities that coral reefs provide for the purpose of tourism and recreation, the biophysical attributes that occur at these sites need to be measured (Driver et al., 1987; Hammitt et al., 1993). However, these must be measured and described in a way that is informative of the interactions that occur between the SCUBA divers and the environment. To do this, the typical swim-behaviour of the SCUBA divers at specific sites must be replicated as much as possible to ensure what the researcher measures, are also the attributes most likely to be encountered by the SCUBA divers. Information that needed to be collected at specific sites included the physical attributes (e.g. the abiotic or non-living attributes such as the physical landscape and the horizontal visibility of the water), and the biological attributes (e.g. the species and number of organisms available to be seen) (Driver, 1985; Hammitt et al., 1993), and how predictable certain species are within a given spatial and temporal scale (Duffus & Dearden, 1990).

Study Two was an assessment of the biophysical attributes that occur at five selected coral reef dive sites from the Ribbon Reef and Osprey Reef locations over a 10-month period. The five sites were selected as they differed in location, and the biophysical attributes that occur there, allowing for an investigation of a variety of coral reef SCUBA diving opportunities. To ensure that measurements of the biophysical attributes by the researcher were also those most likely to be encountered by the SCUBA divers, the typical swim behaviour of the SCUBA divers was mapped at each of the sites using the researcher's extensive local knowledge, and information provided by the live-aboard diving operators and crews. Once mapped, a visual census technique, a modification of the Roving Diver Technique (RDT) (REEF, 2002b), was designed to assess the sites. Four separate surveys were conducted using the Modified RDT (MRDT) to capture the range of biophysical attributes that occur on the coral reef dive sites. These surveys were:

- Survey 1 - Broad-scale site descriptions
- Survey 2 - Roving Diver Diversity (RDD) of corals
- Survey 3 - Roving Diver Diversity (RDD) of marine organisms
- Survey 4 - Standard and specific marine organism presence/absence and relative abundance monitoring

Survey 1 was designed to provide a rapid descriptive and qualitative assessment of the biophysical attributes that occur on coral reef dive sites, using variables adapted from the Australian Institute of Marine Science (AIMS) long term monitoring methodology (Miller, 2003), and those designed specifically for this study.

Survey 2 was designed as a descriptive measure of the diversity of coral species at each of the dive sites. It was not an exhaustive survey of the coral species present at each site, but an indication of the diversity of species a certified SCUBA diver is most likely to experience on a typical dive at each of the sites. This was termed the Roving Diver Diversity (RDD) of coral species.

Survey 3 was designed as a descriptive measure of the diversity of marine organisms other than corals at each of the dive sites. Just as in Survey 2, this was not an exhaustive measure of the diversity, but an indication of the diversity of species a certified SCUBA diver is most likely to experience on a typical dive at the site, and was termed the RDD of marine organisms.

Survey 4 was designed to provide an understanding of the presence/absence and abundance of a list of 'standard' and 'specific' organisms at the sites thought to be important to SCUBA divers' experiences, as indicated by Birtles et al., (in prep), Curnock (1998), and the live-aboard diving operators pre-diving briefings. This survey was conducted to determine the likelihood of certain species being seen by the SCUBA divers on each of the sites including both aspects of rarity and seasonality. Only with such information can we understand the specific influence of particular species on the divers' experiences. Therefore, the data collected was concerned with how often an organism was sighted at each of the sites over a 10-month period (sighting frequency), and when sighted, its relative mean abundance. Data were also collected on the depth and habitat type where organisms were sighted to understand where on each site the organisms was likely to be found. A detailed account of the methods used for Study Two, including each of the four surveys, can be found in Chapter Four.

2.3.3 Study Three – The influence of coral reef biophysical attributes on divers' experiences (Chapter Five)

Understanding visitors' experiences requires understanding their expectations, actual experiences, and perceptions and evaluations of the biophysical attributes that they encounter at specific sites. By examining the actual experiences that SCUBA divers are having at specific sites, coupled with detailed data regarding the biophysical attributes that occur there, we are able to understand the influence of these on the wildlife tourism experience (Birtles et al., in prep; Hammitt et al., 1993).

Study Three was an investigation of certified SCUBA divers' experiences in terms of their pre-trip expectations for the biophysical attributes to be encountered during the trip, and their post-trip perceptions and evaluations of the biophysical attributes encountered during the trip. This methodology allowed for a gap-analysis examination of the attributes that influence evaluations of the experience (Parasuraman & Zeithaml, 1988). Study Three also aimed to understand the actual experiences that SCUBA divers were having at the five study sites assessed in Study Two. This was to determine the influence of specific biophysical attributes on divers' experiences. This was achieved by linking the information that the divers provided on their actual experiences at the study sites with the biophysical data measured at the study sites. This approach was similar to that of Hammitt et al., (1993), who used the 'Quality of Wildlife Viewing Model' which considers both the quality of the wildlife viewing opportunities (measured as the species and number of animals that could be seen), and the visitors' experiences during actual encounters. This study also established the biophysical attributes most significant to divers' experiences.

To achieve this, the same on-site self-administered questionnaires used in Study One, and thus the same respondents, were used to collect data on divers' pre-trip expectations, actual experiences, and post-trip perceptions and evaluations. To do this a before-during-after questionnaire design was constructed (Parasuraman & Zeithaml, 1988). This questionnaire was run over a 10-month sampling period in conjunction with Study Two. This was to allow an understanding of the specific attributes that influence the SCUBA diving wildlife tourism experience, and how these differed within and between sites. A detailed account of the methods used for Study Three can be found in Chapter Five.

2.3.4 Study Four – The influence of Diving and Coral Reef History (DACRH) Specialization on divers' experiences

It is suggested that the experiences had by different types of visitors will be different and related to their level of history within the activity or setting (Driver et al., 1987).

The recreational specialization construct (Bryan, 1977) provides the tools to allow this notion to be tested in a marine tourism context.

Study Four combines the data sets from Studies One and Three, and investigates whether certified SCUBA divers level of DACRH Specialization (Study One) is able to explain variations in divers' experiences, measured in Study Three. To achieve this, the four DACRH specialization groups are compared, to test if differences occurred in the measurements of: a) the pre-trip expectations for the biophysical attributes to be encountered during the trip, b) actual experiences with the biophysical attributes at the study sites, and c) post-trip perceptions and evaluations of the biophysical attributes encountered during the trip. A detailed account of the methods used for Study Four can be found in Chapter Six.

This chapter has provided a brief description of the research methodology used in this thesis to investigate certified SCUBA divers' experiences on coral reefs, including diving operator and site selection. The next chapter, Study One, is an assessment of the types and profiles of the certified SCUBA divers that participate in the live-aboard diving trips to the Ribbon Reef and Osprey Reef locations. This study uses the recreational specialization construct to segment the sample into known levels of DACRH Specialization.

CHAPTER 3

UNDERSTANDING CERTIFIED SCUBA DIVERS: AN APPLICATION OF THE RECREATIONAL SPECIALIZATION CONSTRUCT

3.1 Introduction

The application of recreational specialization to the activity of SCUBA diving has not been studied, but is likely to apply for several reasons. Divers must be trained and certified in order to be able to SCUBA dive unassisted. There are several global training agencies like the Professional Association of SCUBA Instructors (PADI), SCUBA Schools International (SSI), and the National Association of Underwater Instructors (NAUI), however PADI is the largest of these. While each training agency differs slightly in the way that they teach participants how to dive, the structure of learning and the acquiring of skills is the same. Divers are trained in a clearly defined structure comprised of five broad certification levels that need to be completed in a sequential order from: Open Water (minimum certification level needed to dive unassisted), Advanced Open Water, Rescue Diver, Dive Master, and finally Open Water SCUBA Instructor (PADI, 1999). In completing each certification level, new knowledge and skills are acquired that allow divers to undertake more technical pursuits, for example deep diving, navigation, rescue procedures, and night diving. The acquiring of skills and knowledge eventually culminates in the Dive Master and Open Water SCUBA Instructor certifications, both recognised as professional certifications that allow the holder to lead commercial diving tours (Dive Master and Open Water SCUBA Instructor) and/or teach new and certified divers (Open Water SCUBA Instructor). Therefore, a natural and structured approach to recreational specialization already exists within SCUBA diving, something that is not seen in other recreational activities such as fishing, hiking, and birdwatching, all of which have received considerable attention within the recreational specialization literature.

Previous research has also shown that SCUBA divers who visit the Ribbon Reef and Osprey Reef locations vary widely in terms of number of years diving history (0 to 38 years), total number of dives (0 to 5,000), and certification level (Open Water to Open Water SCUBA Instructor) (Birtles et al., in prep; Curnock, 1998). Similar ranges in these measurements of SCUBA diving history are also seen in other diver populations from day-trips to the GBR (Rouphael & Inglis, 1995), divers at a Spanish resort (Mundet & Ribera, 2001), day-trips to the Florida Keys (Cottrell & Meisel, 2004; Meisel & Cottrell, 2004), and active and non-active divers in New York (Todd, 2000). Such varied history within the activity of diving is likely to mean that live-aboard diving trip participants, and SCUBA diver populations in general, will be scattered along the specialization continuum broadly from beginners to specialists.

Todd (2000) found that divers do develop from ‘beginners’ to ‘experts’, reflected by experience, skill, participation, knowledge, equipment, and commitment. However, no studies have yet defined specific differences and boundaries between diver groups, but only that divers do differ significantly the longer they participate. Todd (2000), through the use of a self-rating measure of development to segment the divers, had respondents place themselves in one of five categories including ‘beginner’, ‘intermediate’, ‘advanced’, ‘expert’, or ‘post-expert’. This approach relied solely on the ability of the divers to reliably perceive their own level of development, without clearly defined descriptions of what type of diver each category represented, or how any two groups differed. This also meant the researcher had no information as to why respondents chose one category and not another. While self-rating measures have proved to be successful in accurately segmenting populations in recreational specialization research (e.g. Scott et al., 2005), these have been multidimensional within their definition, and have used clearly defined descriptions of each category developed from previous research. While it is generally accepted by recreational specialization researchers that the construct is multidimensional, and in the past it has been measured this way, there is little consensus on how it should be measured.

The level of history that SCUBA divers have with coral reef settings also raises the potential for specialization within the type of activity, and thus the environment in which it takes place. There are many types of SCUBA diving activities, for example temperate diving, coral reef diving, cave diving, freshwater diving, ice diving, wreck diving, and technical diving. Understanding how much history a diver has with coral reefs will be an important consideration in determining how recreational specialization might influence divers' experiences on coral reefs. While it might be expected that the more diving history a diver has, and the more comfortable they are in the underwater environment, they more they are able to divert their attention to the marine life. How knowledge-driven this attention will be is likely to be modified by their level of history with the marine life and the environment.

3.1.1 Measuring recreational specialization in the interest of Diving and Coral Reef History (DACRH) Specialization.

Participation

Increased participation within an activity is characterised by a focussing of behaviour and commitment for an activity from the general to the specialised (Bryan, 1977). Participation has been measured by recreational specialization researchers in terms of number of years of activity history, frequency of participation, and the number of sites visited for example (Bricker & Kerstetter, 2000; McFarlane, 1994; Scott et al., 2005; Scott & Shafer, 2001; Sutton, 2001, 2003). Participation within diving can also be measured in similar ways by understanding how long participants have been diving (number of years diving history), and in that time how many times they participated (the total number of dives).

Training and associated skills

The level of training and associated skills participants bring to an activity is measured differently depending on the activity in question. Many researchers have recognised that the longer a person participates in an activity, the more skills and knowledge they are likely to accumulate. Bryan (1977) looked at the technique trout fishers used to catch fish as an indicator of specialization, while McFarlane (1994) found that identification ability of birdwatchers increased with the number of trips they had taken over the last year and the distance travelled to see particular birds and habitats. However, Scott and Shafer (2001), warn that such measurements should be treated as a unique dimension of participant progression within an activity, and thus be conceptually distinct from past experience. This is due to some participants demonstrating high levels of skills and knowledge but participating infrequently, while the opposite is also true. For these reasons, the dimension of training and associated skills should be measured for SCUBA divers using at least two variables.

Training levels in SCUBA diving are quite clear and easily measured because they are sequential. Divers may only progress to higher certification levels in a set order, with the three higher certification levels having a prerequisite number of total dives. Embedded in this training structure is the acquiring of knowledge, which is specifically tested, and the development of a large range of skills including deep diving. For example, newly certified divers are recommended to maximum depths of 18m, while Advanced Open Water divers are recommended to dive to a maximum of 30m. All other certification levels are recommended to dive no deeper than 42m, the recreational no-decompression depth limit (PADI, 1999). Thus, the highest certification level for participants not only represents the formal recognition of training, skills, and knowledge, but is also an indicator of recreational specialization within the activity.

Some SCUBA divers might only have the minimum certification level (Open Water) yet still participate very frequently and for long periods of time. It is not essential that divers progress to higher certifications if they have no desire to do so. If this is the case it is likely the acquisition of skills still continues, as in other activities like fishing that have no formal training programs. Todd (2000) found that the maximum diving depth participants had been to was a suitable indicator of skill, with the least developed divers having dived to much shallower depths than 'experts'. The deeper a diver has been, the more they are likely to have progressed within the activity. Training and associated skill measurements are essential additions in characterizing recreational specialization within the activity of SCUBA diving.

Setting history

History and repeat experience in a particular setting might indicate that participants are also able to become specialists with respect to an environment, and may exhibit specific preferences and evaluations for such places (Driver et al., 1987). Orientation of the setting is also a major component of the conceptual framework of recreational specialization according to Bryan (1977), especially if the activity can take place in several different settings, or variations within a setting. Bryan was very particular about this measurement, finding that the highest fisher specialization group had distinct preferences for specific water types, such as streams instead of lakes, or even bends within a stream. Furthermore, Jacob & Schreyer (1981), propose that increasing amounts of participation for fishers should make them more familiar with site attributes and resources, be more sensitive to changes in the resource, and show greater understanding and support of management practices aimed at reducing adverse user impacts on the resource.

SCUBA divers with high levels of setting history in coral reef environments might also be more familiar with site attributes and resources likely to be found at sites. With familiarity should come increased knowledge levels for the setting (Duffus & Dearden, 1990). It is essential that the level of history in coral reef settings be explicitly measured as a component of SCUBA divers' recreational specialization, and the degree of knowledge tested, if we are to understand what effect this may have on certified SCUBA divers' experiences on coral reefs.

3.2 Objectives

In light of the recreational specialization construct's ability to segment participants in an activity into definable groups along the specialization continuum from beginners to specialists, the objectives of this study are:

1. To determine the types of certified SCUBA divers participating in live-aboard diving trips to the Ribbon Reef and Osprey Reef locations in terms of their:

    - demographics;
    - previous SCUBA diving history;
    - ownership of SCUBA related equipment;
    - previous history of SCUBA diving in coral reef environments; and
    - level of coral reef interest and knowledge.

2. Construct a Multidimensional Recreational Specialization Index (MRSI) based on the amount of participation, training and associated skills, and setting history, in order to segment the sample of certified SCUBA divers into four Diving and Coral Reef History (DACRH) specialization groups to:

   - determine the extent to which the DACRH specialization groups differ with respect to diving and coral reef history measurements, and ownership of SCUBA related equipment; and
   - determine the extent to which DACRH specialization groups differ with respect to the level of coral reef interest and knowledge.

3.3 Methods

This section provides a detailed account of the methods employed to undertake Study One and begins with the sampling technique used to collect the data from the certified SCUBA divers participating in live-aboard diving trips to the Ribbon Reef and Osprey Reef locations. The design and content of the questionnaire given to respondents is then presented. The development of the four DACRH specialization groups is detailed, including the construction of the MRSI, with a section covering variable selection and group definitions. This section concludes with a description of the sample obtained, with particular reference to sample size, response rate, and responses over time.

3.3.1 Sampling technique

This study focused on certified SCUBA divers visiting the Ribbon Reef and Osprey Reef locations on six live-aboard diving vessels between 16 August 2003 and 29 May 2004 (See Chapter Two for live-aboard diving operator and study site selection). This period was selected as most representative of a full diving season due to the presence of minke whales in the Ribbon Reef location from late May to late July of each year (Birtles, Arnold, & Dunstan, 2002a). During this time many of the operators alter their schedules to maximise encounters with these animals. The demographics of the visitors participating in minke whale trips include more non-divers as most whale encounters are done on snorkel (Birtles et al., in prep; Curnock, 1998). Both of these considerations meant that sampling during these times would not be representative of certified SCUBA divers, or the study sites of interest. This study attempted to sample as many live-aboard diving trip participants over the sample period to ensure a wide range of certified SCUBA diver histories were represented.

Non-random sampling methods were deemed most suitable for this study given the financial constraints and limited access to the passengers over the sample period (Ryan, 1995). The researcher was present on each of the vessels at the beginning of the sampling period to distribute questionnaires. This was to familiarise the crew with the administration of the questionnaire. The researcher also provided a one-page introduction to the research and its aims, and instructions on how to complete the questionnaire (Appendix A). This was done to ensure all respondents were given the same information prior to completing the questionnaire regardless of the vessel or which crewmember was distributing and explaining it. The page of instructions was laminated and given to a key crewmember, usually the Trip Director who was in charge of crew-passenger relations. After the initial demonstration by the researcher on the first trip, the designated crewmembers distributed questionnaires at the beginning of subsequent trips until the end of the sample period. Enough questionnaires were made available for all passengers on each of the trips. Crew were instructed to distribute and explain the questionnaire before leaving port. Completed questionnaires were handed to the crew at the end of the trip. Questionnaires were then either sent to the researcher by the operators, or picked up by the researcher. The researcher made additional personal visits to reinforce the process and support crew with the surveys.

3.3.2 Questionnaire design

The survey instrument was designed as an on-site self-administered questionnaire. Self-administration was selected over other methods such as structured interviews because the survey instrument could be distributed to a large number of participants on-board several vessels concurrently over the sampling period. Previous work with the exact same live-aboard diving industry by Birtles et al., (in prep), and Curnock (1998), exploring certified SCUBA divers' experiences on the GBR and Coral Sea dive sites, and Birtles et al., (2002b) and Valentine et al., (2004), exploring passengers minke whale experiences in the northern GBR with on-site self-administered questionnaires provided a good basis for the design of this survey instrument. The questionnaire was provided in English only.

The survey instrument used was titled "Towards sustainable high-quality diving experiences: Questionnaire 2003-2004" (See Appendix B). The questionnaire was constructed of three major sections: Section 1 - Before Diving, Section 2 - Specific dive sites, and Section 3 - End of trip. Those questions relating to diver demographics, diving and coral reef history, ownership of SCUBA related equipment, and levels of coral reef interest and knowledge in Section 1 - Before Diving, were the focus of Study One. All other questions in the survey instrument relate specifically to Studies Three and Four (the design of the three section questionnaire relating to these studies is explained in Chapter Five, Section 5.3).

3.3.3 Questionnaire Content

Diver demographics

To understand divers' demographics, variables of interest were: gender, age, country of residency, state of residence for Australian respondents, and education level.

Previous SCUBA diving history

The variables used to measure previous SCUBA diving history were adapted from Birtles et al., (in prep), Curnock (1998), and Todd (2000). Divers were asked to report information on several different aspects of their diving history, most of which have been shown by Todd (2000) to increase with the level of diver-development. It was expected that divers would have little difficulty recalling this information, as most variables relate to SCUBA certification and previous diving history, which in many cases is recorded in the diver's log books. Divers' log books are also required when participating in certified SCUBA diving activities, and allow the dive supervisor or crewmember to quickly access the participant's history and certification levels, and thus approximate diving competency. There were seven variables of interest regarding respondents' diving history, each of which explored different aspects of participation, training, and associated skills in recreational SCUBA diving. These were: diving agency which certified the respondent, highest SCUBA diving certification level, number of years diving history, number of dives in the last 12 months, total number of dives, maximum diving depth, and most comfortable diving depth. In addition, information regarding ownership of SCUBA equipment, underwater camera equipment, and coral reef guidebooks were also requested.

Self-rating of SCUBA diving ability

Respondents' self-rating of diving ability was scored on a 10-point scale ranging from 1 (basic) to 10 (extremely competent) following Birtles et al., (in prep), and was a measure of how competent divers considered themselves to be underwater. Diving ability is an important element within the activity of SCUBA diving as it encompasses skills such as buoyancy control, navigation, and air consumption. Buoyancy control, the rate at which a diver floats or sinks in the water column, has been described as one of the hardest skills for divers to master (Korosec, Slavinec, Bernard, Kolaric, & Prnaver, 2003), and also one of the major factors of diver damage to reef benthos (Harriott et al., 1997). A self-rating measure for diving ability was selected due to the large sample of divers targeted for this study and the inability of the researcher to directly assess respondents' diving ability.

Previous history of SCUBA diving in coral reef environments

The total number of dives undertaken on coral reefs primarily measured previous history of SCUBA diving in coral reef environments. In addition, the number of previous dives on the GBR, and whether respondents had dived at seven other major coral reef locations around the world were also obtained. These locations were: Red Sea, Caribbean, South Pacific, Other Pacific, South East Asia, East Africa, and 'Other Indian Ocean'. This question also had the option of 'Other', where respondents could list coral reef locations they thought had not been provided. However, respondents used this open-ended option primarily to list locations dived other than tropical coral reefs such as 'Germany' or 'Tasmania', or to list coral reef locations that fell under one of the location headings provided. When this occurred, the researcher allocated them to the correct location. As the focus of this study was specifically targeting diving on coral reefs, the non-coral reef locations were omitted from analyses.

Level of coral reef interest and knowledge

The level of coral reef knowledge was initially measured using a 10-point scale ranging from 1 (basic) to 10 (very advanced). In addition, level of coral reef interest and knowledge was measured with nine five-point rating scales with response categories ranging from “not at all accurate” to “extremely accurate”. The nine items were adapted from Kim, Scott, & Crompton (1997) who originally used them to measure centrality to lifestyle of bird watchers, and Sutton (2001) who adapted and used them to measure centrality to lifestyle of bluefin tuna fishers. Although the items used in this study do not measure centrality to lifestyle for divers’, as this was not the variable of interest, they did individually measure a divers’ level of coral reef interest and knowledge.

3.3.4 Diving and Coral Reef History (DACRH) specialization groups

Responses from the five questionnaire items were combined to create a MRSI of DACRH Specialization. This allowed respondents to be segmented into four groups based on a conceptual framework of recreational specialization within the activity of SCUBA diving, as Bryan (1977) had done for trout fishers. This method was selected as the main interest was not to determine how many of each type of recreationist there are in a diver population, but to make specific inferences about divers that have clearly defined and known levels of diving and coral reef history.

The groups were specifically designed to capture those divers who had only recently started diving (‘beginners’), those that were no longer new to the activity but had limited diving and coral reef history (‘intermediates’), those that had higher-level certifications and had established diving as a regular part of their leisure with moderate exposure to coral reef settings (‘enthusiasts’), and those that had professional certifications, and were highly engaged in the activity of diving with high exposure to coral reef settings (‘specialists’). Following Bryan (1977), and Scott and Shafer (2001), these items reflected participation, training and associated skills, and setting history. Two items measured participation, the number of years diving and total number of dives. Response categories were open-ended. Training and associated skills were measured by both highest SCUBA diving certification level and maximum diving depth. Setting history with coral reef environments was measured by the total number of dives on coral reefs, and was again open-ended. Any one of the five variables used to measure DACRH Specialization could not reliably measure specialization alone. For example, respondents that had been diving for the same amount of years had a large range of total number of dives, certification level, maximum dive depth, and the number of dives on coral reefs. These same patterns existed across all the variables. Only a combination of the five variables, or combined index such as the MRSI could reliably pinpoint a type of diver, because there were several factors affecting diving and coral reef history specialization.

Each of the five variables was divided into four groups based on the DACRH specialization group typologies, designed to reflect the varying degree of specialization both within the activity of diving, and within coral reef settings. This method was again based on Bryan's (1977) study, but used information from diver training agencies, a limited number of previous SCUBA diver research (Birtles et al., in prep; Curnock, 1998; Todd, 2000), highly experienced SCUBA Instructors, and the researchers five-year history working within the diving tourism industry as a PADI Open Water SCUBA Instructor, to design group definitions.

Tests were performed between each DACRH specialization group for all diving and coral reef history variables originally measured for the whole sample to ensure no two DACRH specialization groups were alike. Finally, the self-rating of coral reef knowledge, and the nine coral reef interest and knowledge items were tested between the DACRH specialization groups to determine if differences existed. Differences between groups were used to confirm that specialization groups had actually captured divers that differed in levels of coral reef interest and knowledge, an essential consideration for making inferences about diver typologies in Study Four of this thesis.

3.3.5 Sample

Divers were surveyed on each of the six live-aboard diving vessels selected for the study. Due to confidentiality agreements with the operators (see Chapter Two, Section 2.1), the vessels are identified throughout this thesis as A, B, C, D, E, and F. The survey was conducted over a 10-month (41-week) sampling period from 16 August 2003, to 29 May 2004. Four of the vessels took part in the study from start to finish except for a three-week annual maintenance period when the vessels were in dry dock. Although the timing of the maintenance period differed slightly between vessels, this usually occurred between late January and late March. Questionnaires were not given out on some trips because new crewmembers had not been briefed about the study, or because the boat unexpectedly did not go to sea. New crewmembers are common on live-aboard diving vessels due to the high incidences of crew turnover (Birtles et al., 2002b). Through emails, phone calls, and visits to the vessels during their time in port, the researcher made every effort to contact new and current crew regarding the study periodically throughout the sampling period.

Two of the vessels did not participate in the study for the full duration of the sample period due to changes in the management and operation of these companies, which made it difficult to continue with sampling. Of the four vessels that took part in the study from start to finish, two of these undertook two 10-day trips to the Far North Section of the GBR during November and December, and these trips were also removed from the sample period. They were specialised trips visiting very remote areas, were longer in duration (ten days), and were exploratory with respect to the dive sites they visited. Because none of the dive sites visited were of relevance to the study, and only a small number of respondents would have been sampled, questionnaires were not distributed.

Sample size

A total of 651 completed questionnaires were returned over the sample period from 116 vessel trips (Table 3.1). However, these vessels conducted more than 270 trips during the 41-week sampling period (Table 3.1). The response rate, expressed as a proportion of passengers who filled in questionnaires from the total number of passengers who received/accepted questionnaires, over the 116 trips was 53.9%. The actual size of the sample compared with the actual number of passengers onboard during these trips was 37.2%. Passengers might have declined to participate, or chose to participate but failed to complete of return the questionnaire initially because English was not their first language. This meant that only those passengers that could read and write proficiently enough in English participated in the study. Another reason might have been the length of the questionnaire, requiring respondents to participate for the entire duration of their trip. It is also possible that seasickness and the difficultly of writing on a moving boat might have also meant that some passengers declined to participate.

On examining the number of passengers sampled from the total population of passengers on board all trips over the 41-week period (n=3730), 17.4% completed questionnaires (Table 3.1). However, this figure is not a relevant measure of the response rate because many of the passengers were on trips when questionnaires were not distributed during the sampling period as discussed later. The total sample sizes from each of the vessels are: Vessel A, n=175; Vessel B, n=104; Vessel C, n=91; Vessel D, n=77; Vessel E, n=37; Vessel F, n= 165 (Table 3.1). Exact numbers of trips and passengers for each vessel were kindly supplied by the operators, however these figures were not available for vessel E.

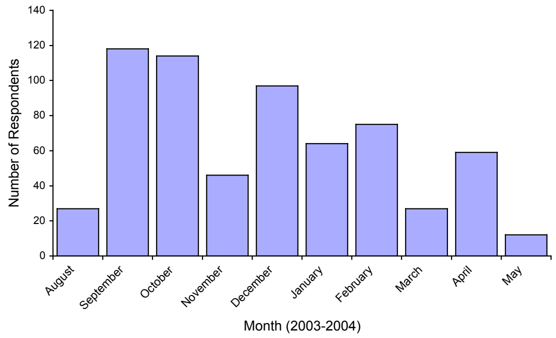
Table 3.1. Total response rate and sample size for August 2003 to May 2004 sampling period.

Vessel	No. of questionnaires provided to passengers	n (no. of questionnaires collected)	Response Rate (n/no. questionnaires provided to passengers)	Total no. of trips on which questionnaires collected during sampling period	N1 (total no. of passengers on sampled trips)	n/N1 (sample size compared to population on these trips) (%)	Total no. of trips during sampling period	N2 (total no. of passengers during sample period)	n/N2 (% of total population sampled)
A	258	175	67.83%	18	283	61.84%	54	455	38.46%
B	194	104	53.61%	25	425	24.47%	63	1122	9.27%
C	196	91	46.43%	20	362	25.14%	63	1293	7.04%
D	122	77	63.11%	15	285	27.02%	16	304	25.33%
E	71	37	52.11%	8	80	46.25%	12	Data Unavailable	Data Unavailable
F	366	165	45.08%	30	314	52.55%	63	566	29.15%
Totals	**1207**	**651**	**53.9%**	**116**	**1749**	**37.2%**	**271**	**(excluding vessel E) 3740**	**(excluding vessel E) 17.4%**

Responses over time

The distribution of returned questionnaires was not uniform throughout the entire sampling period. A total of 401 (61.1% of the total sample) questionnaires were returned during the five later months of 2003, and 239 (36.4%) were returned during the first five months of 2004. Eleven questionnaires had no trip start date. The distribution of returns was also not even across months, with a peak period of completed questionnaires returned during September, October, and December of 2003 (Figure 3.1).

Figure 3.1. Distribution of completed questionnaires by month during 2003 to 2004 sampling period (n=640).



Differences in the number of returns by month can be explained by several factors. First, in the initial periods of questionnaire administration (late August to late October 2003) when the researcher was on board each of the vessels to initiate the questionnaire and familiarise crews with this process, it is likely that returns were high due to initial crew enthusiasm, and the presence of the researcher. Also, as mentioned earlier, two of the boats used in the sample undertook expeditions to the Far North Section of the GBR during November and early December, thus reducing the possibility of returns during these periods. In mid-December, operators and crews were given reminders by email about the importance of the research, and visits to the vessels during time in port were undertaken by the researcher for a week in mid-December to re-enthuse crews. During late January to the end of March, vessels undergo annual maintenance periods, and thus returns were lower during these months. This is also considered the low season for operators due to the possibility of tropical cyclones at this time of year.

Towards the end of the sampling period, the number of returns was low with returns from vessels D and E stopping because of changes in the management and operation of these companies. Despite differences in the number of returned questionnaires over the months during the sample period, biases in the results are not expected due to the good overall response rate, and because four of the six vessels consistently provided completed questionnaires throughout the sample period.

3.4 Analysis

Statistical procedures used were Spearman's Rank Order Correlations, Kruskal-Wallis Means Tests, and Mann-Whitney U-Tests (Zar, 1999). Normality of the data was checked using a combination of histograms, P-P plots, and Q-Q plots. Levene's Test of Homogeneity of variance was also performed before undertaking any analyses. However, all variables were highly skewed and did not conform to normality, even after using logarithmic and square root transformations (Sheskin, 2004). Because the appropriate parametric test assumptions were violated, the equivalent non-parametric tests were employed. All tests were performed using SPSS (Version 11.02 for Mac).

The relationship between the total number of dives and the total number of dives on coral reefs was tested using a Spearman's Rank Order Correlation. This correlation was used because the data for both variables were not normally distributed, and transformations were unable to rectify this problem sufficiently.

To determine if cluster analysis techniques were able to produce more reliable groups based on DACRH Specialization than the MRSI, a multidimensional indicator of specialization was created. A series of K-means cluster analyses were performed using SPSS, ranging from three to seven clusters, with a four-cluster solution selected for presentation within the results as this best reflected the original DACRH group typologies. The variables used were the same as those used in the MRSI: years diving; total number of dives; highest SCUBA certification level; maximum diving depth; and total number of dives on coral reefs. For the four-cluster solution, 67.8% of the respondents fell in a cluster with 'low 'scores for the five variables, 28.2% fell in a cluster with 'medium' scores, 3.3% in a cluster with 'high' scores, and 0.7% in a cluster with 'very high' scores (n=580).

To ensure that DACRH specialization group means for the diving and coral reef history variables were significantly different to each other, Kruskal-Wallis Means Tests were used, followed by a series of individual Mann-Whitney U-Tests. To maintain a fixed significance level of 5% for these tests, a Bonferroni correction was applied depending on the number of comparisons needed, making the test results more conservative (Curtin & Shultz, 1998).

To investigate if the DACRH specialization groups had different mean number of diving visits to both the GBR and the seven other coral reef locations (summed), and to test for differences in the self-rated coral reef knowledge variable and each of the nine coral reef interest and knowledge items, Kruskal-Wallis Means-Tests, and a series of Mann-Whitney U-Tests were employed.

3.5 Results

The results of Study One are presented in six sections. These are: Demographics, Previous SCUBA diving history, Previous history of SCUBA diving in coral reef environments, Level of coral reef interest and knowledge, Cluster analysis and specialization groups, and Diving and Coral Reef History (DACRH) specialization groups.

The first section, 3.5.1 (Demographics), explores the age of the respondents, their gender, highest level of education, and their country of origins.

The second section, 3.5.2 (Previous SCUBA diving history), describes the divers level of participation and training in the activity of SCUBA diving. This section explores the certification agency divers were trained by, highest SCUBA diving certification level, the number of years diving history, number of dives in the last 12 months, the number of total dives, the maximum diving depth that respondents had been to, their most comfortable diving depth, ownership of SCUBA related equipment and guidebooks, and the divers' self-rating of their diving ability.

Section 3.5.3, (Previous history of SCUBA diving in coral reef environments), examines the extent of the divers' exposure to the number and types of coral reef environments. The section deals with the number of total dives on coral reefs, the proportion of total dives on coral reefs in relation to their total number of dives, whether the divers had visited the GBR before, and if so the number of visits, and whether the divers had dived at any of the seven other coral reef locations around the world.

Section 3.5.4 (Level of coral reef interest and knowledge), investigates the divers level of coral reef interest and knowledge by analysing their responses to ten scalar questions.

Section 3.5.5 (Cluster analysis specialization groups) looks at the results of the clustering technique to determine whether this method was able to produce adequate specialization groups in the interest of the original DACRH specialization group typologies.

Finally, Section 3.5.6 (Diving and Coral Reef History (DACRH) specialization groups), examines each of the four DACRH specialization groups with respect to measurements of demographics, previous diving and coral reef history, ownership equipment and guidebooks, and levels of coral reef interest and knowledge items.

3.5.1 Demographics

Table 3.2 includes the descriptive information on the profiles of the 651 live-aboard diving trip participants, and their previous diving history. Ages ranged from 16 to 75 (median 35), with a mean of 37.1 years (SD=10.4). Slightly more respondents were male (58.2%). Nearly all the respondents (88.9%) were enrolled in, or had completed a university degree showing that these live-aboard diving trip participants are mostly well educated. Respondents originated from 29 different countries including Australia. Most respondents were overseas visitors and accounted for 81.9% of the sample. Of all the countries represented, most visitors came from the U.S.A (26.6%), the U.K. (20.3%), Australia (18.1%) and Germany (7.1%). Only 1.2% were from Japan. Most (80.6%) Australian respondents were from NSW/ACT and Queensland.

Table 3.2. Certified SCUBA divers' demographics and SCUBA diving history.

Variable	Frequency	Percent
Age categories		
16-20	13	2.0
21-30	189	29.2
31-40	247	38.1
41-50	115	17.7
51-75	84	13.0
Total	648	100
Gender		
Female	272	41.8
Male	378	58.2
Total	650	100
Country of origin		
U.S.A	169	26.6
U.K.	129	20.3
Australia	115	18.1
Germany	45	7.1
Rest of Europe	107	16.9
Rest of World	70	11.0
Total	635	100
Australian residence		
NSW/ACT	42	40.8
QLD	41	39.8
Vic	8	7.8
SA	5	4.9
WA	4	3.9
Tas	2	1.9
NT	1	1.0
Total	103	100
Highest level of education		
Enrolled high school	10	1.6
Completed high school	59	9.5
Enrolled/completed undergrad university degree	334	53.5
Enrolled/completed postgrad university degree	221	35.4
Total	624	100
Diving certification agency		
PADI	497	78.3
NAUI	44	6.9
SSI	38	6.0
CMAS	22	3.5
BSAC	18	2.8
NASDS	1	0.2
Other	15	2.4
Total	635	100
Highest diving certification		
Open Water	194	31.0
Advanced Open Water	246	39.4
Rescue	71	11.4
Dive Master	63	10.1
Open Water SCUBA Instructor	51	8.2
Total	625	100
Years diving		
0-1	89	14.2
2-3	111	17.8
4-5	97	15.5
6-10	152	24.3
11-15	83	13.3
16-20	39	6.2
21-50	54	8.6
Total	625	100

Variable	Frequency	Percent
Dives in last 12 months		
0-10	262	41.9
11-20	146	23.3
21-30	68	10.9
31-40	34	5.4
41-50	37	5.9
51-100	57	9.1
100-600	22	3.5
Total	626	100
Total dives		
4-5	30	4.9
6-10	48	7.8
11-20	62	10.0
21-50	150	24.3
51-100	102	16.5
101-200	99	16.0
201-500	75	12.1
501-1000	34	5.5
1001-5000	18	2.9
Total	618	100
Maximum diving depth		
6-10	10	1.6
11-15	12	1.9
16-20	41	6.6
21-25	26	4.2
26-30	133	21.6
31-35	86	13.9
36-40	132	21.4
41-99	177	28.7
Total	617	100
Most comfortable diving depth		
2-10	15	2.7
11-15	56	10.0
16-20	123	22.0
21-25	81	14.5
26-30	155	27.7
31-35	44	7.9
36-40	50	8.9
41-60	35	6.3
Total	559	100
Own dive equipment?		
Yes	370	58.9
No	258	41.1
Total	628	100
Own underwater camera?		
Yes	242	39.4
No	372	60.6
Total	614	100
Own coral reef guidebook?		
Yes	316	51.7
No	295	48.3
Total	611	100
Rating of diving ability		
1(basic)	20	3.2
2	30	4.8
3	47	7.5
4	28	4.5
5	82	13.0
6	92	14.6
7	123	19.6
8	136	21.6
9	45	7.2
10(extremely competent)	26	4.1
Total	629	100

3.5.2 Previous SCUBA diving history

Certification

Most (78.3%) respondents were certified by PADI, with only relatively small percentages of respondents being trained by other agencies (Table 3.2). For the highest certification level of respondents, over a third (39.4%) were Advanced Open Water certified, followed by Open Water (31.0%). A total of 114 respondents (18.3%) held professional certifications (Dive Master or Open Water SCUBA Instructor). As in other SCUBA diver studies, there is a wide range of certification levels represented in this sample.

Number of years diving history

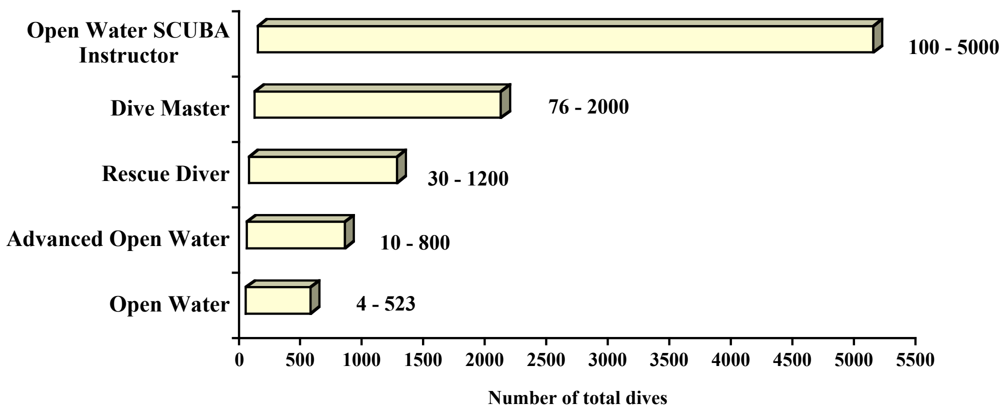
The number of years that respondents had been diving ranged between zero and 50 (Table 3.2). Just under half of the sample (47.5%) had been diving for five years or less, although 28.1% had been diving in excess of ten years. This result shows that the SCUBA divers in the sample vary widely with regard to how long they have been participating in diving activities, with some having only just started diving, while others have been diving for many decades.

Number of total dives and dives in the last 12 months

The number of total dives for respondents varied considerably, and ranged between four and 5,000 (Table 3.2), showing that the sample represents those divers that have only just been trained (four dives) to those divers that have participated extensively. Only a small percentage of the sample had made ten dives or less (12.7%), with over half (53.0%) having made in excess of 100 dives. In the 12 months prior to the trip, most respondents (89%) had been actively diving, with the most dives made in the 12-month period being 600 (by an Open Water SCUBA Instructor). Just over half of the respondents (54.2%) had done between one and 20 dives in the past year.

When the minimum and maximum number of dives are examined for each SCUBA certification level, it is evident that there is a high degree of overlap (Figure 3.2). While some divers increase both SCUBA certification and the total number of dives concurrently, some do not. For example, the Open Water certification level has a minimum number of four total dives, but has a maximum number of 523. This is greatly in excess of the minimum number of dives required to become an Open Water SCUBA Instructor (100 total dives). This means that some divers actively participate but do not go on to complete higher certifications. This same wide range can be seen in all SCUBA certification levels. This result shows that SCUBA certification alone is not a reliable measure of diving history, despite being the formal recognition of education, skill, and training in recreational SCUBA diving. This points to the need of the MRSI to effectively differentiate levels of divers' diving history. This is examined in Section 3.5.6.

Figure 3.2. The minimum and maximum number of total dives, and thus range, for each SCUBA certification level.



Maximum and most comfortable diving depths

Respondents' maximum diving depth ranged between six and 99m, with a mean of 37.2m (median 36.0m). Only 10.1% had dived to 20m or less, while over half (56.9%) had dived between 26 and 40m (Table 3.2). Nearly a quarter (23.7%) of the respondents had dived to depths greater than 42m. As in Todd's (2000) study, the SCUBA divers sampled here also have a wide range of maximum diving depths showing that this variable is likely to be useful in separating the sample according to the measurement of associated skills.

Respondents most comfortable dive depth ranged between two and 66m, with a mean of 27.1m (median 26.0m). This was more than 10m less than the mean maximum diving depth. Over a third (34.7%) of respondents indicated they were most comfortable at depths of 20m or less, while nearly a quarter (23.1%) indicated they were comfortable at depths greater than 30m.

Ownership of equipment and guidebook

Over half (58.9%) of the sample owned a substantial piece of SCUBA equipment such as a Buoyancy Control Device (BCD) and/or regulator. Just over a third (39.4%) of respondents owned underwater camera equipment, and more than half (51.7%) owned a coral reef guidebook.

Self-rating of diving ability

Respondents rated their own diving ability using a 10-point response format from 1 (basic) to 10 (extremely competent), with a mean for the sample of 6.2 (SD=2.2; n=629). Over half (55.8%) of the respondents rated themselves between six and eight, with 11.3% rating themselves at nine or ten (Table 3.2). One fifth (20.0%) of the respondents rated themselves at four or lower.

3.5.3 Previous history of SCUBA diving in coral reef environments

Table 3.3 includes the descriptive information of respondents' previous history of SCUBA diving in coral reef environments. The total number of dives respondents had made on coral reefs ranged from zero to 4,800, thus representing those divers with no history with coral reef environments, to divers with extensive history. Most (61.9%) respondents had made more than 20 dives on coral reefs, while only 44 respondents (7.8%) had not dived on a coral reef at all prior to the trip. When the number of total dives was correlated with the total number of dives on coral reefs for each respondent, a positive and very highly significant relationship exists, explaining 85% of the variance (n=618; r=0.846; *p<0.001*). For divers participating in live-aboard dive trips, previous history with coral reefs makes up a high proportion of their total dives.

Table 3.3. Respondents' previous history of SCUBA diving in coral reef environments.

Variable	Frequency	Percent	Variable	Frequency	Percent
Total dives on coral reefs			Number of previous visits to the GBR		
0-5	91	15.0	1	110	46.6
6-10	54	8.9	2-5	85	36.0
11-20	86	14.2	6-10	12	5.1
21-50	139	22.9	10-150	29	12.3
51-100	112	18.5	Total	236	100
101-200	59	9.7			
201-500	40	6.6	Dived coral reef locations around the world		
501-1000	15	2.5	Yes	533	83.7
1001-4800	10	1.7	No	104	16.3
Total	606	100	Total	637	100
Dived GBR before			Coral reef locations dived		
No	409	63.4	Caribbean	264	41.4
Yes	236	36.6	South East Asia	221	34.7
	645	100	Red Sea	202	31.7
			South Pacific	142	22.3
			Other Indian Ocean (other than East Africa)	122	19.1
			Other Pacific (other than South Pacific)	97	15.2
			East Africa	41	6.4
			Other	78	14.6

Almost two-thirds (63.4%) of the respondents had not dived on the GBR before (Table 3.3). Of the remaining 236 respondents that had, the mean number of visits was five (SD=17.5), ranging from one to 150. Nearly half (46.6%) had made only one visit, while 41.1% had made between two and ten visits. Only 12.3% had made over ten visits. Most (83.7%) of the respondents had dived at coral reef locations around the world other than the GBR. Many (41.4%) respondents had dived in the Caribbean, South East Asia (34.7%), and the Red Sea (31.7%). The least dived of the seven locations was East Africa (6.4%). When the number of locations dived by each respondent was totalled (not including the GBR), just under a third (30.6%) of the sample (n=637) had been to only one of the seven locations, and nearly one quarter (24.8%) had been to two. Furthermore, over a quarter (27.6%) of the sample had been to three or more locations. Only two respondents (0.3%) had been to all seven. Certified SCUBA divers visiting the GBR and Coral Sea dive sites appear to have much history in a wide variety of coral reef locations.

3.5.4 Level of coral reef interest and knowledge

Respondents were asked to rate their own level of coral reef knowledge using a 10-point response format from 1 (basic) to 10 (very advanced). The mean rating was 4.4, and over two thirds (69.5%) of the respondents felt their level of coral reef knowledge was at five or below. Only five (0.8%) respondents felt their knowledge was 'very advanced', while 60 (9.6%) felt their knowledge was 'basic'.

Respondents were also asked to indicate how accurate nine coral reef interest and knowledge items were using 5-point response format from 1 (not at all accurate) to 5 (extremely accurate). Table 3.4 includes the nine coral reef interest and knowledge items listed in descending order according to the mean ratings for the responses. As might be expected in wildlife tourism, respondents highest mean rating was for "I go diving on coral reefs because the marine life interests me a lot", with a mean rating of 4.3. Many of the respondents also indicated that they "very often look up identification books after completing a dive". Although interest in marine life was high, items relating to knowledge of coral reefs and the organisms that live there had the lowest mean ratings. Specific knowledge on the "behaviour and habits of many marine organisms" was rated the lowest (mean 2.5).

Table 3.4. Respondents' ratings of their coral reef interest and knowledge**.**

					Response category				
	Coral Reef Interest and Knowledge Items	n	Mean	SE	Not at all accurate (1)	2	3	4	Extremely accurate (5)
I	I go diving on coral reefs because the marine life interests me a lot	629	4.3	0.03	1.1%	2.9%	12.2%	31.8%	52.0%
I	I very often look up identification books after I complete a dive	628	3.4	0.0.5	9.6%	15.8%	21.3%	31.7%	21.7%
I	I travel to diving destinations to see specific animals and habitats	629	3.2	0.05	12.6%	18.9%	22.3%	30.7%	15.6%
K	I attach great importance to being able to identify coral reef organisms	628	3.0	0.04	8.6%	22.9%	36.3%	24.0%	8.1%
K	I have seen many different coral reefs	629	2.9	0.05	15.4%	23.1%	28.0%	24.0%	9.5%
K	I know more about coral reefs than most other divers	628	2.6	0.05	20.5%	26.6%	30.3%	17.4%	5.3%
K	I know a great deal about my favourite aspects of coral reefs	629	2.6	0.04	17.8%	28.9%	35.0%	14.9%	3.3%
K	I am a good judge of coral reef dive site quality	629	2.6	0.04	16.9%	29.4%	30.4%	20.0%	3.3%
K	I know the behaviour and habits of many coral reef organisms	628	2.5	0.04	20.4%	34.1%	28.7%	13.5%	3.3%

Mean values for all items based on a 5-point response format from 1 (not at all accurate) to 5 (extremely accurate). I in first column indicates Interest item, while K indicates Knowledge item.

3.5.5 Cluster analysis specialization groups

To determine if cluster-analysis techniques were able to segment the sample of certified SCUBA divers according to similarities or proximities between the divers, a four-cluster solution was performed. Table 3.5 shows the mean and range for diving and coral reef history variables for the four-cluster identified. Although the four cluster groups were found to differ significantly for all variables measured ($p<0.001$), the technique was ineffective at capturing the 'beginner' divers outlined in the DACRH group typology. From Table 3.5 it can be seen that the 'low' group was not representative of divers with very low amounts of diving and coral reef history, but rather represents a whole spectrum of divers that had been diving between 0-34 years, with up to 485 total dives, and up to 425 dives in coral reef environments. For this reason alone, the cluster technique will not be used to segment the sample of live-aboard SCUBA divers based on Diving and Coral Reef History.

Table 3.5. Comparisons of previous diving and coral reef history between cluster specialization groups.

	Low (n=393)	Medium (n=164)	Very high (n=19)	High (n=4)
Years dive experience*	5.6 (0-34)	12.8 (1-50)	25.4 (10-39)	16.5. (8-24)
SCUBA certification level (1-5)*	1.6 (1-3)	3.4 (1-5)	4.5 (3-5)	5.0 (5-5)
Dives in past 12 months*	15 (0-300)	51 (0-450)	142 (0-600)	65 (0-150)
Total dives in life*	51 (4-485)	306 (30-1500)	1753 (800-5000)	4250 (3000-5000)
Previous maximum dive depth (metres)*	31.6 (6-57)	46.8 (16-99)	68.5 (42-92)	63.3 (50-73)
Most comfortable maximum dive depth (metres)*	24.4 (2-55)	31.5 (2-60)	37.6 (10-50)	42.5 (30-50)
Self-rating diving ability (1-10)*	5.5 (1-10)	7.7 (2-10)	8.7 (6-10)	8.3 (7-10)
Number of dives on coral reefs*	32 (0-425)	152 (16-99)	1047 (200-2000)	3775 (3000-4800)

* Significant at $p<0.001$. All values presented are mean and range. Self-rated mean value for diving ability based on a response format from 1 (basic) to 10 (extremely competent).

3.5.6 Diving and Coral Reef History (DACRH) specialization groups

Three components were identified for the Multidimensional Recreational Specialization Index (MRSI). These were: participation (measured using number of years diving history and total number of dives), training and associated skills (measured using certification level and maximum diving depth), and setting history (measured using total number of dives on coral reefs). An overview of the results presented so far for these variables shows that each varies widely and thus represents a range of divers, from those that have recently begun SCUBA diving, to those with extensive levels of history. This is essential to capture the SCUBA diver typology desired in the interest of an index measuring Diving and Coral reef History (DACRH) Specialization.

The DACRH Specialization typology of interest was:

- 'Beginners' – divers who had recently started diving.
- 'Intermediates' - no longer new to the activity but with limited diving and coral reef history.
- 'Enthusiasts' - higher level-certifications and who had established diving as a regular part of their leisure with moderate exposure to coral reef settings
- 'Specialists' - professional certifications (Dive Master or Open Water SCUBA Instructor), highly engaged in the activity of diving with high exposure to coral reef settings.

Participation

The proposed typology of divers is based in part on their level of participation, which was measured by the number of years diving history and the total number of dives. The distribution of the number of years diving history for the sample can be seen in Table 3.6. 'Beginner' divers had to have one year or less diving history (14.2%; n=625), while 'intermediates' had between two and four years, reflecting divers who may not have participated in diving any further than their initial training, and those who were moving toward the next specialization group (26.6%). 'Enthusiasts' had between five and ten years diving history representing high participation (31.9%). 'Specialist' divers had 11 years or more diving history reflecting the establishment of the activity as a main leisure or professional activity (28.1%).

Table 3.6. Distribution of years diving history for the sample.

Years diving	n	Valid %
0-1	89	14.2
2-4	166	26.6
5-7	104	15.5
8-10	90	16.4
11-15	83	13.3
16-20	39	6.2
21-50	54	8.6
Total	625	100

The distribution of the total number of dives for the sample can be seen in Table 3.7. Total number of dives was divided to capture each diver typology. To ensure true 'beginners' were captured, those with ten dives or less were selected (12.7%; n=618). The 'intermediate' group ranged from 11 to 50 dives (34.3%). The 'enthusiast' group ranged from 51-200 dives, reflecting high levels of continued participation (32.5%). The 'specialist' group represents those divers who had gone beyond the dive 'enthusiast' with more than 200 total dives, showing very high levels of participation (20.5%).

Table 3.7. Distribution of total number of dives for the sample.

Total dives	n	Valid %
4-5	30	4.9
6-10	48	7.8
11-20	62	10.0
21-50	150	24.3
51-100	102	16.5
101-200	99	16.0
201-500	75	12.1
501-1000	34	5.5
1001-5000	18	2.9
Total	618	100

Training and associated skills

Different types of divers are likely to have different certification levels, and therefore different levels of training. The distribution of the highest certification level for the sample can be seen in Table 3.8. The highest SCUBA diving certification level of the 'beginner' was Open Water, the minimum certification needed to legally dive recreationally (31.0%; n=625). 'Intermediate' divers were those who had gone to the next certification level to Advanced Open Water (39.4%). This certification requires divers to complete a minimum of five training dives, three of which must be a deep dive (30m), navigation, and a night dive. The dive 'enthusiast' was represented by the Rescue Diver certification or equivalent, the highest non-professional certification (11.4%). This certification deals with identifying and addressing potential hazardous situations while diving. The dive 'specialist' consisted of those divers who had moved towards the professional SCUBA certifications, Dive Master and Open Water SCUBA Instructor, where divers are able to assist and train new and certified divers in the lower certification levels (18.3%).

Table 3.8. Distribution of diving certification levels for the sample.

Highest diving certification	n	Valid %
Open Water	194	31.0
Advanced Open Water	246	39.4
Rescue	71	11.4
Dive Master	63	10.1
Open Water SCUBA Instructor	51	8.2
Total	625	100

The maximum diving depth can provide an indication of diving skills. The distribution of the maximum diving depth for the sample can be seen in Table 3.9. 'Beginner' divers were selected using a maximum depth of 18m, a depth limit dictated by the Open Water certification (7.6%; n=617). Depths between 19 and 30m represented 'Intermediate' divers, the depth limit dictated by Advanced Open Water certification (28.4%). Dive 'enthusiasts' had been to depths between 31 and 42m, with 42m being the recommended maximum recreational depth limit (40.4%). The dive 'specialist', however, was characterised by depths beyond 42m (23.2%).

Table 3.9. Distribution of maximum diving depths for the sample.

Maximum diving depth	n	Valid %
6-10	10	1.6
11-18	37	6.0
19-30	175	28.4
31-42	249	40.4
43-50	77	12.5
51-99	69	10.7
Total	617	100

Setting history

In order to compare SCUBA diving history with coral reef settings, the total number of dives on coral reefs was used. Correlations between 'total number of dives' and 'total number of dives on coral reefs' explained 85% of the variance for the divers in this sample showing that as total dives increased, so did the total number of dives on coral reefs. This meant that that almost all divers had at least some coral reef history. The distribution of the total dives on coral reefs for the sample can be seen in Table 3.10. In keeping to the original DACRH specialization group typology, 'beginners' had very little history in coral reef environments and ranged from 0-10 dives (23.9%; n=606). 'Intermediate' divers ranged between 11 and 35 dives showing limited history with the setting (26.9%), while 'enthusiast' divers had between 36 and 100 showing high levels of history (28.7%). 'Specialist' divers had very high levels of coral reef history represented by over 100 total dives in these environments (20.4%).

Table 3.10. Distribution of total dives on coral reefs for the sample.

Total dives on coral reefs	n	Valid %
0-5	91	15.0
6-10	54	8.9
11-20	86	14.2
21-35	77	12.7
36-50	62	10.2
51-100	112	18.5
101-200	59	9.7
201-500	40	6.6
501-4800	25	4.1
Total	606	100

Calculation of DACRH specialization group index

Each of the respondents was scored depending on the values of the five diving and coral reef history variables identified above. From Table 3.11 it can be seen that depending on where the value for each of the variables fell within the specialization groups, a score of one to four was assigned. These were then totalled for each respondent. The lowest possible total score for respondents was five, and the highest 20. The total index scores were then segmented into four groups to again reflect the original DACRH specialization groups desired, with the two tails at either end of the distribution designed to capture the extremes of the sample, the 'beginners' and 'specialists'. The final DACRH specialization group index scores can be seen in the last row in Table 3.11. When examined, 580 respondents had provided information for the five variables used in the construction of the index. The distribution of the DACRH specialization groups were: 'Beginner' (n=46); 'Intermediate' (n=236); 'Enthusiast' (n=246); and 'Specialist' (n=52).

Table 3.11. Divisions of the five diving and coral reef history variables used construct the DACRH Specialization index.

Participation	Beginner	Score	Intermediate	Score	Enthusiasts	Score	Specialists	*Score*
Years diving	0-1	1	2-4	2	5-10	3	>10	4
Total number of dives	0-10	1	11-50	2	51-200	3	>200	4
Training/ Technique								
Highest SCUBA diving certification level	Open Water	1	Advanced Open Water	2	Rescue	3	Dive master/ Instructor	4
Maximum diving depth	0-18	1	19-30	2	31-42	3	>42	4
Setting								
Total number of dives on coral reefs	0-10	1	11-35	2	36-100	3	>100	4
Final group segmentation								
DACRH multidimensional index score		5-7		8-12		13-17		18-20

Demographics of DACRH specialization groups

The mean age of respondents in each of the groups was found to increase significantly with specialization ($p<0.001$). 'Beginners' had the lowest mean age of 32.4, 'intermediates' had 33.7, 'enthusiasts' had 39.3, and 'specialists' had the highest mean age of 44.9. Each group was found to have a significantly higher mean age than the previous ($p<0.05$). The minimum age for the first three groups was 16, 18, and 16 respectively, however for the 'specialist' group it was 27 (Table 3.12). The maximum age for all groups was similar.

Table 3.12. Comparisons of demographics between DACRH specialization groups.

	Beginner (n=46)	Intermediate (n=236)	Enthusiast (n=246)	Specialist (n=52)
Mean Age*	32.4 (16-69)	33.7 (18-61)	39.3 (16-75)	44.9 (27-64)
Gender	50% Male	57% male	65% Male	60% Male
Education level	78% University Degree	78% University Degree	79% University Degree	79% University Degree
Country of origin	37.0 U.S.A. 23.9% U.K. 10.9% Australia 6.5% Canada 17.4% Other	26.5% U.S.A. 23.5% U.K. 20.9% Australia 7.3% Germany 21.8% Other	23.7% U.S.A. 20.4% U.K. 16.7% Australia 9.4% Germany 29.8% Other	27.5% Australia 25.5% U.S.A. 11.8% France 7.8% U.K. 27.4% Other

* Significant at $p<0.001$. Age values are mean and range

There were also slight differences in the gender ratios between groups. Respondents in the ‘beginner’ group had an equal ratio of males (50%) to females (50%; Table 3.12). However, in the upper three groups there were more males than females suggesting that there is a slight gender shift with increasing specialization. ‘Intermediate’ respondents were 57% male, ‘enthusiasts’ were 65% male, and ‘specialists’ were 60% male. The level of education was remarkably consistent between all groups, with 78% of both ‘beginner’ and ‘intermediate’ respondents having a university degree, and 79% of both ‘enthusiast’ and ‘specialist’ respondents having a university degree (Table 3.12).

There were slight differences between groups regarding the country of origin for the respondents in each, although respondents from the U.S.A., the U.K., and Australia were well represented in each (Table 3.12). Most ‘beginner’ divers were from the U.S.A (37.0%), U.K. (23.9%), Australia (10.9%), and Canada (6.5%; Table 3.5). The remaining 17.4% originated from eight other countries. ‘Intermediate’ divers were mostly from the U.S.A. (26.5%), the U.K. (23.5%), Australia (20.9%), and Germany (7.3%). The remaining 21.8% were from 17 other countries. The respondents in the ‘enthusiast’ group were similar in proportion to the ‘intermediate’ group with most originating from the U.S.A. (23.7%), the U.K. (20.4%), Australia (16.7%), and Germany (9.4%). The remaining 29.8% were from 20 other countries. In contrast to all other groups, ‘specialists’ were mostly from Australia (27.5%), closely followed by the U.S.A. (25.5%). For the ‘specialist’ respondents, 11.8% were from France, a country not highly represented in any other group. Respondents from the U.K. made up a further 7.8%, and respondents from nine other countries made up the remaining 27.4%.

Previous SCUBA diving history

The mean number of years diving history increased significantly with each specialization group ($p<0.001$; Table 3.13). ‘Beginners’ had a mean of 1.1 years diving history, ‘intermediates’ had 4.9, ‘enthusiasts’ had 10.7 and ‘specialists’ had 19.4 years. Each group was found to have a significantly higher mean number of years diving history than the last ($p<0.05$). ‘Beginner’ divers were found to have a maximum of two years diving history, while all other groups had much larger ranges. Respondents in the ‘intermediate’ group had as many as 34 years diving history, while ‘enthusiasts’ had up to 50. Therefore, some divers had been diving for many years, but had progressed very little the activity of diving in relation to other specialization measurements. ‘Specialist’ divers had a minimum number of five years diving history, much higher than any other group indicating high levels of history for the activity.

Table 3.13. Comparisons of previous diving history between DACRH specialization groups.

	Beginner (n=46)	Intermediate (n=236)	Enthusiast (n=246)	Specialist (n=52)
Years dive experience*	1.1 (0-2)	4.9 (0-34)	10.7 (1-50)	19.4 (5-39)
SCUBA certification level (1-5)*	1.0 (1-2)	1.6 (1-3)	2.7 (1-5)	4.4 (3-5)
Dives in past 12 months*	5 (1-10)	13 (0-71)	41 (0-500)	75 (0-600)
Total dives in life*	6 (4-10)	31 (4-130)	197 (30-2000)	1235 (190-5000)
Previous maximum dive depth (metres)*	17.7 (6-30)	30.9 (12-60)	42.5 (16-99)	59.0 (40-92)
Most comfortable maximum dive depth (metres)*	16.3 (6-25)	24.0 (2-55)	29.7 (2-60)	34.9 (10-50)
Self-rating diving ability (1-10)*	3.0 (1-8)	5.4 (1-10)	7.2 (2-10)	8.3 (3-10)

* Significant at *p<0.001*. All values presented are mean and range. Self-rated mean value for diving ability based on a response format from 1 (basic) to 10 (extremely competent).

The highest SCUBA certification level was found to increase significantly with each specialization group (*p<0.001*). ‘Beginner’ divers had a mean of 1.1 certifications (Table 3.13), representing the Open Water certification and thus divers that have the minimum amount of formal training. The highest certification a ‘beginner’ had was Advanced Open Water, which can be undertaken directly after the Open Water course after just four dives. ‘Intermediate’ divers had a mean of 1.6 certifications, representing a tendency for either the Open Water or Advanced Open Water certifications. The highest certification an ‘intermediate’ diver had was Rescue Diver which can be completed immediately after the Advanced Open Water course.

‘Enthusiasts’ had a mean of 2.7 certifications, a slightly higher tendency for the Rescue Diver certification than the Advanced Open Water. The lowest certification an ‘enthusiast’ diver had was Open Water, and the highest was Open Water SCUBA Instructor. This result suggests that ‘enthusiasts’ divers can have a wide range of certification levels. These divers might not necessarily be interested in obtaining higher certification levels, but are still very active divers. ‘Specialists’ had a mean of 4.4 certifications, almost the midpoint between the two professional certifications, Dive Master and Open Water SCUBA Instructor. The lowest certification these divers had was Rescue Diver. The ‘specialist’ group is representative of those divers that obtain professional certifications.

The mean number and range of total dives for each DACRH specialization group can be seen in Table 3.13. Differences between groups were found be significant ($p<0.001$) with the mean number of dives significantly increasing with each group ($p<0.05$). ‘Beginners’ had the lowest mean number of dives (six) with a very small range (4-10), showing that this group does represent those divers with very little diving history. ‘Intermediate’ divers had a mean of 31 total dives, with a range of 4-130. The mean value indicates that this group represents mostly divers with limited diving history. ‘Enthusiast’ divers had a mean of 197 total dives, with a range of 30-2000. For most ‘enthusiast’ divers, a high number of total dives is likely. However, ‘specialist’ divers clearly stood out from all other groups with a mean of 1235 total dives ranging from 190-5000, showing very high levels of participation in the activity.

In the 12 months prior to the trip, ‘beginner’ divers had made a mean of six dives, most of which would have been training dives for certifications (Table 3.13). ‘Intermediate’ divers had higher levels of activity with a mean of 31 dives, but a range of 0-71 showing that these divers may or may not have dived for over a year. This was also the case for ‘enthusiasts’, with a range of 0-500 dives, and a mean of 50. ‘Specialist’ divers were the most active in the 12 months prior to the trip with a mean of 75 dives, but also had a wide range from 0-600 dives. This result shows that while the number of dives in a 12-month period does increase with specialization, it is also likely that some divers will have not dived at all in this period making this a poor indicator of specialization.

There were clear increases with specialization for the mean diving depth and the minimum and maximum diving depths for each group (Table 3.13). These differences were found to be significant ($p<0.001$), with each group having dived to a significantly greater depth than the last ($p<0.05$). ‘Beginner’ divers had been to a mean of 17.7m with a range of 6-30m. This is in alignment with their Open Water certification level where divers are trained to dive to 18m. However, some of these divers were also Advanced Open Water certified and are thus trained to dive to 30m thus explaining the greater depth that some ‘beginners’ had been to. ‘Intermediate’ divers had a mean diving depth of 30.9m, however the range was between 12 and 60m, showing that for some 'intermediate' divers, associated skill levels are very high, or that they are overly confident.

'Enthusiast' divers had been to a mean diving depth of 42.5m, with a range of 16 to 99m. While for most 'enthusiasts' the skill level appears high, some have a much lower skill level indicated by the lower depth range, while some have very high skill levels indicated by depths well over the recommended recreational depth limit of 42m. Any dive over 42m is considered dangerous by recreational standards, and the risk of serious injury or physiological impairment is increased significantly (PADI, 1999). 'Specialist' divers had been to a minimum of 40m and a maximum of 92m, with a mean of 59.0m. The 'specialist' diver group clearly represents divers with high associated skill levels for the activity of diving. The maximum depth that a diver has been to appears to be a good indicator of specialization in SCUBA diving. There were also significant differences in the most comfortable diving depths for the groups ($p<0.001$), with 'beginners' being most comfortable at a mean of 16.3m, 'intermediates' at 24.0m, 'enthusiasts' at 29.7m, and 'specialists' at 34.9m (Table 3.13).

The mean self-ratings for diving ability also increased significantly with specialization ($p<0.001$), with 'beginners' rating their diving ability the lowest (3.0 out of 10), and 'specialists' rating theirs the highest (8.3; Table 3.13). However, there was much overlap between the groups for the minimum and maximum ratings of diving ability, with some 'beginners' rating themselves at 8, while some 'specialists' rated themselves at 3. It is likely that this subjective and self-rated measurement might not be a reliable indicator of specialization in this study, probably because no definition of what was meant by 'diving ability' was provided to the respondents in the questionnaire.

Ownership of equipment and guidebook

There were different proportions of ownership of equipment and guidebooks with increasing specialization levels. Interestingly 10.8% of 'beginners' owned a substantial piece of diving equipment, even though divers that had only just been trained with very little amounts of diving history represented this group. Just over a third of 'intermediate' divers owned SCUBA equipment (34.9%), showing a higher level of commitment to diving. However, the proportion of ownership was higher in the ‘enthusiast’ group (82.4%), and especially high in the ‘specialist’ group where almost all respondents owned SCUBA equipment (98.1%).

The ownership of underwater cameras was quite similar between ‘beginner’ and ‘intermediate’ divers, with 23.9% and 28.9% respectively. Nearly half of ‘enthusiasts’ (48.1%), and just over two thirds of the ‘specialist’ respondents (75.5%) owned camera equipment. Interest in underwater photography/videography appears relatively high in all levels of specialization, but especially for ‘enthusiasts’ and ‘specialists’.

Proportions of ownership for coral reef guidebooks again increased with groups, with 19.6% of ‘beginners’ owning a book, 33.5% of ‘intermediates’, 66.7% of ‘enthusiasts’, and almost all of the ‘specialists’ (96.2%). This result indicates an interest in identifying and learning about coral reef organisms for many of the divers, but more so for the ‘enthusiast’ and ‘specialist’ divers.

Previous history of SCUBA diving in coral reef environments

Each DACRH specialization group also show marked differences in the amount of previous SCUBA diving history in coral reef environments, again increasing with specialization. The number of total dives on coral reefs was significantly different between groups ($p<0.001$), with each group having made a significantly higher number of dives in these environments than the last ($p<0.05$). ‘Beginner’ divers had a mean of four dives on coral reefs (range 0-10), showing very little diving history in coral reef environments (Table 3.14). ‘Intermediate’ divers had a mean of 18 dives (range 0-80), and ‘enthusiast’ divers had a mean of 117 (range 0-2000), thus for all of the first three DACRH specialization groups some divers had not dived at all on a coral reefs. However ‘specialist’ divers had at least a minimum of 50 dives in coral reef environments, with a mean of 787, showing that the respondents in the ‘specialist’ group had substantial coral reef diving histories.

Table 3.14. Comparison of SCUBA diving history in coral reef environments between DACRH specialization groups.

	Beginner (n=46)	Intermediate (n=236)	Enthusiast (n=246)	Specialist (n=52)
Total dives on coral reefs*	4 (0-10)	18 (0-80)	117 (0-2000)	787 (50-4800)
Dived GBR before this trip	17.4% Yes	31.8% Yes	41.5% Yes	55.8% Yes
Dived other coral reef locations around the world	43.5% Yes	77.0% Yes	95.9% Yes	94.2% Yes
Dived Red Sea	15.0% Yes	25.8% Yes	44.5% Yes	55.1% Yes
Dived Caribbean	10.0% Yes	42.5% Yes	52.5% Yes	67.3% Yes
Dived South Pacific	10.0% Yes	19.3% Yes	29.7% Yes	46.9% Yes
Dived the Pacific Ocean (other than South Pacific)	5.0% Yes	9.4% Yes	21.2% Yes	38.8% Yes
Dived South East Asia	55.0% Yes	39.2% Yes	40.7% Yes	59.2% Yes
Dived East Africa	0.0 % Yes	5.5% Yes	8.9% Yes	16.3% Yes
Dived Indian Ocean (other than East Africa)	5.0% Yes	12.2% Yes	27.1% Yes	49.0% Yes

* Significant at $p<0.001$. Total dive values are mean and range

Visitation to the GBR before this diving trip differed between groups, and increased with specialization (Table 3.14). For the 'beginner' group, 17.4% had dived on the GBR before the trip, 31.8% of 'intermediates', 41.5% of 'enthusiasts', and over half of the 'specialists' (55.8%). Therefore, the more specialised the diver, the greater the likelihood that they had dived on the GBR.

Many of the divers in the groups also reported having dived at other coral reef locations around the world, with values again increasing with specialization (Table 3.14). A large portion of the 'beginners' indicated that they had dived elsewhere (43.5%), followed by over three quarters of 'intermediates' (77.0%). Almost all of the 'enthusiast' and 'specialist' divers (95.9% and 94.2% respectively) had dived at other coral reef locations around the world.

A large proportion of 'beginner' divers had dived in South East Asia (55.0%), followed by a smaller proportion having dived in the Red Sea (15.0%; Table 3.14). For 'intermediate' divers, the location that most respondents had been to was the Caribbean (42.5%), followed by South East Asia (39.2%), and the Red Sea (25.8%). 'Enthusiast' divers had visited several locations with high frequency, but most had been to the Caribbean (52.5%), the Red Sea (44.5%), and South East Asia (40.7%). 'Specialist' divers indicated that they had visited most of the seven locations listed in Table 3.3. The most visited location for ‘specialist’ divers was the Caribbean (67.3%), followed by South East Asia (59.2%), the Red Sea (55.1%), the South Pacific (46.9%), and the other Pacific Ocean locations such as Hawaii, Palau and Guam (38.8%). For this sample of divers, increasing specialization means a greater number of total dives in coral reef environments from a wider range of locations.

Level of coral reef interest and knowledge

The self-ratings of coral reef knowledge also differed significantly between groups ($p<0.001$), with ‘beginners’ indicating they had the lowest level of coral reef knowledge (2.3 out of 10) and ‘specialists’ indicating that their coral reef knowledge was the highest with a mean rating of 6.7. ‘Intermediate’ divers mean knowledge rating was 3.7, and ‘enthusiast’ was 5.1. All groups were found to differ significantly to each other for mean ratings ($p<0.05$).

The mean ratings for the nine coral reef interest and knowledge items for each of the DACRH specialization groups can be seen in Table 3.15. Although all groups rated the interest item “I go diving on coral reefs because the marine life interests me a lot” the highest of the nine items, ‘beginners’ had a significantly lower rating (3.9) than the other three groups ($p<0.05$). However, the most significant differences between all groups occurred in the knowledge items. Of particular interest was the item “I am a good judge of coral reef dive site quality” with ‘beginners’ having a low mean rating of only 1.6, while ‘specialists’ had a mean rating of 3.5. From Table 3.15, it can be seen that the mean rating scores for all items increased from ‘beginner’ to ‘specialist’. This result indicates that interest and knowledge for coral reef environments increases with DACRH Specialization.

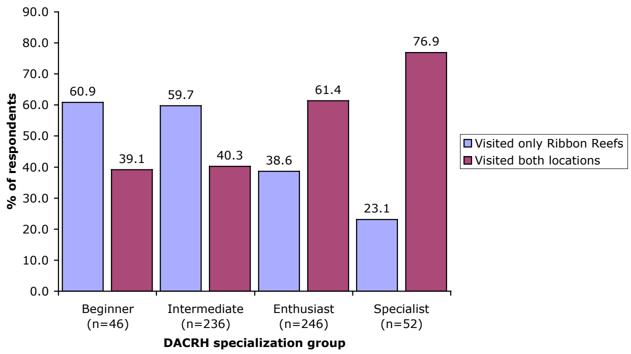
Table 3.15. Mean scores and test results indicating significant differences between DACRH specialization groups for self-ratings of coral reef interest and knowledge items.

	Interest and Knowledge Item	Beginner (n=46)	Sig Diffs (*p<0.05*)	Intermediate (n=236)	Sig Diffs (*p<0.05*)	Enthusiast (n=246)	Sig Diffs (*p<0.05*)	Specialist (n=52)	Sig Diffs (*p<0.05*)
I	I go diving on coral reefs because the marine life interests me a lot (1-5) *	3.9	I,E,S	4.3	B	4.3	B	4.6	B
I	I very often look up identification books after I complete a dive (1-5) *	2.8	E,S	3.2	E,S	3.6	B,I,	3.9	B,I
I	I travel to diving destinations to see specific animals and habitats (1-5) *	2.6	E,S	2.9	E,S	3.4	B,I,	3.8	B,I
K	I attach great importance to being able to identify coral reef organisms (1-5) *	2.2	I,E,S	2.8	B,E,S	3.2	B,I,S	3.7	B,I,E
K	I have seen many different coral reefs (1-5) *	1.6	I,E,S	2.4	B,E,S	3.3	B,I,S	4.1	B,I,E
K	I know more about coral reefs than most other divers (1-5) *	1.5	I,E,S	2.2	B,E,S	2.9	B,I,S	3.8	B,I,E
K	I know a great deal about my favourite aspects of coral reefs (1-5) *	1.5	I,E,S	2.3	B,E,S	2.9	B,I,S	3.4	B,I,E
K	I am a good judge of coral reef dive site quality (1-5) *	1.6	I,E,S	2.3	B,E,S	3.0	B,I,S	3.5	B,I,E
K	I know the behaviour and habits of many coral reef organisms (1-5) *	1.6	I,E,S	2.1	B,E,S	2.8	B,I,S	3.5	B,I,E

* Differences significant for Kruskal-Wallis Means Test ($p<0.001$)
Mean values for all items based on a 5-point response format from 1 (not at all accurate) to 5 (extremely accurate). I in first column indicates interest item, while K indicates Knowledge item.
Letters in the columns right of each DACRH specialization group indicate significant differences between groups ($p<0.05$). Letters in these columns are: B=Beginner, I=Intermediate, E=Enthusiast, S=Specialist.

Finally, respondents were split into two groups depending on the type of trip in which they participated. One trip type visited the Ribbon Reef location only, while the other trip type visited both the Ribbon Reef and Osprey Reef locations. Figure 3.3 shows the distribution of the respondents from each DACRH specialization group between the two types of trips. Fewer ‘enthusiast’ (38.6%) and ‘specialist’ (23.1%) divers participated in the trip that visited the Ribbon Reefs only, and conversely a lower percentage of ‘beginner’ (39.1%) and ‘intermediate’ (40.3%) divers participated in the trip that visited both locations. As specialization increases, the tendency to select the longer and more expensive trip visiting the more remote Osprey Reef location was evident.

Figure 3.3. Percentage of respondents in each DACRH group that visited either the Ribbon Reef locations only, or both the Ribbon Reefs and Osprey Reef locations in the one trip.



3.6 Discussion

The results of this study are based on a sample of 651 certified SCUBA divers from six live-aboard diving vessels visiting the Ribbon Reefs of the GBR, and Osprey Reef in the Coral Sea between August 2003 and May 2004. This study provides an assessment of these divers in terms of their demographics, previous diving and coral reef history, ownership of SCUBA related equipment and guidebooks, and the levels of coral reef interest and knowledge. This study has for the first time, segmented certified SCUBA divers into four groups using a Multidimensional Recreational Specialization Index (MRSI). Recreational specialization was based on the amount of participation, training and associated skills, and coral reef setting history, and when combined provided an index of Diving and Coral Reef History (DACRH) Specialization. The findings of study are discussed below.

3.6.1 Diving and Coral Reef History (DACRH) specialization groups

DACRH specialization groups were designed to make inferences on divers with clearly defined and known levels of diving and coral reef history. Each DACRH group was different significantly to all other group's diving and coral reef history measures, ownership of equipment and guidebooks, level of coral reef interest and knowledge, and diving visitation to coral reef locations around the world. The results clearly show support of the recreational specialization construct for certified SCUBA divers, providing the tools and theory with which to segment the sample. Results also showed that the MRSI of DACRH Specialization performed much better at capturing group typologies than cluster analysis techniques. Both index and cluster methods have been used with high frequency by a variety of specialization researchers to segment populations of activity participants (see Scott et al., 2005 for review). However, the cluster analysis method was ineffective at creating homogenous subgroups in this present study that represented patterns in the data, especially for the 'low' cluster group that was found to be very heterogeneous. For clustering to be productive, there must be an advantage in grouping respondents with a direct empirical base, rather than on some other basis such as investigator judgement or a classification system (Borgen & Barnett, 1987). Because of the need for the group segmentation to represent a defined typology of SCUBA divers, the creation of an index was much more suited to this particular study.

The findings of this study demonstrate that certified SCUBA divers, like previously studied recreational participants, are by no means a homogenous population (Bryan, 1977; Ewert & Hollenhorst, 1997; McFarlane, 1994; McFarlane & Boxall, 1998; Sutton, 2001; Todd, 2000). The divers in this sample vary widely from those that had just been certified to SCUBA dive, to participants with 50 years diving history and up to 5000 total dives. Similar variations in the diving histories of tourists visiting the GBR have been documented both on live-aboard (Birtles et al., in prep; Curnock, 1998), and day-trip operations (Rouphael & Inglis, 1995). This consistency between studies shows that Reef trips to the GBR do not attract a particular type of SCUBA diver, but that there is a high degree of mixing of SCUBA diver types. Rouphael & Inglis (1995) sampled some certified SCUBA divers on day-trips that had up to 3000 total dives (and were likely to be highly specialised). Tourists on day-trip operations are likely to vary to a much greater degree than those on live-aboard diving trips because many of the participants are non divers visiting a coral reef for the very first time (Shafer et al., 1998).

Bryan (1979) noted that the there is a tendency for recreationists to move into more specialised stages of specialization the longer they participate. The findings of this study loosely support this notion for a large number of the divers. Many of the respondents sampled had been diving for many years showing high levels of participation, but did not obtain further certifications or indicate that they had high levels of associated skills. It is likely that many divers will complete the initial certification level (which never expires) and go diving infrequently for many years. However, the opposite is also true. Some divers will complete the initial certification level and go diving very frequently. For some, certification levels will mean very little to their diving activities, while others will be driven toward the professional certifications (Dive Master and Open Water SCUBA Instructor). Todd (2000) found that only 6% of a sample of 849 certified divers were interested in continuing with diving to the extent that they had stopped participating in other activities. It is likely that with SCUBA diving, as is noted for many other recreational activities, that while some people do progress, most people probably do not (Scott & Shafer, 2001). Bryan (2001) did provide a response to this comment and noted that it is not surprising that most do not reach highly specialised destinations within an activity. He says that some people have other interests that are more important to them, or that increasing specialization within a particular activity is too boring or too expensive. There are many reasons why people would not choose to specialise within an activity as outlined above, and it is likely that many of these reasons also apply to the activity SCUBA diving.

SCUBA diving provides an excellent example of recreational specialization because it is an activity that is more clearly defined and structured than previously studied recreational pursuits, such as fishing, hiking, or birdwatching. In addition, it was easy to obtain objective measures of participation, training and associated skills, and setting history without the need for sampling techniques like structured interviews that Bryan (1977) had used. This is because divers record information about their diving history in log books, and it is therefore easily recalled. Similar clearly defined levels of specialization might be seen in activities such as rock climbing, hang-gliding, and other such pursuits where the possibility of serious injury and death is much higher. This is because these activities will also require participants to undertake formal training courses and record measurements of history and participation, for example the number of flights for hang-gliders. There are also strict requirements imposed on these activities, especially commercially, by Work Place Health and Safety Laws requiring activity leaders to be highly trained and proficient.

Multidimensional measures such as those used in this study have dominated the specialization literature for nearly three decades and have proved to be valuable in segmenting recreation populations. Indeed this approach is warranted if the recreational population has been little studied, as is the case for SCUBA divers. However, Scott et al., (2005) comment that resource managers want simple tools to identify user types, and that long surveys and cluster analyses for example are not always feasible. Although self-rated measures are single item by nature, the definition of each category provided to respondents can be multidimensional and thus still satisfy many of the empirical findings in specialization research to date. For these reasons, future research on populations of SCUBA divers might also incorporate the use of a self-rated measure of recreational specialization. However, it is essential that self-rated group definitions are developed from previous research findings to be sure that such typologies actually exist, just as Scott et al., (2005) used McFarlane's (1994) birdwatching study to help define their self-rated specialization groups. The results from this present study provide future researchers four DACRH specialization group definitions derived from empirical tests. The use of these group definitions would give both the researcher and the respondent greater confidence that self-rated category selection was representative of the correct user typology.

3.6.2 Demographics

It was an objective of this study to determine the types of participants that were involved in live-aboard diving activities on the GBR. A greater percentage of live-aboard divers were male, although many females also participated. Most of the divers were middle aged and well educated. This finding is highly consistent with other certified SCUBA diver demographic descriptions (Birtles et al., in prep; Burke, 2002; Curnock, 1998; Mundet & Ribera, 2001; Shafer et al., 1998; Tabata, 1992; Todd, 2000; Wilks, 1993). The divers also came from a wide range of countries, but most were from the U.S.A, U.K., Australia, and Germany. It is well established that the GBR attracts a high diversity of national and international visitors (Birtles et al., in prep; Curnock, 1998; Moscardo et al., 2003; Shafer et al., 1998; Tourism Queensland, 2002). There were no predictable patterns in the country of origin for each DACRH group.

As DACRH Specialization increased there was a significant shift in the proportion of males and females, with higher specialization groups better represented by males. Diving has in the past been regarded as a male dominated sport (Wilks, 1993), and this is supported by the higher proportion of males certified (66.4%) in relation to females (34.6%) by PADI in the U.S.A. for the year 2000 (PADI, 2002). In this study, equal proportions of males and females were 'beginners', showing that participation in diving trips in the early stages of diving now is equally likely to be undertaken by either gender.

3.6.3 Previous SCUBA diving history

It was also an objective of this study to provide an assessment of the diving histories of live-aboard diving trip participants. All respondents in this study were certified divers, unlike those visitors sampled on day-trips to the GBR where as few as 16% took part in SCUBA activities (Shafer et al., 1998). Live-aboard divers represented a wide spectrum of diving histories from the very 'beginner' to the 'specialist'. Despite this wide range of diving histories, most respondents were not 'beginners'.

The majority of divers were trained by PADI with the largest group being Advanced Open Water certified, and had over five years diving history and moderate amounts of diving activity in the 12 months prior to the study. This is consistent with the reported diving histories from other SCUBA diver studies (Cottrell & Meisel, 2004; Curnock, 1998; Meisel & Cottrell, 2004; Mundet & Ribera, 2001; Thailing & Ditton, 2001; Todd, 2000).

The number of total dives ranged from four to 5,000, with a high percentage of divers having in excess of 100 total dives, the minimum number needed to qualify for the Open Water SCUBA Instructor certification. This was also the case in the 1996-1998 live-aboard study (Birtles et al., in prep). These results are in stark contrast to divers studied aboard day-trips to the GBR, with 70% having less than 40 total dives (n=214); (Rouphael & Inglis, 1995). Divers participating in live-aboard diving trips also have a greater number of total dives when compared to other diver samples (Cottrell & Meisel, 2004; Meisel & Cottrell, 2004; Todd, 2000). This reinforces the idea that divers with extensive diving history are very likely to participate in live-aboard diving trips where they are available, because they represent the highest level of certified SCUBA diving opportunities. These trips are concerned with little else than SCUBA diving for extended periods of time.

3.6.4 Ownership of SCUBA related equipment

Over half of the sample owned substantial pieces of SCUBA equipment, over a third owned underwater camera equipment, and nearly half owned a coral reef guidebook. Ownership of such equipment indicates increased commitment to an activity (Bryan, 1977; McFarlane, 1994). This was the case between the DACRH specialization groups with only 10.8% of 'beginners' owning SCUBA equipment, increasing with each group to 'specialist', with 98.1% reporting ownership. This same trend existed for ownership of underwater cameras and coral reef guidebooks. Todd (2000) found that certified divers from the New York's Great Lakes owned or planned to buy an average of 9.4 dive equipment items, and most had already purchased 8.4 of these. Results from this present study add that as specialization increases so does the percentage of divers that own diving-related equipment. This increase in ownership of equipment with increasing specialization has also been observed in other activities such as fishing (Bryan, 1977), and birdwatching (McFarlane, 1994) for example. It makes sense that more specialised divers would own their own equipment, as opposed to renting it each time they dived. This is because SCUBA equipment is an underwater life support system that must function with precision and reliability. The SCUBA diver relies on this equipment each time they dive as much as a skydiver relies on a parachute.

3.6.5 Previous history of SCUBA diving in coral reef environments

Assessing the extent of participants' history with coral reef environments was also an objective of this study. A very strong and positive correlation exists between the total number of dives and the numbers of dives on coral reefs showing that for live-aboard divers, a great proportion of their total dives are undertaken in coral reef environments (see Section 3.5.3). It is well known that SCUBA diving tourism is economically important to coral reef-based communities (Cesar, 2000; Dixon, 1993; Fenton et al., 1998; Tratalos & Austin, 2001). However, this result establishes that coral reefs are extremely important dive destinations for certified SCUBA divers with a range of diving histories and social backgrounds.

This type of dependency on coral reef environments by the diving tourism industry can aid in the establishment or extension of Marine Protected Areas (MPAs), which are known to attract divers and snorkellers because of their perceived environmental quality, and the conservation values they represent (Fenner, 2001; Kenchington et al., 2003). In this respect, coral reef environments and the biophysical attributes sought by diving tourists should be managed appropriately in the interest of the sustainability of the tourism industry. The specific biophysical attributes that influence the SCUBA diving experience are largely unknown, and are explored in Study Three, Chapter Five.

The Caribbean, South East Asia, and the Red Sea, all of which are major diving tourism locations with specialised live-aboard diving operations, were also highly dived by a large percentage of the respondents. Travel for most of the sample is essential if they are to experience tropical coral reef locations. Todd (2000), found that most of the divers living in the temperate New York region of the U.S. trained locally just as a ‘springboard’ to dive in more desirable tropical locations such as the Caribbean. Probably the most distant dive location for most of the divers in this sample was their current trip to the GBR.

DACRH specialization groups again showed positive trends from ‘beginner’ to ‘specialist’ in percentages of coral reef locations dived, including the GBR. ‘Specialist’ divers were also found to have dived a greater number of locations when compared to the other groups. Apart from the ‘beginners’, all groups had high rates of diving visitation to other coral reef locations. These results support the theory that certified divers travel extensively in pursuit of their activity (Tabata, 1992), but adds that with higher specialization comes a greater diversity and number of locations dived.

3.6.6 Level of coral reef interest and knowledge

It was also an objective of this study to determine participants’ levels of coral reef interest and knowledge. Not surprisingly, interest levels in the marine life and the willingness to learn more was high. This is because the focus of SCUBA diving on coral reefs is the natural environment. It has also been stated that because divers invest much time and money in their hobby, they are likely to be more knowledgeable about the environment then the average visitor to a terrestrial park for example (Townsend, 2000). Although knowledge items were not rated as highly as interest items, they were still moderately high. Live-aboard divers appear to have a high interest in the marine life on coral reefs, with the motivation to continually expand their knowledge and understanding of these environments.

DACRH specialization groups were found to differ significantly in the self-rating of coral reef knowledge, as well as the nine coral reef interest and knowledge items. As in all previous sections, rating values increased with each specialization group showing that 'specialist' divers had the highest ratings for both interest and knowledge items. However, all groups had high ratings for the interest items, and the greatest differences were apparent for the knowledge items. Interestingly, 'beginners' found the item "I go diving on coral reefs because the marine life interests me a lot" to be significantly less accurate than all other specialization groups, while the three upper groups did not differ. This might indicate that the marine life is a secondary interest to 'beginner' divers, whereas the first is the activity and adventure of SCUBA diving itself. Wilks (1993) comments that for non-divers, SCUBA diving is seen as an adventurous activity which fits in with traditional views of diving depicted by documentaries such as those made by Jacques Costeau. Meisel & Cottrell (2004), also found divers in the Florida Keys, most of whom were considered new to the activity, were primarily motivated to dive for fun, followed by an interest in the underwater plant and animal life.

It is likely that 'beginner' divers go through an initial 'settling' stage where challenges imposed by breathing underwater, maintaining neutral buoyancy, and checking gauges are more important than the setting where the activity is taking place. Once beyond the initial learning stage, divers on coral reefs may not find themselves challenged by equipment or skills in the same way that, for example cave or ice divers are in terms of equipment and skills, and thus an interest in the reefs themselves is more likely (Townsend, 2000). As specialization increases so do the levels of interest and knowledge in the environment (Duffus & Dearden, 1990). Bryan (1977) conceptualized fly fishers as the highest or most specialised form of trout fishing saying "it represents the end-product of a progression of angling experience leading to a more 'mature' or specialised state". Similarly McFarlane (1994), found that the highest specialization level of birdwatchers were most motivated in improving their birding skills and knowledge, while lower specialization groups were motivated by enjoying nature and conservation.

This 'specialist' state of specialization in the activity of diving may be likened to fishers and birdwatchers in the way they focus much attention on the specifics of the environment. This is also reflected in the higher proportion of more specialised divers owning both underwater camera equipment and coral reef guidebooks, indicating a keen interest in focussing the activity of diving towards the environment, rather than the activity by itself. Just as a fisher or birdwatcher learns about the behaviour and habits of specific species, ideal locations and conditions, and preferred equipment needed in order to maximise the chances of a successful capture or sighting of a species, a diver might also learn the same skills in order to maximise the chances of a successful sighting and/or obtaining a great underwater photo.

3.6.7 Summary

In summary, the results from this study suggest that as divers move along the specialization continuum reflected by Diving and Coral Reef History, they also move along an environmental specialization continuum reflected by knowledge, and a keen interest in acquiring more knowledge about that environment. How this modifies the way in which the biophysical attributes on coral reef sites are expected, experienced and evaluated will be examined in Chapter Five. The next chapter provides an assessment of the biophysical attributes that the SCUBA divers are most likely to encounter at the study sites during their trip.

CHAPTER 4

ASSESSMENT OF THE BIOPHYSICAL ATTRIBUTES THAT OCCUR ON SELECTED CORAL REEF DIVE SITES

4.1 Introduction

Study One of this thesis found that coral reefs are very popular destinations for this sample of certified SCUBA diving tourists. Specific dive sites on coral reefs can be chosen by operators due to their ease of access and safe boating attributes, but most importantly for the outstanding biophysical attributes that occur there (Tabata, 1989). Yet it is unclear what specific biophysical attributes do occur at such sites, and which are most significant to divers' experiences. Such information about natural areas is a vital first step in natural resource management aimed at providing quality experiences for visitors (Driver et al., 1987). It can also provide managers with an inventory of possible viewing opportunities that aids in visitors viewing wildlife more successfully, as well as forming realistic expectations of actually seeing wildlife through appropriate interpretative material (Hammitt et al., 1993). Furthermore, data collected on the biophysical attributes found at tourism sites provides an understanding of the fragility of the environment while also creating a baseline for monitoring programs (Harriott et al., 1997). This will be a necessary step in assessing human impacts on the environment to determine sustainable levels of use (Malcolm, Cheal, & Thompson, 1999; Stankey et al., 1985).

4.1.1 Biophysical attributes of coral reef sites

Physical attributes

Coral reefs on the Great Barrier Reef (GBR) can vary from fringing reefs around continental islands, isolated platform reefs on the continental shelf, and ribbon reefs that are basically elongate platform reefs on the edge of the continental shelf (GBRMPA, 2000). In the Coral Sea, coral reef atolls/seamounts that form on ancient volcanic islands can also be found, rising 1000 metres from the sea floor. Dive sites used by operators are often only small sections of larger reefs, usually located on the leeward sides of a reef or island to get protection from the wind.

The physical seascape of a site can vary considerably both within and between sites, and represent highly complex three dimensional environments (Spalding et al., 2001). Reef sites range from pinnacles, sandy reef slopes, and steep reef walls, while also having additional features such as caves, swim-throughs and overhangs. Other physical attributes such as the horizontal visibility of the water, and current strength can also vary widely within and between sites. Of all the physical attributes that can be found on a coral reef, only good visibility is known to be an important attribute to visitors' enjoyment (Birtles et al., in prep; Curnock, 1998; Shafer & Inglis, 2000; Tabata, 1989). To measure the physical attributes at dive sites, similar methods to those used by the Australian Institute of Marine Science (AIMS) long-term monitoring project, which has for many years assessed the physical attributes on coral reefs using a range of well established and accepted measures, can be applied and or/modified for smaller sections of reefs (see Miller, 2003).

Corals

The coral provides a very distinct backdrop to the coral reef scene. This backdrop can be extremely diverse with over 400 different species of corals occurring on the GBR (GBRMPA, 2000). Corals play a major role in the reef structure, integrity, and ecology (Spalding et al., 2001), but also add colour, size, shapes, and texture to the physical landscape. Corals can be likened to the plants and trees found in terrestrial settings (Shafer et al., 1998), due to their shapes and structure. People who have very little knowledge of coral reefs could not be blamed for thinking corals are plants, when in fact they are animals that house algal cells in a unique symbiotic relationship.

We have little knowledge of visitor's ability to perceive different types and species of corals, or even the quality of the coral at a site. The influence of coral quality on the experience has not been fully assessed, but is of great concern to dive operators and managers. Reduced diving activity and visitation of divers to the Philippines has been directly linked to high levels of coral bleaching and thus a reduction in coral quality (Cesar, 2000). With regard to the importance of coral attributes, Shafer et al., (1998) found that for visitors on day-trips to the GBR, the size, amount, diversity, and colour of the coral were highly influential conditions to their reef experiences. Whether differences in the coral attributes between sites can influence visitors' experiences has not been tested.

Fish and other marine organisms

Fish (bony), sharks, rays, invertebrates, reptiles, and other marine organisms are also very conspicuous components of coral reef environments, although fish represent the dominant vertebrates (Spalding et al., 2001). Diversity of these organisms is also high, with over 1500 species of fish, 4000 species of mollusc, 16 species of sea snakes, and six species of turtles found on the GBR (GBRMPA, 2000). Diversity has been shown to be highly influential to day-trip visitors' experiences to the GBR, especially for fish (Shafer et al., 1998), and is also the case for more specialised divers (Birtles et al., in prep; Curnock, 1998).

Like corals, fish and other marine organisms also come in a variety of shapes, sizes, and colours, but may also exhibit other attributes such as movement and behaviour, and are thus responsible for much of the activity on a reef. Encounters with marine organisms on coral reefs are unlike encounters with organisms in terrestrial environments. Initially, marine organisms appear quite unfamiliar in design when compared to terrestrial organisms. This might be particularly true for visitors who have not experienced, or are new to coral reef environments. Reef organisms move in all directions, some aware of your presence, some not. The colour and movement of all these organisms in concert provide divers with no shortage of things to see.

4.1.2 Biophysical attributes influencing visitor experiences

"*For colour, sheer beauty of form and design, and tremendous variety of life, perhaps no natural areas in the world can equal coral reefs"* (Nybakken, 1997, p338). This quote illustrates how diverse and amazing coral reef environments are. However, we know very little about the influence of specific biophysical attributes on visitors' experiences in these environments. The coral, fish, and other marine life represent the biological attributes (Shafer et al., 1998), while the underwater landscape, visibility, and currents represent the physical attributes. Given that no two dive sites are likely to be the same, each site should provide divers with different experiences. However, there should be some consistency across all coral reef sites in the specific attributes that provide divers with quality experiences, and conversely those that detract from these. Shafer et al., p14 (1998) note that "a better understanding of the relative influence of marine wildlife on visitors and what aspects of it are most important are needed" from both an ecological and social perspective.

Distinctive biophysical attributes

Although there are wide ranges of attributes that can be seen by visitors at a coral reef site, there are likely to be some attributes that are more distinctive, or clearly different than others. These attributes might provide visitors with rich and powerful experiences through one or several factors that relate to the characteristics of an attribute, or aspects of an experience with an attribute. These factors might include: abundance; size; behaviour; duration; popularity or iconic status; special/unusual features; and intensity of experience. The latter four factors have been adapted from Reynolds & Braithwaite (2001), who developed these to describe the nature of a wildlife tourism encounter with an attribute from the viewer's perspective. Explanations of how these factors might be distinctive both within and between sites are explained.

Abundance – Refers to the collective number of a type of organism at a site in relation to the many other types of organisms that can be found. Such distinctive abundance might attract visitors' attention. For this reason, schooling species might be of particular interest because of their sheer collective magnitude and movement (Shafer et al., 1998). Schooling fish on a coral reef site can be likened to a large flock of birds, in that they both group together and move almost as one. The ability of an organism's collective abundance to attract visitors' attention might be heightened if this occurs at very few sites, and is therefore distinctive between sites.

Size – The distinctive size of a biological or physical attribute at a site might also attract special attention and thus be distinctive. The size of fish and other marine organisms ranges dramatically on a coral reef. Organisms can be microscopic like some crustaceans, or huge like the whale shark reputed to reach up to 18 metres in length, although lengths up to 12m are more likely (Randall, Allen, & Steene, 1997). While it might be expected that larger organisms are more conspicuous and thus demand attention as they do in terrestrial wildlife tourism experiences (Hammitt et al., 1993), smaller, harder to find organisms might also provide distinctive aspects of an experience, because finding them in the first place may be reward in itself. For visitors to the Elk Island National Park, the large size of the animals seen was found to be the most mentioned characteristic of a memorable wildlife experience (Chapman, 2003). Conversely, the size of the fish for day-trip visitors to the GBR was found to be the least influential attribute of the fish seen (Shafer & Inglis, 2000).

Physical attributes might also be distinctive at a site for their size, for example the Grand Canyon or the Great Wall of China. While diving on coral reefs, a reef wall or a cave might be extremely large and thus be a distinctive attribute of a site and attract divers' attention. 'Blue holes' or underwater caves and caverns on coral reefs in the Bahamas for example are a main attraction for divers at some sites (Jackson, 1997). Understanding of the influence of biophysical attribute size on visitors' experiences is still in its infancy.

Behaviour – The behaviour of an organism, or group of the same type of organisms, might provide divers with quality experiences because of a particular or interesting type of movement or locomotion, courtship or mating behaviour, or feeding or hunting activities. Interesting behaviours of organisms have been shown to provide visitors with quality experiences in other marine wildlife activities, for example watching humpback whales (Muloin, 2000), swimming with whale sharks (Davis et al., 1997), and swimming with minke whales (Valentine et al., 2004). These wildlife tourism experiences focus on one type of marine organism, while on coral reefs the viewing of wildlife is a multi-species activity (Birtles et al., 2001). Which species are the most distinctive in diverse and abundant coral reef environments due to their behaviour is not known.

Duration – Refers to the length of the encounter with a particular type of organism (Reynolds & Braithwaite, 2001). Many reef organisms are very timid in the presence of divers, while other organisms pay little attention to divers. Some coral reef organisms can engage in long encounters with divers especially when being fed (Vail & Hoggett, 1997). While it is acknowledged that a brief sighting of a particular organism might provide divers with a quality experience, an encounter of longer duration with that same organism is likely to provide a higher quality experience, especially if the organism is distinctive for other factors like behaviour.

Popularity or iconic status– Popularity or iconic status is driven by a range of factors which include physical attractiveness, danger, and/or the publicity they have received in the public media (Reynolds & Braithwaite, 2001). For coral reef organisms such media may include dive magazines and books, web sites, documentaries, advertising material like brochures, and even Hollywood movies like 'Jaws', 'Finding Nemo', 'Open Water', and 'Shark Tale'. Because of this popularity or iconic status, organisms like anemonefish or reef sharks might be easily recognised by visitors and are thus instantly identified. How important these popular and iconic organisms are to experiences when they are seen is not fully understood.

Special/unusual features – This refers to the experience or characteristics of an attribute being regarded as special or unusual and therefore the participant being privileged (Reynolds & Braithwaite, 2001). This might include aspects of the experience such as a first experience, an experience that the visitor had wanted to have for some time, or an experience that wasn't expected. Special or unusual characteristics of an organism might also influence experiences such as particularly good health, perceived or actual rarity of the organism, colouration, unusual shape of form, or that the organism was cryptic or camouflaged. For physical attributes, the special or unusual factor might relate to very good visibility, or an unusual structural formation.

Intensity of experience – refers to the excitement generated by an experience (Reynolds & Braithwaite, 2001). This might have much to do with the wildlife tourism activity itself, for example searching for and finding a particular organism, or behaviours of organisms that create an intense atmosphere such as a feeding or hunting event like those often seen in wildlife documentaries. This factor is likely to be modified by the amount of times the viewer has seen or experienced a particular attribute.

The impact that distinctive biophysical attributes have on divers' experiences over a given time period will be determined by how often the attribute is able to be seen at a site. While some organisms can be seen at a site on every dive, others may be sighted much less often. This may be due to daily or seasonal effects (Birtles et al., 2001), or just because an organism is transient by nature. This difference might also vary between sites; some organisms might occur on all sites, while others are found at very few. Sighting frequency, or how often an attribute can be seen at a site, is mostly related to the biological attributes, but can also be related to physical attributes like the horizontal visibility of the water. Distinctive attributes that occur more often at a site are likely to be the most important and valuable to experiences for a greater number of visitors' over a longer time frame.

4.1.3 Assessing the environmental attributes

It is well established that coral reefs are one of the most diverse and complex ecosystems on Earth. Because of this, a series of survey methods aimed at measuring specific and separate components of coral reef attributes must be employed. This approach is warranted if the purpose of the assessment is to understand the range of biophysical attributes that visiting divers are most likely to encounter. Hill & Wilkinson (2004) list the five methods most commonly used to monitor coral reef environments. These are: site/reef mapping, benthic communities, invertebrates, fishes, and physical parameters. These five categories encompass the notion of 'describing' the reef environment and its biophysical attributes. Other large marine animals like turtles should also be included in assessments of dive sites as they are often seen by visiting divers. Such additions to the traditional coral reef monitoring methods are fundamental in 'describing' and measuring the attributes that occur on dive sites that are most likely to be encountered.

Coral reef communities exhibit high spatial and temporal variation. As a result, collecting information useful for a specific purpose can be challenging (Hallacher &

Tissot, 1999). Quantifying species richness is the simplest way to describe community and regional diversity as well as make basic comparisons between sites (Gotelli & Colwell, 2001). Yet there are many methods available to researchers and managers for the collection of such data (see Hill & Wilkinson, 2004, for extensive review of methodologies). Cost and time constraints may limit the number and type of samples that can be taken from an area, requiring the need for highly efficient sampling methods (Long, Andrews, & Wang, 2004). Visual census methods are usually the most efficient.

A visual census permits an estimate of the presence and abundance of one or more species, with relatively little expenditure of field time, and without the disadvantages inherent in the disturbance caused by destructive sampling procedures (Sale & Sharp, 1983). This is a prime consideration when assessing tourism sites. One of the most cost effective visual census techniques available for coral reef environments is the Roving Diver Technique (RDT). The RDT is a visual survey technique developed by REEF (Reef Environmental Education Foundation) for recreational divers undertaking fish surveys on coral reefs (REEF, 2002b). While transects have been traditionally used to assess fish communities in coral reef environments (Sale & Sharp, 1983), the need for fish data to be collected rapidly and at low cost has seen the RDT become more widely accepted (Pattengill-Semmens, Gittings, & Shyka, 2000; Pattengill-Semmens & Semmens, 1998).

In a study evaluating the use of the RDT and comparing it to traditional transect survey methods to rapidly assess fish populations off south-eastern Hispanola, Schmitt, Sluka, & Sullivan-Sealey (2002) found that both methods were similar in recording the most abundant species. However, a greater number of rarer species were recorded with the RDT. This was because the surveyor was able to explore the site more extensively rather than being restricted to the specified transect dimensions. In addition, the RDT allowed more time to be spent surveying instead of placing and retrieving transect lines, resulting in a greater number of species being recorded. It might be expected that the rarer and harder to find species are in some cases highly valued as part of the diving experience, and should therefore be assessed. The RDT has been shown to do this very effectively.

The RDT is conducted by a diver moving around a site and recording all fish species observed. This method provides an assessment of a site covering all habitats, and encourages divers to look under ledges and throughout the water column. Observers are free to search as they wish with few special restrictions: divers may not physically disturb the habitat and must have a buddy for safety. This methodology can be modified to closely approximate the typical swim behaviour of many visiting divers, especially those that have extensive history and knowledge with coral reef environments who also look under ledges and throughout the water column constantly searching for marine organisms including rarer species. This means the biophysical attributes assessed by researchers can be more closely matched to those attributes encountered by divers, providing an accurate assessment of what attributes occur at a site that visitors might see. Although the RDT has been used in the past to assess fish populations, its flexible methodology allows it to be modified for use on all marine organisms found on coral reefs, making it the perfect tool for rapidly assessing dive tourism sites.

4.2 Objectives

Given our lack of knowledge and understanding of what biophysical attributes visiting divers are most likely to encounter on coral reef dive sites, and which of these might be significant to their experiences because they are the most distinctive at a site, the objectives of this study are:

1. To provide an assessment of the biophysical attributes that certified divers are most likely to encounter on selected Ribbon Reef and Osprey Reef dive sites. These attributes include:

   - physical attributes;
   - corals;
   - fish (bony);
   - sharks and rays (cartilaginous fish); and
   - other marine organisms;

2. To provide an interpretation of these assessments in terms of:

   - how physical attributes vary within and between sites;
   - how biological attributes vary within and between sites;
   - how often selected organisms though to be important to experiences can be seen within and between sites; and
   - which biophysical attributes are most distinctive at each site.

4.3 Methods

This section provides a detailed account of the methods employed to undertake Study Two and begins with a description of each of the five sites selected (see Chapter Two for study site selection), including a site map, the core information presented within the pre-dive briefing by each of the operators, and the typical swim behaviour of the visiting divers (Section 4.3.1). This was to determine where the biophysical assessments on each site would take place to ensure the biophysical attributes assessed by the researchers were closely matched to those attributes encountered by divers. Section 4.3.2 describes the survey technique for carrying out the biophysical assessments, and is followed by a description of the four surveys undertaken at each of the sites used to measure and describe the biophysical attributes (Sections 4.3.3 to 4.3.6).

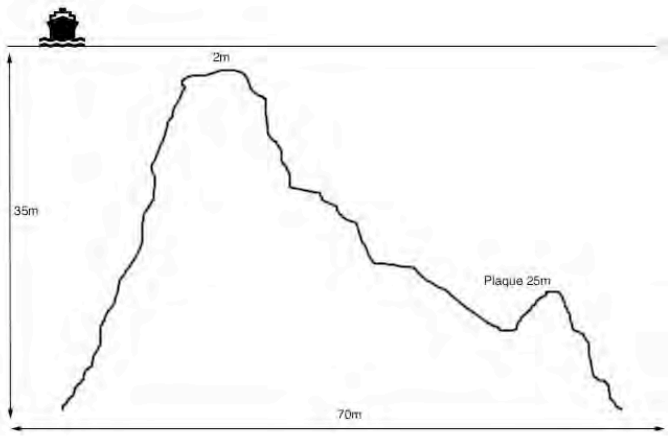
4.3.1 Determining the typical swim behaviour of divers at each of the study sites

In Chapter Two, site selection, location, patterns of use, and brief descriptions of the five study sites were provided. To assess the biophysical attributes at each of the sites that are most likely to be encountered by visiting divers, it was essential to first understand how divers use the sites, and what information they were provided with to do so. Here I provide information given to visiting divers on all participating vessels in the pre-dive briefing, including the site map, and then describe the typical swim behaviour of the divers at each of the sites. While the pre-dive briefing does differ between individual crew and vessels, a core set of biophysical attributes are mentioned on all vessels. These were recorded by the researcher when on board each vessel during the study period. The pre-dive briefing provides operators the opportunity to inform divers of the biophysical attributes that occur there, highlighting those of particular interest. While doing this, the crew also provides a recommended dive plan for divers to safely see and enjoy the site as much as possible. The typical swim behaviour of the divers at the site is therefore a function of both the biophysical attributes at the site, and the information provided in the pre-dive briefing.

Each of the five dive sites from the two locations will be described separately. These are from the Ribbon Reef location: Steve's Bommie (SB), Pixie Pinnacle (PP), and the Cod Hole (CH). The two remaining sites, Admiralty Anchor (AA) and North Horn (NH) are from the Osprey Reef location. The site maps provided for each of the sites are displayed as either plan view or cross section. Plan views were most appropriate for the back reef and reef wall sites to represent the types of diving opportunities represented at each, where divers tend to explore a larger area. Cross sections were most appropriate for pinnacle sites as this was the best way to represent the types of diving opportunities at these sites, where divers spiral the pinnacle itself throughout the dive.

Ribbon Reef location: Steve's Bommie (SB)

Figure 4.1. Plan view site map of Steve's Bommie (South aspect).



Core information presented within the pre-dive briefing at Steve's Bommie

General biophysical attributes at site:

- Site is a large pinnacle rising from 35m
- Current can be strong at times, but only on one side of the pinnacle
- Site is home to wide diversity of marine life

Physical attributes of interest:

- The pinnacle itself
- Site has a plaque placed near pinnacle base at approximately 25m (see map)
- Approximate visibility

Biological attributes of interest:

- Large schools of fish around whole pinnacle
- Large school of bigeye trevally in open water just off the pinnacle
- Turtles often seen at the site
- School of barracuda often seen just off the pinnacle in approximately 15m
- Hunting shark mackerel often seen circling the pinnacle
- Many species of anemonefish and host anemones at all depths around pinnacle
- Cuttlefish can often be seen in approximately 15m on side of the pinnacle
- Lionfish seen at all depths around the pinnacle
- Reef stonefish often seen resting on substrate in approximately 10m
- Mantis shrimp often seen in rubble on the side of the pinnacle
- Red flame file shell hidden in small hole on steep wall of pinnacle at approximately 14m
- Wobbegong sharks can be sometimes be seen resting in caves on side of the pinnacle at approximately 15m
- Whitetip reef sharks often seen around the base of the pinnacle on the sand
- Nudibranchs of many species seen on the steep wall of the pinnacle
- Octopus sometimes seen in rubble on the side of the pinnacle

Recommended dive plan:

- Enter the water, and drop down to preferred maximum depth at start of dive, usually at the base of the pinnacle
- Circle the pinnacle ascending all the time
- Do 3 minute safety stop at 5m and return to vessel

Typical swim behaviour of visiting divers - SB is approximately 4000m^2 in surface area (pinnacle only), and divers will travel no further than 70m away from the main dive vessel. The pinnacle comes within 2m of the surface and is marked by a surface buoy. Divers enter directly from the main vessel from either the southeast or northeast of the site depending on the wind direction. Once under water, divers descend to their preferred maximum depth, but most will reach the bottom at approximately 35m (Figure 4.1). More experienced divers may venture onto the sand substrate around the base before concentrating on the pinnacle itself. All divers will undertake slow spirals up and around the pinnacle searching for organisms, including those mentioned within the pre-dive briefing, until reaching 5m where a safety stop for no less than three minutes is required. The typical dive at SB lasts between 50 and 60 minutes.

Because there is so much to see at this site within the top 2-15m, most divers will not spend much time at depth. Divers do focus much of their attention at this site on the physical substrate of the pinnacle where many of the marine organisms can be found. However, there is also a substantial amount of life surrounding the pinnacle, mostly in the form of large schools of fish in the upper 20m.

Plate 4.1. Photos from Steve's Bommie

(a)  (b) 

(a) Bigeye trevally are always seen in large schools at this site

(b) Steve's Bommie supports a diversity of marine life of all shapes, size, and colour

(c) The plaque at Steve's Bommie (25m)

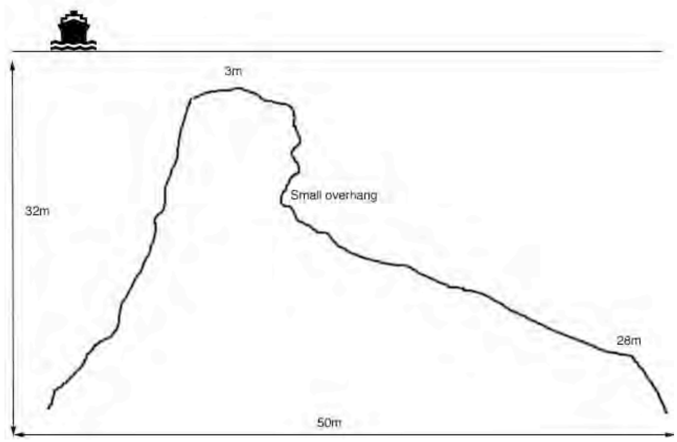
(d) Many cryptic species such as the reef stonefish can be found at Steve's Bommie

(c) 

(d) 

Ribbon Reef location: Pixie Pinnacle (PP)

Figure 4.2. Plan view site map of Pixie Pinnacle (South aspect).



Core information presented within the pre-dive briefing at Pixie Pinnacle

General biophysical attributes at site:
- Site is a medium sized pinnacle rising from 32m
- Currents are usually not very strong here
- Site is home to a wide diversity of marine life

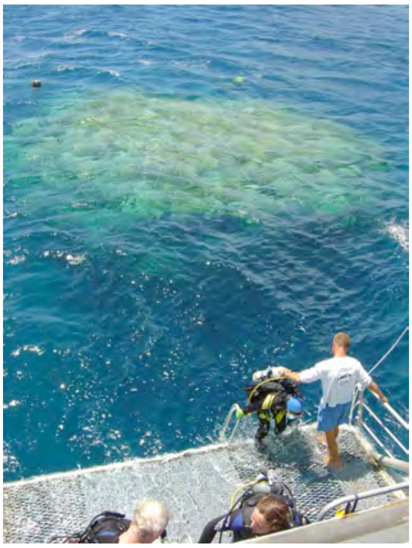
Physical attributes of interest:
- The pinnacle itself
- Approximate visibility
- Small cave at approximately 8m. Divers are not to enter because of gorgonian fans (see biological attributes)

Biological attributes of interest:
- Large schools of schooling fish around whole pinnacle
- Hunting trevally species around the pinnacle
- Large school of chevron barracuda off the pinnacle in approximately 15m
- Lionfish at all depths
- Mantis shrimp in the rubble on the side of the pinnacle
- Nudibranchs of many species on the steep side of the pinnacle
- Red flame file shells in small holes on steep side of the pinnacle at approximately 16m
- Moray eels near the base of the pinnacle
- Pipefish on the steep wall of the pinnacle
- Gorgonian fans inside the cave

Recommended dive plan:
- Enter the water, and drop down to preferred maximum depth at start of dive, usually base of the pinnacle
- Circle the pinnacle ascending all the time
- Do 3 minute safety stop at 5m and return to vessel

Typical swim behaviour of visiting divers - PP is approximately 2000m^2 in surface area (pinnacle only), and divers will travel no further than 50m away from the main dive vessel. The pinnacle is visible from the surface, and is marked by a surface buoy attached to the top. Divers enter directly from the main dive vessel that is always moored to the east of the site. Divers descend down the pinnacle structure to their preferred maximum depth, with most making it to the bottom at approximately 29 to 32m (Figure 4.2). More experienced divers may venture away from the pinnacle to the small coral outcrops in the sand. However, the main interest is the pinnacle itself as this is where much of the marine life is concentrated, especially in the upper 15m. Once the maximum depth has been achieved, divers spiral up and around the pinnacle until reaching 5m, where a safety stop for no less than three minutes is required. The typical dive time at this site is between 50 and 60 minutes. When spiralling this site, divers are able to focus on the diverse marine life living on or in the substrate, while also observing pelagic species that congregate around the pinnacle in open water.

Plate 4.2. Photos from Pixie Pinnacle

(a)  (b) 

(a) The top of Pixie Pinnacle as seen from the dive vessel

(b) Large schools of fusiliers are always seen circling the pinnacle structure

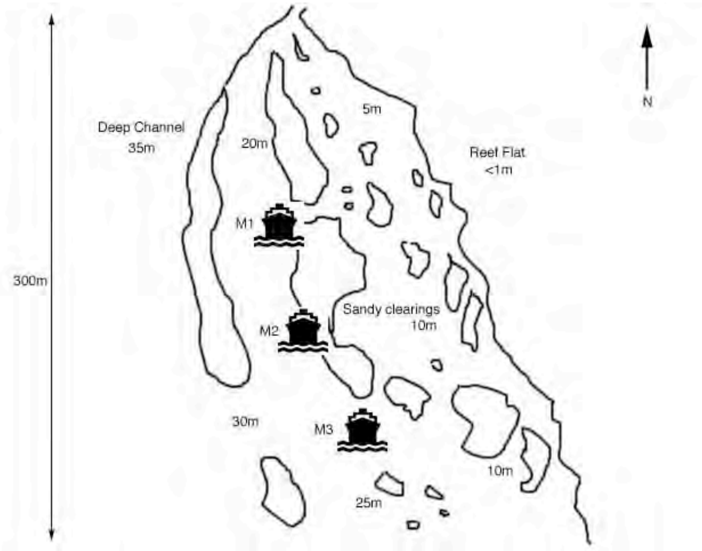
(c) Nudibranchs like this one are regular sights on the steep walls of Pixie Pinnacle

(d) Barracuda can be sighted with very high frequency at Pixie Pinnacle

(c)  (d) 

Ribbon Reef location: Cod Hole (CH)

Figure 4.3. Aerial view site map of the Cole Hole.



Core information presented within the pre-dive briefing at the Cod Hole

General biophysical attributes at site:
- Site is situated on shallow back reef zone, but also has a deep water channel (see map)
- Large sandy clearings separate the coral ridges (see map)
- Currents can be quite strong here on both the incoming and outgoing tide
- Site is famous because of the population of potato cod

Physical attributes of interest:
- Deep water channel
- Large sandy openings
- Caves and swim throughs near reef flat (see map)
- Approximate visibility

Biological attributes of interest:
- Excellent coral growth and formations
- Numerous large potato cod in approximately 10-20m
- Flowery cod in approximately 10-20m
- Adult maori wrasse in approximately 10-20m
- Large school of red bass usually under the vessel
- Moray eels in coral substrate in approximately 10-20m
- Resting whitetip reef sharks on sand in approximately 10-20m
- Occasional sightings of grey reef sharks in open water in approximately 20-30m
- Stingrays hidden in the sand in approximately 10-20m
- Occasional sightings of diagonally banded sweetlip in approximately 10m

Recommended dive plan:
- Enter the water, and drop down to preferred maximum depth at start of dive, usually toward the deep water channel
- Move into the current at the start of the dive, and return to the vessel with the current at the end of the dive
- During feed, rest on the sand (approx 8m), with hands in BCD, and allow potato cod, flowery cod, and maori wrasse to come to you
- Do 3 minute safety stop at 5m and return to vessel

Typical swim behaviour of visiting divers - The CH is approximately 9000m^2 in surface area, and the maximum distance divers will travel from the main dive vessel is 100m either north or south. Divers enter directly from the main dive vessel from one of three commercial moorings (M1, M2, and M3 on map). Once under water, divers have the option of either heading straight down toward the deep channel, or staying in the general site area in approximately 10 to 20m. The recommended dive plan is to move away from the dive vessel while exploring the many scattered bommies and traversing the reef slope up into shallower water in the first half of the dive, and then turning around and continue exploring while returning to the dive vessel in the second half of the dive.

Five out of the six operators also conduct 'cod feeding' activities at this site where divers are asked to rest on the sandy bottom in an open clearing in approximately 8m of water. Here the divers form a circle, and potato and flowery cod (*Epinephelus tukula* and *Epinephelus fuscoguttatus* respectively), maori wrasse (*Cheilinus undulatus*), and red bass (*Lutjanus bohar*) are fed in front of the divers. Best practices for fish feeding activities at the Cod Hole are defined by CHARROA, through their Code of Practice (Alder & Haste, 1994), and a permit is required through the GBRMPA. This permit restricts fish feeding activities to a limit of 1kg per site per day of raw marine product or fish pellets (GBRMPA, 2001).

The cod feeding is carried out by a crewmember taking down a small plastic container with approximately 20-30 pilchards. Once all of the divers have formed a circle on the sand, the crewmember will move into the middle of the circle. The crewmember will feed one pilchard in front of each of the divers (mostly to the potato cod) in the circle so they are able to view or photograph this event up close. This continues until all of the divers have experienced the cod feeding in front of them. While the potato cod get most of the food, large schools of red bass will attempt to steal pilchards from the crewmember or the potato cod. Maori wrasse and flowery cod are occasionally fed by the crew as part of the event. The cod feeding can take anywhere between 10 and 30 minutes. After the feeding is complete the crewmember gives the signal for divers to move away from the area and spend the rest of the dive exploring the site. Regardless of the feeding activity, the average dive time at this site is between 40 and 60 minutes.

Plate 4.3. Photos from the Cod Hole

(a)  (b) 

(a) Divers on the sand during the 'Cod feed' allowing them to see potato cod up close

(b) Potato cod are large and can reach 2m in length

(c) The Cod Hole is a maze of beautiful coral bommies

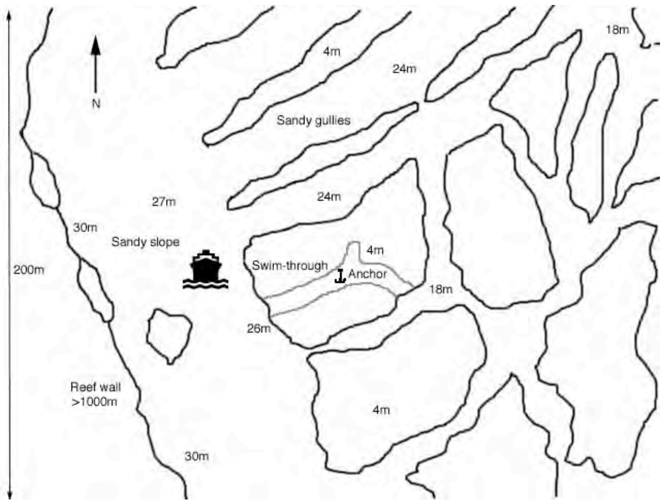
(d) Diagonally banded sweetlip (*Plectorinchus lineatus*) are one of the many species that can be found at the Cod Hole

(c) 

(d) 

Osprey Reef location: Admiralty Anchor (AA)

Figure 4.4. Aerial view site map of Admiralty Anchor.



Core information presented within the pre-dive briefing at Admiralty Anchor

General biophysical attributes at site:

- Site is a maze of coral ridges and sandy gullies on a large flat plateau approximately 20 to 30m deep. This moves off into a large steep reef wall similar to a cliff face over 1000m deep (see map)
- Currents can be quite strong and move east across site
- Site has a large cave that divers can swim through and see the Admiralty style anchor wedged into the coral substrate (see map)

Physical attributes of interest:

- Admiralty style anchor in large cave. Entry is found at 16m and exits about 30m away in 8m of water. Anchor is wedged in the coral substrate and can be seen while moving through the cave.
- Many caves and swim-throughs to explore
- Large sandy gullies that separate high coral ridges (see map)
- Reef wall approximately 1000m deep (see map)
- Approximate visibility

Biological attributes of interest:

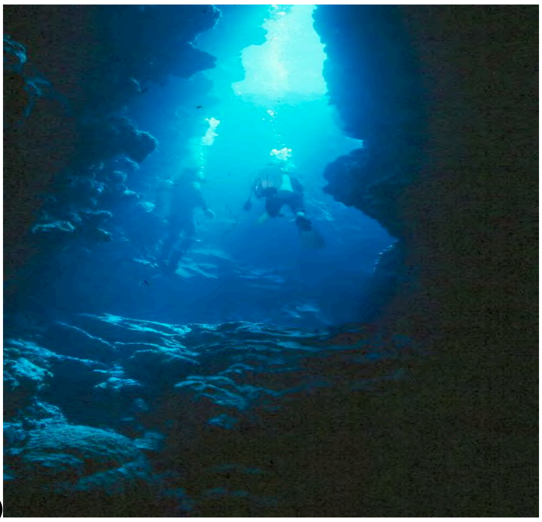
- Moray eels found in the coral substrate in all depths
- Garden eels found on sandy gully forward of the vessel in approximately 26m
- Resting whitetip reef sharks on sand in approximately 20 to 30m
- Occasional sightings of grey reef sharks off the wall in approximately 30m
- Occasional sightings of hammerhead sharks off the wall in approximately 40m
- Occasional sightings of silvertip reef sharks off the wall in approximately 40m
- Lionfish found near coral substrate between 10 and 30m
- Occasional sightings of manta rays in open water at all depths
- Dogtooth tuna in open water usually off wall between 10 and 40 m

Recommended dive plan:

- Enter the water, and drop down to preferred maximum depth at start of dive, usually directly under the dive vessel off the wall
- Move off over the wall and look for any large pelagic species in open water
- Do not dive deeper than 40m, and do not lose sight of the wall
- Enter cave at 16m, do this toward end of dive because you exit the cave at 8m. This eliminates the chance of performing a saw tooth profile (ascending and descending multiple times during a dive)
- Do 3 minute safety stop at 5m and return to vessel

Typical swim behaviour of visiting divers - AA is approximately 11,200m^2 in surface area, and divers will travel no further than 100m away from the main dive vessel in any direction. Divers enter directly from the main dive vessel moored on the leeward side of the reef in approximately 25m of water (Figure 4.4). Once under water, divers descend directly under the vessel to the bottom, which is sand. From here depending on the level of experience, divers may venture over the reef wall to a maximum depth of 40m to search for large pelagic species (40m is the Queensland Workplace Health and Safety recreational depth limit (QLDGOV, 2001). Time is limited at this depth and an average of 5 to 10 minutes may be spent over the wall. Divers then usually ascend up the sandy gullies meeting the wall. Divers then have the option of exploring the sandy gullies, enjoying the large population of garden eels (*Heteroconger hassi*) and resting whitetip reef sharks (*Triaenodon obesus*). The site has a large cave where an Admiralty style anchor can be found, and divers are encouraged to explore this at the end of their dive. The divers then move to the top of the coral ridges that are rich in coral and fish life. Here a three-minute safety stop at 5m is undertaken and then back onto the vessel. The typical dive time at AA is between 50 and 60 minutes.

Plate 4.4. Photos from Admiralty Anchor

(a) 

(b) 

(a) There are many large caves and swim-throughs to be found at Admiralty Anchor

(b) Whitetip reef sharks are regularly seen lying on the numerous sandy gullies that separate the coral ridges on the reef plateau

(c) Divers are able to explore reef walls that drop over 1000 metres at Admiralty Anchor

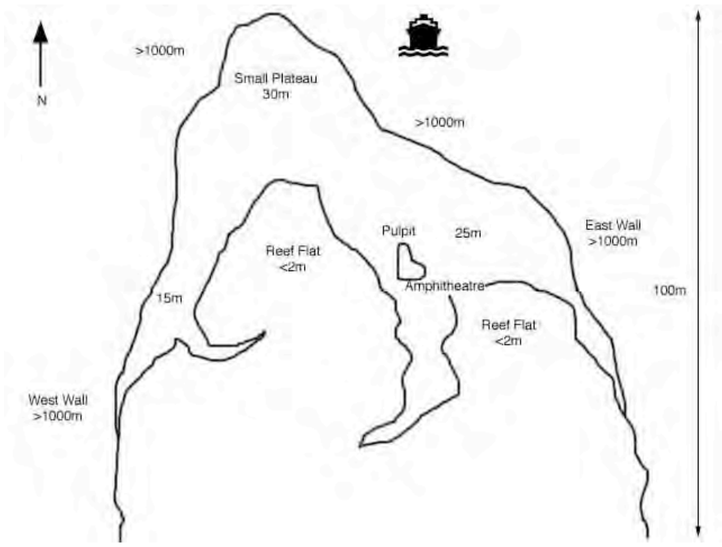
(d) The corals are large and colourful, with a high percentage of live coral cover

(c) 

(d) 

Osprey Reef location: North Horn (NH)

Figure 4.5. Aerial view North Horn.



Core information presented within the pre-dive briefing at North Horn

General biophysical attributes at site:

- Large steep wall with small plateau at approximately 30m (see map)
- Currents can be quite strong and move up or down either wall
- Site is home to a high abundance of sharks

Physical attributes of interest:

- The wall itself dropping into 1000m of water (see map)
- Small pinnacle called 'the pulpit' where shark feeds/attracts are conducted surrounded by a coral 'amphitheatre' (see map)
- Small caves along the wall
- Approximate visibility

Biological attributes of interest:

- Many whitetip reef sharks usually close to reef wall at all depths
- Many grey reef sharks usually out in open water at all depths
- Several large potato cod usually close to reef wall at all depths
- Occasional sightings of dogtooth tuna in open water in approximately 20 to 40m
- Moray eels in substrate in approximately 20m
- Large soft coral trees along west wall at approximately 40m
- Occasional sightings of silvertip reef sharks off the wall in over 40m
- Occasional sightings of hammerhead sharks off the wall in over 40m
- Occasional sightings of manta rays off the wall in all depths

Recommended dive plan:

- Enter the water, and drop down to preferred maximum depth at start of dive, usually directly under the dive vessel
- Move into the current at the start of the dive traversing the reef wall, and return to the vessel with the current at the end of the dive
- Do not venture too far off the wall in open water as you will get swept away from the site by the currents
- Do not dive deeper than 40m
- Do 3 minute safety stop at 5m and return to vessel

Typical swim behaviour of visiting divers - NH is approximately 8800m^2 in surface area, and the maximum distance divers will travel away from the dive vessel is approximately 80m. Divers enter the site directly from the main dive vessel. The depth under the vessel is over 1000m. Those wishing to reach 40m usually hug the reef wall and explore the large soft coral trees on the west wall while swimming between dozens of reef sharks including whitetip reef sharks and grey reef sharks (*Carcharhinus amblyrhyncos*). Reef sharks generally circle the area directly under the dive vessel and so divers do not have to travel far to see them. If divers wish however, they are able to traverse along the reef wall on either side of the main dive area, depending on currents. Most divers will stay close to the vessel initially and enjoy viewing the reef sharks for 15 to 20 minutes. Divers then slowly traverse one of the walls and return, all the time ascending. As usual, a three-minute safety stop is required at 5m. This is usually done on the mooring line. A typical dive time at NH is between 40 and 50 minutes.

All operators visiting NH conduct shark 'feeds' in which the sharks are fed, or 'attracts' in which sharks are attracted with food but are not fed. While it is illegal to feed or attract sharks within the GBRMP (GBRMPA, 2001), shark feeding or attracting activities at Osprey Reef and many other of the Coral Sea mounts outside the GBRMP are not regulated in any way, and thus no permit or Code of Practice exists at present. Up to 20 fish frames (usually tuna due its high oil content and attractiveness to sharks) are taken down to the pulpit (see Figure 4.5) in either the feed or attract to allow divers to watch the sharks feed or just get up close. Divers are positioned on the reef wall in the amphitheatre area (see Figure 4.5).

During a shark feed, the fish frames are either threaded on a large steel cable that is dropped from the surface from an inflatable boat, or released from a large plastic or steel bin by a crewmember once underwater. The effect of the 'feed' is one of intense feeding activity by the many sharks that compete for food with each other and the many other species such as the potato cod. Up to 58 sharks took part in this event on one occasion during the research for this thesis. The grey reef sharks are usually sent into a 'feeding frenzy' during this event and can often become unpredictable. This is a common behaviour of this species during feeding activities (FishBase, 2003).

During the shark ‘attract’, crew will take the fish frames underwater in a plastic bin with many holes in the sides to allow the taste of the food to escape. In doing this, the sharks are attracted to the food but cannot get to it. While the sharks might get the odd piece of fish frame out of the holes in the side of the bin, they do not compete with each other or other species for food, nor are they sent into a frenzy. This event is purely to attract the sharks into a small area so divers can view them up close. Crew takes the food back to the vessel once all divers have exited the water.

During either the shark ‘feed’ or ‘attract’, the sharks and potato cod get very close to the divers, sometimes within as little as one metre, even though divers are positioned at least 10m from the food. The shark feed usually lasts about ten minutes because the sharks quickly consume the food. The shark attract can last up to 30 minutes because the food is not removed or consumed by the sharks or other species. Once the shark feed or attract is finished, all divers are asked to leave the amphitheatre area, and continue with their normal dive, going no deeper than 15m.

Plate 4.5. Photos of North Horn

(a)  (b) 

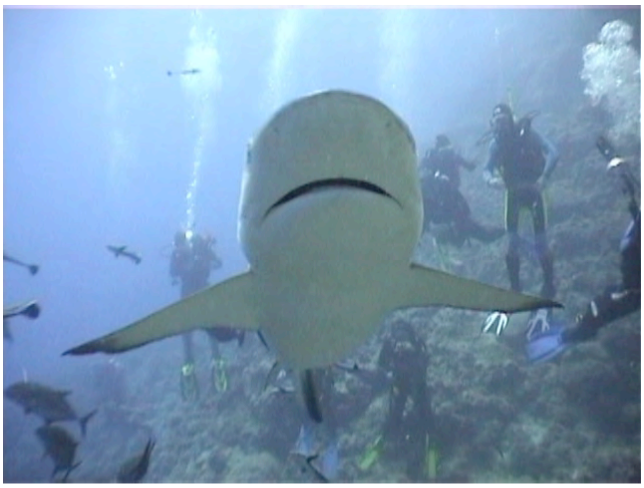
(a) Aerial view of Osprey Reef with North Horn located at the very tip of the reef at the bottom right (source: Undersea Explorer)

(b) Both whitetip reef sharks and grey reef sharks are permanent residents at North Horn

(c) Divers are able to venture down the steep oceanic walls on this coral reef atoll

(d) During shark 'attract' or 'feed' dives, divers get the opportunity to get a closer look at reef sharks


(c)


(d)

4.3.2 Survey techniques

In order to provide an assessment of what biophysical attributes visiting divers are likely to encounter at each of the dive sites, four separate surveys were designed and undertaken using a modified version of the Roving Diver Technique (RDT) (REEF, 2002b). Each survey was designed to capture a separate set of biophysical attributes that occur on coral reef dive sites. These surveys were:

- Survey 1 - Broad-scale site descriptions
- Survey 2 - Roving Diver Diversity (RDD) of coral
- Survey 3 - Roving Diver Diversity (RDD) of marine organisms
- Survey 4 - Standard and specific marine organism presence/absence and relative abundance monitoring

Modified Roving Diver Technique (MRDT)

A modified version of the RDT was adopted as the core sampling methodology for all four surveys undertaken because of its flexible nature for data collection. The modified RDT (MRDT) was not limited in this study to the collection of fish data but was used for all taxa relevant to the study, as well as undertaking physical site descriptions. This method allowed data to be collected without the disturbance inherent to other sampling techniques such as quadrats and transect lines, which are not appropriate for tourism sites. The MRDT was designed to closely approximate the typical swim behaviour of visiting divers at each of the dive sites, but provided a more exhaustive search of the area than would be expected of the average visiting diver. This was because the survey technique had to account for as many biophysical attributes as possible that might be encountered by the divers during a typical dive. This was to appreciate what was at the site from a natural science perspective, compared to what divers actually experienced at the site. Typical swim behaviours at each of the sites were established by talking to dive crews about where visiting divers ventured, and from the experience of the researcher with over 100 dives on each of the sites. Because the MRDT requires no transect lines or quadrats, surveys commenced immediately upon entering the water, making efficient use of the time available. This was an important consideration, as operators are on tight schedules and must move between dive sites constantly.

The following is an outline of the procedure designed for undertaking the MRDT on live-aboard dive sites used for all four surveys undertaken.

1. The dive operator using GPS located the site. The main dive vessel was moored to the site.

2. Two divers entered the water. One was the primary surveyor, the second acted as a buddy for safety and also pointed out reef organisms missed by the primary surveyor. The primary surveyor was equipped with a complete set of SCUBA diving equipment including computer, slate, pencil, data sheets (blank), and an underwater digital camera. The survey begun immediately upon entering the water.

3. Divers reached a maximum depth of 30m continually ascending to shallower depths throughout the dive for 40 to 50 minutes (maximum 60 minutes). A safety stop was performed at 5m for a minimum of three minutes.

4. During the assessment of the dive site the surveyor was permitted to search the site extensively to include cryptic organisms. The surveyor explored all possible habitats including under ledges and throughout the water column, to maximise the number of species seen. At no time was the surveyor permitted to touch or disturb the habitat being assessed.

Qualifications - To undertake each of the four surveys, a high degree of diving ability, and knowledge of coral reef environments was essential due to level of detail needed to be collected at each of the sites (Hill & Wilkinson, 2004). If surveyors had only limited diving ability and knowledge, more time and focus would be needed for the activity of diving itself such as buoyancy control, and not to data collection. It was a prerequisite that surveyors had a graduate Marine Biology degree, a minimum of 100 total dives, and at least Rescue Diver certification.

Timing of dive site assessments - Given that all the boats visit the dive sites during daylight hours, surveys were conducted between 0830 and 1600hrs. This time window also excludes periods of poorer visibility caused by low sun angle.

Species Identification - Identification of corals to family, genus, and species level in the field was accomplished through collaboration with coral taxonomist Dr Doug Fenner while on board the live-aboard diving vessel *Undersea Explorer*. Dr Fenner undertook Survey 2 - RDD of corals at each of the sites. Fish species (bony and cartilaginous) were identified using Randall et al., (1997), while other marine species such as molluscs and crustaceans were identified using Allen & Steene (1996), and Gosliner, Behrens, & Williams (1996), as references. These texts provided a photographic record of the species found on coral reefs in the study area as well as ecological information. Where species could not be positively identified underwater, a digital photo was taken for later positive identification to at least genus level.

Inter-observer standardisation - Because only one surveyor was responsible for each of the RDD surveys, inter observer standardisation was not an issue. For Survey 4, two marine scientists on board *Undersea Explorer*, as well as the primary researcher were responsible for data collection. Organisms selected for monitoring were conspicuous members of coral reef communities at the study sites or were known to exist there through extensive local knowledge. Therefore, it was not expected that identification would pose any problems.

4.3.3 Survey 1 – Broad-scale site descriptions

Because coral reef sites are complex environments that differ in biophysical attributes, it is important to understand what specific attributes occur at each dive sites and how they might influence the diving experience. Survey 1 was designed to provide a rapid descriptive and qualitative assessment of the biophysical attributes that occur at each of the dive sites using variables adapted from the AIMS long-term monitoring project (Bass & Miller, 1996; Miller, 2003), and those designed specifically for this study. The physical attributes of interest at the sites included: reef zone; exposure; reef slope; substratum at reef base; general reef features; structural complexity; maximum depth of site; and sand/rubble presence. The coral attributes of interest at the sites included: percent live coral cover; dominant benthic form; dominant hard coral genus; dominant hard coral form; colour index of corals; and level of coral bleaching. Data on fish and other marine organisms were also collected, based on how conspicuous they were by either presence and/or abundance. Each of the physical, coral, fish and other marine organisms attribute variables and their measurements are explained below.

Physical attributes

The physical attributes on a coral reef are those that are abiotic or non-living which act to produce the shape and landscape of the site, as well as providing the basis for habitat where all marine organisms live. The eight variables selected provide a description of the physical characteristics at each site. These were:

Reef Zone – Almost all dive sites are situated within a small zone of a whole reef that has many zones (exceptions made for pinnacle sites). This is because reefs can be quite large and divers are only able to travel a limited distance underwater due to reduced mobility and a finite air supply. The measurement of which reef zone the dive site was situated in was used to characterise broadly what type of site it was. These were:

- *Reef slope* - zone at the front of the reef usually exposed to high wave energy
- *Reef crest* - transition zone between the reef slope and the reef flat
- *Reef flat* - very top of the reef
- *Back reef* - zone on the leeward side of the reef, can be similar to reef slope but with little to no wave energy
- *Pinnacle* -isolated reef structure rising from the sea floor
- *Reef wall* - near vertical section of reef with virtually no transition between reef flat and wall zone-similar to a terrestrial cliff face

Exposure to weather conditions (modified from AIMS methods) – Depending on the reef zone that the dive site is situated in, exposure to weather conditions can affect the horizontal visibility of the water, current flow, and the wave height on the surface. This variable described the physical environment and the prevailing sea conditions at each site. The description took into account the observer's knowledge of the prevailing conditions in the area rather than the conditions on the day. Only one category was chosen. This comprised:

- *Sheltered* – areas of the reef that are in the lee of prevailing wind and waves (typically from the southeast on the GBR), these are usually the back reef zones
- *Partly exposed* – areas of the reef that have some protection from prevailing waves and winds but are exposed on regular occasions
- *Exposed* – areas of the reef that are exposed to prevailing wind and seas on almost a constant basis, usually the front reef zones

Reef Slope (modified from AIMS methods) - The reef slope was defined as the angle of one or more slopes at the dive sites. This information helps characterise the type of diving activities that will be undertaken, such as deep diving on a vertical wall, or diving at one depth on a shallow back reef. More than one category could be selected, but the most dominant slope at the site was mentioned first. These categories were:

- *Shallow* - (0-20°)
- *Moderate* - (21-45°)
- *Steep* - (46-75°)
- *Vertical* - (76-90°)
- *Broken* – if the reef edge is not well defined, or is made up of scattered bommies
- *Back reef slope* – described as having a steep upper slope and a shallow, sandy, lower slope

Substratum at reef base (modified from AIMS methods) - This measure described the habitat found at the bottom of the reef slope at the reef base, and provides information on what divers are likely to encounter at the deepest part of their dive in many cases. More than one response could be given. Categories were:

- *Sand* –granular particles usually white and composed of carbonate on coral reefs
- *Rubble* – unconsolidated dead coral fragments usually <5cm in size
- *Consolidated rubble* – rubble fragments that have been bound together by coralline algae to form a solid substratum
- *Reef framework* – underlying carbonate structure of the reef, reef building (hermatypic) corals contribute to the reef framework as they produce their calcium carbonate skeletons
- *Live hard coral* – reef building (hermatypic corals)
- *Soft coral* – living colonies of soft-bodied corals belonging to the Order Alcyonacea (i.e. this does not include Gorgonians, Blue Coral or red Organ Pipe Corals)

General reef features (modified from AIMS methods) **-** This measure described the topology of the reef slope and its physical attributes. This was of particular interest as different reef features provide different diving opportunities, for example caves that divers can explore as opposed to a continuous wall that divers can only traverse. More than one response could be given. Categories were:

- Spur and groove – (SG) Mainly found in high-energy areas that regularly encounter the strong wave action of the front of reefs. The spurs and ridges composed of reef framework that rise above the intervening grooves that can be filled with white carbonate sand and scattered larger coral fragments. The spurs often have areas of hard corals or can be colonized by soft corals and algae

- Gullies – (G) Grooves or gaps in the reef that are typically not formed by wave action
- Overhangs – (O) A projection of the reef crest or upper slope beyond the wall or slope of the lower part of the reef
- Caves – (C) Holes in the reef with one obvious entrance large enough for a diver to penetrate
- Swim throughs – (ST) Caves that have an entrance at both ends large enough to accommodate a diver
- Bommies – (B) Isolated discrete outcrops consisting of coral(s) and or reef framework usually 3m or more in diameter and extending vertically (at least 3m) from the underlying substratum towards the surface
- Pavement – (P) A consistent featureless area of the reef slope that has a shallow angle and forms an expanse (>0.2 ha) of flat substratum. Usually restricted to high-energy front reef areas
- Continuous wall – (CW) Reef slope is characterised by a few features and a generally vertical drop off into deeper water. This includes walls at all scales from a metre to tens of metres

Structural Complexity (modified from AIMS methods) - This was a subjective category designed to indicate how structurally complex the reef slope was. Some sites can be flat and featureless (uniform), while others can be complex and diverse with many interesting features to explore such as caves and holes. High complexity habitats are also known to support a higher diversity and abundance of fish species (Syms & Jones, 2000). The structural complexity categories were:

- *Uniform* – a consistent, featureless area of reef, such as pavement, vertical drop-offs, flat, sandy, back areas, or an extended area of staghorn coral
- *Mixed* – a variable reef slope that may be a solid edge interspersed with occasional grooves
- *Complex* – a very diverse slope that may consist of "spur and grooves," caves, holes, overhangs or bommies

Maximum Depth of Site – The maximum depth of a site will determine how deep divers can go and how long they are able to stay there. It will also determine how the site will be dived, and by whom. The maximum depth of each site was measured in metres and was the deepest body of water divers could access. Where vertical reef walls were present, the maximum depth was taken from a depth sounder or chart. If two or more reef zones were present at the one site, such as a shallow angle back reef that connects to a steep reef wall, both depths were recorded, with the depth of the shallowest zone given first.

Sand/Rubble Presence **-** Many dive sites have sand and/or rubble. Sand and/or rubble can often occur on back reef sites creating gentle sandy slopes, or gullies that separate coral bommies. These sand/rubble areas can often be bright white in colour providing a stark contrast to the colours of the corals and fish and thus be visually spectacular. Sand and/or rubble also represents a different habitat type other than the coral or reef structure, and therefore attracts a diversity of other marine organisms that live in or use this substrate. This variable was a measure of these areas within the total area of the dive site. The sand/rubble categories were:

- *None* - no visible sand/rubble
- *Low* - some sand/rubble present, but quite sparse in comparison to other substrate types
- *Moderate* - clear presence of sand/rubble, but less than other substrate types – may also be at the base of a pinnacle site
- *High* - considerable presence of sand/rubble, typical of a back reef site with a sandy slope interspersed with coral bommies
- *Very high* - very high proportion of sand/rubble in comparison to other substrate types

Coral attributes

Coral is a very conspicuous component of coral reef environments. There are two major types of coral: hard coral that have hard limestone skeletons, and soft corals which have no limestone skeletons: Corals cover much of the substrate on coral reefs and provide the reef with colour, texture, and habitats for a wide variety of other marine organisms. Because corals in general are known to influence visitors' experiences highly (Shafer et al., 1998), it was essential that a more comprehensive approach to measuring specific characteristics was undertaken to determine their influence. The following variables were chosen to describe the coral attributes that occurred at each of the dive sites.

Percentage Live Hard Coral Cover Estimate (modified from AIMS methods) – Percent live hard coral cover is a measure of the amount of live hard coral at a site, and has been shown to influence recreational demand for a site (Pendleton, 1994; Williams & Polunin, 2000). Percent hard coral cover is also the information most frequently used by scientists and managers to assess reef health (Hill & Wilkinson, 2004). The amount of live hard coral cover was visually estimated as the percentage of live hard coral found on suitable benthic attachment sites such as bare rock. Estimates of coral cover do not include substrates such as sandy and/or rubble areas, as they generally do not support hard coral formations. The percentage cover estimates were recorded as one of the six following categories:

- 0%
- >0-10%
- 11-30%
- 31-50%
- 51-75%
- 76-100%

Dominant Benthic Forms (modified from AIMS methods) – Benthic forms are the organisms and habitats of the see floor, and help to characterize the reef community and health (Hill & Wilkinson, 2004). The dominant benthic form is the one that visually dominates an area. More than one form could be recorded, but the most dominant was mentioned first. The dominant benthic form categories were:

- *Hard coral* – All hard coral species
- *Soft coral* – All soft coral species
- *Macro algae* – Large, not-filamentous algae with well-developed stems
- *Coralline/turf algae* – All forms of encrusting algae and filamentous turf algae
- *Sand/rubble* – All unconsolidated substrate such as sand and broken fragments of coral and rock
- *Sponge* – Porifera species

Dominant Hard Coral Genus (modified from AIMS methods) – The dominant hard coral genus at each site was recorded. Corals were categorised as *Acropora* or non-*Acropora*. If there appeared to be equal dominance of *Acropora* and non-*Acropora*, then it was classified as 'no one coral genus dominant'.

- *Acropora* genus
- A non-*Acropora* genus
- No one coral genus dominant

Dominant Hard Coral Form (modified from AIMS methods) – The form, or size, shape, and structure of the corals, might provide different experiences to divers. However, the specific influence of coral form on divers' experiences has not been assessed. Furthermore, certain forms are more susceptible to diver-related damage (Hawkins & Roberts, 1992b; Rouphael & Inglis, 1997). Understanding which form is most dominant at a site is then of importance in both characterising the site, but also as a measure of its susceptibility to diver-related damage. There are eight general coral life forms, which commonly dominate a reef slope. If there was no one dominant coral form, or if hard coral was not dominant, then it was recorded as 'no dominant form'. The coral forms are described below (pictures for each hard coral form can be found in Miller (2003), p21-25.

- *Branching* - consists of arborescent branches of variable thickness that have a common base. They are typified by the staghorn corals such as *Acropora grandis* and f*ormosa*. Other branching species include *Porites cylindrica* and *Seriatopora hystrix*.
- *Corymbose* - a growth form characteristic of *Acropora* where colonies are composed of horizontal branches and short to moderate vertical branchlets that terminate in a flat top, such as, *A. tenuis, A. valenciennesi* and *A. cerialis*.
- *Digitate* – a growth form of *Acropora* where colonies are composed of short, non-anastomosing branches like the fingers of a hand e.g. *A. humilis* and *A. gemmifera*.
- *Encrusting* – have a prostrate, spreading growth form, that adheres to the substratum e.g. *Mycedium elephantotus, Lithophyllon edwardsi* and many *Montipora* species.
- *Foliose* – are erect, with a flattened, leaf-like growth form that may be folded and convoluted, often forming whorls. This can sometimes be difficult to differentiate from encrusting corals, e.g. *Turbinaria mesentaria* and *Echinopora lamellose*.
- *Massive* – have a similar shape in all directions (i.e. spherical) and may form very large colonies, e.g. *Favia lizardensis, Diploastrea heliopora* and many *Porites* species.
- *Submassive* – are typically robust but have a wide morphological range and do not easily correspond to any other life form category. Many branching or massive corals may become submassive especially in high-energy zones of the reef, e.g. *Acropora cuneata*, *Sylophoroa pistillata* and *Pocillopora meandrina* which have knobbed or bushlike appearance.
- *Tabulate* – as their name suggests, tabulate corals have a tiered growth form consisting of horizontal, flattened plates, e.g. *A. hyacinthus* and *A. clathrata*.

<u>Colour index of corals</u> – Coral colour is known to influence visitors' experiences positively (Shafer et al., 1998). This variable was selected as a measure of the intensity of coral colour at each site based on the surveyors' judgement and experience of coral reef environments. Category selection was visually based on the colour of all hard and soft coral forms. It was important not to let the present weather conditions and horizontal visibility of the water on the day bias judgements when assigning this category.

- *Low* – Most corals not vibrant in colour consisting of mainly dull browns and greens

- *Medium* – Approximately half of the corals having vibrant and bright colours consisting of mainly pinks, blues, and purples
- *High* - Most corals having vibrant and bright colours consisting of mainly pinks, blues, and purples (not to be confused with 'pre-bleaching symptoms)

<u>Levels of coral bleaching (modified from AIMS methods)</u> – Coral bleaching has become a major concern to reef managers as it directly affects coral health (Hill & Wilkinson, 2004; Wilkinson, 2004b). Bleaching has also been shown to negatively affect divers' experiences, and thus demand and visitation to sites and even regions (Cesar, 2000). Bleaching is one of the major issues facing both coral reef health and reef related tourism. This variable indicated the level of total hard coral colony bleaching, not the level of bleaching within individual coral colonies. Only one response was selected. This was taken as a percentage of the total hard coral cover consisting of individual colonies bleached white, partly, or nearly white. Corals that were partially white but still retaining much of the pigment were not included. The categories of the level of bleaching of total live hard coral were:

- 0%
- Individual colonies (<1% total hard coral cover)
- 1-5%
- 6-10%
- 11-30%
- 31-50%
- 51-75%
- 76-100%

Fish and other marine organisms

Fish and other marine organisms make up the remainder of biological attributes that occur on coral reefs, and are responsible for much of the reefs colour, movement, and activity. These organisms can occur both on the substrate and within the water column. The following variable was chosen to describe the fish and other marine organism attributes that occur at each of the dive sites.

<u>Conspicuous organisms at dive sites (modified from AIMS methods)</u> **-** This measure was designed to provide a general picture of the types of organisms that are easily found in the dive site area. Listing one or more of these organisms meant they were conspicuous by their presence and/or abundance, and therefore have a high potential to be seen by visiting divers. More than one response was noted.

- Baitfish – (BF) all schools of baitfish usually composed of sprat (Spratteloides sp.) or Hardyheads
- Butterfly fish – (BFF) all individuals belonging to the family Chaetodontidae
- Cephalopods – (CP) includes all octopus, cuttlefish, and squid
- Crustaceans – (CR) includes all crustaceans
- Coral trout (CT) all *Plectropomus* spp.
- Echinoderms – (EC) includes all feather stars, sea urchins, sea stars, brittlestars, and sea cucumbers
- Fusiliers – (FS) all individuals of the family Caesionidae
- Giant clams – (GC) all species of giant clams
- Large cods – (LC) includes potato cod, giant Queensland grouper, flowery cod, and goldspot cod
- Moray eels – (ME) all species of moray eels
- Nudibranchs – (NB) all species of nudibranchs
- Pomacentrids – (PC) all individuals of the family Pomacentridae
- Parrotfish – (PF) all individuals of the family Scaridae
- Pelagic predators – (PP) all roving large pelagic fish, typical examples include mackerel, trevally, barracuda and tuna
- Surgeon fish – (SF) all individuals of the family Acanthuridae
- Sharks – (SH) all sharks
- Sweetlip – (SL) all individuals of the genus Lethrinus, in particular *L. nebulosus* and *L. miniatus*.
- Snapper – (SN) all individuals belonging to the family Lutjanidae
- Rays – (SR) all rays
- Sea snakes – (SS) includes all sea snakes
- Turtles – (TR) includes all marine turtles

4.3.4 Survey 2 – Roving Diver Diversity (RDD) of coral

The number of different kinds of coral that visitors see positively influences their Reef experience (Shafer et al., 1998). However, measurements of coral diversity between sites have not been linked to their specific influence on visitors' experiences. Coral diversity is also a primary and fundamental measurement of coral communities (Hill & Wilkinson, 2004). Survey 2 was designed to estimate the diversity of species a visiting diver might encounter on a typical dive at each site, but provided a more exhaustive survey of the coral species present than would be expected of the average diver. This was termed the Roving Diver Diversity (RDD) of coral species.

In November 2003 coral species data were collected during one dive of approximately one hour at each of the study sites using the MRDT. Dives involved collecting data on the number of different species sighted within the defined typical diving area at each of the sites. Surveys ended in as shallow water as possible to include those species encountered during safety stops. The total number of species sighted in the typical diving area was used to create the RDD of corals at each of the sites. RDD was expressed as the total number of coral families, genera, and species.

4.3.5 Survey 3 – Roving Diver Diversity (RDD) of marine organisms

The number of different kinds of fish seen, and to a lesser extent organisms other than coral or fish, positively influences visitors' experiences at reef sites (Birtles et al., in prep; Curnock, 1998; Shafer et al., 1998). Survey 3 was designed to estimate the diversity of species a visiting diver might encounter on a typical dive at each site. It provided a more exhaustive survey of the marine organisms present than would be expected of the average visiting diver. This was termed the RDD of marine organisms.

In July 2003, data were collected on marine organism presence during two dives of at least 50 minutes (maximum 60 minutes) at each of the study sites using the MRDT. Surveys began immediately upon entering the water. Dives involved collecting data on the number of species sighted within the defined typical diving area at each of the sites. Surveys ended in as shallow water as possible to include those species encountered during safety stops. The cumulative number of organisms sighted over the two dives was used to calculate the RDD of marine organisms at each of the sites. Fish species (including sharks and rays) were separated from other marine organisms (e.g. crustaceans, echinoderms, and molluscs) to provide a RDD for fish species at each site, and a RDD for other marine organisms for each site. RDD for fish and the RDD for other marine organisms were expressed as the total number of taxa, whether identified to family, genus or species.

4.3.6 Survey 4 – Standard and specific marine organism presence/absence and relative abundance monitoring

Knowing an organism's presence over time, coupled with relative abundance estimates, can provide an idea of its rarity within and between sites (REEF, 2002a), but also the likelihood of it being encountered by visitors at the sites (Hammitt et al., 1993). This information will help understand how often an organism is likely to be seen at a site (and how this compares to how often other organisms can be seen at the site), and ultimately how this relates to the experiences that visitors are having at that site which are assessed in Study Three, Chapter Five.

Divers might see a particular organism on any dive, but there are certain sites that offer a much higher chance of seeing particular organisms than others. Survey 4 was designed to provide an understanding of the presence/absence and relative abundance of a list of 'standard' and 'specific' organisms thought likely to be important to divers' experiences at each of the study sites. 'Standard' organisms, for example reef sharks, moray eels, and turtles, are those that can be seen with relatively high frequency at a wide range of coral reef dive sites. 'Specific' organisms, for example reef stonefish, garden eels, and hammerhead sharks, are those that can be seen at very few dive sites.

The data collected provided information on how often an organism was sighted at each of the sites over time, or its sighting frequency (SF), and when sighted, its relative abundance. Data were also collected on the depth, and habitat type where organisms were sighted. This was to understand where at each of the sites organisms were most likely to be found. Measurements of horizontal visibility were also undertaken at each of the sites over the 10-month sampling period to give the average visibility, as well as the range. This was because the visibility which is determined by the time of the day, the weather conditions, and the amount of particles suspended in the water, can affect how far a diver can see underwater, and therefore might affect how easy it is to see organisms.

Procedure

'Standard' and 'specific' organisms on each of the five study sites were monitored between 16 August 2003, and 29 May 2004, using the MRDT. Surveys undertaken at each site lasted between 50 and 60 minutes. Upon entering the water, the surveyor recorded the horizontal visibility. The surveyor then dived to a maximum depth of 30m at each of the sites, and proceeded to search for organisms within the defined typical diving area. When an organism was sighted, its presence and relative abundance was recorded, the habitat in which it was found, and the depth of the sighting. Surveys concluded once the surveyor had surfaced.

The ‘standard’ and ‘specific’ organisms monitored at each of the study sites were selected for the following reasons:

- are known to be important to divers’ experiences as indicated from previous research (see Chapter One, Table 1.2);
- were mentioned as part of the pre-dive briefing given by dive crews before divers entered the water at each of the sites (see Section 4.3.1); and
- come from a wide range of taxonomic groupings and thus potentially provide a wide range of diving experiences.

A list of 22 ‘standard’ organisms from a wide range of taxa was generated (Table 4.1). The list of ‘standard’ organisms monitored was divided into broad taxonomic groupings. These were: fish, invertebrates, reptiles, and sharks and rays.

Table 4.1. ‘Standard’ organisms monitored at each of the five study sites between 16 August 2003 and 29 May 2004.

Fish
• Anemonefish - all species of anemonefish (Family Pomacentridae)
• Barracuda - Chevron (*Sphyraena qenie*), and Great (*Sphyraena barracuda*)
• Bumphead parrotfish – *Bolbometapon muricatum*
• Coral trout - *Plectropomus leopardus*
• Lionfish - *Pterois volitans, Pterois antennata*, and *Dendrochirus zebra*
• Maori wrasse - *Cheilinus undulatus*
• Moray eels - mainly Giant morays (*Gymnothorax javanicus*) but others are included
• Potato cod - *Epinephelus tukula*
• Red bass – *Lutjanus bohar*
• Shark mackerel - *Grammatorcynus bicarinatus*
• Titan trigger fish - *Balistoides viridescens*
• Trevally - Bigeye (*Caranx sexfasciatus)*, Giant (*Caranx ignobolis*), and Bluefin (*Caranx melampygus*)
• Tuna – All species of Tunas (Family Scombriade)
Invertebrates
• Crown of thorns starfish (COTS) – *Acanthaster planci*
• Cuttlefish - Broad club cuttlefish (*Sepia latimanus*)
• Nudibranchs - all species of nudibranchs (Order Nudibranchia)
• Octopus - all octopus species (Family Octopodidae)
Reptiles
• Sea snakes - mainly Olive sea snakes (*Aipysurus laevis*) but others are included
• Turtles - mainly Green turtles (*Chelonia mydas*) but others are included
Sharks and rays
• Manta rays - *Manta birostris*
• Rays – includes all species of rays except manta rays (Family Dasyatidae)
• Reef sharks - whitetip reef sharks (*Triaenodon obesus*) and grey reef sharks (*Carcharhinus amblyrhincos*)

Organisms and their descriptions are listed within broad taxonomic groupings in alphabetical order.

In addition to the 22 'standard' organisms listed in Table 4.1, a short list of 'specific' organisms was also included at each site (Table 4.2). These were included to assess their influence on divers' experiences at the sites because they were mentioned as part of the pre-dive briefing and therefore divers were alerted to them. The list of 'specific' organisms monitored at the corresponding sites was also divided into broad taxonomic groupings.

Table 4.2. 'Specific' organisms monitored at each of the five study sites between 16 August 2003 and 29 May 2004.

Steve's Bommie (SB)
Fish
• Anthias – all species of anthias from the (Family Serranidae)
• Bigeye seaperch – *Lutjanus lutjanus*
• Fusiliers – all species of fusiliers from the (Family Caesionidae)
• Goldsaddle goatfish – *Parupeneus cyclostomus*
• Reef stone fish – *Synanceia verrucosa*
Invertebrates
• Corallimorphs – *Amplexidiscus fenestrafer*
• Mantis shrimp – Peacock mantis shrimp (*Odontodactylus scyllarus*)
• Porcelain crabs – *Neopetrolisthes maculata*
• Red flame file shell – *Lima hians*
Sharks and rays
• Wobbegong shark – Tasselled wobbegong (*Eucrossorhinus dasypogon*)
Pixie Pinnacle (PP)
Fish
• Anthias – all species of anthias from the (Family Serranidae)
• Fusiliers – all species of fusiliers from the (Family Caesionidae)
• Scissortail Sergeant Majors – (*Abudefduf sexfasciatus*)
Invertebrates
• Gorgonian fans – all species of gorgonian sea fans (Class Anthozoa)
• Mantis shrimp – Peacock mantis shrimp (*Odontodactylus scyllarus*)
• Red flame file shell – *Lima hians* (Family Limidae)
Cole Hole (CH)
Fish
• Diagonally banded sweetlip – *Plectorhincus chaetodontoides*
• Flowery cod – *Epinephelus fuscoguttatus*
Admiralty Anchor (AA)
Fish
• Spotted garden eels - *Heteroconger hassi*
Sharks and rays
• Silvertip reef sharks – *Carcharhinus albimarginatus*
• Hammerhead sharks – *Sphyrna lewini*
North Horn (NH)
Sharks and rays
• Silvertip reef sharks – *Carcharhinus albimarginatus*
• Hammerhead sharks – *Sphyrna lewini*

Organisms and their descriptions are listed within broad taxonomic groupings in alphabetical order for each of the five study sites.

The number of surveys undertaken over the 10-month sampling period differed between sites. This was because the number of times a site was visited by live-aboard operators depended on weather conditions, the itinerary (some sites like NH are dived at least two times in any one trip), and the type of trip run by the operator (Ribbon Reef trip compared to Ribbon Reef and Osprey Reef trip; see Chapter Two). The total number of surveys at each of the dive sites were: PP=20; SB=21; AA=37; CH=38; and NH=52.

Variables

Visibility - Horizontal visibility was recorded in metres over the sample period to understand the range and mean visibility at each site. This was done at a depth of 5m to avoid surface water aeration, and was measured using a rope with 1m increments tied to the safety chain hanging off the duckboard at the aft of the vessel. Visibility was measured as or corresponding to the point at which the safety chain was no longer clearly visible.

Presence/absence of organisms **-** Surveyors were provided with the list of organisms that needed to be monitored at each site, including the 22 ‘standard’ organisms and any additional ‘specific’ organisms. When an organism was sighted, its presence was recorded.

Abundance of organisms when sighted **-** In the RDT normal protocol, an estimate of fish abundance for each species is measured using the following logarithmic categories: Single (1 fish), Few (2-10 fishes), Many (11-100 fishes), or Abundant (>100 fishes) (Hill & Wilkinson, 2004; REEF, 2002b). Because in this present study there was only a short list of organisms selected at each site for the surveys, the surveyor had enough time to estimate actual abundance, rather than assign broad categories. This allowed for greater accuracy in abundance estimates. Where abundance could only be assumed due to large numbers of organisms (such as fusiliers) an approximate abundance was assigned. Particular fish species seen sporadically over the course of a dive such as coral trout were counted as individuals, and summed together at the conclusion of the survey. Surveyors were careful not to recount individuals.

Habitat where organisms were sighted – To understand where the organisms could be found, the habitat where each organism was sighted was recorded. If two or more of the same organisms were found in differing habitats, the habitat most commonly encountered was the one recorded. The habitat classifications were:

- Coral (C)
- Coral rubble (CR)
- Dead coral (DC)
- Open water (OW)
- Sand (S)
- Algae (A)
- Sponge (SP)
- Wall/ledge (W)
- Cave (CA)
- Cleaner station (CS)

Depth range when sighted – Understanding the depth where organisms were found provides information on the type of divers that are able to experience them. In Study One (Chapter Two), it was found that more specialised divers were comfortable at greater depths than less specialised divers. The depth in metres at which organisms were observed was recorded. For species that occurred at several different depths, a range was given (e.g. 5-15m). Because the surveyors were restricted to a maximum depth of 30m, organisms sighted below 30m were placed into the category >30m. Depth categories of metres were:

- 0-5
- 6-10
- 11-15
- 16-20
- 21-25
- 26-30
- >30

4.4 Analysis

4.4.1 Broad-scale site descriptions

Survey 1 contained only categorical measures of the biophysical attributes at each of the sites. Differences in the biophysical attributes between sites were examined by comparing these categorical responses.

4.4.2 Roving Diver Diversity

For Survey 2, differences in the RDD of coral between sites were examined using frequencies of families, genera, and species represented at each site. In survey 3, the RDD of other marine organisms was divided into two categories for simplicity. These were fish (including sharks and rays), and other marine organisms. The RDD for each category was calculated by the cumulative number of species sighted over two dives at each of the sites. Differences in the RDD of fish and other marine organisms between sites were examined using frequencies of families, genera, and species represented at each site.

4.4.3 Size of fish and other marine organisms

The size distribution was also examined for the marine organisms (excluding corals) surveyed at each of the sites in Survey 3. Each species surveyed was placed into a size class. The size classes were created to reflect five size categories of organisms found on coral reefs. These were:

- *Very small* - <5cm
- *Small* - 6-20cm
- *Medium* - 21-60cm
- *Large* - 61-100cm
- *Very large* - >100cm

Placement into one of the five size classes was based on the maximum known size of the species. The maximum known size for fish, sharks, rays, and eels was taken from Randall et al., (1997). The maximum known size for turtles was based on the green turtle (*Chelonia mydas*) as it is the species most commonly seen on Ribbon Reef and Coral Sea dive sites, and was taken from GBRMPA (2000). All other organism sizes were taken from Gosliner et al., (1996). Maximum known sizes for all species surveyed can be seen in Appendix D and E. Distributions of the species into the size classes were analysed by frequencies of species within each size class. Each species was represented only once.

4.4.4 Sighting Frequency (SF) and relative mean abundance

From Survey 4, presence/absence data were presented as the number of surveys in which an organism was sighted, divided by the total number of surveys undertaken on that site over the 10-month sample period. This was termed the Sighting Frequency (SF). An example of how the SF was calculated is as follows:

Number of surveys in which an organism was sighted = 15

Total number of surveys undertaken at the site over the sample period = 50

SF = 15/50 X 100

SF = 30.0%

The abundance of each organism was calculated as the mean number of individuals sighted during surveys, plus or minus one standard error. Zero values when organisms were not sighted during a survey were not included in the calculation. This was because the SF provided information on how often an organism was sighted over time, while the mean abundance provided information on how many individuals there were when sighted. Therefore, zero values from surveys when an organism was not sighted were not of interest. Anemonefish and garden eels were counted only once at the start of the sampling period. This was because it was considered too time consuming to attempt to locate and count each individual during every survey, however the SF was recorded. Because both of these organisms are known to exhibit territorial behaviour (Randall et al., 1997), initial counts are likely to represent an estimate of the population numbers at each site.

Organisms were also placed into the following seven sighting probability categories for simplicity in understanding how often they could be seen at each site. The sighting probability was based on the SF value for each organism. The sighting probability categories were:

- *Absent* – (0%)
- *Very low* – (1-10%)
- *Low* – (11-20%)
- *Moderate* – (21-50%)
- *High* – (51-75%)
- *Very high* – (75-99%)
- *Assured* – (100%)

4.4.5 Horizontal visibility

To determine if differences existed between sites in the mean visibility over the 10-month sample period, a Kruskal-Wallis Means Test was performed. This was because the parametric ANOVA assumption of homogeneity of variance was violated. Both log and square root transformations were unable to correct this violation. Data were however, normally distributed. For post hoc comparisons, a series of 10 Mann-Whitney U-Tests were performed. To maintain a fixed significance level of 5% for these tests, a Bonferroni correction was applied depending on the number of comparisons needed, making the test results more conservative (Curtin & Shultz, 1998).

4.4.6 Distinctive biophysical attributes

The biophysical attributes that were found to be subjectively distinctive within and between sites were identified. The factors used to categorise attributes identified as distinctive were: abundance; size; behaviour; duration; species iconic status; special/unusual features; and intensity of experience. The allocations of attributes into the factors are provided below.

Abundance – High abundance for an organism at a specific site was calculated as those organisms that had a relative mean abundance of over five individuals for the survey period. While it is acknowledged that many coral reef organisms will have a relative mean abundance of over five individuals at a site, the 22 'standard' organisms selected for monitoring across all sites like manta rays and cuttlefish, and the 'specific' organisms selected for monitoring at specific sites like the stonefish and mantis shrimp, are much less likely to have mean abundances over five individuals within the typical diving area. However, when making comparisons between sites, it was also apparent that some sites provided divers with a chance to see more of a particular type of organism than other sites. Incidences where this occurred are explained within the results, and explanations are provided.

Size – 'Standard' and 'specific' organisms that were classed in either the 'very small' (<5cm) or the 'very large' (>100cm) size classes were considered a distinctive attribute at a site. Differences between sites for the size of organisms were also examined, and the site that had the greatest percentage of 'very small' organisms surveyed was listed as distinctive for very small organisms, and the site that had the greatest percentage for 'very large' organisms surveyed was listed distinctive for very large organisms.

Behaviour – The behaviour of an organism, or group of the same type of organisms was listed if it was considered to be distinctive at a site, and thus likely to draw the attention of divers. Data regarding specific behaviours were referenced with biological literature where possible.

Duration – Refers to the length of the encounter with a particular type of organism. This was a subjective decision based on the length of time a diver could spend interacting with or viewing a particular type of organism. Those organisms that allowed divers to approach them while showing few signs of altering their behaviour were listed as distinctive.

Popularity or iconic status – Popularity or iconic status of an organism is driven by a range of factors, which include physical attractiveness, danger, or the publicity it has received in the public media (e.g. dive magazines and books, web sites, documentaries, advertising material, Hollywood and other popular movies). Where organisms are considered popular or iconic, explanations are given within the results.

Special/unusual features – This refers to the experience with, or characteristics of, an attribute being regarded as special or unusual and therefore the participant being privileged. Again this was a subjective decision based on how special or unusual a particular type of experience or attribute might be from the viewpoint of the visitor. Explanations for each attribute selected are provided within the results.

Intensity of the experience – Refers to the excitement generated by an experience and might include being in the middle of a large school of fish, diving with sharks, or viewing feeding activities. Once again a subjective decision based on the level of activity or excitement that might be generated in a particular situation at a site. Explanations are provided within the results for those attributes selected as distinctive for intensity of experience.

4.5 Results

The results of Study Two are presented in two sections. The first section (4.5.1) is a presentation of the biophysical attributes measured within and between each of the five study sites. This section describes the physical attributes, corals, fish, sharks and rays, other marine organisms, and the size of fish and other marine organisms at each of the sites.

Section 4.5.2 examines the distinctive attributes identified at each of the five sites. Those attributes found to be distinctive to each site when compared to the other sites are also identified, therefore characterising the different diving opportunities that each site represents. Finally a table that lists each of the distinctive attributes identified at each site is provided.

4.5.1 Biophysical attributes within and between sites

Table 4.3 presents a summary of the biophysical attributes measured at each of the five study sites in Surveys 1, 2 and 3, and provides a quick reference for comparisons to be made.

Physical attributes

The physical attributes differed greatly between the sites and offer visiting divers three distinct types of diving opportunities. The first is 'pinnacle' diving opportunities that occur only at SB and PP from the Ribbon Reef location (Table 4.3). Pinnacles, with their 'steep' 'uniform' reef slopes, had very few general reef features apart from a small 'cave' on PP (Table 4.3). The maximum depth of the pinnacle sites was 35m. Because of their conical shape, pinnacles act to concentrate divers in a small area as they spiral the pinnacle from the bottom to the top.

Table 4.3. Summary of the biophysical attributes surveyed at each of the five study sites from the Ribbon Reef and Osprey Reef locations between July 2003 and November 2003.

	Ribbon Reef location (GBR)			Osprey Reef location (Coral Sea)	
Physical attributes	**Steve's Bommie**	**Pixie Pinnacle**	**Cod Hole**	**Admiralty Anchor**	**North Horn**
Reef zone	Pinnacle	Pinnacle	Back Reef	Back Reef/Wall	Wall
Exposure	Partly exposed	Sheltered	Sheltered	Sheltered	Partly exposed
Reef Slope	Steep	Steep	Shallow	Shallow/Vertical	Vertical
Substratum at reef base	Sand	Sand	Sand	Reef framework	Reef framework
General reef features	Continuous wall	Cave Continuous wall	Bommies Gullies Swim-throughs	Bommies Caves Continuous wall Gullies Overhangs Swim-throughs	Caves Continuous wall Gullies Overhangs
Structural complexity	Uniform	Uniform	Mixed	Complex	Uniform
Maximum depth of site	35m	32m	35m	30/1000+	1000+
Sand/rubble presence	Moderate	Moderate	High	Very High	Low
Visibility in metres (mean and range)	18.2 (10-30) (n=20)	19.1 (15-25) (n=20)	17 (5-30) (n=38)	19.7 (10-35) (n=37)	25.2 (15-40) (n=52)
Corals					
Roving diver diversity (RDD) of coral ^ (*)	15 Families 51 Genera 102 Species	16 Families 44 Genera 88 Species	12 Families 25 Genera 67 Species	12 Families 31 Genera 66 Species	14 Families 34 Genera 56 Species
Percentage live hard coral	11-30%	11-30%	51-75%	51-75%	11-30%
Dominant benthic form	Hard Coral	Hard Coral	Hard Coral	Hard Coral	Hard Coral
Dominant hard coral genus	Acropora	Acropora	Acropora	Acropora	Acropora
Dominant hard coral form	Corymbose	Corymbose	Tabulate	Digitate	Digitate
Colour index of corals	Medium	Medium	High	High	High
Level of coral bleaching	0%	0%	1-5%	1-5%	1-5%
Other marine organisms					
Roving diver diversity (RDD) of fish ^ (**)	34 Families 68 Genera 103 Species	31 Families 59 Genera 79 Species	35 Families 65 Genera 92 Species	33 Families 57 Genera 74 Species	32 Families 59 Genera 75 Species
Fish families most represented by number of species	Serranidae Labridae Pomacentridae	Serranidae Chaetodontidae Acanthuridae	Serranidae Labridae Chaetodontidae	Serranidae Chaetodontidae Scaridae	Serranidae Carangidae Scaridae
Roving diver diversity (RDD) of other marine organisms^ (***)	35 Families 46 Genera 49 Species	28 Families 36 Genera 40 Species	16 Families 19 Genera 22 Species	13 Families 16 Genera 17 Species	10 Families 13 Genera 13 Species
Conspicuous organisms by presence and/or abundance	Cephalopods Crustaceans Echinoderms Fusiliers Nudibranchs Pomacentrids Pelagic predators Surgeon fish Snapper Turtles	Crustaceans Echinoderms Fusiliers Nudibranchs Pomacentrids Pelagic predators Surgeon fish Snapper	Butterfly fish Coral trout Large cods Moray eels Pomacentrids Parrotfish Surgeon fish Sharks Sweetlip Snapper Rays	Butterfly fish Coral trout Giant clams Moray eels Pelagic predators Sharks	Coral trout Large cods Moray eels Pomacentrids Pelagic predators Sharks
Size class distribution of organisms. Size classes are: • (VS) Very small (0-5cm) • (S) Small (6-20cm) • (M) Medium (21-60cm) • (L) Large (61-100cm) • (VL) Very Large (>100cm)	(n=156) VS – 2.6% S – 38.5% M – 44.2% L – 9.0% VL– 5.8%	(n=121) VS – 0.8% S – 41.3% M – 41.3% L – 9.9% VL– 6.6%	(n=115) VS – 0.0% S – 32.2% M – 48.7% L – 9.6% VL– 9.6%	(n=91) VS – 0.0% S – 28.6% M – 46.2% L – 13.2% VL– 12.1%	(n=88) VS – 0.0% S – 27.3% M – 39.8% L – 19.3% VL– 13.6%

- All physical attribute data collected in Survey 1 (except for visibility that was collected in Survey 4; n= number of surveys data was collected)
- All RDD of coral data collected in Survey 2 (n=1). Remaining coral attribute data collected in Survey 1.
- All RDD of fish (including sharks and rays) and all RDD of other marine organisms collected in Survey 3 (n=2)
- Fish families most represented by number of species data collected in Survey 3
- Conspicuous organisms by presence and/or abundance, and adventure rating data collected in Survey 1
- (*) – See Appendix C; (**) See Appendix D; and (***) See Appendix E

The second type of diving opportunity was the ‘back reef’, represented by the CH from the Ribbon Reef location and AA from Osprey Reef location (Table 4.3). These sites were ‘sheltered’ with a ‘shallow’ ‘sand/rubble’ slope made up of scattered bommies. Because of the bommies, the structural complexity was ‘mixed’ to ‘complex’ creating a diverse and rugged physical landscape. In addition to the bommies and the sand/rubble gullies that separated them, both sites also had ‘swim-throughs’ that divers were able to explore and enter. However, AA had the most general reef features of all the sites including ‘caves’ and ‘overhangs’ (Table 4.3), and was for this reason the most physically diverse and interesting site.

The third distinct type of diving opportunity was a ‘reef wall’, represented only at the two Osprey Reef location sites NH and AA (Table 4.3). Reef walls at Osprey Reef were characterised by ‘continuous’ ‘vertical’ walls with many ‘overhangs’, dropping over 1000m into the open ocean. The Osprey Reef location sites were also the only sites that offered divers maximum depths over 35m. Reef walls provide divers with opportunities to experience deep and open water with no visible bottom.

The horizontal visibility varied significantly between sites (*chi-square=32.069, df=4,* $p<0.001$) and even between locations (Table 4.3). Post hoc tests revealed that NH had a significantly higher mean visibility than all other sites ($p<0.05$). The two Osprey Reef location dive sites had the highest maximum visibility with 35m at AA, and 40m at NH. Ribbon Reef location dive sites had the lowest minimum visibility of all the sites, especially the CH with 5m. Therefore consistently better horizontal visibility at NH was a distinctive attribute of this site when compared to all other sites.

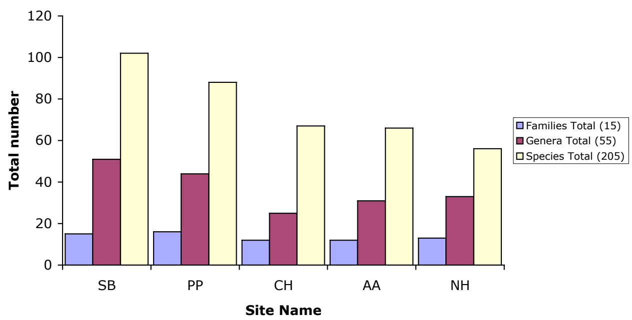
Corals

While the dominant benthic form at each site was hard coral, dominated by the genus Acropora, there were distinctive coral attributes that characterised differences between the sites. The two sheltered back reef sites, CH and AA, had a high percent live coral cover estimate of 51-75% (Table 4.3). Divers are also able to see larger coral structures at the CH because the dominant hard coral form was ‘tabulate’ (CH), while at AA it was ‘digitate’ (Table 4.3). The colour index at both of these sites was ‘high’ with only very low levels of bleaching (1-5%).

The pinnacle sites (SB and PP) and NH had a lower percentage of live coral cover (11-30%) than the back reef sites (Table 4.3). At the pinnacle sites the dominant hard coral form was 'corymbose', while at NH it was 'digitate'. In either case the coral form can be relatively small and does not extend far from the substrate from which it grows. The colour index of the corals at the pinnacle sites was 'medium', while at NH it was 'high' (Table 4.3). Very low levels of bleaching were seen at NH (1-5%), and no bleaching (0%) was seen at the two pinnacle sites.

The RDD of coral species also differed greatly between sites with regard to the number of families, genera, and species surveyed (Table 4.3). A graphical representation of the RDD of coral at each site can also be seen in Figure 4.6. The two pinnacle sites from the Ribbon Reef location, SB and PP, which had the lowest percentage of live coral cover, provided divers the best opportunity to see the most diverse corals of all the sites, with 102 and 88 species respectively (Table 4.3). NH had the lowest RDD for coral with 56 species (Appendix C for full species lists).

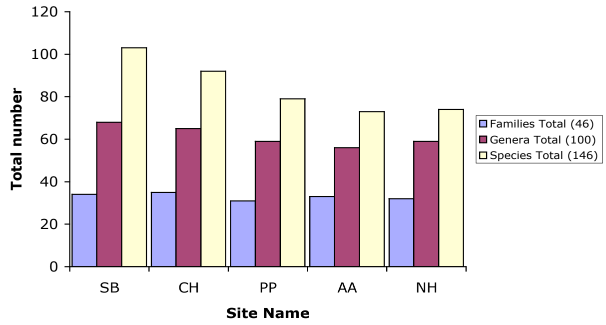
Figure 4.6. Roving Diver Diversity (RDD) of corals surveyed at the five dive sites, examined by family, genera, and species.



Fish (bony)

The diving experience opportunities related to fish differed between the sites. SB provided divers with the highest RDD of fish with 103 species (Table 4.3; Figure 4.7; Appendix D for full species lists). This was followed by the CH with 92 species. Therefore both of these sites were distinctive for fish diversity in comparison with the other sites. AA and NH provided divers with the lowest RDD for fish species of all the sites with 74 and 75 species respectively (Table 4.3).

Figure 4.7. Roving Diver Diversity (RDD) of fish (including shark and rays) for the five dive sites by family, genera, and species.



Certain sites had higher SFs and relative mean abundances for 'standard' and 'specific' organisms when compared to other sites, and thus offered visiting divers distinctly different opportunities for seeing particular organisms. Measurements of SF and relative mean abundance for the 'standard' and 'specific' organisms monitored at each of the sites between 16 August 2003, and 29 May 2004 can be seen in Table 4.4, while the sighting probability distributions of these organisms can be seen in Table 4.5. Appendices F through to H provide a full description of the SF, relative mean abundance, habitat, and depth range for all 'standard' and 'specific' organisms monitored at each of the five study sites.

While the sighting probability for 'anemonefish' was 'assured' at all sites (100%), their estimated abundance at SB (60.0) was higher than at other sites. The sighting probability for 'barracuda' was 'very high' at PP with a SF of 95.0% and a relative mean abundance of 21.2, making this site the best for seeing this type of fish (Table 4.4). 'Bumphead parrotfish' were 'absent' at the two pinnacle sites, SB and PP, but had a 'low' sighting probability at the CH, AA, and NH. However, AA and NH provided divers the opportunity to see more 'bumphead parrotfish' (mean of 19.0 and 41.6 respectively) than at the CH (mean of 1.2; Table 4.4). The sighting probability for 'lionfish' was best at PP (very high), and was also the case for the relative mean abundance (2.9). SB and AA both had 'moderate' sighting probabilities for 'lionfish', while at the CH the probability was 'low'. At NH, 'lionfish' were 'absent' during the sampling period.

Table 4.4. Sighting frequency (SF) and relative mean abundance statistics for 'standard' and 'specific' organisms monitored at all sites between 16 August 2003 and 29 May 2004.

	Ribbon Reef location (GBR)			Osprey Reef location (Coral Sea)	
	Steve's Bommie (n=20)	Pixie Pinnacle (n=20)	Cod Hole (n=38)	Admiralty Anchor (n=37)	North Horn (n=52)
Standard Fish					
Anemonefish	100.0 (60.0)	100.0 (15.0)	100.0 (47.0)	100.0 (12.0)	100.0 (7.0)
Barracuda	52.4 (4.8)	95.0 (21.2)	13.2 (17.0)	29.7 (7.0)	34.6 (24.6)
Bumphead parrotfish	-	-	13.2 (1.2)	16.2 (19.0)	15.4 (41.6)
Coral trout	33.3 (5.1)	55.0 (2.3)	68.4 (4.8)	73.0 (3.6)	55.7 (7.2)
Lionfish	23.8 (2.2)	90.0 (2.9)	10.5 (1.5)	27.0 (2.3)	-
Maori wrasse	23.8 (1.0)	40.0 (1.4)	65.8 (1.4)	27.0 (1.4)	55.8 (3.8)
Moray eels	23.8 (1.4)	5.0 (1.0)	39.5 (1.0)	27.0 (1.2)	40.4 (1.2)
Potato cod	9.5 (1.0)	10.0 (1.0)	81.6 (3.0)	10.8 (2.0)	76.9 (1.9)
Red bass	47.6 (17.3)	45.0 (6.3)	97.4 (27.8)	54.1 (8.0)	55.8 (9.6)
Shark mackerel	42.9 (3.1)	45.0 (2.6)	15.8 (3.8)	13.5 (3.4)	19.2 (5.4)
Titan triggerfish	52.4 (2.1)	55.0 (1.6)	57.9 (1.7)	59.5 (1.9)	34.6 (1.9)
Trevally	100.0 (80.4)	75.0 (9.8)	10.5 (23.3)	18.9 (11.6)	26.9 (18.8)
Tuna	-	-	-	10.8 (1.3)	36.5 (3.9)
Specific Fish					
Anthias	100.0 (845)	100.0 (252.5)	-	-	-
Bigeye seaperch	100.0 (202)	-	-	-	-
Coronation trout	-	15.0 (1.7)	-	-	-
Diagonally banded sweetlip	-	-	18.4 (122.0)	-	-
Flowery cod	-	-	60.5 (1.7)	-	-
Fusiliers	100.0 (1286)	100.0 (902.5)	-	-	-
Garden eels	-	-	-	100.0 (150)	-
Goldsaddle goatfish	100.0 (103)	-	-	-	-
Sergeant majors	-	100.0 (116.3)	-	-	-
Stonefish	42.9 (2.0)	-	-	-	-
Standard Invertebrates					
Crown of thorns starfish	-	-	-	-	-
Cuttlefish	28.6 (1.5)	-	10.5 (1.3)	-	1.9 (1.0)
Nudibranchs	66.7 (1.9)	80.0 (2.4)	31.6 (1.3)	10.8 (1.0)	3.8 (1.0)
Octopus	23.8 (1.4)	15.0 (1.0)	13.2 (1.4)	8.1 (1.3)	-
Specific Invertebrates					
Corallimorphs	100.0 (11)	-	-	-	-
Gorgonian fans	-	100.0 (11.0)	-	-	-
Mantis shrimp	19.0 (1.3)	40.0 (1.1)	-	-	-
Porcelain crab	100.0 (1.3)	-	-	-	-
Red flame file shell	100.0 (1.0)	100.0 (2.0)	-	-	-
Reptiles					
Sea snakes	-	-	-	-	-
Turtles	57.1 (1.3)	5.0 (1.0)	7.9 (1.0)	8.1 (1.0)	11.5 (1.1)
Standard sharks and rays					
Manta rays	-	-	2.6 (1.0)	5.4 (3.0)	-
Rays	9.5 (2.0)	5.0 (1.0)	21.1 (1.0)	16.2 (1.0)	-
Reef sharks	42.9 (1.9)	15.0 (1.0)	92.1 (2.5)	91.9 (3.1)	100.0 (23.4)
Specific sharks and rays					
Hammerhead shark	-	-	-	-	15.4 (1.4)
Silvertip reef shark	-	-	-	5.4 (1.5)	15.4 (1.8)
Wobbegong shark	14.3 (1.3)	-	-	-	-

- (Organisms ranked by type of organism in alphabetical order (fish, invertebrates, reptiles, sharks and rays). Within each of these rankings, organisms are listed in alphabetical order. Values are sighting frequency and (mean abundance)
- Sighting frequency is calculated as the number of surveys an organism was sighted in divided by the total number of surveys undertaken at that site over the sample period, expressed as a percentage.
- Mean abundance is calculated only for surveys when an organism was sighted. Mean abundance for anemonefish and garden eels calculated during one survey only and is thus not a true mean, but an indication of abundance.

Table 4.5. Sighting probability distributions of 'standard' and 'specific' organisms monitored at each of the study sites between 16 August 2003 and 29 May 2004.

	Sighting probability categories						
	Absent (0%)	**Very Low (1-10%)**	**Low (11-20%)**	**Moderate (21-50%)**	**High (51-75%)**	**Very High (76-99%)**	**Assured (100%)**
Steve's Bommie (n=20)	•Bumphead parrotfish •Crown-of-thorns starfish • Manta rays •Sea snakes •Tuna	• Moray eels •Potato cod	• Mantis shrimp •Wobbegong shark	•Coral trout •Cuttlefish •Lionfish •Maori wrasse •Moray eels •Octopus •Red bass • Reef sharks •Shark mackerel •Stonefish	•Barracuda •Nudibranchs •Titan triggerfish •Turtles		•Anemonefish •Anthias •Bigeye seaperch •Corallimorphs •Fusiliers •Goldsaddle goatfish •Porcelain crab • Red flame file shell •Trevally
Pixie Pinnacle (n=20)	•Bumphead parrotfish •Crown-of-thorns starfish •Cuttlefish •Manta rays •Sea snakes •Tuna	•Potato cod •Rays •Turtles	•Coronation trout •Octopus •Reef sharks	•Mantis shrimp •Maori wrasse	•Coral trout •Red bass •Shark mackerel •Titan triggerfish	•Barracuda •Lionfish • Nudibranchs •Trevally	•Anemonefish •Anthias •Fusiliers •Gorgonian fans • Red flame file shell •Sergeant majors
Cod Hole (n=38)	•Crown-of-thorns starfish • Sea snakes •Tuna	•Manta rays •Turtles	•Barracuda •Bumphead parrotfish • Cuttlefish •Diagonally banded sweetlip •Lionfish •Octopus •Shark mackerel •Trevally	•Moray eels •Nudibranchs •Rays	•Coral trout •Flowery cod •Maori wrasse •Titan triggerfish	•Potato cod •Red bass •Reef sharks	•Anemonefish
Admiralty Anchor (n=37)	•Crown-of-thorns starfish •Cuttlefish •Sea snakes	•Manta rays •Octopus •Silvertip reef sharks •Turtles	•Bumphead parrotfish •Nudibranchs •Potato cod • Rays •Shark mackerel •Trevally •Tuna	•Barracuda •Lionfish •Maori wrasse •Moray eels	•Coral trout • Red bass •Titan triggerfish	•Reef sharks	•Anemonefish •Garden eels
North Horn (n=52)	•Crown-of-thorns starfish •Lionfish •Manta rays •Octopus • Rays •Sea snakes	• Cuttlefish •Nudibranchs	•Bumphead parrotfish •Hammerhead sharks •Shark mackerel •Silvertip reef sharks •Turtles	•Barracuda •Moray eels •Titan triggerfish • Trevally •Tuna	•Coral trout • Maori wrasse •Red bass	•Potato cod	•Anemonefish •Reef sharks

- Data for sighting probability distribution taken from Table 4.4. Values were rounded up to the nearest whole number. Organisms within each category listed in alphabetical order.

The sighting probability for ‘maori wrasse’ was the best at the CH and NH (very high) Table 4.5), however significantly more ‘maori wrasse’ could be seen at NH ($p<0.05$). The CH and NH also provided divers with the highest sighting probability for ‘potato cod’ (very high) when compared to all other sites that were ‘very low’ to ‘low’. While ‘trevally’ could be seen at all sites, they were ‘assured’ at SB with a relative mean abundance of 80.4, much higher than at any other site (Table 4.4). Only the two Osprey Reef sites, AA and NH had sightings of ‘tuna’, with NH having a ‘moderate’ sighting probability and AA having a ‘low’ probability.

SB had five ‘specific’ fish that were monitored, four of which were ‘assured’ (Table 4.5). Each of these (anthias, bigeye seaperch, fusiliers, and goldsaddle goatfish) were schooling species with relative mean abundances of over 100 individuals (Table 4.4). ‘Stonefish’ had a ‘moderate’ sighting probability with a relative mean abundance of two. Three of the four ‘specific’ fish species that were monitored at PP (anthias, fusiliers, and sergeant majors) were ‘assured’ with relative mean abundances of over 100 individuals. ‘Coronation trout’ at PP had a ‘low’ sighting probability and a relative mean abundance of 1.7. At the CH, ‘flowery cod’ had a much higher sighting probability than the ‘diagonally banded sweetlip’. When ‘diagonally banded sweetlips’ were sighted they were in high abundance (mean 122.0). ‘Garden eels’ at AA were ‘assured’ and the colony size was initially estimated at 150 individuals. Because this species lives in colonies and resides in individual burrows (Randall et al., 1997), and because no appreciable change in the garden eel bed was noticed during the sampling period, it is assumed that the colony size would have changed little during this time.

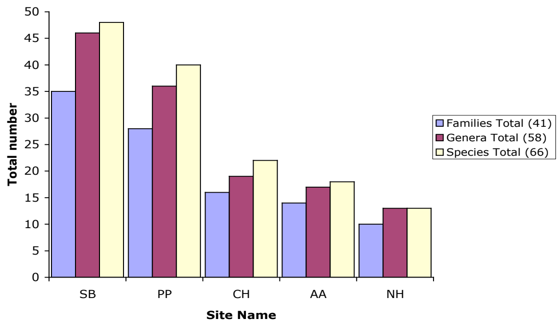
Sharks and rays (cartilaginous fish)

There were also measured and distinct differences in the opportunities to see sharks and rays at each site. ‘Manta rays’ were only sighted at the two back reef sites, the CH and AA, both with ‘very low’ sighting probabilities (Table 4.5). ‘Low’ to ‘moderate’ sighting probabilities for ‘rays’ were also restricted to the two back reef sites, while the two pinnacle sites, SB and PP, had ‘very low’ sighting probabilities. ‘Rays’ were ‘absent’ at NH. While ‘reef sharks’ were seen at all sites during the sample period, they had ‘very high’ sighting probabilities at the CH and AA, and were ‘assured’ at NH (Table 4.5). NH also had a significantly higher relative mean abundance (23.4) for ‘reef sharks' when compared to all other sites ($p<0.05$), with the next closest being AA with a relative mean abundance of 3.1. NH also had the highest diversity of reef shark species that were seen including 'whitetip reef sharks', 'grey reef sharks', 'silvertip reef sharks', and 'hammerhead sharks' (Appendix D for full species lists).

Other marine organisms

Both the pinnacle sites, SB and PP, provided divers with the best opportunity to see a greater diversity of other marine organisms with RDD estimates of 49 and 40 species respectively (Table 4.3; Figure 4.8). This was much higher than the three remaining sites, with NH having the lowest RDD of other marine organism species (13) when compared to all other sites (Appendix E for full species lists).

Figure 4.8. Roving Diver Diversity (RDD) of other marine organisms for the five dive sites by family, genera, and species.



Distinctive differences between the sites were also characterised by the sighting probability of other marine organisms, but all had relative mean abundances no higher than two individuals during the sampling period (Table 4.4). SB provided divers with a 'high' probability of seeing 'turtles', better than all other sites with the next closest being NH with a 'low' probability (Table 4.5). The probability of seeing 'cuttlefish' was also the best at SB (moderate), was 'low' at the CH and NH, and 'absent' PP and AA. PP had a 'very high' probability for 'nudibranchs', followed by SB, which was 'high'. The probability of seeing 'octopus' was the greatest at SB (moderate), followed by the CH (low).

SB had ‘assured’ sighting probabilities for ‘corallimorphs’, ‘porcelain crab’ and the ‘red flame file shell’. PP also had an ‘assured’ probability for the ‘red flame file shell’ and ‘gorgonian fans’. However, the probability for ‘mantis shrimp’ was higher at PP (moderate) than at SB (low; Table 4.5).

Size of fish and other marine organisms

The size class distribution of fish and other marine organisms measured between sites also showed distinctive differences. SB provided divers with the best opportunity to see ‘very small’ (<5cm) organisms, with 2.6% of all organisms surveyed at SB classed this size (Table 4.3). Both of the Osprey Reef sites, AA and NH, provided divers with the best chance to see a greater number of ‘very large’ organisms (>100cm), with 12.1% of organisms classed this size at AA, and 13.6% classed at NH.

4.5.2 Distinctive attributes

Table 4.6 provides a detailed description of each of the biophysical attributes identified to be distinctive at the sites according to the six factors (See Section 4.4.6 for allocation of attributes). Some attributes were found to be distinctive for more than one factor and are therefore listed more than once. Table 4.7 presents a summary of each of the distinctive attributes identified at each of the sites in Study Two, and thus characterises the main diving opportunities at each.

Table 4.6. Descriptions of distinctive attributes identified for each quality factor at the study sites.

	Distinctive attributes
Abundance	• Fish - Schooling fish species including: **fusiliers**, **anthias**, **bigeye seaperch**, **goldsaddle goatfish**, **red bass**, **sergeant majors**, **barracuda**, **bumphead parrotfish**, **diagonally banded sweetlip**, and **trevally**. Also high abundance for non-schooling species like **anemonefish, coral trout,** and **garden eels** at particular sites. • Invertebrates – **Corallimorphs** and **gorgonian fans** • Sharks and rays – **Reef sharks** at NH also have a high relative mean abundance.
Size	• Physical – Large **bommies** and sand filled **gullies** that separate them were distinctive for their large size. Vertical **reef walls**, large **caves**, and **swim-throughs** were also distinctive for this factor. • Fish – **Potato cod**, **maori wrasse, tuna, bumphead parrotfish,** and **moray eels** were distinctive for their 'very large' size (>100cm). • Invertebrates – **Porcelain crabs** were distinctive by their 'very small' size (<5cm) • Reptiles - **Turtles** were distinctive by their 'very large' size. • Sharks and rays – **Reef sharks, silvertip reef sharks**, **hammerhead sharks,** and **manta rays** were distinctive for their 'very large' size.
Behaviour	• Fish – **Titan triggerfish** were distinctive by their movement and foraging behaviour. Titan triggerfish are usually solitary and swim by undulating the second dorsal and anal fins (Randall et al., 1997). They forage the coral rubble and substrate for food by picking up and moving small pieces of reef materials with their mouth. To do this they usually invert their bodies head down. Schooling fish species, particularly the **fusiliers** and **anthias,** move in large schools like large flocks of birds. When one fish makes an erratic movement, the remainder of the school follow. This creates a wave type motion in the school, and their bodies that reflect the light heighten the visual display of mass movement by these fish. Hunting **trevally** can also chase the fusiliers, causing the school to move past divers at high speeds. This is a visual spectacle in itself. **Anemonefish** are virtually always found living in close association with their host sea anemones. While living in these anemones the fish appear to 'flutter' and 'waddle' between the medusa like tentacles, providing an entertaining display of behaviour (Nielsen Tackett & Tackett, 2002). **Potato cod, maori wrasse**, **flowery cod**, and **red bass** were distinctive by their behaviours during cod feeding events (see Section 4.3.1 for full description of cod feeding activities). Each of the species was attracted to the feeding area by the food and activity of the divers, and their behaviour was focussed primarily in obtaining as much of the food being offered as possible. In doing this each of the species comes within very close proximity to the divers and can become quite erratic and unpredictable. **Garden eels** live in resident holes (Randall et al., 1997). The eels will extend most of their bodies out of the holes and feed on the plankton that passes by. In high abundances garden eels look like a field of long grass swaying in the breeze. When divers approach too close all the eels retreat into their holes and will not emerge until they feel it is again safe (Randall et al., 1997). **Lionfish** often swim very slowly and herd small fish into small crevices where they will attack them. In doing this they tend to flutter their elongate fins and spines and provide an interesting display of predatory behaviour. • Invertebrates – **Porcelain crabs** are filter feeders and use small net like structures to capture passing plankton (Nielsen Tackett & Tackett, 2002). This feeding technique is an interesting behaviour to view. **Cuttlefish** look similar to a squid in that their tentacles project out in front of their body. They are about the size of a football, yet can sometimes be well camouflaged with their surrounds because they are able to change their skin texture and colour in an instant to blend in with their background at the time (Gosliner et al., 1996). Once seen, cuttlefish will also produce very interesting behaviours such as defensive poses of the tentacles. Cuttlefish tend to appear on dive sites mostly during breeding times on the GBR (pers obs), when courtship behaviour and egg laying are prevalent. This means that behavioural observations are heightened. **Octopus** also put on interesting displays of behaviour when seen, often retreating to holes, or changing colours and texture of the skin rapidly.

Table 4.5 continued.

	Mantis shrimp are often seen scurrying around outside their burrows, sometimes excavating, and when divers approach they seem almost inquisitive looking with independently moving eyestalks directly into divers masks (Nielsen Tackett & Tackett, 2002). Reptiles – **Turtles** often come in and rest or feed close to the substrate, providing divers with a rare opportunity to see turtles up close. • Sharks and rays – **Reef sharks**, particularly whitetip reef sharks were very often seen sleeping or resting on the sand (Randall et al., 1997), allowing divers to approach them quite closely. Grey reef sharks tended to patrol sites when no shark feeding/attracting activities were undertaken. However, when shark feeding/attracting activities were undertaken the grey reef sharks were primarily focussed on getting as much, or as close, to the food as possible, as were the whitetip reef sharks. During feeding activities this meant a feeding frenzy behaviour was induced (see Section 4.3.1). **Manta rays** will often perform loops and appear to be flying, and may sometimes interact with divers. **Rays** may also show interesting signs of behaviour as they bury themselves in the sand for camouflage.
Duration	• Fish – several fish species allow divers to view them for long periods of time. These include the schooling species: **fusiliers**, **anthias**, **bigeye seaperch**, **goldsaddle goatfish**, **red bass**, **sergeant majors**, **barracuda**, **bumphead parrotfish**, **diagonally banded sweetlip**, and **trevally;** and also non-schooling species like the **anemonefish, moray eels, lionfish,** and **stonefish. Titan triggerfish** also allow divers to view them with little impact on the fish's behaviour if they don't get too close. **Potato cod, maori wrasse**, **flowery cod**, and **red bass** all provided divers with long encounters during cod feeding activities. However, even on dives that cod feeding activities were not undertaken, each of the species could be approached, or themselves approached divers in search of food. • Invertebrates – The **red flame file shell, cuttlefish, octopus, mantis shrimp** and **porcelain crabs** can be viewed for extended periods of time as long as the diver does not get too close. **Nudibranchs, gorgonian fans,** and **corallimorphs** can be viewed for as long as the diver pleases. • Reptiles – When **turtles** come in to rest or feed, divers are able to get very close and view for long periods of time. • Sharks and rays – Because whitetip **reef sharks** could be seen in most cases resting or sleeping on the sand, divers were able to watch and observe the sharks for as long as they pleased, provided they didn't disturb the sharks. When disturbed, the sharks moved away from area and usually settled in a similar habitat. During shark feeding/attracting activities, reef sharks could be viewed for long periods of time.
Popularity or iconic status	• Fish – **Anemonefish** are very popular among divers because they are physically attractive, colourful, provide entertaining behaviours and are the focus of countless underwater diving photographs. In addition, anemonefish were also featured heavily in the recent Hollywood film 'Finding Nemo', adding to their popularity and iconic status. **Potato cod** are very popular among divers because they are physically attractive, large, and can be viewed up close. They are also the subjects of many underwater photographs, and feature heavily in diving brochures in this area. **Maori wrasse** are also popular with divers due to their large size and interesting colouration, and are considered an iconic species of coral reefs. In addition, maori wrasse are also listed as 'threatened' by the IUCN (Cornish, 2004). Species that are rare or endangered are said to hold special attraction for visitors (Reynolds & Braithwaite, 2001). • Invertebrates – **Nudibranchs** are very popular among divers because of their physical attractiveness. They are often very diverse and colourful, and are the subjects of many underwater photographs. **Gorgonian fans** are also featured in many underwater photographs characterising the coral reef scene. • Reptiles – **Turtles** are very popular among divers because they are physically attractive, are iconic organisms of coral reefs, but are also listed as 'threatened' by the IUCN (Seminof, 2004). In addition, turtles were also featured heavily in the recent Hollywood film 'Finding Nemo', adding to their popularity and iconic status.

Table 4.5 continued

	• Sharks and rays – **Reef sharks** were distinctive by their popularity or iconic status. The fascination that humans have with sharks is very clear through the level of publicity these organisms have received in the public media ranging from photographs in magazines, book, and brochures, to Hollywood movies including 'Jaws', 'Deep Blue Sea', 'Open water', 'Finding Nemo', 'Shark Tale', and countless documentaries. In addition these organisms are considered dangerous. Reef shark populations are also threatened by extractive fishing activities, and drastic declines in shark numbers worldwide have been reported (WILDAID, 2001). **Manta rays** were also distinctive by their popularity and iconic status due to their physical attractiveness and their high level of coverage in dive related media.
Special/unusual features	• Physical – Diving on **pinnacles**, or being able to explore large **bommies** and sand filled **gullies**, diving on a **reef wall**, or entering **caves** and/or **swim-throughs** might be considered to be a special/unusual experience for some divers, especially if it is for the first time. • Fish – **Potato cod, maori wrasse**, **flowery cod**, and **red bass** attracted during the cod feed might be considered by divers to be a special/unusual experience because they are able to view them feeding, up close, and for extended periods. This scenario would not be possible without the food to provide the initial attraction for these species. Seeing **garden eels** feeding on passing plankton, or watching them retreat and emerge from their holes might be considered special/unusual. • Invertebrates – The **red flame file shell** was distinctive due to its special/unusual appearance. The red flame file shell produces a 'lightning' type flash within the membrane of the mantle that is a striking blue and gives the appearance that the organism actually has electrical current flowing through its mouth. Such a visual display by an organism is both very special and unusual. **Cuttlefish** or **octopus** might also appear special/unusual in relation to the many other reef organisms that can be seen because of their shape and/or form. • Shark and rays – **Reef sharks**, particularly whitetip reef sharks were very often seen sleeping or resting on the sand. Being able to approach a shark resting on the bottom might be considered to be a special/unusual experience by divers. Viewing reef sharks in high abundance might be considered to be a special/unusual experience by divers. This might especially be the case during shark feeding/attractive activities where divers are able to see many sharks, up close, and feeding. Because of the perceived or actual rarity of viewing **manta rays**, **silvertip reef sharks**, and **hammerhead sharks**, just seeing these animals might be considered a special/unusual experience.
Intensity of experience	• Physical – The vertical **reef wall,** and being able to enter **caves** and **swim-throughs** might provide divers with intense and exciting diving experiences. • Fish – **Fusiliers** and **trevally** are distinctive at the site by the intensity or excitement they may produce when moving, especially when the trevally are hunting the fusiliers. **Potato cod, maori wrasse**, **flowery cod**, and **red bass** attracted during feeding activities can often become quite erratic and unpredictable. The intensity generated by this activity might be distinctive of this site. • Invertebrates – Perhaps finding organisms like **nudibranchs, cuttlefish, octopus**, and **mantis shrimp** might provide intense experiences for some divers. • Sharks and rays – Intense experiences might also be generated by diving with such a high abundance of **reef sharks**, which is likely to be heightened during shark feeding/attracting activities.

• (see Section 4.4.6 for full description of factors, and attribute selection).

Table 4.26. Summary of distinctive biophysical attributes measured at each site in Study Two between August 16 2003 and 29 May 2004.

	Ribbon Reef location (GBR)			Osprey Reef location (Coral Sea)	
	Steve's Bommie (SB)	**Pixie Pinnacle (PP)**	**Cod Hole (CH)**	**Admiralty Anchor (AA)**	**North Horn (NH)**
Abundance	•Fusiliers •Anthias •Bigeye seaperch •Goldsaddle goatfish •Trevally •Anemonefish •Corallimorphs	•Fusiliers •Anthias •Sergeant majors •Barracuda •Trevally •Anemonefish •Gorgonian fans	•Red bass •Anemonefish	•Garden eels •Red bass •Anemonefish	•Reef sharks •Red bass •Coral trout •Anemonefish
Size	•Porcelain crabs (very small) •Turtles (very large)		•Potato cod (very large) •Reef sharks (very large)	•Reef sharks (very large) •Bommies (large) •Gullies (large) •Caves (large) •Swim-through (large •Reef wall (large)	•Reef sharks (very large) •Potato cod (very large) •Reef wall (large)
Behaviour	•Titan triggerfish •Fusiliers •Trevally •Anemonefish •Porcelain crabs •Turtles	•Fusiliers •Trevally •Anemonefish •Titan triggerfish	•Potato cod •Maori wrasse •Flowery cod •Red bass •Reef sharks •Anemonefish •Titan triggerfish	•Anemonefish •Garden eels •Titan triggerfish •Reef sharks	•Reef sharks •Potato cod •Red bass •Anemonefish
Duration	•Fusiliers •Anthias •Bigeye seaperch •Goldsaddle goatfish •Trevally •Titan triggerfish •Red flame file shell •Porcelain crabs •Turtles •Anemonefish	•Fusiliers •Anthias •Barracuda •Trevally •Anemonefish •Red flame file shell	•Potato cod •Maori wrasse •Red bass •Reef sharks •Flowery cod •Anemonefish	•Garden eels •Anemonefish •Reef sharks	•Reef sharks •Potato cod •Red bass •Anemonefish
Popularity or iconic status of organism	•Anemonefish •Nudibranchs •Turtles	•Anemonefish •Nudibranchs •Gorgonian fans	•Potato cod •Anemonefish •Maori wrasse •Reef sharks	•Anemonefish •Reef sharks	•Reef sharks •Potato cod •Maori wrasse •Anemonefish
Special/ Unusual features	•Pinnacle •Red flame file shell •High diversity of coral •High diversity of fish •High diversity of other marine organisms •Probability of trevally 'assured' •Probability of turtles 'high' •Probability of cuttlefish 'moderate' •Probability of octopus 'moderate' •'very small' organisms	•Pinnacle •Red flame file shell •Probability of barracuda 'very high' •High diversity of corals •High diversity of other marine organisms •Probability of nudibranchs 'very high'	•High coral cover •Large plate like corals •High coral colour •High fish diversity •Probability of maori wrasse 'high' •Probability of potato cod 'very high' •Probability of manta rays 'very low' •Probability of rays 'moderate' •Probability of reef sharks 'very high' •Cod feeding activity	•Reef wall •Bommies •Caves •Swim-throughs •High coral cover •High coral colour •Probability of tuna 'low' •Probability of manta rays 'very low' •Probability of rays 'low' •Probability of reef sharks 'very high'	•Reef wall •High coral colour •Probability of maori wrasse 'high' •Probability of potato cod 'very high' •Probability of tuna 'moderate' •High diversity of reef sharks •Probability of reef sharks 'assured' •'very large' organisms •Shark feeding/attracting activities
Intensity of experience	•Fusiliers •Trevally	•Fusiliers •Trevally	•Cod feeding activity	•Caves •Swim-throughs •Reef wall	•Reef wall •Shark feeding/attracting activities

4.6 Discussion

It was a major objective of this study to provide an assessment of the biophysical attributes that were most likely to be encountered by visiting divers on selected Ribbon Reef and Osprey Reef dive sites. This was to understand the types of wildlife tourism experience opportunities that these sites provide (Driver et al., 1987). The findings show that a wide range of biophysical attributes can be seen within a single site, and also between sites. Such diverse biophysical attributes provide visiting divers with a variety of diving opportunities. However, some sites offer divers a much higher chance of seeing particular biophysical attributes than others. This result demonstrates that coral reef dive sites are not homogenous in the sense that they are able to provide visitors with a particular type of experience, but that these experiences are likely to be highly varied both within and between sites. Section 4.6.1 provides a discussion on the physical attributes, corals, fish, sharks and rays, and other marine organisms measured within and between sites.

Although visiting divers at the sites can see many biophysical attributes, there are some attributes that were more distinctive than others, and therefore might attract special attention. These distinctive attributes might provide visitors with rich and powerful experiences through one or several factors. The factors used to identify distinctive attributes in this study were: abundance; size; behaviour; duration; popularity or iconic status; special/unusual features; and intensity of experiences. An explanation of how these factors might be distinctive to divers both within and between sites, and thus help characterise the diving experience opportunities are explained in Section 4.6.2. Lastly, Section 4.6.3 is an examination of the utility of the Modified Roving Diver Technique (MRDT) used to undertake the biophysical assessments on tourism sites.

4.6.1 Attributes measured at the sites

Physical attributes

Measuring the physical attributes allowed an understanding of the diving opportunities that occur at each of the sites. This study found that physical attributes from the Ribbon

Reef and Osprey Reef location sites vary considerably, and that each site provides divers with a different underwater landscape to explore. This level of detail adds a new dimension to interpreting and understanding the way that certified divers' experience coral reef sites that has not yet been considered.

Corals

The coral at the study sites was found to be diverse, colourful, and cover a relatively high percentage of the available substrates. Only coral communities at the back reef sites had the highest percent of live coral cover. High coral cover at dive sites has also been linked to recreational diving demand for that site, with any negative change to the cover said to cause a reduction in diving demand (Pendleton, 1994). Coral cover on the pinnacle sites, as well as at North Horn, was low in comparison to the back reef sites (11-30%). All three sites have steep to vertical reef slopes, and thus suitable coral attachment sites might therefore be limited. Rouphael & Inglis (1997) also found that pinnacle sites on the GBR had low coral cover, especially in comparison to back reef sites.

The three sites from the Ribbon Reef location were estimated to have a higher diversity of coral species than the Osprey Reef sites. However, corals at the Osprey Reef sites are said to be "healthy and abundant" and likely to be more diverse than inner and perhaps middle GBR's (Fenner, 2003, p3). This result is consistent with marine surveys conducted in the both the Coral Sea and outer GBR reefs in 2003, although different survey methods were used. Oxley, Ayling, Cheal, & Thompson (2003) found that hard coral diversity was 1.5 to 2.3 times lower from the Coringa-Herald National Nature Reserve in the Coral Sea, when compared to outer GBR sites of similar latitude. The diversity of corals seen on the Ribbon Reefs and Osprey Reef locations are fine examples of coral communities that divers are able to experience, and are more diverse in coral diversity than the entire Caribbean region (Fenner, 2003; Spalding et al., 2001).

The coral colour index at North Horn, Admiralty Anchor, and the Cod Hole was 'high', with the two pinnacle sites having a 'medium' coral colour index. Very low levels of coral bleaching were apparent only on North Horn, Admiralty Anchor, and the Cod Hole, and only in shallow water (<5m). The pinnacle sites appeared unaffected by bleaching, most probably because of the low amount of coral found in shallow water due to the shape of the pinnacle structure. Coral bleaching in the past has (1997/1998) affected mid-shelf and outer-shelf reefs to a much lesser extent than inshore reefs (GBRMPA, 2005a), and the Ribbon Reefs in particular have been less affected than other reefs on the GBR (Reef CRC, 2002). In addition, bleaching events usually occur in the earlier months of the year on the GBR and Coral Sea (GBRMPA, 2005a). Because surveys were undertaken in July of 2003, it is unlikely that the extent of coral bleaching at the dive sites was fully assessed in this present study. Because bleaching events pose a serious and impending threat to coral reefs (Wilkinson, 2000), and reef related tourism (Cesar, 2000; Graham, Idechong, & Sherwood, 2001; Westmacott, Teleki, Wells, & West, 2000), further research needs to be conducted to monitor the level of coral bleaching on tourism sites, and to measure its impact on divers' experiences. However, given the devastating effects that coral bleaching events have had on other tropical regions of the world in the past decade (Wilkinson, 2004a), the Ribbon Reef and Osprey Reef dive sites appear to be in very good condition.

Fish (bony)

While all sites provide divers an opportunity to see a wide diversity of fish species, Steve's Bommie had the highest estimated fish diversity (103 species) of all the sites. Differences were again apparent between the two locations for estimated diversity of species, with the three Ribbon Reef sites having more fish species to see. Oxley et al., (2003) also found that fish diversity was lower on Coral Sea sites when compared to comparable outer GBR sites, thus supporting this finding.

The types of fish species present at each of the sites over the sample period were also quite different. Pinnacle sites had a distinct abundance of schooling fish species that were not matched at any of the other sites. Osprey Reef sites had larger pelagic species like 'tuna' that were not sighted at all on the Ribbon Reef sites over the 10-months. At the two sites where feeding activities were undertaken, the Cod Hole and North Horn, there were also notable differences in the community structure. These sites both had high 'very high' sighting probabilities for 'potato cod', 'maori wrasse', and 'red bass'. Each of these species has been documented to have taken part in feeding activities at the Cod Hole since 1979 (Alder & Haste, 1994; Vail & Hoggett, 1997). Red bass are also recorded in high abundance at pontoon sites on the GBR, aggregating where fish feeding takes place and actually waiting for vessels to arrive (Sweatman, 1996).

The high sighting probability and relative mean abundance of 'potato cod' that were observed during this study at the Cod Hole are not seen on reefs elsewhere on the GBR, with most reefs in the Cairns section having no records of the species being present at all (Pears, 2005). This makes the population of potato cod at the Cod Hole a special feature in this region. However, the number of potato cod have fluctuated dramatically since early documented dives undertaken at this site in 1979 when 20 potato cod were counted (Alder & Haste, 1994). The average number of potato cod seen between 1992 and 1997 was 8.4 with a range of 0-26 (Vail & Hoggett, 1997). This present study found the mean number of potato cod to be three, with a range of 0-10. Vail and Hogget comment in their discussion that the decreasing trend in cod numbers is cause for concern by the dive industry and reef managers. The present study has shown that the cod numbers appear to have fallen again since their study.

Vail and Hogget (1997) suspect that declines in cod numbers can been attributed to feeding activities by dive operators where animals have been known to be 'bashed' or punched by divers (actions also observed in this present study), and to commercial and recreational fishing activities. In the past, many pieces of fishing gear including hooks and lines have been found by divers (including the researcher) at the Cod Hole. In addition, unsubstantiated reports of 'potato cod' being targeted by commercial fishers when their regular fishing spots yield a poor catch have also been made. It should be noted that all fishing activities have been prohibited at the Cod Hole since 1983 (Alder & Haste, 1994), but somehow seem to continue (as evidenced by the presence of fishing gear) despite the high level of protection.

Sharks and rays (cartilaginous fish)

'Reef shark' sightings were 'assured' at North Horn, and were 'very high' at Admiralty Anchor and the Cod Hole, but were sighted much less often at the pinnacle sites. The greatest diversity and abundance of sharks was recorded at North Horn. The mean abundance of 'reef sharks' at North Horn was 23.4 ranging from one to 58 individuals, more than the abundance reported at other popular shark sites such as "Fish Head" in the Maldives which historically had around 20 sharks before they were fished out in 1997 (Anderson & Waheed, 2002). Similar high abundances of reef sharks are not recorded on any site within the GBRMP, however similar numbers of reef sharks are said to occur at Flinders Reef, also in the Coral Sea (Chinn, 2005). Through the use of telemetry tracking devices, the population of whitetip and grey reef sharks at North Horn have been shown to be permanent residents, most roaming less than one kilometre from the mooring at the site (Fitzpatrick, 2003). It is unknown if this abundance of reef sharks can be attributed to the natural attributes of the site, or if it is an artefact of over ten years of feeding activities. It is likely that it is a combination of both. The population of reef sharks at Flinders Reef has also been fed for divers' entertainment for over ten years. More research needs to be undertaken to determine the impacts of feeding and habituation on reef shark populations on coral reef dive sites.

'Rays' were seen at all sites except North Horn, but were most frequently seen on the two back reef sites, the Cod Hole and Admiralty Anchor. All sightings were of Kuhl's stingray, and were restricted to sandy areas which is consistent with this species habitat preference (Randall et al., 1997). This may explain why none were seen at North Horn, as this site has no sand/rubble, and Admiralty Anchor and the Cod Hole had a high presence of sand/rubble. 'Manta rays' were seen only at the Cod Hole and Admiralty Anchor, and both rarely during the sample period. It appears that the probability of seeing 'manta rays' at any of the sites studied is 'very low'.

Other marine organisms

High diversities of other marine organisms were restricted to the Ribbon Reef location sites. Steve's Bommie was found to have the highest diversity of species (49), and had the most reliable sightings of 'turtles', 'cuttlefish', and 'octopus'. In addition, 'corallimorphs' were found only at Steve's Bommie. Reliable sightings of crustaceans, 'nudibranchs', and 'red flame file shells' were also restricted to the both of the pinnacle sites. Pixie Pinnacle was the second most diverse site (40 species), with the highest probability of seeing 'nudibranchs', 'mantis shrimp', and 'gorgonian fans'. The other three sites were quite low in species diversity and reliable viewing opportunities for other marine organisms, and thus divers' experiences related to these organisms is likely to be limited at these sites.

4.6.2 Distinctive biophysical attributes

Abundance

This study found that there were many organisms on the study sites that were distinctive for their collective abundance, with the schooling fish species like fusiliers and anthias having much higher abundance (over 1000 individuals) than any other organism. Distinctive abundance was also measured for 'reef sharks' at North Horn Osprey Reef. Such high abundance for reef sharks could not be seen at the other sites, and was thus distinctive between sites. At sites where a particular type of organism has unusually high abundance in comparison to other sites, like reef sharks at North Horn, abundance as a distinctive attribute for that organism is likely to have a greater influence on experiences.

Size

The distinctive size of a biological or physical attribute at a site might also attract special attention. On the sites studied visitors have the opportunity to see organisms of many different sizes. Only very few organisms were identified as being distinctive for their 'very small' size (<5cm). On the other hand there were many organisms found to be distinctive for their 'very large' size (>100cm). The largest organism surveyed during this study was the 'manta ray', able to grow up to at least 670cm in disc width (Randall et al., 1997). Other organisms identified for distinctive large size were 'reef sharks', 'silvertip reef sharks', 'hammerhead sharks', 'potato cod', 'turtles', 'moray eels', 'tuna', 'bumphead parrotfish' and 'maori' wrasse. It is likely that distinctive large size will play a significant role in divers' experiences on the study sites, given that most of the organisms surveyed were between 6 and 60cm. This is because larger objects tend to stand out during visual search, especially coupled with movement that also attracts attention (Geisler & Chou, 1995). In terrestrial wildlife tourism activities, this is the case, where large animals are the primary focus of viewing activities for visitors despite there being many smaller animals to see (Chapman, 2003; Hammitt et al., 1993).

Size was also a distinctive attribute for physical structures, most notable of these being the steep 'reef walls' that could be found only at the Osprey Reef sites. These walls are enormous structures dropping over 1000m, and diving near one of these reef walls is likely to be a memorable experience, especially if it is the first. Other physical structures distinctive for their size were the ‘caves’ and ‘swim-throughs’ at Admiralty Anchor, the largest of these being a ‘swim-through’ capable of accommodating up to six divers at once.

Behaviour

The behaviour of an organism, or group of the same type of organisms has been shown to impact on visitors’ experiences for other wildlife tourism encounters (Birtles et al., 2002b; Davis et al., 1997; Muloin, 2000). It is likely that behaviour will also influence divers’ experiences on coral reefs because there are so many organisms, and thus behaviours, to be seen at the sites. The ‘cod feeding’ and the ‘shark feeding/attracting’ activities did induce very strong displays of behaviour for ‘potato cod’, ‘maori wrasse’, ‘red bass’, and ‘reef sharks’ (only during the shark feeding/attract). This type of behaviour would not have been witnessed without the use of food. For natural behaviours, anemonefish do provide divers with an entertaining type of waddling movement, but because this could be seen with ease at each site, its significance is questionable.

Duration

Viewing many of the organisms monitored in this study could be done for extended periods with little impact on the organism’s behaviour. How much this is related to an organism’s habituation to divers being present at a site is not known. However, some organisms might be viewed for longer periods of time because of other distinctive factors they are identified for like behaviour or size for example. The ‘red flame file shell’, with its spectacular light display is likely to be viewed for many minutes because divers might consider it special/unusual, or because they have not seen it before. However, divers might view ‘reef sharks’ at North Horn for longer periods of time because there were so many, but also because they are potentially dangerous. This might especially be the case during the shark ‘feeding/attracting’ activities where divers will sit and watch the sharks for up to 30 minutes. Similar amounts of time might be spent viewing the ‘potato cod’ at the Cod Hole during the cod feeding event. ‘Turtles’ at

Steve's Bommie might also attract attention for duration because they rest on the pinnacle substrate, a situation that appeared to occur only at this site. Divers that see the turtle are able to approach quite closely and observe it as long as they do not disturb it. Many divers also take photographs.

Popularity or iconic status

Popularity or iconic status of an organism is driven by a range of factors, which include physical attractiveness, danger, and/or the publicity it has received in the public media (Reynolds & Braithwaite, 2001). Out of the many organisms surveyed in this study, only a few were considered distinctive because of their popularity or iconic status, and it is possible that there were more. Those identified were: 'reef sharks', 'turtles', 'anemonefish', 'manta rays', 'potato cod', 'nudibranchs', 'maori wrasse', and 'gorgonian fans'. If organisms are well known and familiar to divers they have a greater chance of initially being seen and identified. This is also the case with salient characteristics in visual search (Lubow & Kaplan, 1997). It might be expected that even non-divers are able to correctly identify sharks, turtles, and anemonefish because of their popularity and iconic status.

Special/unusual features

This refers to aspects of the experience or characteristics of an attribute being regarded as special or unusual, and therefore the participant being privileged (Reynolds & Braithwaite, 2001). Many attributes were identified as distinctive because they might be considered by divers to be special/unusual features in general, or at the sites being visited. Both physical and biological attributes were identified to be special/unusual features both for characteristics of the attribute, or experiences with the attribute. Attributes that were identified to be distinctive because they were special/unusual were the attributes that were most useful in characterising the main diving opportunities at each site.

Intensity of experience

Refers to the excitement generated by an experience (Reynolds & Braithwaite, 2001). Few attributes were identified as possibly providing intense experiences while diving at the sites. Intensity of the experience is likely to be a very subjective factor, and is thus likely to vary considerably amongst divers based on their previous history, what they were expecting, and what they were searching for. This might mean that searching for and finding a particular type of nudibranch might provide an exciting and intense experience for one diver, but might not at all be considered to create such an experience for another diver. The biological attributes that are most likely to provide the most intense experiences for the divers at the sites studied are those that were being fed in either the 'cod feed' or the 'shark feed/attract'. 'Potato cod', 'flowery cod', 'maori wrasse' and 'red bass' during the cod feed swim between divers at high speeds, attempting to get to the food being offered. However, during the 'shark feed', the 'reef sharks' (up to 58 during one survey) are sent into a feeding frenzy. During this time the sharks are unpredictable and the intensity of the experience is likely to be very high.

Physical attributes that are most likely to generate intense experiences are the 'reef walls' at the Osprey Reef dive sites. When diving on the reef walls, divers are exposed to deep open water, with no visible bottom and good visibility. For divers that have not been in such situations, this might generate an exciting experience. 'Caves' and 'swim-throughs' might also provide intense and exciting experiences as divers explore the physical landscape of sites.

Distinctive attributes might be more likely to impact on divers' experiences if they are considered to be distinctive for a greater number of factors. For example, reef sharks were identified to be distinctive for each of the seven factors and are therefore likely to be highly distinctive in relation to the many other attributes at a site. In contrast, a porcelain crab, considered distinctive for its 'very small' size and behaviour, might impact on very few divers' experiences because few divers might find it in the first place. Which attributes are most significant to divers' experiences, and for what reasons will be examined in the context of the divers' actual experiences at these sites in the Study Three (Chapter Five).

4.6.3 The Modified Roving Diver Technique (MRDT)

The MRDT used to assess the coral reef attributes at each of the sites in this study was useful in describing and measuring such diverse and abundant environments with limited time and resources. This was because the surveyor needed no transects and was able to start surveying immediately upon entering the water. The freedom to move around the site, and conduct extensive searches of organisms was necessary for collecting data on the attributes that divers are most likely to encounter. This was an important consideration in the design of this study as it allowed the data collected here to be compared and analysed with the data collected on divers' actual experiences at the sites in Study Three (Chapter Five). The MRDT is likely to be useful for well-trained volunteers (Schmitt et al., 2002) that are able to conduct their own surveys on other reef sites, or continue monitoring the sites studied in the present study. Future use of this technique might also incorporate the seven factors used to identify distinctive attributes, so that attributes at sites can be surveyed specifically for abundance or size for example.

One limitation with the MRDT data is that the surveyor has a much better trained eye and focussed approach to the collection of data than is expected of the average tourist diver. This might increase the sighting frequency values for some of the more cryptic species. This was suggested to be the reason for differences between researchers and visitors viewing ability in a terrestrial national park study (Hammitt et al., 1993). Without prior knowledge of the exact location of some of the more cryptic organisms (e.g. stonefish, red flame file shell) at each of the sites in this present study, it is highly likely that even the surveyor would have missed them. Because these organisms can be hard to find, yet are thought to provide quality experiences for visiting divers, dive crews will actually take divers directly to the location of these organisms while underwater to ensure that as many visitors see these organisms as possible. However, assuming that all divers have an equal probability of encountering all the organisms monitored is a limitation of this technique.

4.6.4 Summary

This study has provided an assessment of the biophysical attributes that are most likely to be encountered by visiting divers on coral reef dive sites using a combination of survey techniques. Distinctive attributes were also identified at each site. These distinctive attributes not only characterised the diving opportunities at each site, but might be significant to divers' experiences because they are likely to provide quality experiences. The next chapter is an assessment of the divers' experiences at the dive sites examined in this study, and investigates which of the biophysical attributes are most significant to experiences and why.

CHAPTER 5

THE INFLUENCE OF CORAL REEF BIOPHYSICAL ATTRIBUTES ON DIVERS' EXPERIENCES

5.1 Introduction

In research on customer service, Parasuraman & Zeithaml (1988) suggest that service providers may not understand: 1) what features connote 'high quality' to consumers in advance; 2) what features a service must have in order to meet customer needs; and 3) what performance of those levels are needed to deliver 'high quality' service. These concepts also apply to the wildlife tourism experience, indicating that both reef and dive operation managers (the service providers) need to understand visitors' expectations of the biophysical attributes desired and/or likely to be encountered (Driver et al., 1987), the biophysical attributes that influence the actual experiences received (Borrie et al., 1998), and perceptions and evaluations of the quality of the biophysical attributes and experience overall. However, given the complexity and variability of the natural environment (Chapter Four), the demographic heterogeneity of the visitors (Chapter Three), and the varied nature of the interaction that takes place between the two, that results in the wildlife tourism experience, an integrated multidisciplinary approach is needed (Duffus & Dearden, 1990).

In Study Two (Chapter Four), the biophysical attributes that occur at five selected coral reef dive sites were measured and described to determine what attributes divers were most likely to encounter. Such rich and detailed descriptions of the sites provide the first opportunity to address some interesting questions concerning how visitors' experiences in natural areas are influenced by the attributes that occur there. For instance, does variability in the biophysical attributes between sites affect visitors' experiences, and if so how? Which attributes are most important to visitors' experiences and why? Do expectations for certain attributes affect overall satisfaction with the experience? These questions, and more importantly their answers, will advance our knowledge and theory in understanding the influence of specific biophysical attributes on experiences at natural sites, particularly in a marine tourism context. This will define which sites and attributes are most significant to visitors' experiences, an important step in making decisions about how to manage natural areas (Shafer et al., 1998), and how to protect resources (Borrie & Birzell, 2001).

5.1.1 Measuring visitors' experiences

The principal measure of quality outdoor experiences has traditionally been visitor satisfaction (Manning, 2001; Reynolds & Braithwaite, 2001). Since the 1970's when it was first introduced, 'satisfaction' research in tourism and hospitality has advanced in many respects but still lacks the general consensus on the definition of visitor satisfaction, and ultimately how it should be measured. In the tourism arena, 'satisfaction' is an important evaluative communication process between visitors and managers (Manning, 2001), and is conceptualised as the congruence of need and performance, or an evaluative process between visitors' expectations before the experience, and their perceptions and evaluations after the experience (Ryan, 1995). Therefore to understand how satisfaction is derived, we must also understand the expectations visitors have for specific attributes, a fundamental step in developing the Recreation Opportunity Spectrum (ROS) to plan for a diversity of activities in a given area (Driver et al., 1987). This approach has more recently become an integral paradigm of tourism and leisure research, providing a powerful tool for managers to come to a better understanding of visitors' demands and needs in a wide range of natural settings.

Understanding the biophysical attributes that visitors expect to encounter in natural areas ultimately gives us insight into the quality of experience they are likely to have, and how this relates to satisfaction. When expectations are not met by actual perceptions of the experience, negative disconfirmation or dissatisfaction is said to occur (Ryan, 1995). When expectations are met by actual perceptions, there is said to be confirmation of the expectations, and when expectations are exceeded by actual perceptions there is said to be positive disconfirmation or satisfaction. According to Noe (1999), the expectancy-disconfirmation model has received the widest acceptance among practitioners since it has been interpreted in other theoretical explanations giving a more expanded perspective to understanding expectations and satisfaction.

There are two accepted ways to measure expectancy-disconfirmation. The first is to measure if expectations were confirmed or disconfirmed directly and post hoc (after an experience), requiring respondents to indicate this on a bi polar scale. This method is useful in situations where respondents can be accessed only after an experience, and has been shown to be a good predictor of satisfaction (Page & Spreng, 2002). However, some researchers have commented that post hoc analyses make it impossible to understand when expectations are higher and when perceptions are lower (Parasuraman, Zeithaml, & Berry, 1985), and that asking respondents to reflect on their original expectations after the experience causes a hindsight bias (Zwick, Pieters, & Baumgartner, 1995). Therefore, to reliably identify differences between the attributes originally expected and those actually perceived, a difference format such as the gap-analysis model (before and after an experience) proposed by Parasuraman et al., (1985) seems most useful (Noe, 1999).

This method has not been applied to a marine wildlife tourism setting, but provides a useful opportunity to investigate expectations for biophysical attributes before an experience (pre-trip), and perceptions and evaluations of the same biophysical attributes after an experience (post-trip). This method is not without its criticisms, but most relate to researchers' inability to keep track of respondents before and after an event, making comparisons between the two sample times difficult (see Kozak, 2001). However, in the case of live-aboard diving trips, participants remain on board for the duration of the trip (three to six nights), allowing the researcher to survey throughout this period without the problem of keeping track of respondents.

While the measurement of satisfaction, expectations, and perceptions are of interest and importance in evaluating visitors' experiences, the biophysical attributes that ultimately influence those experiences that lead to satisfaction and expectations being met are more important to natural resource managers. Only with this information can managers make decisions on the sustainable levels of use for specific biophysical attributes by different types of users. By investigating the attributes most influential to visitors' experiences, we can elicit salient indicators of quality. The more visitors concur about the importance of certain attributes, the greater their value will be as an indicator of that experience, and the more useful they will be to natural resource managers (Manning & Lime, 1999). Such attributes can be measured using short open-ended question formats

(Oppenheim, 1994), asking respondents to list those attributes most important to experiences, as well as those that have detracted from experiences such as the amount of litter on campgrounds, or the amount of bare ground (Williams, Patterson, & Roggenbuck, 1992). While this approach is rarely taken in tourism research, especially in marine settings, the richness and detail of information it produces makes it highly warranted. Manning & Lime (1999) suggest that characteristics of useful indicators of quality in terrestrial environments should:

- Be specific rather than general;
- Be objective rather than subjective;
- Be reliable and repeatable;
- Related to visitor use;
- Sensitive to visitor use of a short period of time;
- Manageable;
- Efficient and effective; and
- Significant

Table 5.1 lists the potential indicators of environmental quality that have been shown to contribute or detract from visitors' experiences in coral reef environments. The limited amount of research into Reef visitors' preferences, experiences, and perceptions, gives some insight into what attributes are likely to influence quality experiences. However, a caveat of these studies was that only one had measured the biophysical attributes that actually occur at the sites, and this study was not specifically related to visitors' experiences (Pendleton, 1994). Measuring both the biophysical attributes, and documenting visitors' experiences would have allowed the researchers to demonstrate the interaction between visitors and the environment (Duffus & Dearden, 1990), just as Hammitt et al., (1993) had done in terrestrial settings. In addition, nearly all of the indicators of quality experiences are those provided to respondents by the researchers, and thus are not truly reflective of the visitors' experiences, but are those thought to be important by researchers. Only by asking the visitors to list the attributes that are most salient to their experiences, like Birtles et al., (in prep), and Curnock, (1998), did, are we able to understand which attributes are most important to visitors' experiences and why.

Table 5.1. Summary of previous research highlighting potential indicators of environmental quality that contribute or detract from visitors' experiences in coral reef environments.

Study/area/respondents	Potential indicator of environmental quality in order of importance	Site attributes measured?	Comments
Tabata (1989) Hawaii Dive operators (n=47)	*Positive indicators (provided by researchers)* - Outstanding marine life - Good underwater visibility - Good for underwater photography - Generally calm waters - No strong currents - Caves, lava tubes, arches - Presence of pinnacle or wall - Not crowded - Diveable wreck or plane - Drift dive possible	No	Examined the selection of near-shore dive sites by dive operators using a self-administered questionnaire
Pendleton (1994) Honduras Visitation rates for 20 sites	*Positive indicators (provided by researchers)* - High coral cover	Yes – Measured coral cover at 20 sites and compared to the rate of visitation	Found that recreation demand for dive sites was a function of coral cover
Done (1995) Great Barrier Reef Ecological criteria for valuing coral reefs	*Positive indicators (provided by researchers)* - High biodiversity of corals - High bioconstruction of corals *Negative indicators (provided by researchers)* - Coral damage	No	Suggests a system by which managers and researchers are able to evaluate reef sites via ecological measures
Curnock (1998) Great Barrier Reef Live-aboard divers (n=419)	*Positive indicators (listed by respondents)* - Whales (including minke whales) - Sharks - Potato cod - Fishes in general - Turtles - Clams - Barracuda - Dolphins *Negative indicators (listed by respondents)* - Impacts on the reef in general - Impacts caused by divers - Fish feeding - Anchor damage - Sewage discharge	No	Compared differences between Japanese and non-Japanese live-aboard participants. Respondents experienced the reef via snorkelling and SCUBA diving
Shafer et al., (1998) Great Barrier Reef Day-trip visitors (n=1818)	*Positive indicators (provided by researchers)* - Types of fish seen - Size of the coral seen - Total amount of coral seen - Number of different kinds of coral seen - Colour of the fish seen - Visibility of the water - Colour of the corals seen - Total number of fish seen - Behaviour of the fish seen - Size of the fish seen - Depth of the water - Number of animals other than coral or fish seen	No	Respondents experienced the reef via: underwater observatory, semi-submersible, snorkelling, SCUBA diving. Most were first time reef visitors
Cesar (2000) El Nido, Philippines Tourists in general (n=58)	*Negative indicators (provided by researchers)* - Coral bleaching	No	Found that divers were willing to pay US$202 extra to visit reefs unaffected by coral bleaching, and that snorkellers were willing to pay an extra US$26

Table 5.1 continued.

Rudd and Tupper (2000) Turks and Caicos Islands Day-trip divers (n=87)	*Positive indicators (provided by researchers)* - High abundance of Nassau grouper - Larger Nassau grouper	No	Assessed SCUBA divers preferences for seeing larger and more abundant Nassau grouper. Divers willing to pay more to see a greater number, and larger Nassau grouper
Williams and Polunin (2000) Western Caribbean Day-trip divers (n=195)	*Positive indicators (provided by researchers)* - Variety of fishes - Fish abundance - Variety of corals - Other large animals - Unusual fishes - Coral cover - Big fishes - Reef structure - Unusual corals - Large corals - Crustaceans - Sponges - Algae	Yes – measured fish attributes between protected and non-protected reef sites – but was not empirically linked to divers' experiences	Asked respondents to rate the importance of reef attributes. Respondents experienced the reef via SCUBA diving
Rudd (2001) Turks and Caicos Islands Day-trip divers (n=87)	*Positive indicators (provided by researchers)* - Small group sizes - Sea turtles - Sharks - Spiny lobster	No	Examined non-extractive economic value of various attributes through paired comparison surveys with SCUBA divers. Divers willing to pay more to dive in smaller groups, and see sea turtles, sharks, and spiny lobster
Ngazy et al., (2004) Zanzibar Reef visitors (n=157)	*Negative indicators (provided by researchers)* - Coral bleaching - Dead corals	No	Respondents experienced the reef via snorkelling and SCUBA diving
Birtles et al., in prep Great Barrier Reef Live-aboard divers (n=1045)	*Positive indicators (listed by respondents)* - Minke whales - Fish (non-specific) - Coral (non-specific) - Sharks - Potato cod - Turtles - Animal behaviour - Marine animals (non-specific) - Dolphins - Giant clams - Barracuda - Whale sharks - Nudibranchs *Negative indictors (listed by respondents)* - Broken damaged coral - Disruption to fish behaviour - Divers contacting coral - Anchor damage - Divers in general	No	Respondents experienced the reef via snorkelling or SCUBA diving. Divers ranged in level of dive history from beginners to those who had been diving for 38 years

5.2 Objectives

In order to describe and measure divers' experiences in coral reef environments in a way that demonstrates the interaction between the divers and the biophysical attributes that occur on coral reef dive sites, the objectives of this study are:

1. To provide an assessment of certified SCUBA diving experiences in coral reef environments in terms of:

    - Pre-trip expectations for the biophysical attributes that are likely to be encountered on the dive sites during the trip;
    - Actual experiences with the biophysical attributes that occur at specific dive sites; and
    - Post-trip perceptions and evaluations of the biophysical attributes encountered on the dive sites during the trip.

2. To provide an interpretation of divers' experiences in light of the biophysical attributes that were found to occur at five selected coral reef dive sites in Study Two in order to:

    - Determine the influence of specific biophysical attributes on divers' experiences within and between study sites;
    - Determine which specific biophysical attributes are most significant to divers' experiences and why.

5.3 Methods

This section provides a detailed account of the methods employed to undertake Study Three and begins with a description of the data collection technique (Section 5.2.1). The design (Section 5.2.2) and content (Section 5.2.3) of the questionnaire given to respondents to collect the data on their wildlife tourism experiences on coral reefs is then presented.

5.3.1 Data collection

The data for this study were collected using the same survey instrument as Study One (see Chapter Three, Section 3.3, for sampling design, sample size, and responses over time), and were combined with data collected in Study Two (Chapter Four) that described and measured the biophysical attributes that occur at the five study sites (see Chapter Two, Section 2.4, for study site selection). This enabled an investigation of how the biophysical attributes that occur at specific sites influence divers' experiences at those sites. The sites used to investigate this interaction between visitors and environment were those in Study Two: Steve's Bommie (SB), Pixie Pinnacle (PP) and the Cod Hole (CH) from the Ribbon Reef location; Admiralty Anchor (AA) and North Horn (NH) from the Osprey Reef location (See Chapter Four, Section 4.3.1, for site maps and descriptions).

Study One was an assessment of the types of divers participating in live-aboard trips on board six vessels visiting the Ribbon Reefs and Osprey Reef (See Chapter Two, Section 2.3, for dive operator selection details). Specifically, a sample of 651 certified SCUBA divers were surveyed on board the vessels between 16 August 2003 and 29 May 2004 using a series of on-site self-administered questionnaires. Using the same questionnaires, and thus the same respondents, this present study further investigated those divers' pre-trip expectations, actual experiences with the biophysical attributes at the five study sites, and the post-trip perceptions and evaluations. This allowed for a before, during, and after approach to understanding divers' experiences on coral reef dive sites.

Study Two was an assessment of the biophysical attributes that occur on Ribbon Reef and Osprey Reef location dive sites, and furthermore how these attributes varied within and between the sites between 16 August 2003, and 29 May 2004, the same survey period as Study One. This allowed the data on the biophysical attributes that occur on coral reef dive sites to be matched to the divers' experiences at these sites.

5.3.2 Questionnaire design

The survey instrument used to collect information on the divers' experiences was a series of on-site self-administered questionnaires, constructed of three major sections: Section 1 – Before diving, Section 2 – Specific dive sites, and Section 3 - End of trip (See Appendix B).

The design of the three-section questionnaire allowed the use of the gap-analysis model. The basis of the gap-analysis model is that researchers are able to identify gaps, whether positive or negative, between the expected and perceived quality of the service or experience (Parasuraman & Zeithaml, 1988), or in this case the biophysical attributes that occur on coral reef dive sites. This model can be represented as:

$$\sum(P_i - E_i)$$

where P_i is the perceived performance of attribute *i,* and E_i is the expected level of performance on that attribute. The direction and the size of the gap indicate whether expectations had been confirmed or disconfirmed leading to an understanding of how well the actual biophysical attributes at the sites performed in comparison to the expectations of these things. Only this method allows pre-trip expectations to be measured before any diving activities have taken place (Parasuraman et al., 1985). The before and after survey method has been adopted because it provides a useful opportunity to explore expectations and perceptions for specific biophysical attributes and identifies potential differences between the two measurements. This method is rarely applied to tourism research because it is usually not feasible to track the same respondents throughout an extended tourism experience (Kozak, 2001).

It should be noted that it was not possible to strictly ensure that respondents filled out the three sections of the questionnaire at the desired time, i.e. before diving had taken place, after diving at the specific dive sites, and once all diving for the trip had been completed. This would have required the crewmembers responsible for questionnaire administration to hand out and collect the questionnaires at each stage of the trip, which would have required too much crew time and resources given the tight trip schedules that these operations maintain. Asking the crew to do this over the 10-month sampling period, and on six different vessels, was seen as imposing too greatly on their regular duties and there was a strong possibility that operators would not have agreed to participate in the study.

To ensure that respondents did fill out each section at the appropriate time, the crewmember that administered the questionnaire at the start of the trip was given a one-page instruction sheet that was read verbatim to the respondents (Appendix A). A similar set of instructions were also incorporated into the questionnaire (Appendix B). The instructions stressed the need to complete each section at the three stages of the trip, and the crew were asked to remind respondents at each of these stages to complete the appropriate section. The richness of information provided in each of the three sections of the questionnaires by the 651 respondents, and the differences observed between the pre-trip and post-trip responses, provides a positive indication that in the majority of cases the questionnaire was completed as originally designed.

5.3.3 Questionnaire content

Section 1: Before Diving

Most of this section was a detailed enquiry into participant demographics and diving history that was examined in Study One. The remaining six questions in Section 1 were used in this present study and were designed to explore the importance of the diving trip, perceptions of high and low coral quality, and expectations for the environmental quality and attributes to be encountered at the dive sites to be visited. Of the 651 respondents who had completed information on their demographics and previous diving histories, 96.0% completed information regarding their expectations.

The importance of the trip in respondents' decisions to come to Far North Queensland was measured on a 10-point scale from 1 (not at all important) to 10 (extremely important). Respondents were also asked to list characteristics they use to define both high and low coral quality, because very little is known about divers' knowledge of these. The term environmental quality was defined in Section 1 of the questionnaire as 'both the abundance and size of individual reef species and the overall diversity of corals, marine fish and other animals.' Respondents were then asked to rate the level of expected environmental quality on a 10-point scale from 1 (very low quality) to 10 (very high quality) for the Ribbon Reef location dive sites. Respondents visiting the Osprey Reef location dive sites were also required to rate the expected environmental quality at these sites. Questions asking respondents to rate their perceived level of environmental quality for both locations were also asked in Section 3 at the end of the trip, allowing for the gap-analysis model to be employed.

Using open-ended question formats, respondents were given space to indicate what three marine animals they most wanted to see during the trip, and what features they most enjoy seeing on coral reefs in general. Finally, respondents were provided with a list of 19 specific features representing a wide range of biophysical attributes that can be found at coral reef sites. Features were generated to represent physical attributes (e.g. interesting landscapes, good visibility), corals (diverse coral life, beautiful corals), fish (bony; e.g. large schools of fish, potato cod, big fish >50cm), sharks and rays (cartilaginous fish; e.g. sharks, manta rays, other rays), and other marine organisms (e.g. nudibranchs, turtles, sea cucumbers, cuttlefish and octopus). Respondents were asked to rate how common they expected each of these to be on the dive sites during the trip on a six point scale. The scale ranged from 0 (not present) through to 5 (very common). This question formed the expectations component of the gap-analysis model, with a question identical in format at the end of the questionnaire in Section 3 asking respondents to rate how common they perceived the features at the end of the trip for direct comparison.

Section 2 - Specific Dive Sites

Section 2 was designed as an exploration into divers' experiences at the five study sites. Information regarding respondents' estimates of the horizontal visibility and their maximum depth during their dive was requested. However, the main thrust of the section focussed on respondents' experiences, their enjoyment, how well their expectations were met, and evaluations of quality at each of the dive sites. Acquiring this information was not considered to be an intrusion on the divers, as divers normally complete a 'dive log', a personal record of each dive (pers obs). In the dive log, much of the requested information is documented anyway. This common behaviour of divers to willingly document aspects of their experiences immediately after dives allowed for such rich information to be collected, and at multiple sites. This also helped ensure that the information required in the questionnaire was documented after each dive.

After the dive respondents were asked to list the three best features of the dive site and provided space to indicate why. Enjoyment with the dive sites was measured on a 10-point rating scale from 1 (not at all) to 10 (very much). Respondents were then asked to indicate how well the dive site had met their expectations on a five-point scale. The points on the scale were labelled with “fell well below my expectations”, “somewhat below my expectations”, “met my expectations”, “somewhat above my expectations”, and “well above my expectations”. This format allowed the researcher to measure post-hoc and directly whether disconfirmation of original expectations had occurred, and if so in which direction. This method was selected as it has been shown to be a more superior predictor of satisfaction then the gap-analysis (Page & Spreng, 2002) and has been used by Birtles et al., (in prep) in examining other marine tourism experiences. A ‘before’ section for each dive site, that measured pre-dive expectations, would have increased the length of the questionnaire significantly, and thus the demands on each respondent. This in turn may have caused respondents to abort the questionnaire midway (Ryan, 1995), or not undertake it in the first place.

Ratings for the perceptions of coral and fish quality at each site were also requested. For consistency throughout the survey instrument, 10-point ratings scales were used. The ratings ranged from 1 (very low quality) to 10 (very high quality). The perceptions of the level of human impacts at each of the sites were also measured on a 10-point scale, from 1 (no impact) to 10 (high impact).

The same 19 coral features from Section 1 were again provided to respondents in exactly the same format for each of the dive sites. However, in this section respondents were asked to rate how ‘important’ each of the 19 features were in contributing to their enjoyment of the sites. Ratings ranged from 1 (not at all important) to 5 (extremely important), but also provided was a tick box labelled ‘not seen’, that respondents could tick if they hadn’t encountered the feature.

Finally, nine sources of social impacts, and eight sources of environmental impacts were listed for divers to tick if they had perceived them as having a negative effect on their experiences. All 17 impacts were taken from a previous study on live-aboard divers visiting the Ribbon Reefs and Osprey Reef locations that had used an open-ended question to elicit detracting experiences (Birtles et al., in prep). Because the impacts listed by the respondents were taken from the same dive sites as those used in this present study, it seemed appropriate that tick boxes could be provided as a replacement for an open-ended question. The impacts most frequently listed by respondents in the previous study were used in this study.

Section 3 - End of Trip

Section 3 explored respondents' satisfaction with the dive sites, the best attributes seen, evaluations of environmental quality and attributes encountered, and how well the dive sites met expectations. Satisfaction was measured using a 10-point scale from 1 (not at all satisfied), to 10 (extremely satisfied). Having this question first eliminates bias caused by the wording or reflection process required by the following questions. Respondents were then asked to list the three best attributes at the dive sites for the whole trip. As in Section 2, having this question at the start of the section allowed respondents to provide those attributes most pertinent to their experiences.

The perception component of the gap-analysis model listing the 19 coral reef features was then provided to respondents, using the same format as in the previous sections. Respondents were asked to rate 'how common each of the features were on the dive sites during the trip' on a six point scale ranging from 0 (not present) through to 5 (very common).

Respondents were then asked to indicate how well the dive sites had met their expectations on a five-point scale. Each point of the scale was labelled the same as in Section 2 from 'fell well below my expectations', 'somewhat below my expectations', 'met my expectations', 'somewhat above my expectations', and 'well above my expectations'. Using an open-ended question format, respondents were asked to list their three favourite attributes of the dive sites for the whole trip.

The perception component of the gap-analysis concerning the environmental quality at each location was then provided on a 10-point scale as in Section 1. Respondents were then asked to evaluate coral and fish quality, human impacts, and natural beauty for each of the Ribbon Reef and Osprey Reef locations. Finally, respondents were asked to rate the sea conditions during the dive trip on a 5-point scale from 'very rough' to 'very calm' and included a mid point labelled 'OK'.

5.4 Analysis

5.4.1 Open-ended responses

Open-ended format responses were coded verbatim, and each response was coded only once. This was because all open-ended responses required respondents to list a single feature or animal, and the reasons why these were listed were mostly a single word response such as 'abundance' or 'colours'. Therefore, no actual coding was required. However, responses were grouped depending on the types of attributes they represented, for example 'physical attributes', 'coral attributes', and 'fish attributes'. As responses were basic and direct, no coding or validation was required.

5.4.2 Scalar responses

For all scalar questions, respondents were divided into two groups depending on whether they went to just the Ribbon Reef location on their trip, or if they had visited both the Ribbon Reef and Osprey Reef locations. These two groups were used as independent variables to test for any possible differences in rating measurements. All ratings data were checked for normality using histograms, P-P plots, and homogeneity of variance tests. Because almost all ratings were heavily skewed to one side or the other, indicating a high frequency of low or high values, square root and logarithmic transformations were unable to normalise the data (Sheskin, 2004). Because the strict assumptions of the preferred parametric tests were violated, the alternate non-parametric procedure, the Mann-Whitney U-Test was used.

Because scalar questions were heavily skewed, ratings between dive sites were also compared using non-parametric Kruskal-Wallis Means-Tests. Where post-hoc comparisons were needed, a series of Mann-Whitney U-Tests were used. To maintain a fixed significance level of 5% for these tests, a Bonferroni correction was applied depending on the number of comparisons needed, making the test results more conservative (Curtin & Shultz, 1998).

5.4.3 Gap-analysis

To determine if expectations being met at the sites affected the reported levels of enjoyment and satisfaction, the mean enjoyments and satisfaction ratings for respondents were tested between each expectation category they had selected. The category 'fell well below my expectations' was not used in the analysis, as there were too few respondents that had selected this. The mean values of enjoyment and satisfaction were tested between expectations categories using the Kruskal-Wallis Means Test. This was because mean ratings were highly skewed to the right, violating the assumptions of the equivalent parametric test.

To employ the gap-analysis model to the measurements of the 19 expected and perceived coral reef features collected in Section 1 and Section 3, perceptions were subtracted from the expectations ($\Sigma(P_i-E_i)$) (Parasuraman & Zeithaml, 1988), for each respondent for each feature. This provided either confirmation (perceptions were equal to expectations) or disconfirmation (perceptions fell above or below expectations) as a single value with the direction indicated by a positive or negative sign. Value ranged from –6 to +6. Negative disconfirmation indicated that perceptions had fallen below expectations, while a positive disconfirmation indicated that perceptions had exceeded original expectations.

The 19 expected features were also summed for each respondent, as were the 19 perceived features. This created an overall value of expectations and perceptions for the 19 features for each respondent. Using the gap-analysis model again, the summed perception ratings were subtracted from the summed expectations ratings ($\Sigma(P_i-E_i)$). Values ranged from –95 to +95. Again a negative value indicated that the respondent's overall perceptions had not met original expectations, while a positive value confirmed that expectations for the features had been exceeded. These values were then analysed for each category of how well the dive sites had met expectations as provided by respondents. Categories ranging from 'somewhat below my expectations' to 'well above my expectations' were used as independent variables to test for differences in the overall expected and perceived gap values, to determine the effect of the size of the gap on how well expectations were met. The category 'fell well below my expectations' was not used as an independent variable, as only three respondents selected it, making it unusable in the analysis. A One-Way Analysis of Variance was used to detect differences between categories, and all assumptions including homogeneity of variance were met.

5.4.4 Animal Importance Index (AII)

To understand the influence of a range of animals on divers' best experiences at each site and on sites overall, the Animal Importance Index (AII) was constructed. The data used in the AII included the sighting frequency (SF) of an animal at a specific site collected in Study Two, and the listing frequency (LF) of that animal by respondents as a best experience at that site. Both data sets were collected over the same 10-month period. This was to ensure that animals surveyed by the researcher in Study Two were the same species respondents were likely to have encountered in Study Three. The SF is expressed as a percentage value and indicates the frequency an animal was sighted over the 10-month study period at a particular site (see Section 4.4.4, Chapter Four).

The second data set was taken from the open-ended responses to the question 'what were the three best features of this dive site' over the same sampling period. Although this question generated a diversity of attributes from each dive site, for example 'good visibility' and 'interesting topography', the bulk of responses referred to specifically named animals respondents had sighted. Animal responses were separated from the remainder of the responses to create a sub-set of responses. These were then divided into specifically named animals as listed by respondents, for example 'reef sharks', 'cuttlefish', or 'red bass'. Responses relating to coral were not included in the animal sub-set as the SF for these would have been calculated as 100%, a non-applicable result. The LF is also expressed as a percentage value and indicates the frequency with which respondents listed the animal over the 10-month study period at a particular site. This was calculated as: LF = $(R/T)*100$, where R is the number of respondents who listed an animal, and T is the total number of respondents who visited that site and listed a specifically named animal.

The AII score for each animal is calculated as: AII = LF/SF. This index ranged from 1.00, highest importance to divers' experiences when sighted, to 0, lowest importance to divers' experiences when sighted, or the animal simply not being listed by respondents, or not being present in Study Two. The rationale behind this index refers to how frequently an animal is listed by respondents, in relation to how frequently it occurs at a site, and therefore able to be sighted. For example, if a particular species of fish was sighted at a dive site in 100% of surveys during the 10-month sampling period, but was listed by only 5% of the respondents who visited there, the AII score for that fish would be calculated at 0.05. In other words, the species of fish is always at the site, but very few divers felt it was a best experience despite the reasonable assumption that all of the divers may have encountered it. On the other hand if turtles were sighted at a dive site in 10% of surveys during the 10-month sampling period, and were listed by 10% of the respondents who visited there over the same time frame, the turtles' AII score would be calculated at 1.00. In other words, turtles did not occur at the site very often, however when they were encountered divers listed them as a best experience. This would indicate that the turtle is much more important to divers' best experiences than the abovementioned species of fish.

The construction of the AII allowed a list of animals that were encountered by divers to be ranked according to their importance to experiences. The AII was calculated for the list of 'standard' and 'specific' animals selected in Study Two as they were suspected as being important to divers' experiences as indicated by previous studies (Birtles et al., in prep; Curnock, 1998), and/or because they were mentioned within the pre-dive briefing at that site (see Section 4.3.1, Chapter Four). This was done for each of the five dive sites. The AII scores for animals found at all five dive sites were averaged, and these scores were used in the overall AII. Only 'standard' animals were included in the overall index.

5.4.5 Distinctive attributes

The reasons why respondents felt features were best experiences at each site were used to determine why a particular biophysical attribute was distinctive. The reasons provided were grouped according to either characteristics of the attribute (e.g. colours, abundance, size), or aspects of the experience with the attribute (e.g. a first experience, not expected, getting close). These reasons were collated for each type of attribute, and presented as percentage values. The total numbers of responses for each type of reason were also collated, and were classed according to which of the seven factors (identified in Study Two) they represented. This allowed an analysis of which factor was most important to experiences, and thus distinctive at a site, by looking at the frequency of responses.

5.4.6 Roving diver diversity (RDD) of marine life and best experiences

The Roving Diver Diversity (RDD) of coral, fish, and other marine organisms as surveyed in Study Two were used to estimate the diversity of the marine life at each site. RDD of coral, fish, and coral, fish, and other marine organisms combined were correlated with the percentage of best experiences listed by respondents at each site relating specifically to the diversity of coral, fish, and coral fish, and other marine organisms combined. The Spearman Rank-Order correlation was used as the assumptions for the parametric correlation were violated by the use of percentages as values (Sheskin, 2004).

5.4.7 Size of fish and other marine organisms (excluding coral) and best experiences

Every species of fish and other marine organisms (excluding coral) surveyed in Study Two at each of the sites was placed into a size class according to the species' known maximum length (see Section 4.4.3, Chapter Four). The size classes were: 'very small' (0-5cm), 'small' (6-10cm), 'medium' (21-60cm), 'large' (61-100cm), and 'very large' (>100cm). Respondents' comments for specifically named fish and other marine organisms (not coral) were also placed into the same size classes, again according to their known maximum length. This allowed for comparisons between the size of the organisms at a site and the sites overall, and the size of the organisms that provided best experiences at a site and sites overall.

5.4.8 Pre-dive briefing and best experiences

Each specifically named organism listed by respondents at each of the sites as a best experience was checked to see if that organism had been mentioned within the pre-dive briefing at each of the sites as documented in Study Two. Organisms listed as best experiences that were mentioned within the pre-dive briefing were compared to those not mentioned in the pre-dive briefing by looking at the differences in percentages for each site, and the sites overall. This was to determine the influence of the pre-dive briefing content on the experiences that divers were having once underwater.

5.5 Results

The results of Study Three are divided into three sections, following the order of the questionnaire. First, Section 5.5.1 is a presentation of the information on respondents' pre-trip expectations for the biophysical attributes to be encountered on the dive sites, and the locations to be visited. Section 5.5.2 presents respondents' actual experiences at each of the five study sites. The results section concludes with Section 5.5.3, respondents' post-trip perceptions and evaluations of the biophysical attributes encountered during the trip, and the locations visited.

Section 5.5.1 (pre-trip expectations), explores how important the live-aboard diving trip was in respondent's decision to come to Far North Queensland. The characteristics that respondents use to define high and low coral quality are also identified, as are the attributes of coral reefs that respondent's most enjoy seeing and the animals respondents most wanted to see on this trip. Expectations for how common coral reef features will be on the dive sites this trip, and the expectations of environmental quality at the Ribbon Reef and Osprey Reef dive sites are also examined.

Section 5.5.2 (site-specific diving experiences), looks at the respondents' experiences and evaluations of the biophysical attributes at the five study sites, Steve's Bommie (SB), Pixie Pinnacle (PP), the Cod Hole (CH), Admiralty Anchor (AA), and North Horn (NH), and links these to data collected in Study Two that measured the biophysical attributes that occur at these sites. This section explores the enjoyment of the dive sites and how well dive sites met expectations. Ratings of the information received in the pre-dive briefing are examined, as are the features most important in contributing to enjoyment at each site. Respondents' best experiences are investigated, including an examination of the results in light of the Animal Importance Index (AII). The influence of the diversity of marine life on best experiences is evaluated, as are the distinctive attributes most significant to divers' experiences. The influence of the size of fish and other marine organisms, and pre-dive briefing content are also examined in context of best experiences. Finally attributes that were found to detract from divers' experiences are identified.

Section 5.5.3 (post-trip perceptions and evaluations), explores respondents' satisfaction with the dive sites overall and how well dive sites met expectations. Also examined are the perceptions of how common coral reef features were on the dive sites during the trip, and the biophysical attributes contributing to best experiences during the trip. This section concludes by exploring respondents' evaluations of environmental quality, coral quality, fish quality, human impacts, and natural beauty for the Ribbon Reef and Osprey Reef dive sites, as well as the sea conditions during the trip.

5.5.1 Pre-trip expectations

Trip importance

Respondents rated the importance of the trip in their decision to come to Far North Queensland from 1 (not at all important) to 10 (extremely important) as high, with a mean of 8.1 (±1 SE 0.10; n=625). A large proportion (41.9%) rated the importance at 10. The mean importance rating for respondents visiting the both the Ribbon Reef and Osprey Reef locations in one trip (8.3, ±1SE 0.13) was higher than for the respondents visiting only the Ribbon Reefs location (7.9, ±1SE 0.16), but this was not found to be significant (z =1.909; sig = 0.056). For most respondents, live-aboard diving trips are the primary reason for travel to Far North Queensland.

Characteristics of high and low coral quality

The characteristics respondents used to define 'high' and 'low' coral quality are listed in Table 5.2 in descending order from the most frequently listed, to the least frequently listed. The most defining character for high coral quality was 'colourful' for 53.1% of respondents (n=584). Other important characteristics were the 'diversity of corals' (39.2%), 'high coral abundance/cover' (20.4%), and that that corals were 'not broken/damaged' (15.9%). The most defining character for low coral quality was that the coral was 'bleached/no colour' for 53.7% of respondents, followed by 'coral is broken/damaged' (32.3%), the 'coral is dead' (27.4%) and a 'low diversity of coral' (13.9%; n=546). Respondents have well developed notions about the characteristics they use to define high and low coral quality. There was high agreement that colourful, diverse and abundant corals represent high quality, and bleached, broken/damaged, and dead coral represent low quality.

Table 5.2. Characteristics respondents used to define high and low coral quality.

Characteristics of high coral quality	Number of respondents (n=584)	Valid % of respondents	Characteristics of low coral quality	Number of respondents (n=546)	Valid % of respondents
Colourful	310	53.1	Coral bleached/no colour	306	53.7
Diversity of corals	229	39.2	Coral is broken/damaged	184	32.3
High coral abundance/cover	119	20.4	Coral is dead	156	27.4
Corals not broken/damaged	93	15.9	Low diversity of coral	79	13.9
Live coral	66	11.3	Low abundance/cover of coral	59	10.4
Large corals	59	10.1	High presence of bare substrates	45	7.9
Healthy looking corals	49	8.4	Algae on or around corals abundant	39	6.8
Good and new coral growth	42	7.2	No new coral growth	27	4.7
Good coral formations	27	4.6	Pollution on or around corals abundant	21	3.7
Coral is not bleached	25	4.3	Coral rubble abundant	21	3.7
Abundance of hard coral	14	2.4	Sediments on or around corals abundant	18	3.2
Abundance of soft coral	13	2.2	Crown of thorns starfish abundant	18	3.2
No algae on or around coral	10	1.7	Poor coral health	10	1.8
No pollution on or around coral	8	1.4	Presence of warm water	3	0.5
No Crown of thorns starfish	5	0.9	Abundance of soft coral	2	0.4
Abundance of sponges	3	0.5	**TOTAL COMMENTS**	**988**	
Lack of sediment on or around coral	3	0.5	Left blank (question not completed)	105	
Presence of gorgonian fans	3	0.5			
TOTAL COMMENTS	**1145**				
Left blank (question not completed)	67				

Note: Respondents often listed more than one response. Valid % equals respondents that listed that feature of the total n

Attributes of coral reefs respondents most enjoy seeing

Attributes that respondents most enjoy seeing while diving on coral reefs are listed in Table 5.3 by major attribute themes. Study One found the respondents in this sample have travelled to a wide range of coral reef locations around the world. The attributes listed in Table 5.3 are therefore likely to represent the most enjoyable attributes from coral reef sites in general from these locations. A total of 584 respondents provided 2034 comments. Of the 2034 comments, there were 153 different biophysical attributes listed, with 76 of these being for specifically named organisms. On further examination, 44 were for fish (bony and cartilaginous), 27 were for other marine organisms, and five were for coral.

For this sample of divers, over a quarter agreed (26.2%) that ‘reef sharks’ are the most enjoyable coral reef attribute to see while diving, followed by ‘turtles’ (18.2%), and ‘large fish’ (16.8%). The ‘coral’ (non-specific) is also an attribute enjoyed by many respondents (16.4%), as is the ‘diverse fish life’ (13.7%). This result shows that a wide diversity of biophysical attributes are enjoyed by divers on coral reefs, with a high number of specifically named organisms adding to this enjoyment, most of these being fish species. However, certain attributes like ‘reef sharks’ and ‘turtles’ have provided enjoyment to a greater number of divers at a wide range of locations.

Responses relating to specifically named organisms were placed into their respective size class according to their known maximum length (see Appendix D and E). Of the 813 responses that could be classified, 63.8% were for ‘very large’ (>100cm) organisms, followed by 20.1% for ‘small’ (6-20cm) organisms. A further 8.0% were classed ‘medium’ (21-60cm), and 6.2% ‘large’ (61-100cm). Only 1.9% of specifically named organisms that respondents most enjoyed seeing were 5cm or less in maximum length (very small). For this sample of divers, many have most enjoyed seeing marine organisms that are ‘very large’.

Table 5.3. Attributes that respondents most enjoy seeing while diving on coral reefs.

Attributes	Number of respondents	Valid % of respondents (n=584)	Attributes	Number of respondents	Valid % of respondents (n=584)
Fish			**Marine life general**		
Large fish	98	16.8	Diversity of marine life	80	5.0
Diversity of fish life	80	13.7	Top 5 metres of reef	45	2.8
Fish (non-specific)	69	11.8	Marine life (non-specific)	38	2.4
Colourful fish	61	10.4	Small marine life	22	1.4
Large schools of fish	59	10.1	Abundance of marine life	21	1.3
Abundance of fish life	57	9.8	Colourful marine life	16	1.0
Pelagic fish	35	6.0	Other marine life general responses	48	3.0
Small fish life	33	5.7	**TOTAL MARINE LIFE**	**270**	
Anemonefish	29	5.0	**Sharks and rays**		
Small coral fish	25	4.3	Reef Sharks	153	26.2
Potato cod	17	2.9	Rays (non-specific)	40	6.8
Interesting fish life	12	2.1	Manta rays	38	6.5
Moray eels	11	1.9	Whale sharks	5	0.9
Maori wrasse	9	1.5	Hammerhead sharks	4	0.7
Other fish responses	99	17.0	Eagle rays	1	0.2
TOTAL FISH	**694**		Large sharks	1	0.2
Coral			Other shark and ray responses	3	0.6
Coral (non-specific)	96	16.4	**TOTAL SHARKS AND RAYS**	**245**	
Colourful corals	72	12.3	**Physical**		
Diversity of corals	56	9.6	Good visibility	39	6.7
Healthy coral	46	7.9	Interesting topography	13	2.2
Soft corals	31	5.3	Interesting bommies	4	0.7
Beautiful corals	18	3.1	Caves	3	0.5
Abundance of corals	17	2.9	Open sandy areas	2	0.3
Hard coral	14	2.4	Small dive sites	1	0.2
Other coral responses	77	13.2	Other physical	2	0.4
TOTAL CORALS	**427**		**TOTAL PHYSICAL**	**64**	
Other Marine Organisms			**Other**		
Turtles	106	18.2	Anything new!	15	2.6
Nudibranchs	51	8.7	Everything!	9	1.5
Octopus	15	2.6	Not too many divers	2	0.3
Cuttlefish	14	2.4	Other responses	2	0.3
Invertebrates (non-specific)	13	2.2	**TOTAL OTHER**	**28**	
Anemones	12	2.1	**TOTAL COMMENTS**	**2034**	
Dolphins	9	1.5	Left blank (question not completed)	67	
Crustaceans	8	1.4			
Other marine organisms responses	78	13.4			
TOTAL OTHER MARINE	**306**				

Note: Many respondents listed more than one response. Valid % equals respondents that listed that feature of the total n

Animals respondents most wanted to see on this trip

In an open-ended question format, respondents were asked to list the animals that they most wanted to see while diving on this trip, and a summary of their responses are listed in Table 5.4 by major attribute themes. A total of 619 respondents provided 1822 comments. Of these 1822 comments, there were 127 different comments listed, with 87 of these being for specifically named animals. On further examination, 61 were for fish (bony and cartilaginous), and 26 were for other marine organisms. Over half of the sample (59.8%) listed that they most wanted to see 'reef sharks', followed by 'manta rays' (31.7%), 'turtles' (29.7%), 'potato cod' (22.0%), 'hammerhead sharks' (13.9%), and 'stingrays' (13.2%).

Responses relating to specifically named animals were put into size classes. Of the 1682 responses that could be classed, 74.6% were for 'very large' organisms, followed by 11.3% for 'small'. A further 8.3% were classed as 'medium', and 5.6% 'large'. Only 0.2% of the animals that respondents most wanted to see were 5cm or less in maximum length (very small). Clearly, the majority of the animals that this sample of divers most wanted to see are 'very large', with 'reef sharks', 'manta rays', 'turtles', 'potato cod', and 'hammerhead sharks' topping the list.

Table 5.4. Animals that respondents most wanted to see on this trip.

Attributes	Number of respondents	Valid % of respondents (n=619)	Attributes	Number of respondents	Valid % of respondents (n=619)
Sharks and rays			**Fish**		
Reef sharks	370	59.8	Potato cod	136	22.0
Manta rays	196	31.7	Anemonefish	43	6.9
Hammerhead sharks	86	13.9	Moray eels	28	4.5
Stingrays	82	13.2	Lionfish	21	3.4
Whale sharks	48	7.8	Maori wrasse	21	3.4
Tiger sharks	13	2.1	Sea horses	21	3.4
Eagle rays	10	1.6	Pelagic fish	18	2.9
Diversity of sharks	8	1.3	Fish (non specific)	17	2.7
Other shark and ray responses	18	2.9	Large fish	16	2.6
TOTAL SHARKS AND RAYS	**831**		Colourful fish	14	2.3
Other marine organisms			Barracuda	11	1.8
Turtles	184	29.7	Other fish responses	117	18.9
Nudibranchs	71	11.5	**TOTAL FISH**	**463**	
Dolphins	51	8.2	**Marine life general**		
Octopus	50	8.1	Large marine animals	9	1.5
Whales	37	6.0	Small marine life	6	1.0
Cuttlefish	24	3.9	Diverse marine life	3	0.5
Sea snakes	16	2.6	Interesting marine life	3	0.5
Anemones	8	1.3	Other marine life general	4	0.6
Other marine organism responses	62	10.0	**TOTAL MARINE LIFE GENERAL**	**25**	
TOTAL OTHER MARINE	**503**		**TOTAL COMMENTS**	**1822**	
			Left blank (question not completed)	32	

Note: Many respondents listed more than one response. Valid % equals respondents that listed that feature of the total n

Expectations of how common coral reef features will be on the dive sites

Table 5.5 includes the 19 coral reef features listed in descending order of how common respondents expected them to be at the dive sites during the trip, from the most common to the least common. Respondents expected ‘diverse fish life’, ‘lots of fish’, ‘beautiful’ and ‘diverse’ corals, and ‘good visibility’ to be the most common features at the dive sites. Respondents visiting both the Ribbon Reefs and Osprey Reef in the one trip expected ‘sharks’, ‘big fish (>50cm)’, and ‘pelagic fish’ to be significantly more common at the Osprey Reef sites ($p<0.05$). ‘Manta rays’ were expected to be the least common of all the features at the sites. Respondents expect the dive sites they will visit to be diverse and abundant with marine life, but expect that more of the larger and pelagic organisms will be seen at the Osprey Reef location.

Table 5.5. Respondents’ expectations of how common specific features will be on dive sites during the trip.

Features expected at dive sites	Number of respondents	Mean rating of how common feature would be (1-5)	± 1 SE
Diverse fish life	594	4.62	0.03
Lots of fish	586	4.58	0.03
Beautiful corals	591	4.55	0.03
Diverse coral life	594	4.51	0.03
Good visibility	587	4.28	0.03
Large schools of fish	590	4.24	0.03
Interesting landscapes	593	4.21	0.04
Sea cucumbers	588	4.07	0.04
Big fish >50cm	593	3.85	0.04
Potato cod	591	3.70	0.04
Sharks	597	3.59	0.04
Nudibranchs	593	3.35	0.04
Pelagic fish	594	3.32	0.05
Crustaceans	591	3.18	0.04
Other rays	592	3.14	0.04
Turtles	591	2.98	0.04
Cuttlefish and octopus	593	2.76	0.04
Sea snakes	592	2.38	0.04
Manta rays	595	2.31	0.05

Mean value based on a 5-point response format from 01(rare) to 5 (very common)

Expectations of environmental quality for the Ribbon Reef and Osprey Reef dive sites

Respondents expected the environmental quality at the Ribbon Reefs to be high, with a mean of 8.4 out of 10 (±1 SE 0.05; n=625), but expected the environmental quality at the Osprey Reef sites to be significantly higher with a mean of 9.0 (±1 SE 0.06; n=411), (n=410, z=-10.520; sig=0.000).

Respondents that visited only the Ribbon Reefs expected the environmental quality of the Ribbon Reef dive sites (8.6; n=273) to be significantly higher than those respondents that visited both the Ribbon Reefs and Osprey Reef in the one trip (8.2; n=331), (z=-3.898; sig 0.000).

5.5.2 <u>Site-specific diving experiences</u>

Enjoyment of dive sites

Respondents' enjoyment with the dive sites was rated from 1 (not at all) to 10 (very much). Responses indicated that enjoyment with all sites combined was high, with a mean of 8.3 (±1 SE 0.04; n=651). The distribution of the ratings was skewed, with 76.3% of respondents rating their enjoyment at eight or above. The mean enjoyment rating for each of the five study sites can be seen in Table 5.6. Respondents reported that their enjoyment was highest at NH (9.2; n=287), which was significantly higher than all other sites ($p<0.05$). The next highest ratings of enjoyment were reported the CH (8.4; n=445), and SB (8.3; n=384), and both were significantly higher than the enjoyment ratings at PP (7.9; n=349) and AA (7.8; n=221) ($p<0.05$).

Table 5.6. Mean ratings and Kruskal-Wallis Means-Test results for how much respondents enjoyed each of the five study sites.

	Steve's Bommie (n=384)	Pixie Pinnacle (n=349)	Cod Hole (n=445)	Admiralty Anchor (n=221)	North Horn (n=287)	Chi-square	df	Asymp. Sig (<0.001)
Mean rating of enjoyment at each dive site (1-10)	8.3	7.9	8.4	7.8	9.2	150.313	4	0.000

Mean value based on a 10-point response format from 1 (not at all) to 10 (very much)

Respondents were also asked to indicate how well each of the dive sites had met their expectations from 1 (fell well below my expectations) to 5 (well above my expectations). The mean rating of 3.8 (±1 SE 0.02; n=651) indicated that for this sample expectations were exceeded. The distribution of the ratings was skewed to the right, showing that for 91.2% of respondents, dive site expectations had been met (rating of 3) or exceeded (4 and 5). Very few respondents (8.8%) felt that their expectations had not been met at the sites (ratings of 1 or 2). The mean ratings for each of the study sites can be seen in Table 5.7. The highest expectation rating was at NH (4.2; n=287), and was significantly higher than all other sites ($p<0.05$). In addition, the mean ratings for SB

(3.9; n=384) and the CH (3.7; n=445) were significantly higher than at PP (3.6; n=349) and AA (3.5; n=221)($p<0.05$).

Table 5.7. Mean ratings and Kruskal-Wallis Means-Test results for how well each of the five study sites met respondents' expectations at each of the five study sites.

	Steve's Bommie (n=384)	Pixie Pinnacle (n=349)	Cod Hole (n=445)	Admiralty Anchor (n=221)	North Horn (n=287)	Chi-square	df	Asymp. Sig (<0.001)
Mean rating of how well dive sites met expectations at each dive site (1-5)	3.9	3.6	3.7	3.5	4.2	94.684	4	0.000

Mean value is based on a 5-point response from 1 (fell well below my expectations) to 5 (well above my expectations)

To determine if expectations being met at the sites affected the reported levels of enjoyment, the mean enjoyment ratings for respondents were tested between each expectation category they had selected. Enjoyment ratings were found to increase significantly with each expectation category ($p<0.001$; Table 5.8), with each category having a significantly higher mean enjoyment rating than the last ($p<0.05$). This result shows that how well dive sites meet respondents' initial expectations does play a significant role in how much they will enjoy a site.

Table 5.8. Descriptive statistics and Kruskal-Wallis Means-Test results for the levels of reported enjoyment according to how well dive sites met respondents' expectations.

How well dive sites met expectations	Number of respondents	Mean enjoyment rating	± 1SE	Chi-square	df	Asymp.Sig (<0.001)
Fell well below my expectations	12	3.7	0.36	783.718	4	0.000
Somewhat below my expectations	135	5.7	0.15			
Met my expectations	477	7.7	0.05			
Somewhat above my expectations	587	8.6	0.04			
Well above my expectations	449	9.5	0.03			

Mean enjoyment is based on a 10-point response format from 1 (not at all) to 10 (very much).

Information received in the pre-dive briefing

Using a 10-point response format from 1 (very poor) to 10 (excellent), respondents rated the quality of the information they received in the pre-dive briefing as very high, with a mean of 8.6 (±1 SE 0.03; n=648). Only 1% of respondents rated the information less than five. The pre-dive briefing provides divers with an opportunity to understand what they are likely to encounter while diving at a site.

Features most important in contributing to enjoyment at each site

Respondents were asked to indicate on a 5-point scale from 1 (not at all important) to 5 (extremely important) which coral reef features were most important in contributing to their enjoyment at each site. Table 5.10 presents the ten most important features at each of the study sites. The most important features differed for each site, and these differences correspond to the distinctive attributes that were identified in Study Two.

Only 'diverse fish life', 'lots of fish' and 'large schools of fish' were rated highly important at the two pinnacle sites, SB and PP (Table 5.10). Study Two found SB to have the highest and most distinctive fish diversity of all the sites (102 species), with PP having the third highest fish diversity (79 species). In addition, both sites had distinctive abundances of schooling fish species that could not be experienced by divers at other sites. 'Potato cod' were the most important feature at the CH, and were also listed as important at NH, with these being the only two sites to have 'very high' sighting probabilities of potato cod, and thus being distinctive for that attribute. Similarly, 'sharks' were only listed as highly important at AA, the CH, and NH, the three sites that provided divers with SFs of over 90% for reef sharks. However, the abundance of reef sharks at NH was found to be distinctive at the site (relative mean abundance of 23.4), much higher than at the CH and AA (2.5 and 3.1 respectively). This difference might account for 'sharks' being the most important feature at NH and not at the CH or AA. The visibility at NH was also identified as a distinctive attribute when compared to all other sites in Study Two, and 'good visibility' was rated as the third most important feature at NH, much higher than any other site.

Table 5.9. Ten most important coral reef features that contributed to respondents' enjoyment at each of the sites.

Steve's Bommie (SB) (n=384)			Pixie Pinnacle (PP) (n=349)			Cod Hole (CH) (n=445)			Admiralty Anchor (AA) (n=221)			North Horn (NH) (n=287)		
Feature	**n**	**Mean**	**Feature**	**n**	**Mean**	**Feature**	**n**	**Mean**	**Feature**	**n**	**Mean**	**Feature**	**n**	**Mean**
Diverse fish life	361	4.51	Diverse fish life	323	4.43	Potato cod	418	4.61	Interesting landscapes	208	4.36	Sharks	275	4.79
Lots of fish	358	4.33	Lots of fish	321	4.26	Big fish >50cm	416	4.41	Beautiful corals	209	4.13	Big fish >50cm	272	4.55
Large schools of fish	352	4.18	Beautiful corals	331	4.13	Beautiful corals	423	4.06	Manta rays	9	4.11	Good visibility	275	4.24
Diverse coral life	359	4.05	Diverse coral life	330	4.12	Diverse coral life	415	4.03	Diverse coral life	208	4.11	Diverse fish life	275	4.03
Turtles	125	3.98	Large schools of fish	301	4.03	Diverse fish life	419	3.98	Turtles	14	4.00	Interesting landscapes	261	3.90
Cuttlefish and octopus	148	3.97	Interesting landscapes	321	3.96	Interesting landscapes	410	3.96	Diverse fish life	201	3.88	Beautiful corals	273	3.86
Beautiful corals	359	3.95	Good visibility	321	3.68	Sharks	308	3.94	Good visibility	203	3.84	Diverse coral life	273	3.84
Interesting landscapes	356	3.91	Big fish >50cm	278	3.38	Lots of fish	400	3.86	Sharks	160	3.67	Potato cod	234	3.84
Good visibility	354	3.64	Nudibranchs	192	3.37	Good visibility	413	3.83	Lots of fish	188	3.54	Lots of fish	261	3.84
Nudibranchs	222	3.40	Pelagic fish	188	3.31	Large schools of fish	354	3.52	Big fish >50cm	168	3.40	Pelagic Fish	214	3.75

- Mean value based on a 5-point response format from 1 (not at all important) to 5 (extremely important)
- N for each dive site is the number of respondents that visited the site
- N for each of the means corresponds to the number of respondents that saw the feature at the site

In Study Two, AA was found to have the most distinctive physical attributes of all the sites including the reef wall, bommies, gullies, caves, and swim-throughs, and also a distinctive high coral cover dominated by 'digitate' corals. Table 5.10 shows that 'interesting topography' and 'beautiful coral' were the two most important features at AA, which were not rated as the top two features at any other site. In addition, only 'manta rays' were rated highly at AA, the site that provided divers the best chance to see these organisms.

This result shows that all coral reef features do not have the same importance at all sites, but that importance for a particular feature appears to be dependant on how distinctive it is within a site, and when compared to other sites. Where a feature can be experienced by respondents at very few sites (i.e. it is distinctive because it is special/unusual; like the highly complex physical attributes at AA), these appear to be the most important to enjoyment.

Best experiences

Respondents' best experiences at the five dive sites combined are listed in Table 5.10 by major attribute themes. A total of 445 respondents provided 4797 best experience comments at the five study sites. Of these 4797 comments, there were 208 different biophysical attributes listed, with 118 of these being specifically named marine organisms. On further examination, 74 were for fish (bony and cartilaginous), 36 were for other marine organisms including crustaceans, reptiles, and molluscs, and eight were for coral. Live-aboard dive trip participants visiting the Ribbon Reef and Osprey Reef locations gained their best experiences from a very wide range and diversity of biophysical attributes (as seen in Table 5.10). This also infers that the respondents' level of knowledge and understanding of coral reef environments is high, and that they are able to list many individual organisms, most notably for fish.

The single best experience at the sites was 'reef sharks', making up 32.2% of all comments. This was followed by 'amazing coral' (25.4%), 'potato cod' (24.4%), 'interesting topography' (11.9%), 'amazing fish life' (10.4%), and 'good visibility' (11.9%). The results show that while there are many biophysical attributes that provide respondents with best experiences, a high percentage of the sample are in agreement that certain attributes, like those listed above, are the best diving experiences on the Ribbon Reef and Osprey Reef dive sites. The most frequently listed best experiences incorporate both biological and physical attributes, demonstrating that these are extremely important to experiences, and that they are seen with high frequency at the sites (as indicated by the number of respondents who listed them). Respondents' ten best experiences at each of the sites can be seen in Table 5.11.

Table 5.10. Biophysical attributes that respondents listed as best experiences at all sites

Attributes	Number of comments	Valid % of comments (n=1612)	Attributes	Number of comments	Valid % of comments (n=1612)
Fish			**Sharks and rays**		
Potato cod	394	24.4	Reef sharks	519	32.2
Amazing fish life	167	10.4	Rays (non-specific)	23	1.4
Abundance of fish	117	7.3	Shark attract/feed	19	1.2
Lionfish	99	6.1	Abundance of sharks	14	0.9
Diversity of fish	91	5.6	Manta rays	12	0.7
Anemonefish	80	5.0	Silvertip reef shark	10	0.6
Large schools of fish	76	4.7	Hammerhead sharks	7	0.4
Barracuda	70	4.3	Other shark and ray responses	12	0.7
Maori wrasse	65	4.0	**TOTAL SHARKS AND RAYS**	**616**	
Scorpion fish	55	3.4	**Other Marine Organisms**		
Stone fish	54	3.3	Red flame file shell	102	6.3
Cod feed	43	2.7	Nudibranchs	76	4.7
Small fish life	43	2.7	Turtles	65	4.0
Moray eels	33	2.0	Cuttlefish	59	3.7
Other fish responses	450	27.9	Anemones	29	1.8
TOTAL FISH	**1837**		Octopus	28	1.7
Physical			Giant clams	20	1.2
Interesting topography	192	11.9	Mantis shrimp	10	0.6
Good visibility	149	9.2	Other marine organisms responses	89	5.5
The pinnacle itself	111	6.9	**TOTAL OTHER MARINE ORGANISMS**	**478**	
Reef wall	98	6.1	**Marine life general**		
Swim-throughs	74	4.6	Diversity of marine life	80	5.0
Caves	36	2.2	Top 5 meters of reef	45	2.8
Other physical	88	5.5	Marine life (non-specific)	38	2.4
TOTAL PHYSICAL	**748**		Small marine life	22	1.4
Coral			Abundance of marine life	21	1.3
Amazing coral	409	25.4	Colourful marine life	16	1.0
Diversity of coral	52	3.2	Other marine life general responses	48	3.0
Soft corals	45	2.8	**TOTAL MARINE LIFE GENERAL**	**270**	
Interesting coral formations	39	2.4	**Other**		
Beautiful corals	32	2.0	Site easy to dive	51	3.2
Coral gardens	27	1.7	Site easy to navigate	45	2.8
Large corals	23	1.4	Anchor in cave	29	1.8
Gorgonian fans	20	1.2	Other responses	26	1.6
Other coral responses	50	3.1	**TOTAL OTHER**	**151**	
TOTAL CORALS	**697**		**TOTAL CODED ELEMENTS FROM COMMENTS**	**4797**	
			Left blank (question not completed)	74	

Note: Many respondents listed more than one response. Valid % equals respondents that listed that feature of the total n

Table 5.11. Top ten biophysical attributes that respondents listed as best experiences at each of the five study sites.

Steve's Bommie (SB) (n=366)		Pixie Pinnacle (PP) (n=279)		Cod Hole (CH) (n=429)		Admiralty Anchor (AA) (n=207)		North Horn (NH) (n=279)	
Attribute	**Valid % of respondents**	**Attribute**	**Valid % of respondents**	**Attribute**	**Valid % of respondents**	**Attribute**	**Valid % of respondents**	**Attribute**	**Valid % of respondents**
Amazing coral	19.7	Lionfish	29.6	Potato cod	75.8	Reef sharks	35.0	Reef sharks	96.4
Large schools of fish	16.1	Amazing coral	29.0	Reef sharks	33.4	Interesting topography	32.4	Potato cod	23.7
Pinnacle	15.6	Red flame file shell	19.6	Amazing coral	31.2	Amazing coral	31.9	Reef wall	21.9
Abundance of fish	15.0	Pinnacle	16.3	Interesting topography	17.2	Swim -through	27.5	Good visibility	17.2
Stonefish	14.5	Barracuda	16.0	Amazing fish life	11.0	Amazing fish life	16.9	Amazing coral	14.7
Anemonefish	14.2	Amazing fish life	13.9	Cod feed	10.0	Reef wall	15.5	Maori wrasse	9.3
Cuttlefish	13.7	Abundance of fish	12.7	Good visibility	9.3	Caves	15.0	Amazing fish life	9.0
Amazing fish life	13.4	Site easy to dive	11.8	Maori wrasse	7.9	Anchor	14.0	Soft coral trees	7.9
Turtles	11.7	Nudibranchs	10.0	Coral formations	3.7	Good visibility	11.0	Shark feed/attract	6.8
Site easy to dive	11.2	Diversity of fish	7.3	Diversity of fish	3.3	Garden eels	7.2	Abundance of fish	4.7

Note: Respondents often listed more than one response.

Physical attributes - The most highly listed physical attribute at all sites was 'interesting topography', which made up 11.9% of all comments (n=1612; Table 5.10). Physical attributes were listed highly by respondents at each of the sites, but were more highly listed at AA (Table 5.11), with five of the ten best experiences at the site being 'interesting topography' (32.4% of respondents), 'swim-through' (27.5%), 'reef wall' (15.5%), 'caves' (15.0%) and the 'anchor' (14.0%) within the swim-through (n=207). 'Good visibility' at NH was listed as a best experience by 17.2% of respondents who dived there, however the steep 'reef wall' was more frequently listed (21.9%; n=279). At the two pinnacle sites, SB and PP, the 'pinnacle' itself was a best experience for 15.6% (n=366) and 16.3% (n=279) of respondents respectively, and at the CH, 'interesting topography' was a best experience according to 17.2% of respondents (n=429). The physical attributes on coral reef sites played an important role in providing best experiences to this sample of divers. Where these attributes are diverse and complex they can provide the best experiences at a site.

Corals - There were 20 different coral comments listed by respondents as best experiences including 'colourful corals', 'hard corals', 'soft corals', 'new coral growth', 'interesting coral formations', and 'pristine coral' for example. The most listed coral attribute at all sites combined was 'amazing coral', making up 25.4% of all comments (n=1612; Table 5.10). When asked why this was a best experience, 38.5% of the 409 respondents said it was because of the 'diversity', 26.3% said it was the 'colours', and 20.9% said it was because of the 'health'. 'Amazing coral' was listed with very high frequency at all sites, but was listed most frequently by respondents at the CH and AA (Table 5.11). In addition, 'amazing coral' was the most frequently listed best experience at SB. 'Coral formations' were also listed by 3.7% of the respondents at the CH (n=429), and at NH 7.9% of respondents felt the 'soft coral trees' were a best experience (n=279; Table 5.11). Although respondents were unable to list individual species of corals as a best experience, coral as an attribute was found to contribute very highly to experiences at each of the sites.

Fish (bony) - There were 78 different fish best experiences listed by respondents, with 64 of those for specifically named fish. At all sites combined, 'amazing fish life' made up 10.4% of all comments, followed by the 'abundance of fish' (7.3%), the 'diversity of fish' (5.6%), and 'large schools of fish' (4.7%; Table 5.10). When the 167 respondents who listed ‘amazing fish life’ were asked why this was a best experience, 59.9% said it was because of the ‘diversity’, followed by 40.7% who said it was the ‘abundance’, and 9.0% who said it was the ‘colours’. For specifically named fish, ‘potato cod’ made up 24.4% of all comments, and scorpaenoid fish including ‘lionfish’ and ‘stonefish’ made up 18.4%. ‘Anemonefish’, ‘barracuda’, ‘maori wrasse’, and ‘moray eels’ were also highly listed (Table 5.10).

Fish that provided the best experiences for respondents at each site differed (Table 5.11). At SB, ‘large schools of fish’ were the most frequently listed fish attribute by 16.1% of respondents, followed by the ‘abundance of fish’ (15.0%) and the ‘stonefish’ (14.5%; n=366). At PP, the most frequently listed fish attributes were ‘lionfish’ (29.6%) and ‘barracuda’ (16.0%; n=279). At the CH, ‘potato cod’ were the best experience for over three quarters (75.8%) of the respondents that dived there (n=429). ‘Potato cod’ was also the best fish attribute for divers at NH according to 23.7% of the respondents (n=279). For 16.9% of respondents that dived at AA, the best fish attribute was ‘amazing fish life’, followed by ‘garden eels’ (7.2%; n=207), a species ‘specific’ only to this site in Study Two.

Fish provide divers with a wide range of best experiences at each of the sites through much diversity and abundance, however certain fish like the potato cod have a very strong influence on experiences, and for a very large number of divers. The divers in this sample show much knowledge and ability in identifying a large number of specific types of fish, more than any other type of marine organism.

Sharks and rays (cartilaginous fish) - In total there were 16 different shark and ray comments listed by respondents as best experiences, with 10 of those for specifically named sharks or rays. These included ‘whitetip reef sharks’, ‘grey reef sharks’, ‘silvertip reef sharks’, ‘hammerhead sharks’, ‘manta rays’, ‘leopard sharks’, ‘nurse sharks’, ‘epaulette sharks’, ‘wobbegong sharks’ and ‘whale sharks’. From the total 616 shark and ray comments, 3.7% were for rays (non-specific) and 1.9% were for ‘manta rays’ (Table 5.10). The most listed shark and ray attribute was ‘reef sharks’ (whitetip and grey reef sharks) making up 32.2% of all comments (Table 5.10).

Reef sharks were clearly the most influential attribute on best experiences in this study. This was especially the case at NH where 96.4% of the respondents who dived there felt ‘reef sharks’ were the best experience at the site (n=279; Table 5.11). This very high level of agreement between divers was also apparent at AA, with 35.0% of the respondents listing ‘reef sharks’ as a best experience (n=207), and also at the CH for 33.4% of the respondents (n=429; Table 5.11).

<u>Other marine organisms</u> - In total there were 36 different other marine organism best experiences listed, all of which were for specifically named organisms. The most frequently listed of these at all sites combined were the ‘red flame file shell’ (21.3%), ‘nudibranchs’ (15.9%), ‘turtles’ (13.6%), ‘cuttlefish’ (10.7%), ‘anemones’ (6.1%), ‘giant clams’ (4.2%), and ‘octopus’ (4.2%; Table 5.10).

Differences between the sites for the best experiences relating to other marine organisms were quite clear (Table 5.11). At SB, other marine organisms that were listed as a best experience were ‘cuttlefish’ (13.7% of respondents), ‘turtles’ (11.7%), the ‘red flame file shell’ (10.1%), and ‘nudibranchs’ (9.6%; n=366). At PP, the ‘red flame file shell’ was listed by 19.6% of respondents, followed by ‘nudibranchs’ (10.0%), and ‘octopus’ (2.4%; n=279). Other marine organisms made up only very few of the best experiences at the three remaining sites with ‘giant clams’ listed by 6.3% of respondents at AA (n=207), ‘turtles’ listed by 2.1% of respondents at the CH (n=429), and ‘turtles’ also by 2.5% of the respondents at NH (n=279). Other marine organisms also provided the divers in this sample with a range of best experiences, but for a greater number of divers on the two pinnacle sites.

Animal Importance Index (AII)

Animals that are more rare at the sites did not rate highly in the best experience data because fewer respondents were able to list them as a best experience due to their low sighting frequency. Because of this, an importance index was created to determine how important certain animals are to divers’ experiences when they are sighted (see Section 5.4.4 for calculation of AII).

Table 5.12 lists the results of the Animal Importance Index (AII) with the 22 ‘standard’ animals monitored at all sites in descending order from the most important to the least important. ‘Sea snakes’ had an AII score of 1.00, meaning that in all cases they were not sighted during surveys in Study Two, but were listed as best experiences by respondents when seen, indicating a high level of importance to experiences. In addition, they were listed as best experiences in (Birtles et al., in prep). The remaining animals were sighted in at least one survey in Study Two and so the AII score is more indicative of the actual situation occurring at the dive sites.

Table 5.12. Animals most important to respondents’ experiences according to the Animal Importance Index (AII).

Animal	Mean SF	Mean LF	Score
Sea snakes (R)	0.0	0.7	1.00
Manta rays (S)	1.6	1.2	0.75
Potato cod (F)	37.8	22.9	0.61
Reef sharks (S)	68.4	41.2	0.60
Cuttlefish (I)	10.3	5.5	0.53
Lionfish (F)	30.3	9.6	0.32
Turtles (R)	17.9	5.1	0.28
Tuna (F)	23.7	5.9	0.24
Bumphead parrotfish (F)	14.9	3.2	0.21
Rays (S)	10.4	1.9	0.18
Octopus (I)	15.0	2.7	0.18
Nudibranchs (I)	38.6	6.2	0.16
Barracuda (F)	45.0	5.9	0.13
Moray eels (F)	27.1	2.8	0.10
Maori wrasse (F)	42.5	4.4	0.10
Trevally (F)	46.3	3.7	0.08
Anemonefish (F)	100.0	7.7	0.08
Shark mackerel (F)	27.3	0.8	0.03
Red bass (F)	60.0	0.9	0.02
Titan triggerfish (F)	51.9	0.8	0.02
Coral trout (F)	57.1	0.7	0.01

(F)=Fish (bony), (I)=Invertebrates, (R)=Reptiles, (S)=Sharks and Rays (cartilaginous fish)
(Calculated as: LF/SF, where LF = number of respondents who listed an animal divided by the total number of respondents who visited a site and listed a specifically named animal, and SF= number of surveys an animal was sighted divided by the total number of surveys undertaken at the sites).

‘Manta rays’ had a high AII score of 0.75, while ‘potato cod’ had an AII score of 0.61. However, both of these scores were generated very differently. Manta rays were sighted very infrequently at the sites, and were listed by a very small number of respondents as best experiences, giving manta rays a high AII score. In contrast, potato cod could be seen with ‘moderate’ frequency at the sites, and were listed by a high number of respondents as best experience, also giving them a high AII score. ‘Reef sharks’ were very similar in importance to ‘potato cod’ (0.60). ‘Cuttlefish’ had the highest AII score of all invertebrates (0.53), followed by ‘octopus’ (0.18) and ‘nudibranchs’ (0.16). ‘Coral trout’ had the lowest AII score of ‘standard’ organisms at all sites (0.01).

Table 5.13 provides the Animal Importance Index (AII) scores for animals at each of the five study sites, where animals ‘specific’ to each site were also included to determine their importance on experiences. ‘Manta rays’ were either not sighted, or sighted very infrequently in Study Two, but were listed by respondents at the sites as best experiences. Therefore, ‘manta rays’ remained the most important animals at most of the sites. This was also the case for ‘sea snakes’. ‘Reef sharks’ had high AII scores at all sites except SB.

At SB, ‘cuttlefish’ was the most important animal (that was sighted at least once in Study Two) to divers’ experiences with an AII score of 0.67, followed by ‘stonefish’ (0.58), and ‘lionfish’ (0.52). Schooling fish such as the ‘anthias’ and ‘fusiliers’, as well as other animals such as ‘octopus’, ‘turtles’ and ‘nudibranchs’ also had high AII scores (Table 5.13). At NH, ‘reef sharks’ were present 100% of the time in Study Two and were listed by every respondent that listed an animal as a best experience, giving them a perfect AII score of 1.00. ‘Potato cod’ was the second most important animal at NH (0.33), followed by ‘bumphead parrotfish’ (0.28). ‘Hammerhead sharks’ and ‘silvertip reef sharks’ each had an AII score of 0.18, possibly because they were only sighted below 30m in Study Two, making them quite difficult to spot by respondents.

At PP, the most important of all the animals sighted in at least one survey was ‘moray eels’ (0.75), followed by ‘reef sharks’ (0.50), ‘rays’ (0.42), and the ‘red flame file shell’ (0.27). The AII score for the ‘red flame file shell’ might have been greater if it were not so hard to find by respondents, requiring dive crews to actually point out its exact location. At the CH, potato cod had a SF of 81.6%, with 87.4% of respondents who listed a specific animal listing ‘potato cod’, giving it a perfect AII score of 1.00. This was followed by ‘reef sharks’ (0.44), and ‘turtles’ (0.36).

Table 5.13. Animals most important to experiences at each of the five study sites according to the Animal Importance Index (AII).

Steve's Bommie (SB) (n=366)		Pixie Pinnacle (PP) (n=279)		Cod Hole (CH) (n=429)		Admiralty Anchor (AA) (n=207)		North Horn (NH) (n=279)	
Animal	**Score**	**Animal**	**Score**	**Animal**	**Score**	**Animal**	**Score**	**Animal**	**Score**
Manta rays	1.00	Cuttlefish	1.00	Potato cod	1.00	Manta rays	0.67	Manta rays	1.00
Sea snakes	1.00	Manta rays	1.00	Sea snakes	1.00	Reef sharks	0.56	Reef sharks	1.00
Cuttlefish	0.67	Moray eels	0.75	Reef sharks	0.44	Tuna	0.54	Potato cod	0.33
Stonefish	0.58	Reef sharks	0.50	Turtles	0.35	Lionfish	0.40	Bumphead parrotfish	0.28
Lionfish	0.52	Rays	0.42	Manta rays	0.21	Turtles	0.36	Turtles	0.24
Anthias	0.32	Red flame file shell	0.27	Cuttlefish	0.16	Silvertip reef sharks	0.40	Cuttlefish	0.21
Octopus	0.30	Lionfish	0.25	Diagonally banded sweetlip	0.15	Rays	0.22	Silvertip reef shark	0.18
Turtles	0.28	Barracuda	0.23	Maori wrasse	0.14	Bumphead parrotfish	0.27	Hammerhead reef shark	0.18
Fusiliers	0.28	Octopus	0.22	Lionfish	0.13	Moray eels	0.16	Maori wrasse	0.18
Nudibranchs	0.19	Fusiliers	0.21	Rays	0.12	Nudibranchs	0.13	Tuna	0.16

Calculated as: LF/SF, where LF = number of respondents who listed an animal divided by the total number of respondents who visited a site and listed a specifically named animal, and SF= number of surveys an animal was sighted divided by the total number of surveys undertaken at the sites.

The most important animal at AA was the 'manta ray' with an AII score of 0.67. Manta rays were sighted in Study Two at AA more than at any other site. 'Reef sharks' were the second most important animal (0.56), followed by 'tuna' (0.54). Tuna were sighted in only 10.8% of surveys, but were listed with high frequency by respondents when seen. 'Silvertip reef sharks' also had a high AII score of 0.40, demonstrating their importance to experiences when seen.

The influence of diversity on best experiences

The percentage of responses relating specifically to 'diversity of coral' at each site was positively and significantly correlated with the estimated diversity of coral species measured at each site in Study Two (r= 0.900; sig 2-tailed 0.037). This result shows that as the diversity of coral species increases at sites (up to 46 additional species), so does its contribution to best experiences. On the other hand, the percentage of responses relating specifically to 'diversity of fish' at each site was not correlated significantly with the estimated diversity of fish species measured at each site (r= 0.300; sig 2-tailed 0.624). However it should be noted that all sites had relatively high diversity of fish species, and comparisons with sites that have very low diversity of fish are likely to yield different results.

The estimated diversity of coral, fish, and other marine organisms combined at each of the sites was correlated with the percentage of best experiences relating specifically to 'diversity' of coral, fish, and other marine organisms combined. There was a strong positive and significant relationship between the two measures (r=0.99; sig <0.01), showing that divers are able to effectively evaluate the diversity of marine life, and sites that are perceived to have a high diversity of marine life, have a greater positive influence on best experiences.

Distinctive attributes

Table 5.14 lists the reasons why respondents felt attributes were best experiences at all the sites combined, and thus indicates why each attribute was distinctive. There were 12 main characteristics why attributes were distinctive. The most frequently listed characteristic was that the attribute was 'special'. This was especially the case for the ‘red flame file shell’, ‘stonefish’, ‘garden eels’, ‘good visibility’, ‘pinnacles’, ‘reef walls’, and ‘caves’. ‘Abundance’ was the second most frequently listed characteristic, and was distinctive for ‘reef sharks’, ‘lionfish’ ‘schooling fish’, ‘barracuda’, and ‘bumphead parrotfish’. ‘Large size’ was also frequently listed, and attributes distinctive for this were ‘potato cod’, ‘maori wrasse’, and ‘tuna’. Other frequently listed characteristics of attributes were ‘interesting behaviour’, ‘perceived beauty’, and also ‘perceived rarity’. The least frequently listed characteristic of an attribute was its ‘small size’.

There were 12 aspects of the experience listed for attributes that made them distinctive to divers. The most frequently listed aspect was having a ‘first experience’, and was distinctive for ‘sea snakes’ and ‘octopus’, although many other attributes were also listed for this aspect. The ‘love of the organism’ was also a frequently listed aspect for ‘anemonefish’, ‘silvertip reef sharks’, and ‘turtles’. Other frequently listed aspects of an experience with an attribute were ‘getting close’, ‘exciting encounter’, and an encounter that was ‘not expected’. The least frequently listed aspect was ‘touching’ which was listed on nine occasions.

Table 5.14. Respondents' reasons why biophysical attributes were a best experience at the dive sites presented as percentage of total comments for each attribute (n=445).

	Characteristics of attribute	Special	Abundance	Large size	Intersting behaviour	Perceived beauty	Diversity	Perceived rarity	Colours	Cryptic	Perceived health	Shapes	Small size	**Aspects of experience**	First experience	Love of organism	Getting close	Exciting encounter	Not expected	Photo opportunities	Always wanted to see	Potentially dangerous	Long encounter	Touching	Total number of responses
Biological																									
Reef sharks		7.7	26.8	5.0	10.6	2.6	1.8	3.5			0.7	2.4	0.2		7.9	13.0	6.8	4.2	2.9	1.8	0.6	0.9	0.4		545
Potato cod		6.0	3.5	34.3	17.9	3.1		2.4			0.6				12.5	1.7	9.3	1.5		0.6	3.2	0.2	1.1	1.9	463
Red flame file shell		36.6				12.9		16.8	1.0						32.7										101
Lionfish		11.0	37.8	3.7	3.6	12.2	3.7	4.9							10.9	4.9	2.4		2.4	1.2	1.2				51
Anemonefish			18.8		12.9	10.5	20.0	3.5	2.4				2.4		2.4	21.2				5.9					85
Schooling fish		10.0	44.3		8.5	5.7	5.7	0.7	12.1		0.7		2.1		1.4	5.7	1.4	1.4							140
Nudibranchs		5.6	11.1	4.2		8.3	13.9	12.5	15.3	6.9			1.4		5.6	8.3	1.4		5.6						72
Barracuda		11.3	41.3	18.8	3.8	3.8		3.8							5.1	3.8	5.0	1.3				2.0			80
Turtles		19.4	4.2	11.3		5.6		11.1			2.8				8.3	22.2	1.4	2.8	5.6	1.4	2.8		1.4		72
Maori wrasse		7.9	6.3	25.4	15.9	7.9		4.8							9.5	11.1	4.8	1.6	1.6	1.6	1.6				63
Cuttlefish		12.1	10.3	1.7	20.6	5.2		5.2							15.5	6.9	3.4		3.4	8.6	1.7		5.2		58
Stonefish		20.8		13.2		7.6		11.3	1.9	17.0			1.9		18.9	3.8			1.9			1.9			53
Soft coral trees		1.8	5.4	17.9		7.1	10.7		25.0		17.9	5.4				3.6				5.4					56
Moray eels		2.9	2.9	11.8	44.1	5.9		2.9		2.9			2.9		8.8	2.9		2.9	2.9			5.9			34
Octopus		11.5			15.3			19.2	7.7						19.2	15.4			3.8	7.7					26
Rays		5.0		5.0	15.0			15.0		40.0					15.0		5.0								20
Gorgonian fans			11.8	5.9		23.5	5.9		5.9		23.5					11.7					11.7				17
Bumphead parrotfish		8.7	39.1	4.3				8.7	4.3						26.2		8.7								23
Garden eels		50.0	20.0		10.0										10.0	10.0									10
Manta rays		37.5		6.3	6.3			6.3							31.3	12.6									16
Diagonally banded sweetlip			53.8		7.7	23.1		7.7									7.7								13
Mantis shrimp		20.0			20.0			40.0								20.0									5
Silvertip reef shark		25.0						25.0								25.0	25.0								4
Red bass			40.0		30.0										10.0		10.0					10.0			10
Sea snakes		33.3						22.2							33.3	11.1									9
Hammerhead shark		25.0	12.5			6.3									12.5	6.3	6.3	12.5			12.5	6.3			16
Dogtooth tuna		20.0	13.3	20.0		6.7									6.7	6.7	6.7				6.7	13.3			15
Tital triggerfish			25.0	25.0	25.0											25.0									4
Wobbegong shark										100.0															1
Physical																									
Topography		10.5				16.4	73.1																		134
Good visibility		59.0							41.0																78
Pinnacle		88.7				11.3																			97
Reef wall		55.2				28.1												16.7							96
Swim-throughs						14.9									12.8			72.3							47
Caves		64.3				28.6									7.1										28
Sand		35.7				28.6			35.7																14
Total number of responses		429	348	260	220	184	152	104	87	24	24	16	10		221	163	102	89	31	30	28	14	11	9	2556

Note: Attributes are listed in descending order of frequency from top to bottom according to best experience data in Table 5.10. The characteristics of why an attribute was a best experience are listed in descending order of frequency from left to right, as are the aspects of the experience. Yellow squares indicate the most highly listed reason why an attribute was a best experience. Respondents often listed more than one response.

To understand which of the seven factors makes an attribute most distinctive at a site, and thus most important to experiences, the characteristics of each attribute and aspects of the experience, were classed according to which factor they represented. Table 5.15

presents each of the characteristics or aspects within the factors the attributes represented in descending order from the most frequently listed to the least frequently listed.

Table 5.15. Reasons why attributes were best experiences according to factors that relate to characteristics of an attribute, or aspects of an experience with an attribute (n=445).

Factor	Number of comments	Valid % of comments
Special/unusual feature		
Special	429	16.8
First experience	221	8.6
Diversity	152	5.9
Perceived rarity	104	4.1
Getting close	102	4.0
Colours	87	3.4
Not expected	31	1.2
Photo opportunities	30	1.2
Always wanted to see	28	1.1
Cryptic	24	0.9
Perceived health	23	0.9
Shapes	16	0.6
Touching	9	0.4
TOTAL SPECIAL/UNUSUAL	**1256**	49.1
Popularity or iconic status		
Perceived beauty	184	7.2
Love of organism	163	6.4
Potentially dangerous	14	0.5
TOTAL POPULARITY/ICONIC	**361**	14.1
Abundance		
Abundance	348	13.6
TOTAL ABUNDANCE	**348**	13.6
Size		
Large size	260	10.2
Small size	10	0.4
TOTAL SIZE	**270**	10.6
Behaviour		
Interesting behaviour	220	8.6
TOTAL BEHAVIOUR	**220**	8.6
Intensity of experience		
Exciting experience	89	3.5
TOTAL INTENSITY	**89**	3.5
Duration		
Long encounter	11	0.4
TOTAL DURATION	**11**	0.4
TOTAL COMMENTS	**2556**	**100.0**

Data for quality factors taken from Table 5.14.

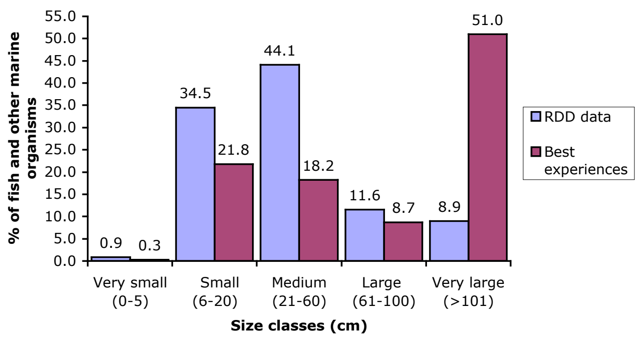
The most important factor making an attribute distinctive was that it was ‘special/unusual’ to experiences, making up 49.1% of the 2556 comments. The most special/unusual factor was that the attribute was listed by the respondents as being ‘special’, followed by a ‘first experience’. ‘Diversity’, ‘perceived rarity’ and ‘getting close’ were also frequently listed reasons why an attribute was distinctive due to it being special/unusual. Any attribute that is considered by divers to be special/unusual, is likely to be the most important reason for that attribute being distinctive, and thus a best experience.

The second most important factor making an attribute distinctive at a site was its 'popularity or iconic status', making up 14.1% of all comments. This was followed by an attribute's 'abundance' (13.6%). 'Size' as a factor was also important (13.1%), with 'large size' being listed more frequently than 'small size' (Table 5.12). This was followed by the factor 'behaviour' (8.6%). The factors 'intensity of experience' and 'duration', played a relatively small role in why an attribute was a best experience and thus distinctive at a site.

Size of fish and other marine organisms (excluding coral) and best experiences

Figure 5.1 shows the size class distribution of fish and other marine organisms surveyed in Study Two, and the size class distribution of specifically named organisms as best experiences. Most organisms (44.1%) surveyed in Study Two were classed 'medium' sized, followed by 'small' (34.5%), with only 11.6% in the 'large' size class, and 8.9% in the 'very large' size class (n=571). However, when the distribution of best experiences was examined, over half (51.0%) of all responses were for organisms larger than 100cm, or 'very large' (n=2411).

Figure 5.1. Size class distribution of fish and other marine organisms from Roving Diver Diversity surveys and best animal experiences (all sites; n=445)



The second highest percentage of best experiences was for ‘small’ organisms with 21.8%. This result shows that despite the low number of ‘very large’ organisms surveyed at all of the sites, their contribution to best experiences is more than twice that of the ‘small’ size class, and nearly three times that of the ‘medium’ size class. However, ‘small’ organisms provide more best experiences than do ‘medium’ sized, despite there being fewer of the ‘small’ organisms to see.

Pre-dive briefing content and best experiences

The percentage of best experience responses relating to organisms mentioned within the pre-dive briefing at all sites combined was 65.5%. At each site however, the percentage differed. At the CH, only 44.4% of responses related to the information provided in the pre-dive briefing, indicating that respondents were most able to define their own best experiences at this site. This increased at other sites with PP having 61.4%, AA 65.0%, SB having 78.2%, and NH having 87.2% of all best experience responses relating specifically to organisms mentioned within the pre-dive briefing.

Detracting experiences

Table 5.16 includes the nine social and eight environmental impacts that detracted form respondents’ experiences at all sites combined, listed in descending order from the most detracting to the least detracting.

Table 5.16. Perceived social and environmental impacts that detracted from respondents’ experiences at the study sites.

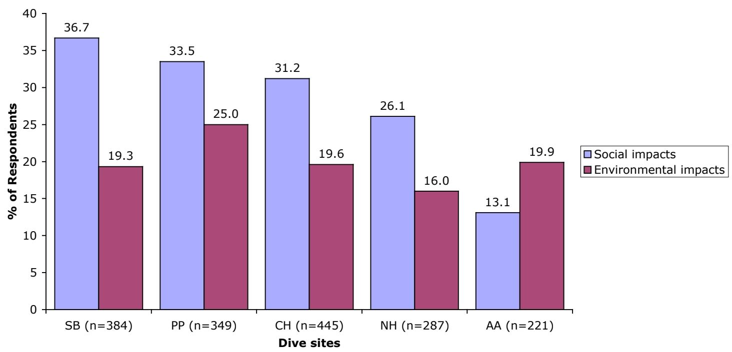
Social impacts	Number of times checked (n= 347 respondents)	% of total social impacts	Environmental impacts	Number of times checked (n= 281 respondents)	% of total environmental impacts
Too many divers	229	27.4	Damaged coral	201	29.6
Diver coral contact	200	23.9	Coral rubble	138	20.4
Inexperienced divers	100	11.9	Dead coral	133	19.6
Divers with cameras	95	11.4	Coral bleaching	69	10.2
Fish/shark feeding	58	6.9	Not enough fish	64	9.4
Bottom-time limit	55	6.6	Moorings	37	5.5
Divers touching marine life	54	6.5	Not diverse enough	25	3.7
Wildlife harassment	33	3.9	Waste from boat	11	1.6
Maximum-depth limit	13	1.6	**TOTAL COMMENTS**	**678**	**100.0**
TOTAL COMMENTS	**837**	**100.0**			

Note: Respondents often listed more than one response. Valid % equals respondents that listed that feature of the total n

Social impacts – Of the 651 respondents, 347 (53.3%) reported that at least one social impact detracted from their experiences at the sites (Table 5.16). The impact of ‘too many divers’ made up 27.4% of all social impacts. This was followed by ‘diver coral contacts’ (23.9.%), ‘inexperienced divers’ (11.9%), and ‘divers with cameras’ (11.4%). While the activity of ‘fish/shark feeding’ is undertaken by operators to enhance the experiences for the divers, 6.9% of all the social impacts indicated that this was a detracting experience. Figure 5.2 presents the percentage of respondents that checked at least one social and/or environmental negative impact at each of the dive sites.

Of the 384 respondents that dived at SB, 36.7% (141) indicated that at least one social impact had detracted from their experiences at the site (Figure 5.2). This was followed by PP, with 33.5% (117) of respondents (n=349). At both of these sites, over half of the respondents that perceived an impact indicated the most detracting experience was ‘too many divers’, followed by ‘diver coral contact’, ‘inexperienced divers’, and divers with cameras’ (Table 5.17). Pinnacle sites, due to their shape, act to concentrate divers into a smaller area. This is likely to have contributed to the high incidences of social impacts perceived at these sites.

Figure 5.2. The percentage of respondents that checked at least one social and/or negative impact at each of the dive sites.



The CH had the third highest percentage of respondents (31.2%) that had perceived at least one social impact (n=445; Figure 5.14). The most frequently checked impact was ‘fish/shark feeding’ by 33.1% of these respondents who perceived at least one impact, and 10.3% of all divers that visited the site (Table 5.17). This was followed closely by ‘too many divers’, and ‘diver coral contact’. NH had the third highest percentage of respondents (17.4%) that checked at least one social negative impact (n=264; Figure 5.2), with 'diver coral contact' making up 48.0% of all social impacts (Table 5.17). The impacts 'bottom-time limit', 'inexperienced divers', and 'fish/shark feeding' were also checked as detracting experiences at NH. AA had the lowest percentage of respondents (13.1%) who perceived at least one social impact of all the sites (n=221; Figure 5.2). This site was by far the largest of the study sites and allowed divers to explore with little chance of seeing other divers during the dive. The impact most highly checked by respondents at AA was 'diver coral contacts', but only by very few of the divers (13) that visited the site (n=221; Table 5.17).

Environmental impacts – Overall, 281 (43.2%) of the 651 respondents reported that at least one environmental impact detracted from their experiences at the sites (Table 5.16). The most detracting of these was 'damaged coral', making up 29.6% of all environmental impacts. This was followed by 'coral rubble' (20.4%), 'dead coral' (19.6%), and 'coral bleaching' (10.2%). This result shows that perceived impacts relating to corals are detracting experiences for a large number of the divers in this sample.

Of the 349 respondents that dived at PP, 24.9% (87) indicated that at least one environmental impact had detracted from their experiences at the site (Figure 5.2). However, the remaining sites had similar percentages of respondents that perceived an environmental impact. For all sites, the most frequently checked environmental impact was 'damaged coral' (Table 5.18). For all sites except AA, this was followed by the impacts 'coral rubble', and 'dead coral'. At AA however, a greater number of respondents felt that 'coral bleaching' and 'not enough fish' were more detracting (Table 5.18).

Seeing social and/or environmental impacts do detract from experiences for a large number of divers in this sample. This result indicated that these divers are most perceptive to crowding effects at the sites, but also to present or past impacts on the coral.

Table 5.17. Perceived negative social impacts that detracted from respondents' experiences at each of the five study sites.

	Steve's Bommie (SB) (n=384)		Pixie Pinnacle (PP) (n=349)		Cod Hole (CH) (n=445)		Admiralty Anchor (AA) (n=221)		North Horn (NH (n=287)	
Social impact	**Number of respondents (n=141)**	**Valid % of respondents**	**Number of respondents (n=117)**	**Valid % of respondents**	**Number of respondents (n=139)**	**Valid % of respondents**	**Number of respondents (n=29)**	**Valid % of respondents**	**Number of respondents (n=75)**	**Valid % of respondents**
Too many divers	96	68.1	63	53.8	45	32.4	6	20.7	19	25.3
Diver coral contact	60	42.6	50	42.7	41	29.5	13	44.8	36	48.0
Inexperienced divers	29	20.6	26	22.2	24	17.3	8	27.6	13	17.3
Divers with cameras	31	22.0	27	23.1	24	17.3	5	17.2	8	10.7
Fish/shark feeding	0	0.0	0	0.0	46	33.1	0	0.0	12	16.0
Bottom-time limit	13	9.2	9	7.7	13	9.4	6	20.7	14	18.7
Divers touching marine life	13	9.2	12	10.3	23	16.5	1	3.4	5	6.7
Wildlife harassment	6	4.3	5	4.3	18	12.9	0	0.0	4	5.3
Maximum-depth limit	1	0.7	2	1.7	1	0.7	3	10.3	6	8.0

Note: Respondents often listed more than one response. Social impacts are presented in descending order from the most frequently checked, to the least frequently checked according to the whole sample.
Valid % equals respondents that listed that feature of the total n

Table 5.18. Perceived negative environmental impacts that detracted from respondents' experiences at each of the five study sites.

	Steve's Bommie (SB) (n=384)		Pixie Pinnacle (PP) (n=349)		Cod Hole (CH) (n=445)		Admiralty Anchor (AA) (n=221)		North Horn (NH (n=287)	
Environmental impact	**Number of respondents (n=74)**	**Valid % of respondents**	**Number of respondents (n=87)**	**Valid % of respondents**	**Number of respondents (n=87)**	**Valid % of respondents**	**Number of respondents (n=44)**	**Valid % of respondents**	**Number of respondents (n=46)**	**Valid % of respondents**
Damaged coral	44	59.5	52	59.8	48	55.2	23	52.3	34	73.9
Coral rubble	28	37.8	44	50.6	35	40.2	14	31.8	17	37.0
Dead coral	36	48.6	40	46.0	29	33.3	14	31.8	14	30.4
Coral bleaching	16	21.6	14	16.1	17	19.5	16	36.4	6	13.0
Not enough fish	9	12.2	11	12.6	25	28.7	15	34.1	4	8.7
Moorings	8	10.8	2	2.3	11	12.6	7	15.9	9	19.6
Not diverse enough	5	6.8	6	6.9	9	10.3	1	2.3	4	8.7
Waste from boat	3	4.1	2	2.3	4	4.6	0	0.0	2	4.3

Note: Respondents often listed more than one response. Environmental impacts are presented in descending order from the most frequently checked, to the least frequently checked according to the whole sample
Valid % equals respondents that listed that feature of the total n

5.5.3 Post-trip perceptions and evaluations

Satisfaction with the dive sites overall

Using a 10-point response format from 1 (not at all satisfied) to 10 (extremely satisfied), respondents rated their satisfaction with the dive sites overall as very high, with a mean of 8.7 (±1SE 0.05; n=518). The distribution of the ratings was heavily skewed to the right, with 87.9% rating their satisfaction with the dive sites at eight or above, and 29.0% rating their satisfaction at 10. Only 1.4% of respondents rated their satisfaction with the dive sites at five or less. The mean satisfaction rating for respondents who visited the Ribbon Reefs only was not significantly different to those who visited both the Ribbon Reefs and Osprey Reef (z=-0.030; sig = 0.970).

How well dive sites met expectations

Respondents' ratings of how well the dive sites met their expectations from 1 (well below my expectations) to 5 (well above my expectations) was high, with a mean of 3.8 (±1SE 0.04; n=501). The distribution of the ratings was again skewed to the right, showing that for 93.2% of respondents expectations had been met (rating of 3) or exceeded (4 and 5).

To determine if expectations being met at the sites affected the reported levels of satisfaction, the mean satisfaction ratings for respondents were tested between each expectation category they had selected. Satisfaction ratings were found to increase significantly with each expectation category (Table 5.19), with each category having a significantly higher mean enjoyment rating than the last ($p<0.05$). This result shows that how well dive sites meet respondents' initial expectations, does play a significant role in their satisfaction with the dive sites overall.

Table 5.19. Descriptive statistics and Kruskal-Wallis Means-Test results for the levels of reported enjoyment according to how well dive sites met respondents' expectations.

How well dive sites met expectations	Number of respondents	Mean satisfaction rating	± 1 SE	Chi-square	df	Asymp.Sig (<0.001)
Somewhat below my expectations	33	7.1	0.21	175.138	3	0.000
Met my expectations	139	8.2	0.09			
Somewhat above my expectations	201	8.8	0.06			
Well above my expectations	125	9.6	0.06			

Mean satisfaction is based on a 10-point response format from 1 (not at all satisfied) to 10 (extremely satisfied).

Perceptions of how common coral reef features were on the dive sites during the trip

Table 5.20 includes the 19 coral reef features listed in descending order of how common respondents perceived them to be on the dive sites during the trip, from the most common to the least common. 'Diverse fish life' and 'diverse coral life' were perceived to be the most common, followed closely by 'beautiful corals', 'lots of fish', and 'interesting landscapes'. With respect to specific types of organisms, 'sea cucumbers' had the highest rating, followed by 'big fish (>50cm)', 'sharks', and 'potato cod'. 'Sea snakes' and 'manta rays' were perceived to be the least common of all the features at the sites.

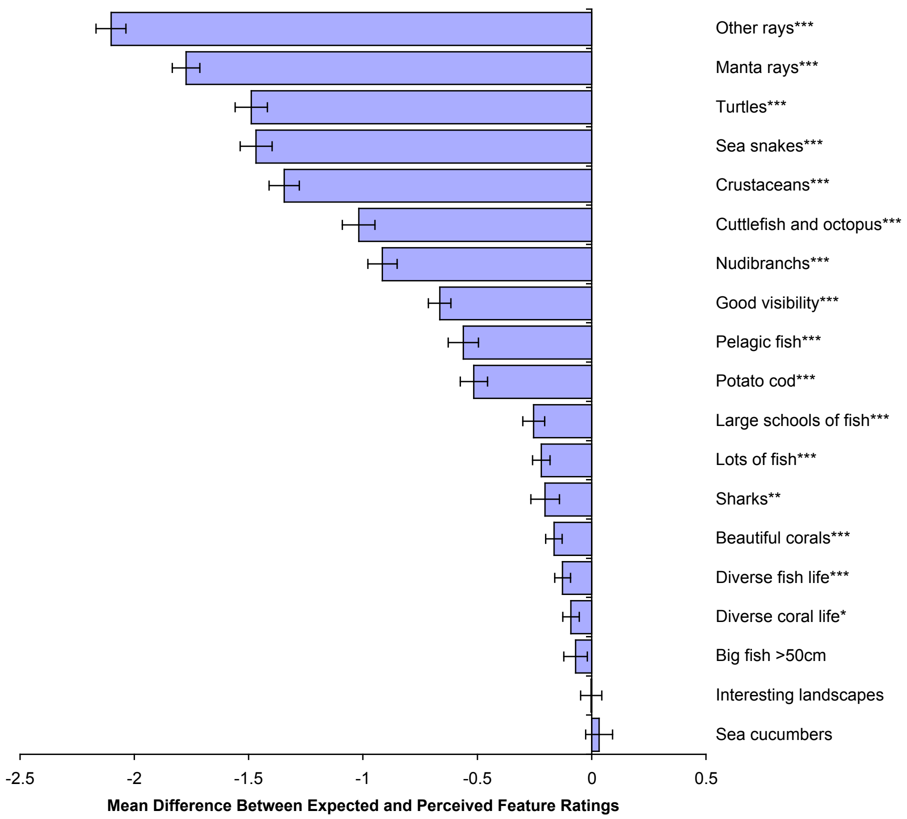
Table 5.20. Respondents' mean ratings for perceptions of how common specific features were on dive sites during the trip.

Features perceived at dive sites	Number of respondents	Mean rating of how common feature was (1-5)	± 1 SE
Diverse fish life	496	4.52	0.03
Diverse coral life	495	4.44	0.03
Beautiful corals	497	4.39	0.03
Lots of fish	496	4.36	0.04
Interesting landscapes	497	4.20	0.04
Sea cucumbers	495	4.09	0.05
Large schools of fish	492	4.01	0.04
Big fish >50cm	496	3.77	0.04
Good visibility	497	3.60	0.04
Sharks	496	3.41	0.05
Potato cod/groupers	496	3.20	0.05
Pelagic fish	496	2.77	0.07
Nudibranchs	494	2.50	0.06
Crustaceans	496	1.88	0.06
Cuttlefish and octopus	497	1.76	0.06
Turtles	498	1.50	0.06
Other rays	494	1.06	0.06
Sea snakes	494	0.94	0.05
Manta rays	498	0.52	0.04

Mean value based on a 6-point response format from 0 (not present) to 5 (very common)

To determine how well respondents' expectations for each of the 19 coral reef features had been met by their experiences for these at the sites, post-trip perceptions were subtracted from pre-trip expectations for each feature. Figure 5.3 shows that for 16 of the 19 features there were significant negative differences between pre-trip and post-trip ratings. The largest differences were all for specific types of organisms including 'other rays', 'manta rays', 'turtles', 'sea snakes' and 'crustaceans'. In Study Two, all of these organisms had very low sighting frequencies at the sites. Smaller mean differences were found between ratings for features including 'large schools of fish', 'sharks', beautiful corals', 'diverse fish life', and 'diverse coral life', indicating that these features were closer to respondents' original expectations. Features that were as common as respondents had expected them to be were 'big fish>50cm', 'interesting landscapes', and 'sea cucumbers'.

Figure 5.3. Mean difference scores between how common 19 coral reef features were expected to be at the start of the trip, and how common they were perceived to be at the end of the trip (n=486).



Mean value based on a 6-point response format from 0 (not present) to 5 (very common) for both expected and perceived ratings. Calculated as the mean difference between the mean expected and perceived feature ratings.

For each respondent, the sum of the post-trip perceptions for the 19 coral reef features was subtracted by the sum of the pre-trip expectations for the 19 coral features to determine if the difference between the pre-trip and post-trip ratings had an affect on overall expectations being met at the dive sites. The mean difference scores between the ratings increased significantly with each expectation rating ($p<0.001$, Table 5.21). The greater the mismatch between pre-trip expectations and post-trip perceptions for the 19 features, the less the dive sites met and fulfilled expectations overall.

Table 5.21. Descriptive statistics and One-Way Analysis of Variance test results for the mean difference scores (sum of post-trip perceptions – sum of pre-trip expectations) according to how well dive sites met respondents' expectations.

How well dive sites met expectations	Number of respondents	Mean difference score (perceptions – expectations)	±1 SE	Mean Square	F	Asym.Sig (<0.001)
Somewhat below my expectations	32	-23.94	2.00	2411.976	22.97	0.000
Met my expectations	126	-14.70	0.89			
Somewhat above my expectations	181	-12.73	0.71			
Well above my expectations	114	-7.83	1.04			

Biophysical attributes contributing to respondents' best experiences during the trip

The best features on all of the dive sites during the trip can be seen in Table 5.22 by major attribute themes. A total of 434 respondents provided 1414 comments. According to 34.3% of respondents, 'amazing corals' were among the best attributes on the dive sites, followed by 'reef sharks' (34.1%), 'amazing fish life' (16.6%), 'diversity of marine life' (16.6%), 'good visibility' (16.4%), 'potato cod' (14.3%), 'diversity of fish life' (13.8%), and 'interesting topography' (12.4%), making up 48.7% of all comments.

Responses relating to specifically named organisms were put into size classes. Of the 446 comments that could be classified, 76.0% were for 'very large' organisms, 16.1% for 'small', 5.8% for 'medium', and 1.6% for 'large'. Only 0.5% of specifically named marine organisms that respondents listed as best attributes were 5cm or less in maximum length (very small).

Table 5.22. Biophysical attributes contributing to respondents' best experiences during the trip (n=434).

Attributes	Number of respondents	Valid % of respondents (n=434)	Attributes	Number of respondents	Valid % of respondents (n=434)
Fish			**Marine life general**		
Amazing fish life	72	16.6	Diversity of marine life	72	16.6
Potato Cod	62	14.3	Marine animals (non-specific)	23	5.3
Diversity of fish life	60	13.8	Abundance of marine life	14	3.2
Abundance of fish life	44	10.1	Colourful reef scenes	11	2.5
Large fish	42	9.7	Small marine animals	9	2.1
Large schools of fish	20	4.6	Large marine animals	8	1.8
Pelagic fish	14	3.2	Other marine life general responses	28	6.5
Small coral fish	11	2.5	**TOTAL MARINE LIFE GENERAL**	**165**	
Potato cod feed	11	2.5	**Physical**		
Anemonefish	8	1.8	Good visibility	71	16.4
Small fish life	6	1.4	Interesting topography	54	12.4
Lion fish	5	1.2	Reef walls/drop offs	18	4.1
Maori wrasse	5	1.2	Open sandy areas	5	1.2
Colourful fish life	4	0.9	Pinnacles	5	1.2
Other fish responses	27	6.2	Good diving depth	4	0.9
TOTAL FISH	**391**		Other physical	7	1.6
Coral			**TOTAL PHYSICAL**	**164**	
Amazing coral	149	34.3	**Other Marine Organisms**		
Diversity of coral	37	8.5	Turtles	38	8.8
Beautiful coral	26	6.0	Nudibranchs	15	3.5
Healthy corals	21	4.8	Cuttlefish	10	2.3
Interesting coral formations	9	2.1	Sea snakes	9	2.1
Abundance of corals	7	1.6	Flame file shell	7	1.6
Coral gardens	7	1.6	Anemones	4	0.9
Colourful corals	6	1.4	Whales (non-specific)	4	0.9
Other coral responses	21	4.8	Giant clams	3	0.7
TOTAL CORALS	**283**		Other marine organisms responses	17	3.9
Sharks and rays			**TOTAL OTHER MARINE ORGANIAMS**	**107**	
Reef sharks	148	34.1	**Other**		
Shark attract/feed	20	4.6	Sites easy to dive	22	5.1
Manta rays	9	2.1	Great crew	13	3.0
Abundance of sharks	8	1.8	Diversity of dive sites	12	2.8
Rays (non-specific)	4	0.9	Other responses	62	14.3
Hammerhead sharks	3	0.7	**TOTAL OTHER**	**109**	
Eagle rays	1	0.2	**TOTAL COMMENTS**	**1414**	
Other shark and ray responses	2	0.4	Left blank (question not completed)	217	
TOTAL SHARKS AND RAYS	**195**				

Note: Respondents often listed more than one response. Valid % equals respondents that listed that feature of the total n

Evaluations of environmental quality, coral quality, fish quality, human impacts, and natural beauty for the Ribbon Reef and Osprey Reef dive sites

Table 5.23 includes respondents' mean evaluation ratings of environmental quality, coral quality, fish quality, human impacts, and natural beauty for the Ribbon Reef and Osprey Reef locations. Table 5.23 also shows the test results for comparisons between the two locations for each of the ratings. Respondents evaluated the environmental, coral, and fish quality to be significantly higher at the Osprey Reef sites, as well as the natural beauty ($p<0.001$; Table 5.23). Respondents also evaluated the level of human impact to be significantly lower at the Osprey Reef sites ($p<0.001$; Table 5.23)

Table 5.23. The mean ratings and test results of environmental quality, coral quality, fish quality, human impacts, and natural beauty for the Ribbon reef and Osprey Reef locations.

Evaluation variable	Number of respondents	Mean rating (1-10)	±1 SE	z	Sig 2-tailed (<0.001)
Ribbon Reef environmental quality	498	7.86	0.06	-12.052	0.000
Osprey Reef environmental quality	291	8.97	0.06		
Ribbon Reef coral quality	499	7.82	0.07	-11.577	0.000
Osprey Reef coral quality	290	8.76	0.07		
Ribbon Reef fish quality	500	8.23	0.06	-10.29	0.000
Osprey Reef fish quality	291	8.88	0.07		
Ribbon Reef human impacts	489	5.43	0.11	-10.209	0.000
Osprey Reef human impacts	287	3.95	0.14		
Ribbon Reef natural beauty	492	8.60	0.06	-9.625	0.000
Osprey Reef natural beauty	291	9.19	0.06		

Note: Ribbon Reef and Osprey Reef environmental quality, coral quality, and fish quality mean values based on a 10-point response format from 1 (very low quality) to 10 (very high quality). Human impact mean values based on a 10-point response format from 1 (no impact) to 10 (high impact). Natural beauty mean values based on a 10-point response format from 1 (not at all beautiful) to 10 (very beautiful).

The mean ratings for respondents that only visited the Ribbon Reefs were significantly greater than those who visited both the Ribbon Reefs and Osprey Reef for Ribbon Reef environmental quality, coral quality, fish quality, and natural beauty ($p<0.001$), and significantly lower for Ribbon Reef human impacts ($p<0.01$). This result shows when respondents also visit the Osprey Reef location in addition to the Ribbon Reef location, they evaluate the Ribbon Reef sites to be of significantly lower quality than respondents that visited the Ribbon Reefs only.

To determine if the perceived environmental quality of each location had met respondents' expectations, respondents' post-trip ratings were subtracted from their pre-trip ratings. Differences in the ratings were significant for both the Ribbon Reef and Osprey Reef locations (Table 5.24). This shows that both the Ribbon Reef and Osprey Reef locations were perceived to be of significantly lower quality than respondents had expected them to be.

Table 5.24. Wilcoxon Signed-Rank Test for difference between ratings of perceived environmental attributes and ratings of expected environmental attributes of Ribbon Reef and Osprey Reef dive sites

Wilcoxon Signed Rank Test	N	Mean difference	Z-score	Asymp. Sig (2-tailed)
Perceived environmental quality of Ribbon Reef dive sites compared with Expected environmental quality of Ribbon Reef dive sites	494	-0.5202	-6.583	0.000
Perceived environmental quality of Osprey Reef dive sites compared with Expected environmental quality of Osprey Reef dive sites	295	-0.1525	-1.987	0.047

Sea conditions during trip

Ratings of the sea conditions during the dive trip (scored as 1=very rough to 5=very calm) were generally good, with a mean of 3.4 (±1 SE 0.04; n=492). For 82.5% of respondents, the sea conditions were 'OK' (rating of 3) or calm (4 and 5). For respondents that visited the Ribbon Reef location only, the mean sea condition rating was not significantly different from respondents that visited both the Ribbon Reef and Osprey Reef locations (z=-0.524; sig = 0.60). This was interesting, because respondents that visited the Osprey Reef location also undertook an overnight steam across the Coral Sea in open-ocean for up to 12 hours, while respondents that visited only the Ribbon Reef location did so in the protection of the GBR. However, it should be acknowledged that even within the protection of the GBR, sea conditions can still be very rough.

5.6 Discussion

This study provides the first detailed investigation of the biophysical attributes influencing certified SCUBA divers' experiences on coral reef dive sites. This was achieved by measuring both the biophysical attributes at the sites and the visitors' experiences, allowing a clearer understanding of the importance that visitors place on specific attributes. Furthermore, the high level of agreement among divers regarding the attributes that contribute and detract from quality diving experiences makes them suitable as indicators of quality. Many of these potential indicators of quality experiences in marine environments closely reflect terrestrial indicators of quality (see

Manning & Lime, 1999). Such high consistency between marine and terrestrial indicators make these useful in a Limits of Acceptable Change (LAC) planning process in marine environments, partly because of their long history of use and acceptance elsewhere (Manning & Lawson, 2002; Manning & Lime, 1999).

The findings of this study are discussed in three sections. Section 5.6.1 examines respondents' pre-trip expectations including trip importance, animals that respondents most wanted to see, and expectations for specific coral reef features. Section 5.6.2 will explore how much the divers enjoyed their experiences at specific dive sites, how these differed between the sites, and which attributes were most significant to their experiences. Lastly, Section 5.6.3 examines divers' post-trip perceptions and evaluations of the biophysical attributes, and the locations visited. An exploration of divers' satisfaction and the meeting of expectations are followed by an examination of the gap-analysis between the expected and perceived attributes of the sites.

5.6.1 Pre-trip expectations

Trip importance

For the certified SCUBA divers sampled in this study, participating in the live-aboard diving trip was the main reason for travelling to Far North Queensland. This demonstrates a very focused approach to travel purpose and destination selection. Several of the operators in this study informed the researcher that participants generally book six to 12 months in advance of the trip date showing much preparation and planning on behalf of the divers. The decision to come to the GBR to dive is likely to have been made in preference to other destinations with similar qualities (Ryan, 1995). Such a focussed approach to visiting the GBR, and selecting an operator well in advance, is likely to be very different to the way day-trip participants visit the GBR, as many would do so as part of a package tour (Shafer et al., 1998).

Animals that respondents most wanted to see

More than half of the sample indicated that 'reef sharks' were the animals they most wanted to see while diving on this trip, and nearly a quarter had indicated that 'reef sharks' were already a feature they had previously most enjoyed. This was followed by 'manta rays', 'turtles', and 'potato cod'. In total, 127 different comments were generated with 87 of these being for specifically named marine organisms. This result demonstrates that the experiences live-aboard divers want to have on Ribbon Reef and Osprey Reef dive sites are of a multi-species nature, with particular emphasis placed on 'reef sharks', and to a lesser extent 'manta rays', 'rays' and 'potato cod'. In addition, a very large percentage of the animals that respondents most wanted to see were 'very large' (over 100cm in length). Reef sharks and other very large organisms such as potato cod might even be the primary reason for the initial selection of the trip to the Ribbon Reef and Osprey Reef locations. Evidence to support this comes from the percentage of divers who wanted to see 'potato cod', a species known to occur frequently at very few dive sites (such the Cod Hole on the GBR), and a key feature of all operators' itineraries. In addition, North Horn at Osprey Reef is renowned as being one of the best reef shark dives in the world (AustralAsia SCUBA Diver, 2003). It is highly likely that organisms that are key features of operators' itineraries would be known in advance of booking the trip, and that particular biophysical attributes of interest do drive the visiting' divers decision to visit a specific location, as suggested by Tabata (1992).

Expectations for coral reef features

Respondents demonstrated well-developed expectations about how common a broad range of coral reef features were likely to be on the dive sites, indicating a high level of understanding of the biophysical attributes that occur on coral reefs, and how these are distributed in space and time. Features that divers expected to be most common on the dive sites during the trip were 'diverse fish life', 'lots of fish', 'beautiful corals', 'diverse coral life', 'good visibility', 'large schools of fish', and 'interesting landscapes'. High ratings of these features would suggest that divers believe the Ribbon Reef and Osprey Reef sites to be of very high quality, with all of these features describing very healthy, diverse, and abundant coral reef communities. This was the case, as evidenced by the high expectation ratings of the environmental quality for both the Ribbon Reef and Osprey Reef dive sites, however respondents rated the Osprey Reef dives sites significantly higher. In addition, respondents also expected that 'sharks', 'big fish>50cm', and 'pelagic fish' would be more common at the Osprey

Reef sites. Reasons why discrepancies exist between the two locations are most likely due to advertising material that help generate initial expectations (Noe, 1999). On reading the operators' brochures, they depict Osprey Reef as having "crystal clear water", "sharks and large pelagics", "large schools of tuna and barracuda" and the location being "remote". In contrast, Ribbon Reef dive sites are depicted as having "pristine coral gardens", "isolated coral heads", having a "huge variety of marine species", "turquoise waters", "clouds of colourful tropical fish", and "overwhelming fish life on the pinnacles". While both descriptions promote the idea of very healthy, diverse, and abundant reef communities, the Osprey Reef description places greater emphasis on clear water, large marine life, and remote diving, thus inferring higher quality, and perhaps less affected by human activity.

5.6.2 Site-specific experiences

Enjoyment and expectations

Respondents' mean rating of enjoyment at the sites was very high (8.3 out of 10), and was closely tied to how well dive sites had met expectations. That is, the more the dive sites met and fulfilled respondents' expectations, the higher the level of enjoyment. This is in line with traditional expectancy-disconfirmation literature, that holds where expectations are exceeded, higher enjoyment and satisfaction is likely to result (Ajzen & Fishbein, 1980; Ryan, 1995). Expectations for individual dive sites are most likely to be generated within the pre-dive briefing.

The pre-dive briefing allows operators to provide a basic description of the site, and the biophysical attributes of interest to respondents immediately before they dive at the site. In doing this, specific organisms are also highlighted and divers are encouraged to look for these. Information about the specific organisms usually includes a brief description of the organism and its ecology, as well as instructions on how to locate it at the site, and on some occasions being directed to it while underwater. Such information increases the chances of visitors seeing wildlife, thus enhancing experiences (Hammitt et al., 1993). This type of information was rated very highly by the divers in this study. The pre-dive briefing has also been shown to be the most important source of information for dive trip participants to the GBR and Coral Sea in understanding the places that they visited and the things they saw (Birtles et al., in prep).

Of the best experiences relating to specifically named organisms at all sites, most were for those mentioned within the pre-dive briefing. This demonstrates for the first time that the pre-dive briefing is effective in alerting and directing divers to specific attributes at each of the sites, and thus enriching experiences. This was especially true for organisms such as the 'red flame file shell' and 'stonefish' that might have been missed completely by divers if they weren't told about them. An application of this result might be particularly useful to increase dive experiences on dive sites that have been degraded through natural or human impacts. In conjunction with detailed information regarding the biophysical attributes that occur at a site, operators are able to alert divers to attributes of interest that are known to occur with high consistency, ensuring that quality experiences can still be obtained.

Best experiences

In total there were 208 different best experiences listed from the five study sites, with 118 of these for specifically named organisms. This represents the largest and most comprehensive list of best experiences for certified divers on coral reefs, perhaps the most comprehensive list of best experiences for any wildlife tourism experience. There is high consistency between the findings of this study and earlier studies undertaken in the same locations (Birtles et al., in prep; Curnock, 1998), providing support for these results. This study shows that the best experiences on coral reef dive sites stem from a wide variety of biophysical attributes, and that both physical attributes like caves and reef walls, and biological attributes like reef sharks and large schools of fish, are equally regarded as best experiences for a large number of the divers. It is well accepted that coral reefs are a source of great aesthetic beauty and unparalleled marine biodiversity (Pendleton, 1994). It is no surprise then that they are able to produce such rich and varied experiences, possibly the most diverse wildlife tourism experiences in the world.

The divers in this study were able to list more than seven times the number of specifically named organisms than respondents studied in a terrestrial wildlife tourism experience (Hammitt et al., 1993), perhaps because there were more to see, but also showing that their skill level in identification and knowledge for a wide range of coral reef marine organisms is very high. Due to this high skill level it is suggested that divers participating in live-aboard diving trips should not be considered average reef visitors, but are in many ways underwater naturalists. In Study One, nearly half of the respondents owned a coral reef guidebook, 74.7% indicated that they look up identification books after they complete a dive, and 68.7% of respondents indicated that they attached great importance in being able to identify coral reef organisms.

Divers taking part in live-aboard diving trips might be likened to birdwatchers, in that both are interested in, and able to identify, many different species. Experienced birdwatchers, or those who had a personal fascination with birds, were defined as those who could identify over 40 species of birds (Kellert, 1985). It is likely that live-aboard divers also hold a personal fascination with coral reef environments and their inhabitants, and that their ability to positively identify a wide range of species reinforces this. This ability of recreational divers to reliably identify a wide range of coral reef organisms has been harnessed to collect scientific data where money and resources are limited (Pattengill-Semmens & Semmens, 2003; Schmitt & Sullivan, 1996).

The influence of biophysical attributes on best experiences

Understanding how biophysical attributes influence divers' experiences on coral reef dive sites, and which of these are most significant to divers' experiences and why, was a main objective of this study. This study has shown that divers do not have the same experiences at all coral reef sites, but that each site provides divers with very different experiences depending on the biophysical attributes that occur at each site. The attributes that were most distinctive within a site, and also distinctive when compared to other sites, were the most significant to experiences. Distinctive attributes that occur rarely make certain sites more special, and no doubt more valuable both ecologically and economically. For example, Julian Rocks in northern New South Wales which is famous for the population of Grey Nurse Sharks (*Carcharias taurus)* that can be found regularly at very few other sites, have been termed 'no substitute sites' (Davis & Tisdell, 1996). In these cases, the ecological and economic value of the distinctive attributes will be highest.

While the diversity of coral and fish is important at all coral reef dive sites, distinctive attributes will contribute more highly to divers' enjoyment. This study adds to our understanding of how marine environments are valued by visitors. At sites where a greater number of distinctive attributes occur, enjoyment is undoubtedly higher, as was the case at North Horn where a high abundance of reef sharks and big fish, high visibility, and the steep reef wall all co-occur. These results support Tabata's (1992) notion that popular dive sites do not require pristine conditions or biological diversity, but that divers can be attracted to a site based on a few particular attributes.

Distinctive attributes most significant to divers' experiences

Biophysical attributes that were listed as best experiences by the divers were examined in light of the seven factors that made them distinctive through characteristics of the attribute, or aspects of an experience with the attribute. This was to determine which of these factors was the most important to divers' experiences.

<u>Special/unusual feature</u> - Findings showed that an attribute that is considered to be special/unusual by respondents was most important to best experiences. This factor was represented by a range of characteristics of an attribute such as 'diversity', 'perceived rarity', and 'cryptic', and also for aspects of the experiences such as a 'first experience', 'getting close', or an attribute that was 'not expected'. Being 'special/unusual' related to both physical (e.g. good visibility, reef wall) and biological attributes (e.g. red flame file shell, sea snakes). 'Colours' of the organisms was a highly listed characteristic making them distinctive, mainly for schooling fishes, nudibranchs, corals, and fish (non-specific). Nowhere else on Earth are the colours of natural environments so vibrant and rich as on a coral reef. Coral and fish colour were also attributes that highly influenced visitors on day-trip sites on the GBR (Shafer et al., 1998), and was found to be the second most listed characteristic of favoured animals in general (Moscardo et al., 2001).

The special/unusual factor of an attribute might explain why divers, especially those divers that have extensive diving histories, regularly participate in coral reef diving activities, because they continue to have experiences that they still consider to be special/unusual. Given the high biodiversity and abundance of organisms on coral reefs, and the high diversity of specifically named organisms that provided best experiences, it might be expected that there are many biophysical attributes that divers are yet to discover or continue to be amazed by. This in itself might be one of the main the attractions of diving on coral reefs.

Popularity or iconic status - The second most important factor was that an attribute had popularity or iconic status, mainly due to high levels of publicity in the public media (Reynolds & Braithwaite, 2001). This factor was mainly related to biological attributes, especially for ‘anemonefish’, ‘reef sharks’, ‘gorgonian fans’, and ‘turtles’. It is expected that these organisms are able to stand out from the reef scene because they are highly sought after, and therefore visitors’ search image is well developed to identify these. This makes them highly distinctive at a site especially in relation to the myriad of other marine organisms at a site that can often be just a mix of colour and movement to the untrained eye. Popular or iconic organisms are likely to provide many best experiences for a wide range of divers, even when seen on many different occasions. This makes these organisms important and valuable to experiences, and thus the diving industry.

Abundance - Abundance was the third most important factor that made an attribute distinctive. This was a highly listed characteristic for ‘anemonefish’, ‘lionfish’, ‘schooling fish’, ‘barracuda’, and ‘bumphead parrotfish’ for example. However at North Horn, where reef sharks were found to have a distinctively high abundance in comparison to all other sites, this was the most important characteristic to divers’ experiences. The more abundant an attribute is, the more distinctive it will be to divers, and the more it contributes to best experiences. This result supports the findings by Rudd and Tupper (2002), who found that higher abundance of Nassau grouper are more highly preferred by divers, and that they were willing to pay more to see these. However, abundance is most distinctive for an attribute where it occurs at very few sites, which also makes it special/unusual.

Size - Size was also an important factor making an attribute distinctive, and mostly for biological attributes. Large size was found to be much more distinctive than small size. While this result may infer the large size of a type of organism is important, it also infers that individuals of a particular species might be larger than previously seen elsewhere, and thus also important. Shafer et al., (1998), indicated that the large size of maori wrasse and grouper for instance would attract special attention and heighten experiences, and the results of this study provide evidence that this is indeed the case. To further demonstrate the importance of large size on best experiences, over 50% of all best experiences relating to specifically named organisms were for those over 100cm in total length, despite this size class representing only 8.9% of all organisms surveyed at sites. In addition, larger fish of the same species are also those that divers prefer, and they are willing to pay more to see these (Rudd & Tupper, 2002), Focussing on large animals is also reported in terrestrial wildlife experiences (Chapman, 2003; Hammitt et al., 1993; Margulis, Hoyos, & Anderson, 2003), despite many smaller organisms also being present (Hammitt et al., 1993). The larger the organism, the more distinctive it is, and the more it contributes to best experiences.

Behaviour - Behaviour was the fifth most important factor making an organism distinctive. Seeing 'interesting behaviour' was listed for many of the organisms, but most highly for 'reef sharks' and 'potato cod'. Interesting behaviours for these organisms are likely to be in most cases attributed to feeding/attracting activities undertaken by the operators at two of the study sites. It appears that the behaviours of these organisms observed during these activities does have a positive influence on divers' experiences, perhaps because it is not possible to see such behaviours at sites where no feeding/attracting takes place.

However, viewing interesting behaviour was listed for a wide range of organisms not included in the feeding/attracting activities, showing that natural behaviours are also distinctive. Greater attention within the pre-dive briefing might be taken in educating divers about how to observe natural behaviours on coral reef sites, given that there are so many possible viewing opportunities provided by the high diversity of organisms. Displays of natural behaviour have also been reported to contribute highly to other wildlife experiences (Hammitt et al., 1993; Reynolds & Braithwaite, 2001; Valentine et al., 2004; Woods, 2002).

Intensity of experience - Intensity was the sixth most important factor and refers to the excitement generated by an experience (Reynolds & Braithwaite, 2001). An 'exciting experience' was listed for both physical (e.g. swim-throughs, reef walls) and biological (e.g. reef sharks, turtles, hammerhead shark) attributes, but by relatively few respondents. Even though many respondents witnessed the feeding/attracting activities, it appears that these do little to generate ‘exciting experiences’. While the intensity of an experience does make some coral reef attributes distinctive, diving activities in these environments are mainly passive observations of the marine life. Perhaps more exciting diving experiences can be gained from technical diving pursuits, for example deep or cave diving that rely on the thrill and challenge of the activity.

Duration - Finally, duration was the least important of all the factors, and was most highly listed for organisms like ‘reef sharks’, ‘potato cod’, and ‘cuttlefish’. As mentioned in Study Two, many reef organisms can be viewed for extended periods with little impact on their behaviour. Therefore duration is less likely to be a distinctive factor for coral reef organisms. This result indicates that extended viewing opportunities of organisms are prevalent at coral reef sites, which is likely to be very different when compared to the viewing opportunities of organisms in a rain forest for example.

Attributes most significant to divers' experiences

Sharks and rays - Sharks and rays were listed as best experiences by respondents at all sites. In Study Two, only eight species of sharks and rays were surveyed, however ten different species of sharks and rays were listed by respondents. Ribbon Reef and Osprey Reef location dive sites provide divers with good opportunities to see a diversity of sharks and rays, as well as high sighting frequencies of these animals on at least three of the five sites.

The single most highly listed attribute contributing to respondents’ best experiences at the dive sites was ‘reef sharks’. This result reflects their extremely high value and importance as a best experience to visitors, but also their high sighting frequency at the sites. When examined in light of the Animal Importance Index (AII), ‘reef sharks’ are the third most important animal to divers’ experiences at the sites, indicating that when they are seen, they are enjoyed by many. Nowhere was this more the case than at North Horn, where *every* diver that listed an organism as a best experience at this site, listed ‘reef sharks’. The main reason why reef sharks were the best experience was because of their ‘abundance’.

Reef sharks in particular, and sharks in general, are said to be the major attraction of dive destinations where they can be seen with high frequency (Anderson & Waheed, 2002; Landman, 2003; Rudd, 2001), and the numbers of divers wanting to see them is increasing (Anderson, 1994). Rudd (2001), found that all visiting divers, regardless of age, certification level, or annual income, to the Turks and Caicos Islands had a high preference for seeing sharks, and that they were willing to pay higher prices in order to do so. This confirms the idea that the species that provoke the most stimulation in wildlife encounters are the predators (Duffus & Dearden, 1990), but adds that sharks in particular are able to provide extremely powerful experiences for divers. Our fascination with these marine predators is longstanding, but only in recent decades has SCUBA diving allowed divers to swim and interact with wild sharks in ways that non-divers would find hard to believe. A survey conducted in England by the BBC called the '50 most important things to do before you die' found that the general public voted diving with sharks as number two (BBC, 2004). This study demonstrates that reef sharks are the single most important natural resource to live-aboard dive tourism from the Ribbon Reef and Osprey Reef locations. This is evidenced by: reef sharks being the attribute that divers most enjoy seeing while diving on coral reefs; reef sharks being the animal that divers most wanted to see during this trip; reef sharks being the best experience at the study sites; reef sharks being the third most important animal to divers' experiences when seen; and because reef sharks can be seen with high frequency at several sites.

'Manta rays' were also a best experience for divers, but were seen very infrequently at the sites. This meant not as many respondents could list them as a best experience. Using the AII, 'manta rays' appeared more important than reef sharks when sighted, although the sample size is low. Divers considered manta rays to be 'special'. This might be due to the manta ray being a graceful swimmer and often performing loops or somersaults (Jackson, 1997). The 'perceived rarity' of the sighting also played a role as indicated by respondents in this present study. Where manta rays do occur with greater frequency and abundance, they are an extremely important resource. For instance, dive tourism in Yap, Micronesia, is centred around the high potential for encounters with these animals (Jackson, 2003).

‘Rays’ (non-specific) were the second most listed of the sharks and rays, and reflects their relative sighting frequency at the sites. ‘Rays' were also found to have a high AII score, demonstrating their high importance to divers’ experiences when seen. In the Cayman Islands, it is estimated that the southern stingray (*Dasyatis americana*), occurring in large numbers (over 250) to be fed at one site called ‘Stingray city’ (Jackson, 1997), attract 80,000 to 100,000 visitors a year, contributing significantly to the region’s economy (Shackley, 1998).

<u>Fish</u> - Visiting divers perceived the fish quality at both the Ribbon Reef and Osprey Reef sites to be very high. Experiences relating specifically to fish made up the greatest percentage of all best experiences. Fish add much to the visual reef scene through ‘diversity’, ‘movement’, ‘colour’, and ‘abundance’ as indicated by respondents who listed the ‘amazing fish life’ as a best experience. Given these characteristics, and the fact that a high diversity and abundance of fish was found at each site, it makes sense that fish would be the type of organisms that generated the highest proportion of best experiences. In total there were 78 different fish responses, with 64 of those being for specifically named fish. However, only seven types or species of fish made up most of all specific fish responses. These were ‘potato cod’, ‘lionfish’, ‘anemonefish’, ‘barracuda’, ‘maori wrasse’, ‘stonefish’, and ‘moray eels’. When the fish responses were examined with the AII, ‘potato cod’ were the most important fish when seen, followed by ‘lionfish’, ‘tuna’, ‘bumphead parrotfish’, ‘barracuda’, ‘moray eels’, and ‘maori wrasse’.

Differences in fish attributes at specific sites had a dramatic effect on which types of fish divers considered best experiences. Where large fish occur such as the potato cod, maori wrasse, tuna, and bumphead parrotfish, these were the fish attributes of most importance. In the absence of larger fish, at the pinnacle sites for instance, smaller fish such as the lionfish, schooling fishes, and the stonefish were those favoured. Previous research on divers’ preferences found that divers were most disappointed with the lack of big fish, and lack of fish abundance on non-protected sites when compared to sites within Marine Protected Areas (MPAs) (Williams & Polunin, 2000). The study also found on Jamaican dive sites (where high levels of over-fishing have occurred), divers were most disappointed with the lack of variety and abundance of fish.

It is suggested that as long as diverse and abundant fish life is present on coral reef dive sites, divers will be satisfied with the fish quality, and will alter their specific best experiences for fish according to the species on offer. This means that no one fish species is needed at a site to provide divers with quality experiences, but that a wide range of fish (at least 64 named types) are able to provide best experiences. Where certain species do occur, for example lionfish, potato cod, tuna, moray eels, bumphead parrotfish, maori wrasse, and barracuda, higher quality experiences are more likely because these will be the most distinctive at a site for a number of different factors like size and behaviour for example.

Corals - Visiting divers perceived the coral to be very high quality at both the Ribbon Reef and Osprey Reef sites. The coral attributes most highly listed by respondents as best experiences were 'amazing corals', 'coral diversity', 'soft corals', and 'interesting coral formations'. Reasons why the 'amazing coral' was a best experience included its 'diversity', 'colour', and 'health'. These responses echo the characteristics respondents used to define 'high coral quality' in this study. Dinsdale, (2004), found that people make health judgements on the quality of a reef scene using the level of broken or damaged coral as one of the major indicators, as well as colour, and that such judgements are independent of their level of history with coral reefs. It is likely that the divers in this study also do the same. Coral attributes have also been sources of much enjoyment for other reef visitors (Birtles et al., in prep; Curnock, 1998; Shafer et al., 1998; Williams & Polunin, 2000). This study further stresses the key role that corals play in contributing to quality reef experiences for visitors, especially corals that are large, colourful, and plate-like. This reinforces Done's (1995) comments that coral with more complex physical structure could have a higher value to tourism.

Although respondents were unable to be very specific about the coral as a best experience, they did use terms that scientists use to describe and measure coral attributes such as 'diversity', 'colour', and 'abundance' (Hill & Wilkinson, 2004). Diverse and colourful corals with a moderate live coral cover will provide quality experiences for divers. However, sites with exceptional coral attributes, such as large and structurally complex coral such as plate corals, or large individual coral colonies like brain corals, will be more important to divers.

Physical attributes - Where physical attributes are complex and diverse and highly visible, they can be the most important attribute of a site. Best experiences relating to physical attributes often referred to ‘landscapes’ and ‘topography’, and ‘good visibility’. The steep reef walls at Osprey Reef provided many divers with quality experiences, as did the good visibility. Good visibility might infer to divers that conditions surrounding the site are pristine and/or remote, further adding to the enjoyment of the natural environment. Good visibility has also been shown to highly influence experiences for visitors elsewhere (Birtles et al., in prep; Curnock, 1998; Shafer et al., 1998; Tabata, 1989, 1992).

The ‘structure’ and ‘shape’ of the pinnacles were best experiences also, and provided divers with easy diving conditions and simple navigation without the need for large distances to be covered. The pinnacles also acted to concentrate a high diversity and abundance of marine life in a small area. Other general reef features were also frequently listed as best experiences, like open ‘sandy’ clearings, but ‘caves’ and ‘swim-throughs’ were more frequently listed. Non-reef attributes like the ‘anchor’ within the Admiralty Anchor cave also generated best experiences for some divers. Similarly, other non-reef structures such as shipwrecks and airplanes can be the sole focus of diving activities, for example the S.S. President Coolidge, the largest sports diveable shipwreck on earth, at Santo Island, Vanuatu. This site allows divers to swim in and around the ship, with little to no focus on marine life at all.

This present study has demonstrated for the first time that the physical attributes at a dive site play a major role in positively influencing divers’ experiences, with the more interesting, complex, and diverse sites having a much greater impact. Where such physical attributes occur in conjunction with distinctive biological attributes (i.e. North Horn), the experiences provided are of the highest quality.

Other marine organisms - Marine organisms other than fish and coral, such as ‘turtles’, ‘cuttlefish’, and ‘crustaceans’, were the least sighted and abundant of all organisms surveyed at the sites in Study Two. The most frequently listed of these as best experiences were the ‘red flame file shell’, ‘nudibranchs’, ‘turtles’, ‘cuttlefish’, ‘anemones’, ‘octopus’, and ‘giant clams’. When examined with the AII, the most important animals at all sites combined were ‘cuttlefish’, ‘turtles’, ‘octopus’, and 'nudibranchs'. At specific sites such as Steve's Bommie and Pixie Pinnacle where these organisms were distinctive attributes, their AII scores were much higher. However, it is a limitation of the AII scores, especially for the other marine organisms that are more difficult to find, that the researcher has a much better trained eye and extensive local knowledge in comparison to the one time visitor at a site. This means that AII scores for some of the organism's such as the 'red flame file shell' for instance, might be higher if all respondents had the same opportunity of viewing it. This was also the case for differences observed between researchers and visitors inventories in terrestrial wildlife tourism viewing situations (Hammitt et al., 1993).

While it is well accepted that turtles highly influence divers' experiences where present (Birtles et al., 2001; Curnock, 1998; Landman, 2003; Rudd, 2001; Shafer et al., 1998), as they did in this present study, the role that invertebrates such as cuttlefish play in best experiences for divers on coral reefs has not been reported. Cuttlefish have been shown in temperate waters to also provide quality experiences where they aggregate in large numbers, and are the main attraction for example at Whyalla, South Australia (Birtles et al., 2001). Cuttlefish had the highest AII score of all organisms sighted at Steve's Bommie where they occurred most frequently. Sites that have greater viewing opportunities for invertebrates like cuttlefish will be of high importance to divers' experiences.

The list of best experiences for the dive sites is quite similar to the list generated by respondents for those attributes they most enjoy seeing at other coral reef locations. This means that best experiences derived from coral reefs previously visited, and those from the Ribbon Reef and Osprey Reef location are comparable. Given that many of the coral reef organisms found on the dive sites from this study can be found on coral reefs worldwide, the results from this study can be applied to coral reefs elsewhere.

Detracting experiences

While is it important to understand what attributes of the coral reef setting influence quality experiences, it is equally as important to understand those that are able to detract from these experiences. This section provides an examination of the social and environmental impacts that negatively influence the diving experience.

Negative social and environmental impacts were perceived by a large percentage of respondents at all sites, with more social impacts perceived than environmental. The most powerful social impact was ‘too many divers’. This has also been documented for reef visitors elsewhere, with most respondents preferring smaller group sizes (Inglis, Johnston, & Ponte, 1999; Rudd & Tupper, 2002; Shafer et al., 1998). The negative effect of crowding in natural terrestrial settings is also well established in the tourism literature (Dawson & Watson, 1999; Hollenhorst & Gardner, 1994; Manning & Lime, 1999; Watson, 2001).

Crowding effects were most obvious at the two pinnacle sites. This can be explained by the small size of these sites and the shape of the pinnacle itself, both of which act to concentrate divers into small areas. When divers are concentrated like this, the chance for conflict between the divers increases dramatically. Reasons why crowding would cause a problem at a dive site include: bubbles from other divers lower in the water column ruining photos/video; crowding around a particular attribute of interest (queuing), scaring off or disturbing a particular attribute; and divers bumping into each other and the substrate, especially coral. The crowding effect is worst at the end of a dive when all divers tend to group near the top of the pinnacle, at its smallest diameter. The main impact of seeing too many divers can be mitigated to some extent by staggering the time of divers entering the water, ensuring that while some divers are deep, others are shallow. Given tight operator schedules, this is not always a solution. However, the effect of crowding does not seem to be a major problem on the larger sites such as Admiralty Anchor, where divers are able to explore the site as they wish, and may not see other divers at all during their dive.

Of greater concern is the number of divers who reported seeing other divers come into contact with the coral as a detracting experience. Divers come into contact with the coral (mostly accidentally) with their fins, gauges, and hands, and 15% of divers cause noticeable damage (Rouphael & Inglis, 1995). Divers with fewer number of dives have been found to make a greater number of accidental contacts with the substrate, while the opposite is true for deliberate contacts (Walters & Samways, 2001). Seeing other divers break or damage components of the environment that they have come to enjoy is a powerful detracting experience, as it is for recreationists in terrestrial environments (Manning & Lime, 1999; Watson, 2001).

On many occasions during the study period, the researcher saw some divers virtually pulling themselves around the sites by grabbing the coral. These divers were often wearing gloves and/or using cameras. Dive crews on several of the vessels ignored this behaviour, possibly to avoid conflict with passengers. Greater attention on educating visitors about environmentally friendly diving behaviour should be taken within the pre-dive briefings (Rouphael & Inglis, 1997), as it has been shown to significantly reduce the number of damaging contacts (Medio et al., 1997; Townsend, 2000). How dive crews can best deal with divers who damage or repeatedly come into contact with the coral is unclear. Asking divers to not wear gloves, as some vessels already do, might act to reduce the amount of 'grabbing' of reef substrates, which is a positive first step.

Divers also found the amount of 'broken', 'damaged', or 'dead' coral to be the major environmental impact perceived on the sites. The damage seen by divers on the sites is likely to be attributed to the cumulative impact of diver coral contacts, and not to anchor damage due to the mooring facilities available at each site. The amount of dead and broken coral on popular dive sites in the Red Sea is also said to be noticeable, unattractive, and a concern to operators and tourists (Zakai & Chadwick-Furman, 2002). In the Maldives, 47% of the tourists surveyed who visited the reefs considered dead corals from bleaching events to be the most disappointing experience during their holiday (Westmacott et al., 2000). If such damage continues, researchers are concerned that tourists may be deterred from sites altogether (Hawkins & Roberts, 1992b). In addition, reduced coral complexity due to high occurrence of breakage can also act to reduce the habitat structure and dynamics of reef fish communities (Syms & Jones, 2000).

Divers also reported that coral bleaching had a negative impact on their experiences. Bleaching has been found by several other researchers to dramatically affect the experiences and visitations patterns of divers, which in turn effects local economies (Cesar, 2000; Graham et al., 2001; Westmacott et al., 2000). Coral bleaching has the potential to be one of the most significant threats to reef-based tourism. The findings of this present study demonstrate that any perceived damage to the coral leads to negative impacts on divers' experiences, possibly because divers attribute such high importance to the corals.

Fish and shark 'feeding' activities that are undertaken at the Cod Hole and North Horn were also seen as a negative impact on divers' experiences. The cod feed was the most highly checked negative impact at the Cod Hole. At North Horn, the shark feed was also seen as a negative experience. This fact that some divers find these two activities a negative experience, possibly because they perceive them to harmful or unsustainable is cause for concern. The negative effects of feeding wild animals can include health problems and altering of natural diets, disruptions of natural ecological processes, and the increased risk to people from wildlife attack (Alevizon, 2000; Burgess, 2005; Weatherly, 2005). However, shark feeding dives, such as the ones at North Horn, are undertaken in many places around the world such as the Bahamas, Florida, the Maldives, and others (Burgess, 2005), with very few reported attacks on divers (Weatherly, 2005).

The potato cod, flowery cod, maori wrasse, and red bass at the Cod Hole, and the reef sharks and potato cod at North Horn, would not naturally approach divers at close range (<1m) without the use of food incentives. On dives where no food is offered at the sites, these animals, with the exception of potato cod at the Cod Hole, remain distant from divers especially if approached. Feeding of the potato cod at the Cod Hole has taken place since the first discovery of the site in 1973 (Vail & Hoggett, 1998), and has changed the behaviour of the cod. Even when food is not offered, the cod will follow divers in expectation of an easy meal. Behaviours have been so altered by food that "the cod become agitated during feeding, bumping divers and fighting each other for food scraps. It was especially at that time that divers had their hands bitten" (Quinn & Kojis, 1990, p308).

Sharks at North Horn also alter their behaviour to get as close as possible to the food source during an 'attract' when no food is actually consumed. This seems to be less of an impact on the sharks, both behaviourally and ecologically than the shark 'feeding' activities. During feeds, sharks are sent into a frenzy, a behaviour typical of the grey reef shark during any feeding activities (FishBase, 2003). Sharks can often become aggressive and erratic, as can the potato cod.

Feeding may also play a conservation role, by promoting education and awareness for the animals. However, if a diver is bitten by the animals being fed, this may have a serious negative effect through bad publicity toward the animals (Burgess, 2005). Unfortunately no studies have shown that divers, and tourists in general for that matter, actually change their views and perceptions after such experiences. Operators are under considerable pressure to provide the experiences they have advertised and used as a selling point for their trips. Further research must be conducted that fully assesses the impacts of fish and shark feeding on the animals, and the experiences that visitors are having.

5.6.3 Post-trip perceptions and evaluations

Expectations and Satisfaction

Both 'satisfaction' with the dive sites, and 'how well the dive sites met expectations' were very high, indicating that these live-aboard diving trips provided divers with very high quality experiences. The ratings of satisfaction with the dive sites differed significantly depending on how well the dive sites met expectations. Because of the very focused approach to travel purpose and destination selection for respondents, the strength of the disconfirmation in either direction, satisfaction or dissatisfaction, is also likely to be greater (Martilla & James, 1977). The extent to which dive sites met expectations was significantly influenced by the gap between divers' pre-trip expectations and post-trip perceptions for 19 coral reef features. The greater the mismatch between expected and perceived ratings, the lower the dive sites met expectations overall. This result shows that pre-trip expectations of coral reef attributes play a large role in divers' overall satisfaction.

The gap-analysis showed that respondents had perceived 16 of the 19 coral reef features to be less common than originally expected, with the top seven of these (other rays, manta rays, turtles, sea snakes, crustaceans, cuttlefish and octopus, and nudibranchs) being specific types of organisms. In Study Two, all of these organisms were found to have low sighting frequencies, which might explain the discrepancy. The gap-analysis also showed that respondents expectations for features including 'large schools of fish', 'sharks', 'beautiful corals', 'diverse fish life', and 'diverse coral life' were much closer to their original expectations, although still significantly different. Such a small gap indicates that the sites visited are perceived to be of high quality, but are not as good as expected. Features that were as common as respondents expected them to be were 'big fish >50cm', and 'interesting landscapes'. The fact that big fish were as common as divers expected them to be might be an important angle for advertising and promotion material, given that big fish were also found to provide best experiences for many of the divers.

This study found that the more accurate respondents' expectations are about the features of coral reefs at a location, the greater their chances are for high satisfaction. Because of this link between expectations and satisfaction, it is crucial that operators and managers promote truth in marketing and advertise the types of experiences divers are most likely to have. This will allow divers' expectations to be met, if not exceeded by actual experiences.

Evaluations of the Ribbon Reef and Osprey Reef locations dive sites

Respondents that visited both the Ribbon Reef and Osprey Reef locations in the one trip had significantly lower expectations of environmental quality for the Ribbon Reef sites. They also expected there to be more sharks, big fish (>50cm), and pelagic species on the dive sites. In addition, divers perceived the Ribbon Reef dive sites to be lower in environmental quality, coral quality, fish quality, natural beauty, and significantly higher in the level of human impacts that respondents who visited only the Ribbon Reefs. This effect on the perception of the Ribbon Reef sites might be due to the higher perceived quality of the Osprey Reef sites, making the Ribbon Reef sites less appealing in comparison. Cognitive history of perceived high quality environments would no doubt be used as a comparative standard in judging all other environments (Fenton et al., 1998). Visiting two or more locations of different quality in the one trip more strongly influences the perception of both locations. Even though the Ribbon Reef sites were found to have a greater diversity of species than Osprey Reef sites, it is suspected that higher visibility, and large predators such as sharks and tuna, connotes a higher quality for Osprey Reef beyond that of the Ribbon Reef sites that do not provide such attributes.

Because of this apparent location effect, it will be necessary to focus on the subset of respondents that visited both the Ribbon Reef and Osprey Reef locations to examine the influence of respondents' level of Diving and Coral Reef History (DACRH)

Specialization on experiences in the next chapter. This will allow a reliable assessment of the differences between diver groups visiting both locations.

CHAPTER 6

THE INFLUENCE OF DIVING AND CORAL REEF HISTORY (DACRH) SPECIALIZATION ON DIVERS' EXPERIENCES

6.1 Introduction

In Study One of this thesis (Chapter Three), a sample of 651 live-aboard SCUBA divers were segmented into four Diving and Coral Reef History (DACRH) specialization groups using a Multidimensional Recreational Specialization Index (MRSI). All groups differed in diving and coral reef history measurements, ownership of SCUBA related equipment, and levels of coral reef interest and knowledge. These groups were: 'beginner'; 'intermediate'; 'enthusiast'; and 'specialist'. What remains to be investigated is whether DACRH Specialization can explain variations in divers' wildlife tourism experiences. This means examining the way in which the biophysical attributes on coral reef dive sites are experienced, perceived, and evaluated. Such an application of the recreational specialization construct has not been tested in a wildlife tourism setting, but could advance our knowledge of the way participant history within an activity and setting influences experiences.

Recreational specialization has been shown to affect many other aspects of recreation activity such as motivations and expected rewards (Ditton, Loomis, & Choi, 1992; Kuentzel & Heberlein, 1992; McFarlane, 1994), preferences for physical and social attribute settings (Ditton et al., 1992; Ewert & Hollenhorst, 1997; Kuentzel & Heberlein, 1992), place attachment (Bricker & Kerstetter, 2000), and the use of information to make trip decisions (Ditton et al., 1992). In light of such research, it seems reasonable that recreational specialization might also affect expectations for specific attributes of the setting, and thus the satisfaction derived from experiencing these attributes.

6.1.1 Satisfaction and expectations

While satisfaction measurements arise out of the need for some evaluative communication between visitors and managers (Manning, 2001), previous experience with a place and an activity changes the nature of satisfaction to be derived from that activity (Ryan, 1995). This is because expectations are influenced by past experiences, and how well expectations are confirmed or disconfirmed is said to drive satisfaction (Ajzen & Fishbein, 1980). In Study Three (Chapter Five), it was found that experiences that exceeded expectations for dive sites led to higher levels of satisfaction for respondents. It was also found that a smaller gap between expected and perceived measures for coral reef features led to a greater exceeding of expectations. Whether increasing levels of DACRH Specialization can influence expectations is unclear.

6.1.2 Knowledge, interest and perceptions

Bryan (1977) noted that recreational specialists spend considerable time and money in pursuing their activity of choice, often travelling large distances to see specific species or habitats. He found that more specialised fishers had very specific preferences for the activity and setting compared to occasional fishers who just wanted to catch a fish. Because of these specific preferences, it might be expected that more specialised wildlife recreationists might have a greater knowledge and understanding of the environments they visit. This is indeed true of more specialised birdwatchers, who are said to have a personal fascination with the animals they view, know specific habitats that they are likely to be encountered in, and are able to list and identify many different species (McFarlane, 1994). For divers on coral reefs, this is also likely to be the case. In Study One, DACRH 'specialists' rated their own coral reef knowledge, as well as several other items relating to coral reef interest and knowledge, significantly higher than all lower DACRH specialization groups. Once the initial learning stages of diving have been achieved, the decision to continue diving in coral reef environments is likely to be because of the interest in the marine life and the reefs themselves (Townsend, 2000). This might mean that more specialised divers experience coral reef sites differently to those divers that have just begun diving.

Recreational specialists are also likely to become very attached to specific places or environments where their activity is undertaken (Williams et al., 1992). Bricker & Kerstetter (2000), found that more specialised whitewater recreationists were more likely to agree with the importance of place identity and lifestyle (place attachment dimensions) than less specialised recreationists. While place attachment might be high for activities such as whitewater rafting, the level of attachment is likely to be higher if the activity focuses heavily on the natural environment or the wildlife that live there (e.g. fishing, birdwatching or SCUBA diving). Such high place attachment, interest, and knowledge should also translate into differences in the way that the environment itself is perceived and evaluated. Hammitt & McDonald (1983), and Schreyer, Lime, & Williams (1984), both found that more specialised river rafters were more perceptive and sensitive to environmental impacts such as the trampling of vegetation, as well as social impacts such as crowding. In Study Three (Chapter Five), perceptions of environmental and social impacts at specific sites were found to occur with high frequency for this sample of SCUBA divers. Whether more specialised divers are more perceptive and sensitive to a greater number of impacts than ‘beginner’ divers is presently not understood.

Davis and Tisdell (1995), comment that participants new to the activity of diving may be less aware of dive site degradation where it occurs, possibly because they are unable to make comparisons with other sites. This may have much to do with their lack of cognitive history. Fenton et al., (1998), found that visitors, particularly in novel environments such as coral reefs, interpret places in the context of past experiences and reef images created by advertising material for example. In Study One (Chapter Three), ‘specialist’ divers indicated they had visited more coral reef environments than all lower DACRH specialization groups, some of which were no doubt of very high quality, and some which were not. Because of such extensive cognitive history with coral reef settings, it might be expected that more specialised divers will perceive and evaluate coral reef environments differently to ‘beginner’ divers.

6.2 Objectives

1. To investigate variations in divers' experiences on coral reef dive sites in the context of known levels of Diving and Coral reef History (DACRH) Specialization in terms of:

   - pre-trip expectations for the biophysical attributes that are likely to be encountered on the dive sites during the trip;
   - actual experiences with the biophysical attributes that occur at specific dive sites; and
   - post-trip perceptions and evaluations of the biophysical attributes encountered on the dive sites during the trip.

6.3 Methods

This section provides a detailed account of the methods employed to collect the data that was used in this study, as well as presenting the DACRH specialization group profiles.

6.3.1 <u>Data collection</u>

Data from Studies One and Three were used to form the data set for this Study. Study One investigated the demographics and previous diving and coral reef histories, and levels of coral reef interest and knowledge for 651 divers participating in live-aboard diving trips to the Ribbon Reef and Osprey Reef locations. Study One was also able to segment the divers according to their DACRH Specialization using a Multidimensional Recreational Specialization Index (MRSI). Each of the specialization groups was designed to typify a predefined DACRH specialization level, reflected by participation, training and associated skills, and setting history. This enabled the development of four DACRH specialization groups. These were: 'beginners' (n=46); 'intermediates' (n=236); 'enthusiasts' (n=246); and 'specialists' (n=52).

Study Three used a series of on-site self-administered questionnaires to investigate divers' experiences (the same divers sampled in Study One) on coral reef sites from the Ribbon Reef and Osprey Reef locations. The variables explored in Study Three are also those explored in this Study, only this time the interest is whether DACRH Specialization can explain variations in experiences.

However, Study Three found that there was a significant location effect in the responses relating specifically to the expectations, experiences, perceptions, and evaluations of the biophysical attributes on the dive sites. This effect was apparent between the respondents who went to both the Ribbon Reef and Osprey Reef locations in the one trip when compared to respondents that just went to the Ribbon Reef location only. Those respondents that went to both locations had significantly lower perceptions and evaluations of the Ribbon Reef location, and the dive sites within this location, than respondents that visited just the Ribbon Reef location. This effect was not an issue for variables relating to previous experiences, characteristics of coral quality, or the features of coral reefs divers had previously most enjoyed seeing. To ensure that investigations between DACRH specialization groups for variables relating specifically to the trip were not confounded by the location effect, only those divers visiting both locations were used for these analyses. The number of respondents in each of the DACRH specialization groups after the divers visiting the Ribbon Reef location only were removed for the analyses were: 'beginners' (n=18), 'intermediate' (n=95), 'enthusiast' (n=151), 'specialist' (n=40).

Table 6.1 compares these four DACRH specialization groups after the removal of the Ribbon Reef location respondents for seven diving history variables, the self-rating of diving ability, the proportions of ownership of diving related equipment, and the coral reef locations dived. In addition, Table 6.2 includes the means and test results for the DACRH specialization groups for ratings of the nine coral reef interest and knowledge items listed in descending order according to the mean ratings of the responses. These two tables show that the four DACRH specialization groups, although somewhat smaller than the original groups created in Study One, still differ in all diving and coral reef history measures, as well as coral reef interest and knowledge items. This means that all assumptions about the groups outlined in Study One, also apply to this subset of those groups.

Table 6.1. Comparison of DACRH specialization group profiles for respondents that visited both the Ribbon Reef and Osprey Reef locations in the one trip.

	Beginner (n=18)	Intermediate (n=95)	Enthusiast (n=151)	Specialist (n=40)
Age*	36.3 (16-69)	33.6 (18-54)	39.2 (16-75)	44.1 (27-64)
Gender	38.9% Male	56.8% Male	60.2% Male	62.5% Male
Education level	78% University Degree	78% University Degree	79% University Degree	79% University Degree
Country of origin groups	33.3% U.S.A. 22.2% U.K. 22.2% Aust 22.2% Other	27.4% Aust 24.2% U.K. 21.1% U.S.A. 9.5% Germany 17.9% Other	20.7% U.S.A 20.7% Aust 19.3% U.K. 10.0% Germany 29.3% Other	25.6% U.S.A. 23.1% Aust 12.8% France 7.7% Sweden 30.8 Other
Years dive experience*	1.1 (0-2)	5.0 (0-22)	10.3 (1-41)	19.0 (5-39)
SCUBA certification level (1-5)*	1.0 (1)	1.7 (1-3)	2.7 (1-5)	4.4 (3-5)
Dives in past 12 months*	5.2 (1-10)	14.7 (0-65)	41.4 (0-450)	77.0 (0-600)
Total dives in life*	6.4 (4-10)	37.9 (4-130)	211.2 (40-1000)	1356.8 (190-5000)
Total dives on coral reefs*	3.5 (0-10)	19.0 (0-54)	114.5 (0-1000)	844.8 (60-4800)
Previous maximum dive depth (metres)*	18.1 (6-30)	30.8 (12-60)	43.6 (25-99)	60.2 (40-92)
Most comfortable maximum dive depth (metres)*	15.9 (9-23)	24.5 (12-55)	30.5 (10-60)	35.5 (10-50)
Self-perceived diving ability (1-10)*	3.1 (1-8)	5.4 (1-10)	7.2 (2-10)	8.4 (6-10)
Own SCUBA equipment	5.6%	43.2%	83.4%	97.5%
Own Underwater camera equipment	16.6%	33.0%	53.7%	78.4%
Own coral reef guide book	16.7%	38.3%	53.7%	97.5%
Dived GBR before this trip	33.3%	31.6%	43.0%	52.5%
Dived other coral reef locations around the world	22.2%	72.3%	96.0%	95.0%
Dived Red Sea	0.0%	27.9%	45.5%	52.6%
Dived Caribbean	0.0%	45.6%	52.4%	65.8%
Dived South Pacific	0.0%	22.0%	34.5%	52.6%
Dived the Pacific Ocean (other than South Pacific)	0.0%	11.8%	23.4%	42.1%
Dived South East Asia	16.7%	50.0%	42.1%	68.4%
Dived East Africa	0.0 %	8.8%	11.7%	15.8%
Dived Indian Ocean (other than East Africa)	0.0%	17.6%	26.2%	50.0%

* Differences significant at $p<0.001$ for Kruskal-Wallis Means Test. All values presented are mean and range. Self-rated mean value for diving ability based on a response format from 1 (basic) to 10 (extremely competent).

Table 6.2. Mean scores and test results for DACRH specialization groups for self-perceived rating of coral reef knowledge and coral reef interest and knowledge items for respondents that visited both the Ribbon Reef and Osprey Reef locations in the one trip.

	Interest and knowledge items	Beginner (n=18)	SigDiffs ($p<0.05$)	Intermediate (n=95)	SigDiffs ($p<0.05$)	Enthusiast (n=151)	SigDiffs ($p<0.05$)	Specialist (n=40)	SigDiffs ($p<0.05$)
I	I go diving on coral reefs because the marine life interests me a lot (1-5) *	3.7	E,S	4.4		4.4	B	4.5	B
I	I very often look up identification books after I complete a dive (1-5) ***	2.8	E,S	3.3	E,S	3.7	B,I,	3.9	B,I
I	I travel to diving destinations to see specific animals and habitats (1-5) ***	2.4	E,S	3.0	E,S	3.5	B,I,	3.9	B,I
K	I attach great importance to being able to identify coral reef organisms (1-5) ***	2.2	I,E,S	2.9	B,E,S	3.3	B,I	3.6	B,I
K	I have seen many different coral reefs (1-5) ***	1.4	I,E,S	2.4	B,E,S	3.3	B,I,S	4.1	B,I,E
K	I know more about coral reefs than most other divers (1-5) ***	1.6	I,E,S	2.4	B,E,S	2.9	B,I,S	3.7	B,I,E
K	I know a great deal about my favourite aspects of coral reefs (1-5) ***	1.3	I,E,S	2.5	B,E,S	2.9	B,I	3.3	B,I
K	I am a good judge of coral reef dive site quality (1-5) ***	1.6	I,E,S	2.4	B,E,S	3.0	B,I	3.4	B,I
K	I know the behaviour and habits of many coral reef organisms (1-5) ***	1.5	I,E,S	2.2	B,E,S	2.9	B,I,S	3.5	B,I,E

* Significant at 0.05, ** Significant at 0.01, *** Significant at 0.001
Mean values for all items based on a 5-point response format from 1 (not at all accurate) to 5 (extremely accurate). I in first column indicates interest item, while K indicates Knowledge item.
Letters in the columns right of each DACRH specialization group indicate significant differences between groups ($p<0.05$). Letters in these columns are: B=Beginner, I=Intermediate, E=Enthusiast, S=Specialist.

To overcome the problem of small group size for the 'beginner' category, two DACRH specialization groups were constructed. The 'lower' level DACRH group combined the 'beginner' and 'intermediate' groups and represented those divers that were either new to the activity of diving and coral reef environments, or had limited diving and coral reef history. The 'upper' level DACRH group combined the 'enthusiast' and 'specialist' groups and represented those divers with extensive diving and coral reef histories. The number of respondents in the 'lower' level DACRH group was 113, and the 'upper' level DACRH group was 191.

The second method was to combine the responses from the variables collected in Section 2 of the questionnaire at the five study sites. This meant that depending on the sites that were visited during the trip, each respondent could contribute to the data set up to five times. This allowed for comparisons to be undertaken between all four DACRH specialization groups concerning divers' experiences at the study sites. However, caution should be taken in the interpretation of the results due to the small number of divers in the ‘beginner’ group. More reliable results for less specialised divers can be obtained from the ‘lower’ level DACRH specialization group.

6.4 Analysis

For scalar responses, all data was checked for normality using histograms, P-P plots, and homogeneity of variance tests. Because almost all ratings were heavily skewed to one side or the other, indicating a high frequency of low or high values, square root and logarithmic transformations were unable to normalise the data (Sheskin, 2004). This meant that assumptions for the preferred parametric means tests were violated, and thus the alternative non-parametric Kruskal-Wallis Means-Test was employed for comparisons between the four DACRH specialization groups. Where post-hoc comparisons were needed, a series of Mann-Whitney U-Tests were used. To maintain a fixed significance level of 5% for these tests, a Bonferroni correction was applied depending on the number of comparisons needed, making the test results more conservative (Curtin & Shultz, 1998).

Mann-Whitney U-Tests were also used for comparisons between the ‘lower’ and ‘upper’ level DACRH specialization groups where scalar variables were investigated. For variables that required respondents to provide a response to an open-ended type question, differences between DACRH specialization groups were examined using the percentage of responses.

6.5 Results

The following results are presented in three sections, based on the design of the questionnaire. Section 6.5.1 is a presentation of the information on the DACRH specialization groups’ pre-trip expectations for the biophysical attributes to be encountered on the dive sites, and the locations to be visited. Section 6.5.2 examines DACRH specialization group’s actual experiences at the study sites, and concludes with Section 6.5.3, the specialization group’s post-trip perceptions and evaluations of the biophysical attributes encountered during the trip, and the locations visited.

Section 6.5.1 (pre-trip expectations), explores how important the live-aboard diving trip was in each DACRH specialization group's decision to come to Far North Queensland, The characteristics that the DACRH specialization groups use to define high and low coral quality are also identified, as are the attributes of coral reefs that DACRH specialization groups most enjoy seeing and the animals that they most wanted to see on this trip. Expectations for how common coral reef features will be on the dive sites on their trip, and the expectations of environmental quality at the Ribbon Reef and Osprey Reef dive sites are also examined.

Section 6.5.2 (site specific diving experiences), looks at the DACRH specialization groups' experiences and evaluations of the biophysical attributes at the study sites. This section will explore the enjoyment of the dive sites and how well dive sites met expectations. Ratings of the information received in the pre-dive briefing and features most important in contributing to enjoyment at each site are also examined. Each group's best experiences are identified, and the influence of the size of fish and other marine organisms, as well as the pre-dive briefing content, on best experiences are explored. Finally the detracting experiences for each DACRH specialization group are identified.

Section 6.5.3 (post-trip perceptions and evaluations), explores DACRH specialization groups' satisfaction with the dive sites overall, and how well dive sites met expectations. Also examined are the perceptions of how common coral reef features were on the dive sites during the trip, and the biophysical attributes contributing to best experiences during the trip. This section concludes by exploring DACRH specialization groups' evaluations of environmental quality, coral quality, fish quality, human impacts, the natural beauty for the Ribbon Reef and Osprey Reef dive sites, and the sea conditions during the trip.

6.5.1 Pre-trip expectations

Trip importance

'Lower' and 'upper' level DACRH specialization group ratings of the importance of the trip in their decision to come to Far North Queensland from 1 (not at all important) to

10 (extremely important) were both similar and high, with means of 8.3 (±1SE 0.20; n=110) and 8.4 (±1SE 0.17; n=188) respectively. Differences between the means were not significant (Mann Whitney U=9696.00; z=-0.949, Asymp.Sig (2-tailed)=0.342). This result shows that the trip was the primary reason for travel to Far North Queensland for most respondents regardless of DACRH Specialization.

Characteristics of high and low coral quality

The characteristics that the four DACRH specialization groups used to define high coral quality are listed in Table 6.3 in descending order from top to bottom according to 'beginner' rankings. Most 'beginners' (71.1%) agreed that the coral 'colour' was the most defining characteristic of high coral quality (n=38). This was followed by 'diversity of corals' (44.7%), 'high coral abundance/cover' (23.7%), and 'corals not broken/damaged' (21.1%). 'Intermediates' comments were similar to the 'beginners', with 'colour' being the most frequently listed characteristic (67.5%), followed by 'diversity of corals' (37.4%), 'high coral abundance/cover' (26.1%), and 'corals not broken/damaged' (17.7%; n=203).

A high percentage of 'enthusiasts' also listed 'colour' as the most defining characteristic (57.1%), followed by 'corals not broken/damaged' (19.6%), and 'high coral abundance/cover' (16.1%; n=224). However, 14.7% of 'enthusiasts' also listed 'good and new coral growth' as a characteristic of high coral quality. While a high percentage of 'specialists' also listed 'colour' (39.1%), a greater percentage agreed that the 'diversity of coral' was the most defining characteristic (67.4%; n=48). This was followed by 'high coral abundance/cover' (28.2%), 'good and new coral growth' (19.6%), and 'large corals' (15.2%). Only 'intermediate', 'enthusiast', and 'specialist' respondents listed characteristics such as 'no algae on or around coral', 'no crown of thorns starfish', and 'lack of sediments', showing a greater understanding of the impacts associated with declining coral quality.

Table 6.3. Comparison of the characteristics that DACRH specialization groups use to define high coral quality.

High coral quality characteristics	Rank	Valid % of Beginners (n=38)	Rank	Valid % of Intermediates (n=203)	Rank	Valid % of Enthusiasts (n=224)	Rank	Valid % of Specialists (n=48)
Colour	1	71.1	1	67.5	1	57.1	2	39.1
Diversity of corals	2	44.7	2	37.4	2	46.9	1	67.4
High coral abundance/cover	3	23.7	3	26.1	4	16.1	3	28.2
Corals not broken/damaged	4	21.1	4	17.7	3	19.6	7	10.9
Live coral	5	15.8	6	11.3	6	13.8	6	13.0
Large corals	6	7.9	5	11.8	8	11.2	5	15.2
Healthy looking corals	7	7.9	8	8.9	7	11.6	12	4.3
Good coral formations	8	7.9	7	10.8	15	0.4	15	-
Coral is not bleached	9	2.6	9	3.0	9	7.1	13	4.3
Abundance of hard coral	10	2.6	10	2.5	10	2.2	9	6.5
Abundance of soft coral	11	2.6	11	2.5	12	1.8	10	6.5
Abundance of sponges	12	2.6	15	-	17	-	17	-
Good and new coral growth	13	-	16	-	5	14.7	4	19.6
No algae on or around coral	14	-	12	1.0	13	1.8	8	8.7
No pollution on or around coral	15	-	14	0.5	11	2.2	14	4.3
No crown of thorns starfish	16	-	17	-	14	0.9	11	6.5
Lack of sediment on or around coral	17		13	1.0	16	0.4	16	-
TOTAL COMMENTS		**81**		**413**		**482**		**113**
Left blank (question not completed)		8		33		22		4

Note: Characteristics listed in descending order from top to bottom according to 'beginner' ratings. Respondents often provided more than one response. Valid % equals respondents that listed that feature of the total n

Table 6.4. Comparison of the characteristics that DACRH specialization groups use to define low coral quality.

Low coral quality characteristics	Rank	Valid % of Beginners (n=38)	Rank	Valid % of Intermediates (n=194)	Rank	Valid % of Enthusiasts (n=221)	Rank	Valid % of Specialists (n=46)
Coral bleached/no colour	1	73.3	1	70.1	1	52.9	1	54.3
Coral is broken/damaged	2	36.8	2	37.1	2	35.7	2	41.3
Coral is dead	3	23.7	3	27.3	3	34.4	3	39.1
Low abundance/cover of coral	4	15.8	5	13.9	6	8.6	6	15.2
Low diversity of coral	5	13.2	4	16.5	4	14.5	5	21.7
No new coral growth	6	7.9	9	5.2	9	4.5	10	8.7
Coral rubble abundant	7	5.3	11	3.6	11	4.5	13	4.3
Pollution abundant on or around corals	9	2.6	10	4.1	10	4.5	12	4.3
Poor coral health	10	2.6	14	0.5	14	3.6	15	-
High presence of bare substrates	11	-	6	10.8	5	9.5	11	6.5
Algae abundant on or around corals	12	-	7	5.7	7	7.2	4	26.1
Sediments abundant on or around corals	13	-	12	2.1	12	4.1	9	10.9
Crown of thorns starfish present	14	-	13	1.5	13	4.1	7	13.0
Presence of warm water	15	-	15	0.5	16	0.5	14	2.2
Abundance of soft coral	16	-	16	-	15	0.9	16	-
TOTAL COMMENTS		**69**		**386**		**419**		**114**
Left blank (question not completed)		8		42		25		6

Note: Characteristics listed in descending order from top to bottom according to 'beginner' ratings. Respondents often provided more than one response. Valid % equals respondents that listed that feature of the total n

The characteristics that the DACRH specialization groups used to define low coral quality are listed in Table 6.4 in descending order from top to bottom according to the ‘beginner’ rankings. There was high agreement between all DACRH specialization groups that ‘coral bleached/no colour’ was the most defining characteristic of low coral quality, but more so for ‘beginners’ (73.3%; n=38) and ‘intermediates’ (70.1%; n=194), than ‘enthusiasts’ (52.9%; n=221) and ‘specialists’ (54.3%; n=46). There was also high agreement between the groups that the next two most defining characteristics were ‘coral is broken/damaged’ and ‘coral is dead’. Over a quarter of the ‘specialists’ (26.1%) felt that ‘algae abundant on or around corals’ was a defining character, and 13.0% also listed ‘crown of thorns starfish present’, both characteristics not listed at all by ‘beginners’.

All DACRH specialization groups have well-developed notions about the characteristics they use to define high and low coral quality. There is high agreement that colourful, diverse, and abundant corals represent high quality, and that coral that is bleached/no colour, broken, or dead represents low quality. However, the ‘beginner’ group did not list some of the more specific characteristics of quality, especially those not directly associated with the coral such as presence or absence of ‘crown of thorns starfish’, or ‘algae’ on or around the coral. The remaining three groups did list these, with the ‘specialist’ group listing them with higher frequency.

Features of coral reefs DACRH specialization groups most enjoy seeing

Features of coral reefs that DACRH specialization groups most enjoy seeing while diving on coral reefs are listed in Table 6.5 in descending order from top to bottom according to ‘beginner’ rankings. ‘Turtles’ were the most frequently listed feature by 28.9% of ‘beginners’, closely followed by ‘reef sharks’ and ‘coral (non-specific) (23.7% respectively; n=38). ‘Big fish’, ‘fish (non-specific)’ and ‘colourful fish’ were also listed by 21.1% of ‘beginners’. Of the 216 respondents in the ‘intermediate’ group, 22.7% agreed that ‘reef sharks’ was the feature they most enjoy seeing, followed by ‘coral (non-specific)’ (21.8%), ‘turtles’ (18.1%), ‘colourful corals’ (17.1%), ‘colourful fish’ (16.7%), and the ‘diversity of fish’ (16.2%).

Table 6.5. Comparisons of the features of coral reefs DACRH specialization groups most enjoy seeing.

Features of coral reefs DACRH specialization groups most enjoy seeing	Rank	Valid % of Beginners (n=38)	Rank	Valid % of Intermediates (n=216)	Rank	Valid % of Enthusiasts (n=230)	Rank	Valid % of Specialists (n=50)
Features								
Turtles	1	28.9	3	18.1	3	18.3	4	14.0
Reef sharks	2	23.7	1	22.7	1	28.7	1	24.0
Coral (non specific)	3	23.7	2	21.8	7	11.7	17	4.0
Big fish	4	21.1	7	14.8	2	20.9	14	8.0
Fish (non specific)	5	21.1	8	14.8	16	6.5	11	12.0
Colourful fish	6	21.1	5	16.7	18	4.8	20	2.0
Colourful corals	7	15.8	4	17.1	11	8.7	16	6.0
Colours (non specific)	8	15.8	9	10.2	19	4.8	15	8.0
Large schools of fish	9	13.2	11	7.9	6	12.2	12	10.0
Good visibility	10	10.5	13	6.5	20	3.9	3	16.0
Abundance of fish	11	7.9	12	7.9	5	13.5	7	12.0
Diversity of corals	12	7.9	10	9.7	10	9.6	9	12.0
Rays (non specific)	13	7.9	15	5.6	12	8.7	18	4.0
Diversity of fish	14	5.3	6	16.2	8	11.3	8	12.0
Manta rays	15	5.3	18	3.7	13	8.3	6	14.0
Large marine life	16	5.3	14	6.5	15	7.4	19	4.0
Pelagic fish	17	5.3	20	3.2	14	8.3	10	12.0
Nudibranchs	18	2.6	19	3.7	4	13.9	5	14.0
Healthy corals	19	2.6	17	4.6	9	10.4	2	16.0
Small marine life	20	-	16	5.1	17	6.1	13	10.0
TOTAL COMMENTS		**129**		**701**		**849**		**202**
Left blank (question not completed)		8		20		16		2

Note: Features listed in descending order from top to bottom according to 'beginner' ratings. Respondents often provided more than one response. Valid % equals respondents that listed that feature of the total n

'Enthusiasts' also listed 'reef sharks' with the highest frequency (28.7%), followed by 'big fish' (20.9%), 'turtles' (18.3%), and 'nudibranchs' (13.9%; n=230). Nearly a quarter of 'specialists' (24.0%) agreed that 'reef sharks' was the feature they most enjoy seeing, but felt that 'good visibility' and 'healthy corals' (16.0% respectively), were also features they enjoyed (n=50), much more than any of the other groups. 'Turtles', 'nudibranchs', and 'manta rays' were also listed with high frequency by 'specialists' (14.0% respectively).

Comments relating to specifically named organisms were put into size classes. Of all the DACRH specialization groups, 'beginners' had the highest percentage of comments for 'very large' marine organisms (>100cm), making up 84.8% of the 33 comments. This was followed by 9.1% for 'small' organisms (6-20cm), 6.1% for medium (21-60cm). No comments were for 'large' (61-100cm) or 'very small' organisms (0-5cm). Of the 193 comments for the 'intermediate' group, 73.6% were for 'very large' organisms, followed by 14.5% for 'small', 10.9% 'medium', and 1.0% for 'large'. No comments were for 'very small' organisms.

‘Enthusiast’ and ‘specialist’ respondents most enjoyed seeing a greater percentage of ‘small’ organisms than the two other two DACRH specialization groups, although ‘very large’ organisms made up most of the comments. Of the 355 comments for ‘enthusiasts’, 55.5% were for ‘very large’, 31.0% for ‘small’, 10.1% for ‘medium’, and 3.1% for ‘large’. Only 0.28% of comments were for ‘very small’ organisms. Of the 63 comments for ‘specialists’, 52.0% were for ‘very large’ organisms, 33.0% for ‘small’, 7.9% ‘medium’, and 6.3% for ‘large’. No comments were for ‘very small’ organisms.

All DACRH specialization groups appear to agree that ‘reef sharks’, ‘turtles’, corals, fish, and ‘very large’ organisms in general are the features that they most enjoy seeing on corals reefs. However, more respondents in the ‘specialist’ group also enjoy seeing ‘healthy corals’.

Animals DACRH specialization groups most wanted to see on this trip

The animals that ‘lower’ and ‘upper’ level DACRH specialization groups most wanted to see whilst diving on this trip are listed in Table 6.6 in descending order from top to bottom according to the ‘lower’ group rankings. The ‘lower’ group listed 31 specifically named animals, while for the ‘upper’ group there were 61. Both groups most wanted to see ‘reef sharks’ on this trip, although a greater percentage of the ‘lower’ group wanted to see them (80.2%; n=106), than the ‘upper’ group (51.0%; n=186). For the ‘lower’ group, ‘turtles’ were the second most frequently listed animal by 38.7% of respondents, followed by ‘manta rays’ (30.2%), and ‘potato cod’ (18.9%). However, a greater percentage of the ‘upper’ group most wanted to see ‘manta rays’, with 41.9% of respondents listing them. This was followed by ‘whale sharks’ and ‘hammerhead sharks’ as indicated by 30.1% of the ‘upper’ group respectively.

Comments relating to specifically named animals were put into size classes. For both groups, ‘very large’ animals were those they most wanted to see. Of the 299 comments for specifically named animals for the ‘lower’ group, 86.3% were for ‘very large’ animals, followed by 7.0% for ‘medium’, 6.7% ‘small’, and 0% for ‘large’. No comments were for ‘very small’ animals. Of the 608 comments for specifically named animals for the ‘upper’ group, 80.1% were for ‘very large’ animals, followed by 12.2%

for ‘small’, 5.76% ‘medium’, and 2.0% ‘large’. None of the comments were for ‘very small’ animals.

Table 6.6. Comparisons of the animals that ‘lower’ and ‘upper’ level DACRH specialization groups most wanted to see whilst diving on this trip**.**

Animals most wanted to see on this trip	Rank	Valid % of ‘lower’ level DACRH specialization group (n=106)	Rank	Valid % of ‘upper’ level DACRH specialization group (n=186)
Animals				
Reef sharks	1	80.2	1	51.0
Turtles	2	38.7	5	20.4
Manta rays	3	30.2	2	41.9
Potato cod	4	18.9	6	18.3
Whale sharks	5	13.2	3	30.1
Hammerhead sharks	6	12.3	4	30.1
Dolphins	7	11.3	9	8.1
Rays (non-specific)	8	10.4	7	16.7
Octopus	9	8.5	12	6.5
Whales (non specific)	10	7.5	11	7.5
Anemonefish	11	7.5	10	8.1
Cuttlefish	12	5.7	17	4.3
Nudibranchs	13	4.7	8	16.7
Sea snakes	14	3.8	18	2.7
Fish (non specific)	15	3.8	19	2.7
Sea horses	16	2.8	15	5.4
Moray eels	17	2.8	16	4.8
Tiger sharks	18	1.9	13	6.5
Pelagic fish	19	1.9	14	5.9
TOTAL COMMENTS		**337**		**667**
Left blank (question not completed)		7		5

Note: Animals listed in descending order from top to bottom according to ‘lower’ level DACRH specialization group ratings. Respondents often provided more than one response. Valid % equals respondents that listed that feature of the total n.

Expectations of how common coral reef features will be on the dive sites

To determine if the ‘lower’ and ‘upper’ level DACRH specialization groups had different expectations for how common 19 coral reef features were likely to be on the dive sites based on a six-point response format from 0 (not seen) to 5 (very common), comparisons between the groups were made. With the exception of four of the 19 features, both ‘lower’ and ‘upper’ level groups were in agreement about how common a wide range of coral reef features were likely to be on the Ribbon Reef and Osprey Reef sites.

The ‘lower’ DACRH group expected ‘lots of fish’ and ‘beautiful corals’ to be more common than the ‘upper’ group expected them to be (Mann-Whitney U=8332.00;

z=26287.00; Asymp.Sig (2-tailed)=0.004; Mann-Whitney U=8582.00; z=26348.00; Asymp.Sig (2-talied)=0.022). In contrast, the ‘upper’ group expected both ‘nudibranchs’ and ‘other rays’ to be more common than the ‘lower’ group expected them to be (Mann-Whitney U=7933.00; z=13498.00; Asymp.Sig (2-talied)=0.003; Mann-Whitney U=8570.00; z=14241.00; Asymp.Sig (2-talied)=0.036) respectively.

Expectations of environmental quality for the Ribbon Reef and Osprey Reef dive sites

To determine if ‘lower’ and ‘upper’ level DACRH specialization groups had different expectation ratings for the environmental quality at both the Ribbon Reef and Osprey Reef sites, comparisons were made between the groups. ‘Lower’ level divers rated their expectations for the environmental quality at the Ribbon Reef dive sites (8.4, ±1 SE 0.13) significantly higher than ‘upper’ level divers (8.1, ±1 SE 0.11) (Mann-Whitney U=9240.00; z=-1.962.00; Asymp.Sig (2-talied)=0.05). However, both groups were in agreement about their expectations for the environmental quality at the Osprey Reef sites, with means scores of 9.1, (±1 SE 0.10) for the ‘lower’ group, and 9.1, (±1 SE 0.08) for the ‘upper’ group. There was no significant difference between these ratings (Mann-Whitney U=10192.00; z=-0.138.00; Asymp.Sig (2-tailed)=0.89).

6.5.2 Site specific diving experiences

Enjoyment of the dive sites

The mean ratings of enjoyment at the sites from 1 (not at all) to 10 (very much) for the four DACRH specialization groups were found to be significantly different (*p<0.001*), with the ‘beginner’ group having the highest ratings of enjoyment (8.7), and the ‘specialist’ group indicating the lowest (7.9; Table 6.7). Post-hoc tests revealed that both the ‘beginner’ and ‘intermediate’ groups had significantly higher mean enjoyment ratings than the ‘specialist’ group (*p<0.05*).

How well dive sites met expectations

The mean ratings of how well dive sites met expectations from 1 (well below my expectations) to 5 (well above my expectations) for the DACRH specialization groups were significantly different ($p<0.001$), with 'beginners' reporting the highest level of expectations being met (4.0), and 'specialists' reporting the lowest (3.4; Table 6.7). Post-hoc tests showed that 'beginner', 'intermediate', and 'enthusiast' groups had significantly higher mean ratings of expectations being met than the 'specialist' group ($p<0.05$). It should be noted that despite differences, all group means indicated that expectations for the dive sites had been exceeded.

Table 6.7. Descriptive statistics and Kruskal-Wallis Means-Test results for enjoyment ratings at sites, ratings for expectations being met at sites, maximum diving depth at sites (m), perceived visibility, pre-dive briefing content, coral quality ratings, and fish quality ratings for each DACRH specialization group.

Variable	**Beginner (n=18) Combined ratings from 5 study sites = 46**	**Intermediate (n=95) Combined ratings from 5 study sites = 270**	**Enthusiast (n=151) Combined ratings from 5 study sites = 505**	**Specialist (n=40) Combined ratings from 5 study sites = 141**	**Chi-square**	**df**	**Asymp.Sig (2-tailed)**
Enjoyment at sites (1-10)**	8.7 (0.2)	8.4 (0.1)	8.2 (0.1)	7.9 (0.1)	15.656	3	0.001
Expectations met at sites (1-5)**	4.0 (0.1)	3.9 (0.1)	3.7 (0.0)	3.4 (0.1)	20.457	3	0.000
Max diving depth at sites (m)**	22.9 (1.0)	24.4 (0.4)	25.6 (0.3)	27.3 (0.6)	19.123	3	0.000
Perceived visibility (m)	22.9 (1.5)	22.6 (0.6)	23.7 (0.4)	23.6 (0.8)	3.423	3	0.331
Pre dive-brief information at sites (1-10)	8.7 (0.2)	8.6 (0.1)	8.5 (0.1)	8.2 (0.1)	4.792	3	0.188
Coral quality at sites (1-10)*	8.3 (0.2)	8.0 (0.1)	7.7 (0.1)	7.6 (0.1)	10.452	3	0.015
Fish quality at sites (1-10)**	8.9 (0.2)	8.4 (0.1)	8.1 (0.1)	7.9 (0.1)	23.136	3	0.000

* Significant at 0.05, ** Significant at 0.001

Values for each DACRH specialization group are means and one standard error. Enjoyment mean values based on a 10-point response format from 1 (not at all) to 10 (very much). Expectation mean values based on a 5-point response format from 1 (fell well below my expectations) to 5 (well above my expectations). Mean diving depth and visibility values are based on respondents' open-ended responses in metres. Pre-dive briefing mean values based on a 10-point response format from 1(very poor) to 10 (excellent). Fish and coral quality mean values based on a 10-point responses format from 1(very low quality) to 10 (very high quality).

Maximum diving depth, perceived visibility, and ratings of pre-dive briefing information

The mean maximum depth that each of the DACRH specialization groups had dived to at the study sites ranged from 22.9m for 'beginners' to 27.3m for 'specialists'. Differences between the groups were significantly different ($p<0.001$; Table 6.7). Post-hoc tests revealed that the 'specialist' group had dived significantly deeper than both the 'beginner' and 'intermediate' groups ($p<0.05$).

All DACRH specialization groups were in agreement about the perceived horizontal visibility of the water at the sites, with no significant differences observed between groups (*p>0.05*; Table 6.7). The DACRH specialization groups were also in agreement that the information presented in the pre-dive dive briefing at the study sites was high, with no significant differences observed (*p>0.05*; Table 6.7).

Evaluations of coral and fish quality at sites

The ratings of coral quality at the study sites ranged from 8.3 for 'beginners', to 7.6 for 'specialists'. Differences in mean ratings of coral quality were significant (*p<0.05*; Table 6.7), but post-hoc tests revealed no significant differences between particular groups at *p<0.05*.

Differences in the ratings of fish quality at the study sites were more apparent, ranging from 8.9 for 'beginners', to 7.9 for 'specialists'. Differences in mean ratings of fish quality were significant between groups (*p<0.001*; Table 6.7), and post-hoc tests revealed that both the 'beginner' and 'intermediate' groups rated the fish quality significantly higher than the 'specialist' group, and 'beginners' also had significantly higher ratings than 'enthusiasts' (*p<0.05)*.

Features most important in contributing to enjoyment at the study sites

To determine how important 19 coral reef features were to the different DACRH specialization groups' enjoyment at the study sites using a 5-point response format from 1 (not at all important) to 5 (extremely important), the mean ratings of importance were compared between groups. Table 6.8 shows the means and test results for the ratings of importance placed on each of the 19 coral reef features listed in descending order according to 'beginner' ratings from most important to least important. All groups were in agreement that 'cuttlefish and octopus', 'interesting landscapes', 'big fish>50cm' 'turtles', 'nudibranchs', 'pelagic fish', and 'crustaceans' were equally as important to enjoyment. Post-hoc tests revealed that for the remainder of the features (with the exception of 'manta rays' and 'sea snakes' which the 'beginners' did not see at all), 'beginners' ratings were significantly higher than specialists' (*p<0.05*).

Table 6.8. Means and Kruskal-Wallis Means-Test results for the importance of features contributing to DACRH specialization groups' enjoyment at the study sites.

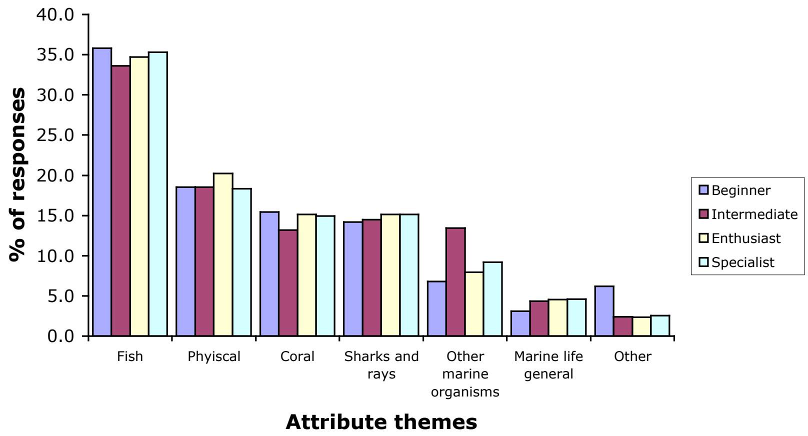
Features contributing to enjoyment at dive site	Beginner (n=18) Combined ratings from 5 study sites = 46	Intermediate (n=95) Combined ratings from 5 study sites = 270	Enthusiast (n=151) Combined ratings from 5 study sites = 505	Specialist (n=40) Combined ratings from 5 study sites = 141	Chi-square	df	Asymp.Sig (2-tailed)
Cuttlefish and octopus	4.7	3.7	4.1	3.6	4.222	3	0.238
Sharks**	4.5	4.2	4.1	3.8	15.252	3	0.002
Diverse fish life***	4.4	4.3	4.0	3.9	25.149	3	0.000
Diverse coral life***	4.3	4.1	3.9	3.9	15.626	3	0.001
Beautiful corals*	4.3	4.0	3.9	3.8	10.989	3	0.012
Interesting landscapes	4.3	4.0	3.9	3.9	4.108	3	0.250
Lots of fish***	4.3	4.1	3.7	4.0	29.626	3	0.000
Large schools of fish***	4.3	3.8	3.6	3.6	18.098	3	0.000
Potato Cod/groupers*	4.2	3.9	3.7	3.4	10.851	3	0.013
Big fish >50cm	4.1	3.9	3.9	3.8	2.548	3	0.467
Good visibility***	4.1	4.0	3.7	3.4	26.642	3	0.000
Turtles	4.0	4.2	4.3	3.7	5.844	3	0.119
Other rays*	4.0	4.7	3.0	3.7	10.501	3	0.015
Nudibranchs	3.2	3.2	3.0	3.0	1.567	3	0.667
Pelagic fish	3.0	3.3	3.4	3.4	2.752	3	0.431
Crustaceans	2.7	2.9	2.5	2.8	3.833	3	0.280
Sea cucumbers*	2.2	2.4	2.1	2.4	11.101	3	0.011
Manta rays	-	5.0	4.3	3.0	-	-	-
Sea snakes	-	2.8	3.4	3.3	-	-	-

Note: Features listed in descending order from top to bottom according to 'beginner' ratings. Mean importance value is based on a 5-point response from 1 (not at all important) to 5 (extremely important).
* Significant at 0.05, ** Significant at 0.01, *** Significant at 0.001

Best experiences for each DACRH specialization group

Figure 6.1 shows the distribution of the open-ended best experience responses to the question 'what were the three best features on the dive site', grouped into major attribute themes for each DACRH specialization group. For each DACRH specialization group, the percentages of best experience responses relating to each attribute theme were very similar. Fish responses made up the greatest percentage of all best experiences, followed by physical attributes, corals, and sharks and rays. 'Beginners provided a total of 162 comments with 15 different specifically named organisms listed (n=18). 'Intermediates' provided 917 comments with 48 specifically named organisms (n=95), 'enthusiasts' provided 1547 comments with 56 specifically named organisms (n=151), and 'specialists' provided 436 comments with 44 specifically named organisms listed.

Figure 6.1. Distribution of best experiences grouped into major attribute themes for each DACRH specialization group.



Note: 18 'beginners' provided 162 comments, 95 'intermediates' provided 917 comments, 151 'enthusiasts' provided 1547 comments, and 52 'specialists' provided 436 comments. All comments were combined from the five study sites, and respondents often listed more than one response.

The top 10 best experiences for each DACRH specialization group at the study sites are listed in Table 6.9 in descending order from top to bottom. All DACRH specialization groups agreed that 'reef sharks' was the single best experience on the study sites. For 'beginners' the next most frequently listed attributes were 'potato cod' with 8.0% of the 162 comments, followed by 'amazing coral' (7.4%), and the 'abundance of fish' (6.2%). Only 'beginners' listed that a site being 'easy to dive' was a best experience. This was slightly different to the 'intermediate' divers who provided 917 comments, with 8.4% of these being for 'cuttlefish', 7.7% for 'potato cod' and 7.6% for 'amazing coral'.

Both the 'enthusiast' and 'specialist' groups were in high agreement for the most frequently listed best experiences at the sites, with the top seven being the same. These were 'reef sharks', 'amazing corals', 'potato cod', interesting topography', 'amazing fish life', the 'reef wall', and 'good visibility'. 'Specialists' also listed other specifically named organisms like 'barracuda', 'stonefish', and 'soft corals' as best experiences. These results show that each DACRH specialization group experiences the sites in very similar ways, and that the same types of attributes provide best experiences across all groups.

Table 6.9. Top ten biophysical attributes that DACRH specialization groups listed as best experiences at the study sites.

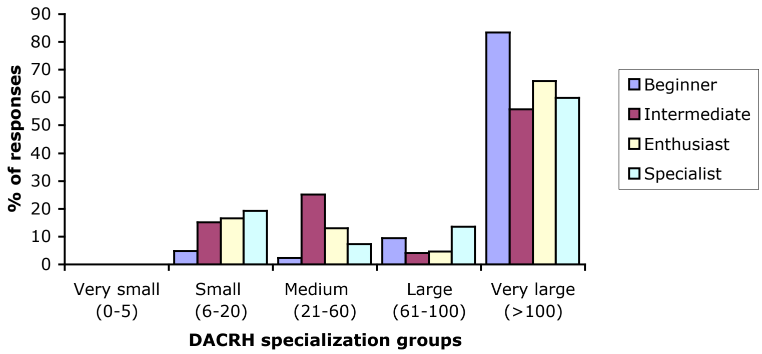
	Beginner (n=18)		Intermediate (n=236)		Enthusiast (n=246)		Specialist (n=52)	
Rank Order	**Attribute**	**Valid % of comments**	**Attribute**	**Valid % of comments**	**Attribute**	**Valid % of comments**	**Attribute**	**Valid % of comments**
1	Reef sharks	8.6	Reef sharks	12.5	Reef sharks	13.2	Reef sharks	11.2
2	Potato cod	8.0	Cuttlefish	8.4	Amazing coral	7.9	Amazing coral	8.5
3	Amazing coral	7.4	Potato cod	7.7	Potato cod	7.0	Potato cod	6.2
4	Abundance of fish	6.2	Amazing coral	7.6	Interesting topography	5.4	Interesting topography	5.0
5	Interesting topography	4.3	Amazing fish life	4.1	Amazing fish life	3.9	Amazing fish life	4.1
6	Good visibility	4.3	Good visibility	3.9	Reef wall	3.6	Reef wall	3.2
7	Large schools of fish	3.7	Interesting topography	2.9	Good visibility	3.4	Good visibility	3.2
8	Sites easy to dive	3.2	Reef wall	2.3	Swim-throughs	2.7	Barracuda	2.5
9	Amazing fish life	3.1	Swim-throughs	2.3	Abundance of fish	2.4	Stonefish	2.3
10	The pinnacles	3.1	Lionfish	2.1	Anemonefish	2.1	Soft corals	1.8
	TOTAL COMMENTS	**162**	**TOTAL COMMENTS**	**917**	**TOTAL COMMENTS**	**1547**	**TOTAL COMMENTS**	**436**

Responses presented are the most frequently listed attributes using an open-ended response format to the question 'what were the three best features on the dive site'. Responses are those combined from the five study sites. Respondents often listed more than one response. Valid % equals respondents that listed that feature of the total n

Size of fish and other marine organisms and best experiences

Figure 6.2 shows the size class distribution of specifically named organisms DACRH specialization groups listed as best experiences at the study sites. 'Very large' organisms were the most frequently listed by all groups making up between 55.7% of the 509 responses for 'intermediate' divers, and 83% of the 64 responses listed by 'beginners'. Organisms in the 'small' size class were also frequently listed by all DACRH groups, with increasing frequency from 'beginners' (4.8%) to 'specialist' (19.3% of the 234 responses).

Figure 6.2. Size class distribution of specifically named organisms DACRH specialization groups listed as best experiences.

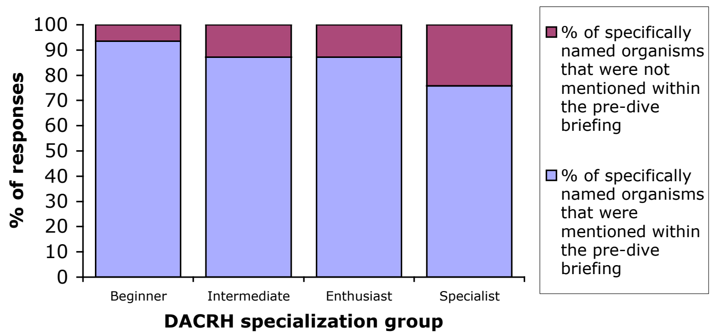


Note: 18 'beginners' provided 64 comments for specifically named organisms, 95 'intermediates' provided 509 comments for specifically named organisms, 151 'enthusiasts' provided 766 comments for specifically named organisms, and 52 'specialists' provided 234 comments for specifically named organisms. All comments were combined from the five study sites, and respondents often listed more than one comment.

Pre-dive briefing content and best experiences

To determine how important the pre-dive briefing was in directing each DACRH specialization group to specifically named organisms at the study sites, comments for specifically named organisms listed by each group were classed as either being mentioned within the pre-dive briefing, or not being mentioned within the pre-dive briefing. Figure 6.3 shows the distribution of the comments into these two categories for each DACRH specialization group. For all groups, a very high percentage of specifically named organisms were mentioned within the pre-dive briefing showing that it is an important and informative means of guiding best experiences. However, this was most apparent for the 'beginners', with 93.5% of the 64 responses being mentioned within the pre-dive briefing. For both 'intermediate' and 'enthusiast' divers, 87.1% of responses were for organisms mentioned within the pre-dive briefing (509 and 766 comments respectively. ‘Specialists’ listed the highest percentage of specifically named organisms that were not mentioned within the pre-dive briefing, with 25.2% of 234 comments listed.

Figure 6.3. Distribution of best experience comments for specifically named organisms at the study sites classed as either mentioned or not mentioned within the pre-dive briefing for each DACRH specialization group.

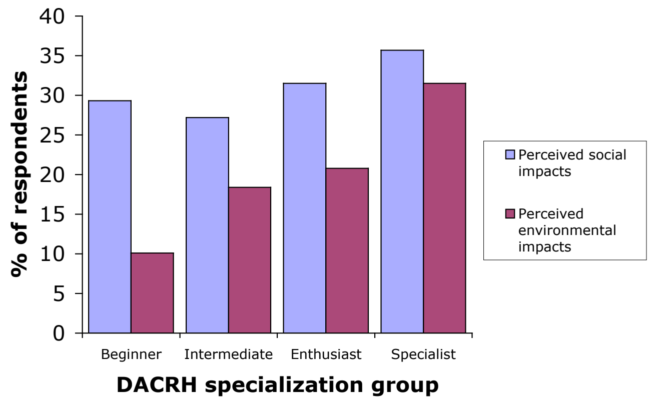


Note: 18 ‘beginners’ provided 64 comments for specifically named organisms, 95 ‘intermediates’ provided 509 comments for specifically named organisms, 151 ‘enthusiasts’ provided 766 comments for specifically named organisms, and 52 ‘specialists’ provided 234 comments for specifically named organisms. All comments were combined from the five study sites, and respondents often listed more than one comment.

Detracting experiences

Each DACRH specialization group was examined to see if there were differences in the perception of social and/or environmental impacts at the study sites that detracted from their experiences. The percentage of respondents from each DACRH specialization group that perceived at least one negative social and/or environmental impact can be seen in Figure 6.4. The percentage of respondents that perceived at least one negative social impact ranged from 27.2% for ‘intermediate’ divers (n=236), to 35.7% for ‘specialist’ divers (n=52). This shows that similar proportions of respondents from all DACRH specialization groups perceived social negative impacts on all sites. In contrast, the proportion of respondents from each DACRH specialization group that perceived at least one negative environmental impact showed a clear positive increase from ‘beginner’ to ‘specialist’ (Figure 6.4). While only 10.1% of ‘beginners’ perceived a negative environmental impact (n=46), nearly a third of ‘specialists’ (31.5%) perceived a negative environmental impact. This suggests that as DACRH Specialization increases, so does the awareness of environmental impacts at sites.

Figure 6.4. The percentage of respondents from each DACRH specialization group that perceived at least one negative social and/or environmental impact on the study sites that detracted from their experience.



Note: 'Beginners' (n=46); 'Intermediates' (n=236); 'Enthusiasts' (n=246); 'Specialists' (n=52).

The negative social impacts perceived at the study sites for each of the DACRH specialization groups can be seen in Table 6.10. All DACRH groups most frequently perceived 'too many divers'. For 'beginners' the second most frequently perceived social impact was having a 'bottom-time limit', while for all other groups it was seeing 'diver coral contact'. 'Inexperienced divers' and 'divers with cameras' were also highly perceived by the upper three groups. From Table 6.10 it can also be seen that 'beginners' did not perceive the social impacts of 'divers touching marine life', 'wildlife harassment', and 'maximum-depth limit', while these were all perceived by more specialised groups.

The negative environmental impacts perceived at the study sites for each DACRH specialization group can be seen in Table 6.11. For 'beginners', the most frequently perceived impacts were 'damaged coral' and 'not enough fish', but by very few respondents (2). For all other groups, 'damaged coral' was also the most frequently perceived environmental impact, followed generally by 'coral rubble', 'dead coral' and 'coral bleaching'. From Tables 6.10 and 6.11 it can also be seen that the 'specialist' group, when examined in the context of the group sample sizes, more frequently perceived all social and environmental impacts. This result indicates that not only did more 'specialists' perceive environmental impacts at the sites, but they also perceived a greater number of them.

Table 6.10. Perceived negative social impacts that detracted from DACRH groups' experiences at the study sites.

Social impact	Beginner (n=46) Number of times this was perceived	Beginner (n=46) Proportion of perceived impacts to sample size	Intermediate (n=236) Number of times this was perceived	Intermediate (n=236) Proportion of perceived impacts to sample size	Enthusiast (n=246) Number of times this was perceived	Enthusiast (n=246) Proportion of perceived impacts to sample size	Specialist (n=52) Number of times this was perceived	Specialist (n=52) Proportion of perceived impacts to sample size
Too many divers	6	13.0	42	17.8	67	27.2	19	36.5
Diver coral contact	2	4.3	37	15.7	62	25.2	19	36.5
Inexperienced divers	2	4.3	18	7.6	25	10.2	7	13.5
Divers with cameras	4	8.7	13	5.5	30	12.2	13	25.0
Fish/shark feeding	1	2.2	9	3.8	16	6.5	6	11.5
Bottom-time limit	5	10.9	13	5.5	14	5.7	6	11.5
Divers touching marine life	0	0.0	12	5.1	16	6.5	3	5.8
Wildlife harassment	0	0.0	9	3.8	7	2.8	1	1.9
Maximum-depth limit	0	0.0	3	1.3	4	1.6	7	13.5

Responses presented are the most frequently perceived impacts at the study sites from a list provided to respondents in descending order from the most frequently perceived to the least frequently perceived according to the whole sample. Respondents often listed more than one response.

Table 6.11. Perceived negative environmental impacts that detracted from DACRH groups' experiences at the study sites.

Environmental impact	Beginner (n=46) Number of times this was perceived	Beginner (n=46) Proportion of perceived impacts to sample size	Intermediate (n=236) Number of times this was perceived	Intermediate (n=236) Proportion of perceived impacts to sample size	Enthusiast (n=246) Number of times this was perceived	Enthusiast (n=246) Proportion of perceived impacts to sample size	Specialist (n=52) Number of times this was perceived	Specialist (n=52) Proportion of perceived impacts to sample size
Damaged coral	2	4.3	37	15.7	65	26.4	28	53.8
Coral rubble	1	2.2	36	15.3	33	13.4	20	38.5
Dead coral	0	0.0	26	11.0	41	16.7	16	30.8
Coral bleaching	1	2.2	16	6.8	19	7.7	7	13.5
Not enough fish	2	4.3	17	7.2	18	7.3	8	15.4
Moorings	1	2.2	3	1.3	14	5.7	5	9.6
Not diverse enough	0	0.0	8	3.4	5	2.0	5	9.6
Waste from boat	0	0.0	0	0.0	3	1.2	1	1.9

Responses presented are the most frequently perceived impacts at the study sites from a list provided to respondents in descending order from the most frequently perceived to the least frequently perceived according to the whole sample. Respondents often listed more than one response.

6.5.3 Post-trip perceptions and evaluations

Satisfaction with the dive sites overall

'Lower' and 'upper' level DACRH specialization groups rated their satisfaction with the dive sites overall from 1 (not at all satisfied) to 10 (extremely satisfied) as high, although the 'lower' group had a significantly higher mean rating for satisfaction (8.9) than the 'upper' group (8.6; $p<0.05$; Table 6.12).

Table 6.12. Descriptive statistics and Mann-Whitney U-Test results for ratings of satisfaction with dive sites and expectations being met for 'lower' and 'upper' DACRH specialization groups.

Variable	Lower level DACRH specialization group (n=95)	Upper level DACRH specialization group (n=178)	Mann-Whitney U	z	Asymp.Sig (2-tailed)
Satisfaction with dive sites (1-10)*	8.9 (0.11)	8.6 (0.08)	7057.00	-2.811	0.019
Expectations met for dive sites (1-5)**	3.9 (0.08)	3.6 (0.07)	6677.50	-2.350	0.005

* Significant at 0.05, ** Significant at 0.01
Values for each DACRH specialization group are means and one standard error. Satisfaction mean values based on a 10-point response format from 1 (not at all satisfied) to 10 (extremely satisfied). Expectation mean values based on a 5-point response format from 1 (fell well below my expectations) to 5 (well above my expectations).

How well dive sites met expectations

Ratings of how well the dive sites met expectations from 1 (well below my expectations) to 5 (well above my expectations) for the 'lower' and 'upper' level DACRH specialization groups was high. However, divers in the 'lower' group had a mean rating of 3.9, significantly higher than the 'upper' group (3.6) at $p<0.01$ (Table 6.12).

Perceptions for how common coral reef features were on the dive sites during the trip

To determine if the 'lower' and 'upper' level DACRH specialization groups had different perceptions for how common 19 coral reef features were on the dive sites based on a six-point response format from 0 (not seen) to 5 (very common), comparisons between the groups were made. Both groups were in agreement for 12 of the 19 features, showing no significant differences in the ratings for these ($p>0.05$). The ‘lower’ group perceived ‘diverse fish life’, ‘diverse coral life’, ‘sea cucumbers’, ‘large schools of fish’, ‘lots of fish’, and ‘good visibility’ to be significantly more common than the ‘upper’ group perceived them to be ($p<0.05$). In contrast, the ‘upper’ group perceived ‘nudibranchs’ to be significantly more common than the ‘lower’ group perceived them to be ($p<0.01$).

To determine how well the two groups expectations for the 19 coral reef features had been met by their experiences for these features at the sites, post-trip perception ratings were subtracted from pre-trip expectation ratings for each feature. For the ‘lower’ group, 12 of the 19 features were perceived to be significantly less common than they had expected them to be ($p<0.05$). Only ‘sea cucumbers’ were perceived to be significantly more common than expected ($p<0.05$). However, there were six features that were perceived to be as common as they were expected to be. These were (listed in order of smallest mean difference to the greatest mean difference): ‘big fish (>50cm)’, ‘diverse fish life’, ‘interesting landscapes’, ‘diverse coral life’, ‘sharks’, and ‘large schools of fish’.

For the ‘upper’ group, 15 of the 19 features were perceived to be significantly less common than they were expected to be ($p<0.05$). The four features that were perceived to be as common as they were expected from the smallest mean difference to the greatest were: ‘interesting landscapes’, ‘sharks’, ‘sea cucumbers’, and ‘diverse coral life’.

Biophysical attributes contributing to DACRH specialization groups best experiences during the trip

The ‘lower’ group listed a total of 285 comments (n=73). Of these 285 comments there were 73 different biophysical attributes, with 20 of these being for specifically named organisms. The ‘upper’ group listed a total of 536 comments (n=140). Of these 526 comments there were 86 different biophysical attributes, with 23 specifically named organisms. Both DACRH specialization groups’ best features on the dive sites for the trip are listed in Table 6.13, in descending order from top to bottom according to the ‘lower’ group rankings. For both groups, ‘reef sharks’ was the single best feature according to 54.8% of the ‘lower’ group, and 48.6% of the ‘upper’ group. This was followed by 'amazing corals' for both the 'lower' and 'upper' groups (39.7% and 35.7% respectively). More respondents in the 'lower' group listed the 'diversity of fish' and the 'diversity of corals' as a best experience than in the 'upper' group, while the opposite was the case for 'interesting landscapes' and the 'abundance of fish'. Generally, the biophysical attributes that contributed most to best experiences for each of the groups were quite similar with only slight differences in the percentages of respondents within groups listing these.

Comments relating to specifically named organisms were put into size classes. For the 'lower' group, 89% of the 74 comments were for 'very large' organisms, followed by 5.4% for 'large' organisms, 3.2% for 'small', and 2.4% for 'medium'. For the 'upper' group, 83.7% of the 141 comments were for 'very large' organisms, followed by 12.8% for 'small' organisms, and 3.5% for 'medium'.

Table 6.13. Comparisons of the biophysical attributes contributing most to best experiences for 'lower' and 'upper' level DACRH specialization groups.

Best features seen on this trip	Rank	Valid % of lower level DACRH specialization group respondents (n=73)	Rank	Valid % of upper level DACRH specialization group respondents (n=140)
Feature				
Reef sharks	1	54.8	1	48.6
Amazing coral	2	39.7	2	35.7
Diversity of marine life	3	24.7	4	19.3
Good visibility	4	23.3	3	20.7
Diversity of fish	5	23.3	9	12.1
Amazing fish life	6	21.9	6	15.7
Diversity of corals	7	16.4	11	9.3
Large fish	8	13.7	10	12.1
Interesting landscapes	9	12.3	5	19.3
Potato cod	10	11.0	7	14.3
Turtles	11	11.0	12	9.3
Abundance of sharks	12	11.0	14	8.6
Abundance of fish	13	9.6	8	14.3
Deep reef walls	14	9.6	16	6.4
Marine life (non-specific)	15	8.2	20	3.6
Diversity of dive sites	16	4.1	18	4.3
Large schools of fish	17	4.1	19	4.3
Beautiful corals	18	2.7	13	9.3
Pelagic fish	19	1.4	15	7.9
Nudibranchs	20	1.4	17	6.4
TOTAL COMMENTS		**285**		**536**
Left blank (question not completed)		40		51

Note: Characteristics listed in descending order from top to bottom according to 'lower' level DACRH specialization group ratings. Respondents often provided more than one response. Valid % equals respondents that listed that feature of the total n

Evaluations of environmental quality, coral quality, fish quality, human impacts, and natural beauty for the Ribbon Reef and Osprey Reef dive sites

To determine if 'lower' and 'upper' level DACRH specialization groups gave different evaluation ratings of the environmental quality, coral quality, fish quality, level of human impacts, and the natural beauty for the Ribbon Reef and Osprey Reef dive sites, comparisons were made between the groups for each evaluation. 'Lower' level divers had significantly higher ratings than 'upper' level divers for the 'environmental quality' at both locations, the 'coral quality' on the Ribbon Reef dive sites, the 'fish quality' at both locations, and the 'natural beauty' of the Ribbon Reef dive sites ($p<0.05$; Table 6.14). Interestingly, evaluations did not differ significantly for the Osprey Reef 'coral quality', the levels of 'human impacts' at both locations, and the Osprey Reef 'natural beauty' ($p>0.05$). This result shows that evaluations of quality do differ between groups, but that there appears to be agreement regarding the levels of human impacts at sites.

Table 6.14. Descriptive statistics and Mann-Whitney U Test results for mean ratings (± 1 SE) of environmental quality, coral quality, fish quality, human impacts, and natural beauty for the Ribbon Reef and Osprey Reef locations by 'lower' and 'upper' level DACRH specialization groups.

Evaluation Variable	Lower level DACRH specialization group (n=95)	Upper level DACRH specialization group (n=178)	Mann-Whitney U	z	Asymp.Sig (2-tailed)
Ribbon Reef environmental quality***	7.9 (0.14)	7.3 (0.12)	5899.50	-3.739	0.000
Osprey Reef environmental quality*	9.1 (0.12)	8.9 (0.07)	6951.50	-2.071	0.038
Ribbon Reef coral quality*	7.7 (0.15)	7.3 (0.12)	6825.50	-2.153	0.031
Osprey Reef coral quality	8.9 (0.13)	8.7 (0.08)	7127.50	-1.737	0.082
Ribbon Reef fish quality***	8.3 (0.13)	7.6 (0.12)	5690.00	-4.163	0.000
Osprey Reef fish quality**	9.1 (0.11)	8.8 (0.09)	6620.50	-2.647	0.008
Ribbon Reef human impacts	5.7 (0.25)	5.7 (0.18)	7908.50	-0.059	0.953
Osprey Reef human impacts	4.2 (0.25)	3.8 (0.19)	6900.00	-1.345	0.178
Ribbon Reef natural beauty**	8.5 (0.13)	8.0 (0.12)	6249.50	-2.806	0.005
Osprey Reef natural beauty	9.3 (0.11)	9.2 (0.08)	7121.50	-1.060	0.289

Note: Ribbon Reef and Osprey Reef environmental quality, coral quality, and fish quality mean values based on a 10-point response format from 1 (very low quality) to 10 (very high quality). Human impact mean values based on a 10-point response format from 1 (no impact) to 10 (high impact). Natural beauty mean values based on a 10-point response format from 1 (not at all beautiful) to 10 (very beautiful). Mean values (±1SE) are given.

Sea conditions during trip

Ratings of the sea conditions during the dive trip from 1 (very rough) to 5 (very calm) were significantly different between the 'lower' and 'upper' level DACRH specialization groups, with the 'upper' group indicating that conditions were better during the trip (mean 3.5 ±1SE 0.08) than the 'lower' group (3.2 ±1SE 0.10; Mann Whitney U = 6331.50; z = -1.190; Asymp.Sig=0.006).

6.6 Discussion

This study provides an application of the recreational specialization construct to examine wildlife tourism participants' experiences in natural areas. The findings of this study are discussed in three sections. Section 6.6.1 examines DACRH specialization groups' pre-trip expectations including trip importance, animals that DACRH specialization groups most wanted to see, and expectations for coral reef features.

Section 6.6.2 discusses differences between the DACRH specialization groups' actual experiences at the study sites in terms of the biophysical attributes that contributed to experiences, as well as detracting experiences. Lastly, Section 6.6.3 examines how DACRH specialization affected perceptions of the coral reef features at the sites, evaluations of quality, and finally concludes with a discussion of the ratings of satisfaction, enjoyment, and expectations being met at the sites.

6.6.1 Pre-trip expectations

Trip importance

For both the 'lower' and 'upper' level DACRH specialization groups, participating in the live-aboard diving trip was the main reason for travelling to Far North Queensland. This shows that divers that have just been certified and those that have been diving for many years have an equally focussed approach to travel purpose and destination selection in the interest of SCUBA diving activities. However, it should be noted that this research did take place on the GBR, one of the most famous destinations in the world for visiting coral reef environments. Both domestic and international tourists visit this region with the primary intent of experiencing the GBR (Greenwood & Moscardo, 1999). It is not surprising then that all levels of divers placed the same importance on the trip.

Animals that DACRH specialization groups most wanted to see

There was high agreement between the DACRH specialization groups that 'reef sharks' were the animals that they most wanted to see while diving on this trip, but this was especially the case for the 'lower' level group as indicated by 80.2% of respondents. Both groups also listed 'manta rays' and 'turtles' with high frequency. Differences between 'lower' and 'upper' groups existed for 'whale sharks', 'hammerhead sharks', 'nudibranchs', and 'tiger sharks', which the 'upper' group listed with higher frequency. These animals could all be considered rare sights on coral reef sites. 'Upper' level DACRH specialization respondents might be likened to specialist birdwatchers or fishers, in that species lists are generated by participants based on those they have seen or caught which can be termed a 'life list' (McFarlane, 1994; Scott et al., 2005), and those they are yet to see or catch which can be termed a 'wish list'. This fits in with Bryan's (1977) comments that with greater specialization comes a greater need to travel further and to more remote destinations in order to see particular species or habitats. This might explain why more specialised divers have a greater desire to see some of the more rare animals, possibly because they are yet to encounter them, but also because they are highly prized experiences.

The majority of all the animals that both 'lower' and 'upper' level DACRH specialization groups most wanted to see were over 100cm in total length, showing strong preferences for 'very large' animals on coral reef dive sites. The 'upper' level group did however list nearly twice as many specifically named animals than the 'lower' group. This result indicates that with increasing specialization comes a greater ability not only to identify more types of marine organisms, but also to want to enjoy a more diverse range of organisms. Increased ability to identify a greater number of species is also reported for more specialised birdwatchers (Kellert, 1985). In general though, the animals that both 'lower' and 'upper' level DACRH specialization groups most wanted to see were very similar, showing that desired experiences on coral reefs do not vary widely between groups.

Expectations for coral reef features

There were very few differences between 'lower' and 'upper' level DACRH specialization groups about how common a broad range of coral reef features were expected to be on the dive sites. This result suggests that although respondents in the 'lower' group had limited diving and coral reef history, they do have well developed notions of how these environments are constructed in space and time. By asking respondents with and without a working association with coral reefs to describe photos of coral reef environments, Dinsdale (2004) also found that all participants had a remarkably consistent conceptualisation of how these environments were constructed. In Study One of this thesis (Chapter Four), almost all the respondents had dived on a coral reef prior to this trip, and many also indicated a high interest in marine life. It is likely that as little as one or two visits to a coral reef combined with a high interest in these environments can play a large role in developing realistic expectations for a wide range of coral reef features. This is similar to the way that idealized images of coral reefs presented in advertising material help form expectations for visitors with no direct contact with a coral reef (Fenton et al., 1998).

The 'lower' level group had higher expectations of the environmental quality for the Ribbon Reef dive sites than the 'upper' level group, while both 'lower' and 'upper' level groups had equal and very high expectations of the environmental quality for the Osprey Reef dive sites. As mentioned in the Chapter Five, Osprey Reef is advertised by the operators as being a remote and pristine dive location. It appears that the advertising material for Osprey Reef has produced the same high expectations for a wide range of divers. Discrepancies in the expectations for the Ribbon Reef sites might be explained by the high percentage of more specialised divers having already visited the GBR before. Expectations for these divers are therefore likely to be based on past experiences, whereas the less specialised divers' expectations are likely to be based on advertising material. Because advertising plays such a significant role in forming expectations for Reef visitors, reef managers and operators need to be mindful about how they represent sites and even locations (Fenton et al., 1998)

6.6.2 Actual experiences

Biophysical attributes contributing to experiences

The biophysical attributes that contributed most to best experiences for all DACRH groups were similar in origin and distribution showing that the same features provide best experiences for all divers. Fish attributes made up the highest percentage of best experience comments, followed by the physical attributes such as 'interesting topography' and 'good visibility', and then coral attributes. The most frequently listed best experience by all DACRH specialization groups was 'reef sharks', again demonstrating their high importance and value to dive tourism.

For 'beginner' divers the 'potato cod' was the second most listed best experience, while for 'intermediate' divers it was 'cuttlefish'. For both 'enthusiast' and 'specialist' divers, 'amazing coral' was the second most highly listed best experience, indicating that for more specialised divers, the coral attributes play a major role in quality experiences. 'Amazing coral' was also a high listed attribute by 'beginner' and 'intermediate' divers. All DACRH specialization groups indicated that 'very large' organisms were those that provided the best experiences at the sites, however this was most apparent for the 'beginners'. For 'beginner' divers, 'very large' organisms might be the most distinctive at a site, especially given the high biodiversity and abundance of organisms that can be seen at the sites as found in Study Two (Chapter Four). Novice birdwatchers are also reported to look primarily for the most obvious and familiar species (McFarlane, 1994). In contrast, 'specialist' divers listed a higher frequency of best experiences for organisms that were 'small' (6-20cm) than all other groups, indicating that these divers experience a much wider range of organisms, and are also able to locate and identify them. Hammitt et al., (1993) also reported that repeat visitors have a greater number of viewing encounters with smaller and harder to find organisms than the first time visitors who focussed primarily on larger mammals in terrestrial environments.

'Specialist' divers were also able to have best experiences with a greater number of specifically named organisms not listed in the pre-dive briefing, whereas 'beginner' divers' best experiences were almost all mentioned within the pre-dive briefing. While diving, it is not possible for the dive crews to inform participants of the resources on offer throughout the dive, therefore the pre-dive briefing becomes an essential tool in explaining what the divers are likely to encounter. Although the information presented within the pre-dive briefing was rated equally and high by all groups, it appears that the content is especially important to 'beginners' experiences.

DACRH specialization groups were also in agreement regarding how important 'turtles', 'cuttlefish and octopus', 'big fish>50cm', 'pelagic fish', 'nudibranchs' and 'crustaceans' were in contributing to their enjoyment at the sites. However, for most of the coral reef features that the divers were asked to provide ratings of importance for, 'beginner' divers had the highest mean ratings, while 'specialist' divers had the lowest. It might be expected that many of the coral reef features encountered on the dive sites for 'beginners' would seem more important to their enjoyment because they have had little previous history with these. In contrast, it is likely that 'specialists' would have encountered these features on many occasions, and therefore place them in the context of all previous experiences (Fenton et al., 1998). This might also explain why the ratings of coral and fish quality at the sites also differed significantly between groups, with 'beginners' providing the highest ratings, and 'specialists' the lowest.

There were also differences in the ways that DACRH specialization groups were experiencing the sites. The mean maximum diving depth of respondents increased with each DACRH specialization group, with 'specialists' diving the deepest. In addition, 'beginner' divers were the only group to indicate that a site being 'easy to dive' was a best experience. It is suggested here that less specialised divers are more likely to enjoy biophysical attributes that can be found at shallower depths, and enjoy sites that do not place high demands on their diving ability (e.g. navigation). This is due to their limited training and education, but also because they will feel more comfortable under easy diving conditions. Both of these considerations would allow 'beginners' to pay more attention to the biophysical attributes, instead of focussing on concerns about their skills and ability.

Detracting experiences

The findings of this study show that as DACRH Specialization increases, so does the number of participants that will perceive an environmental impact, as well as the number of environmental impacts perceived. More specialised divers were also found to have greater understanding of the impacts associated with defining coral quality in this present study which may have increased their ability to perceive environmental impacts. These results support Davis and Tisdell's (1995) suggestion that beginner divers would be less aware of dive site degradation because they are unable to make comparisons to other sites. Other studies have also shown that participants with more history in an activity and setting are also more perceptive to environmental impacts. Fishers that are more familiar with site attributes have been shown to be more sensitive to changes in the resource (Jacob & Schreyer, 1981), and more specialised participants in river settings have also been shown to be more sensitive and perceptive to the trampling of vegetation for example (Hammitt & McDonald, 1983; Schreyer et al., 1984).

Schreyer et al., (1984) also found that more experienced river rafters were more perceptive to social conflicts such as crowding. However, this present study found that all DACRH specialization groups were able to perceive negative social impacts, such as crowding and diver-coral contact, in much the same way. In Study Three (Chapter Five), it was found crowding effects were most obvious on the smaller pinnacle sites where divers are concentrated in small areas. It appears that all divers, regardless of DACRH Specialization, do not enjoy being in close proximity to other divers, which results in detracting experiences.

6.6.3 Post-trip Perceptions and evaluations

Perceptions of coral reef features

Only slight differences between 'lower' and 'upper' level DACRH specialization groups were found to occur in how common they perceived 19 coral reef features to be on the dive sites. In general, both groups were in agreement about how common 12 of the 19 features were, showing a high level of consistency between the groups. Using the gap-analysis (post-trip perceptions minus pre-trip expectations) it was possible to determine how the 'lower' and 'upper' level DACRH specialization groups' expectations for the 19 coral reef features had been met by their actual experiences. Features that were perceived to be as common as expected for 'lower' level divers were 'big fish >50cm', 'diverse fish life', 'interesting landscapes', 'diverse coral life', ‘sharks’, and ‘large schools of fish’. ‘Sea cucumbers’ were perceived to be more common than expected. For ‘upper’ level divers the features they perceived to be as common as they expected them to be were ‘interesting landscapes’, ‘sharks’, ‘sea cucumbers’, and ‘diverse coral life’. These features are likely to be the most useful in advertising material for the Ribbon Reef and Osprey Reef locations that aim to provide a wide range of divers with experiences that meet expectations.

Evaluations of quality

At the end of the trip, evaluations of environmental quality, coral quality, fish quality, and natural beauty of the Ribbon Reef dive sites were influenced by increasing specialization, with ‘specialist’ divers having significantly lower ratings than ‘beginners’. In Study One (Chapter Three), more specialised divers were found to have visited a greater number of coral reef sites from a wider range of locations. This might enable them to make accurate value judgements based on previous high and low quality experiences in these environments. In doing this, more specialised divers might provide a more accurate assessment of quality than ‘beginner’ divers, because they are able to make such comparisons. For ‘beginner’ divers, the sites they visit and the experiences they have during this trip will form a major part of the coral reef image and cognitive history that they will use to compare all subsequent reef sites.

Ratings for Osprey Reef coral quality, natural beauty, and levels of human impacts, were not significantly different between DACRH specialization groups. Divers agreed that the Osprey Reef dive sites were of very high environmental and coral quality, and low human impact. This result shows that sites that are perceived to be of very high quality are seen as such by all divers similarly, regardless of specialization level. It is likely that sites that are evaluated in this way are of the highest value to dive tourism where more specialised divers are concerned.

Enjoyment, satisfaction, and expectations

As DACRH Specialization increased, the ratings of enjoyment, satisfaction and expectations being met at the study sites decreased significantly, despite all DACRH specialization groups reporting high levels for each of these measurements. This result is consistent with a study conducted on terrestrial and marine wildlife tourists, where participants with more history with wildlife encounters were the least satisfied with their experiences, despite satisfaction still being high (Muloin, 2000). However, the findings of this and Muloin's study are in contrast with other studies that have examined participant history and satisfaction. Kerstetter, Confer, & Graefe (2001), found that increasing specialization in heritage tourists resulted in higher reported levels of satisfaction, while for river rafters there was no significant difference in the reported satisfaction with a trip despite differences in participants' level of previous participation (Schreyer et al., 1984).

It is likely that more specialised divers in this sample place the quality of the sites seen in the context of all their previous experiences in coral reef environments (Fenton et al., 1998). In addition, more specialised divers also rated the coral and fish quality lower than less specialised divers, and also had a higher perception for environmental impacts. These considerations might explain why 'specialist' ratings of enjoyment, satisfaction, and expectations being met were not as high as for 'beginners'. This demonstrates that divers with little or no previous history with the activity or setting were able to have experiences that exceeded their expectations, even though their expectations did not differ greatly from more specialised divers. This leads to higher levels of satisfaction, and is in accordance to traditional satisfaction theory (Ajzen & Fishbein, 1980; Noe, 1987; Ryan, 1995). Clearly being a new participant in a rich, diverse, and abundant environment must have a much greater impact on the wildlife tourism experience of a novice than for a participant who has spent many years visiting the same type of environment.

CHAPTER 7

SUMMARY AND CONCLUSIONS: DIVERS' EXPERIENCES ON CORAL REEFS

7.1 Introduction

This research on certified SCUBA divers' experiences on coral reefs of the Great Barrier Reef (GBR) and Coral Sea is timely and highly significant because it contributes to our theoretical understanding of wildlife tourism experiences, and also the ecologically sustainable management of natural areas. Several researchers have stressed the need to understand better how coral reefs are experienced and evaluated by the different types of tourists that visit them, from both an ecological and social perspective (Birtles et al., 2001; Birtles et al., in prep; Shafer & Inglis, 2000; Shafer et al., 1998). This also includes understanding how specific biophysical attributes influence experiences (Borrie & Birzell, 2001). The need for such information is placed in the context of a worldwide increase in demand for marine wildlife tourism experiences, particularly SCUBA diving on coral reefs. SCUBA diving tourism has been described as probably the most popular and ubiquitous adventure sport in the world, with over 15 million active divers visiting over 2,000 diving centres in more than 91 countries and states (Spalding et al., 2001).

Because of this popularity, the economic opportunities created by SCUBA diving tourism are significant to reef-based communities, as are the potentials for positive outcomes for coral reef environments, particularly the preservation and conservation of coral reefs and their resources. These opportunities and potentials are largely dependent on the quality of the reefs and the marine life that occur there (Chadwick, 2005). However, the quality of coral reefs and the diversity and abundance of the life they support is rapidly being compromised worldwide by a range of natural (e.g. cyclones, floods, crown-of-thorns), anthropogenic (e.g. commercial and recreational extractive fishing and collecting activities, tourism, deteriorating water quality), and global (e.g. coral bleaching) impacts (Wilkinson, 2004a). These impacts have the potential to damage and/or remove the biophysical attributes of coral reef sites that are most significant to divers' experiences. Such impacts are likely to reduce the demand for dive sites and locations. This means that maintaining and protecting the environmental quality and attributes responsible for the attraction of visitors and the experiences they have is crucial to the sustainability of this economically important tourism industry. Our limited understanding of the biophysical attributes that are most significant to divers' experiences is due in part to coral reefs supporting extremely diverse and abundant marine life, and being difficult to study because of the limitations imposed on researchers by underwater environments, often located in remote areas.

The limited amount of previous research on visitors' experiences in coral reef environments has established the types of participants, the benefits they receive from activities, and the biophysical attributes that contributed most to their experiences. While this information was informative to managers and essential to the development of the research presented in this thesis, it was unclear what specific biophysical attributes visitors were encountering at the sites studied, and therefore which of these were most important. There has been little empirical research reported in the recreation or tourism literature for marine and terrestrial environments that demonstrates what was actually present at a site, and what is actually experienced by the participants, other than the work undertaken by Hammitt et al., (1993). The research presented in this thesis provides the first multidisciplinary approach to understanding divers' experiences on coral reef sites by using natural science techniques to measure and describe the biophysical attributes that occur at tourism sites, and social science techniques to understand the divers and the experiences they are having. This chapter provides a synthesis of the findings of the four studies in this thesis, highlights the management implications and recommendations, and provides an agenda for future research on divers' experiences on coral reefs.

7.2 Significance of findings

7.2.1 The biophysical attributes at the study sites

This research demonstrates how the biophysical attributes on coral reef tourism sites can be measured and described to understand the diving opportunities that are provided to visitors. While this approach is well established in terrestrial settings, especially for the planning and management of natural areas for the purpose of recreation as prescribed by Recreational Opportunity Spectrum (ROS) management framework (Driver & Brown, 1978), it has not been applied in an underwater coral reef context.

This research has shown that coral reef dive sites from the Ribbon Reef and Osprey Reef locations provide divers with extremely diverse and abundant diving opportunities made possible through a wide range of biophysical attributes. The findings support the suggestion that over 50 species from a wide range of taxa can be encountered during a single SCUBA dive or snorkel (Shafer et al., 1998). In fact, well in excess of this number of species is likely to be encountered by divers on each of the sites studied with the most diverse of the sites estimated to have 102 species of corals, 103 species of fish (including sharks and rays), and 49 species of other marine organisms (e.g. crustaceans, molluscs, echinoderms, reptiles). These organisms ranged in size from very small (<5cm) to very large (>100cm), with each site having good viewing opportunities and sightings of a wide range of organisms. Coral attributes at each of the sites were abundant, diverse, and colourful with no sightings of crown-of-thorns starfish, and only very limited levels of coral bleaching. The sites studied represent fine examples of high quality coral reef environments.

The physical attributes at the sites were also diverse, and determined more or less how the sites would be experienced. For example, pinnacle sites, due to the conical shape of the reef structure, meant that divers spent most of their time spiralling the site. In contrast, back reef sites allowed divers to explore the site moving between bommies along sand filled gullies and entering caves and swim-throughs. Reef walls meant that divers were exposed to deep and open water, and because the reef wall is like a cliff face divers are only able to swim around on the outside of these structures. The horizontal visibility of the water also varied greatly at each site ranging from 5m to 40m during the study period. This research provides the first account of the physical attributes that occur at coral reef tourism sites.

Although many biophysical attributes can be seen by visiting divers at the sites, there were attributes that were more distinctive, or clearly different and separate, than others. These distinctive attributes did provide visitors with rich and powerful experiences through one or several factors that relate to the characteristics of an attribute, or aspects of an experience with an attribute. The factors used to identify distinctive attributes were: abundance; size; behaviour; duration; popularity or iconic status; special/unusual features; and intensity of experience. The latter four factors have been adapted from Reynolds & Braithwaite (2001), who developed these to describe the essence of quality and richness of wildlife tourism encounters from the viewers perspective. The impact of these distinctive attributes on visitors' experiences is determined by how often they can be seen at the sites, with those seen frequently having a much greater impact on a larger number of visitors. Distinctive attributes at each site included both physical (e.g. very large reef wall, caves) and biological attributes (e.g. high abundance of schooling fish, large size of potato cod). These distinctive attributes were important in characterising the diving opportunities that each site provided divers, and fits well with the way that the ROS is able to identify recreation opportunities for visitors within a given area.

Only when the five study sites were compared was it clear that each site, and even the two locations of the Ribbon Reefs and Osprey Reef, provided divers with very different diving opportunities based on the measurements of the biophysical attributes. Some sites provided divers with complex and diverse physical attributes (e.g. caves, reef walls, good visibility), while other sites provided divers with much higher chances of seeing certain organisms (e.g. reef sharks, cuttlefish, turtles, tuna). Therefore, coral reefs dive sites are not homogenous in the sense that they are able to provide only one type of diving experience that might be provided at tourism sites where one or two species are the focus of the activity, instead they offer very heterogeneous opportunities depending on the specific attributes that occur at each site. This level of information could only be gained by measuring and describing the biophysical attributes, including the number of organisms available to be seen (Driver, 1985; Hammitt et al., 1993), and how predictable certain species are within a given spatial and temporal scale (Duffus &

Dearden, 1990; Hammitt et al., 1993). Using this methodology it was also apparent that sightings of certain species, for example manta rays, were spatially and temporally rare, as Birtles et al., (2001) suggested is often the case with multi-species wildlife tourism experiences.

According to Reynolds and Braithwaite (2001), the most desirable habitats for wildlife tourism activities are those that: support a number of watchable and interesting species; have large open areas that allow good visibility of animals; have cover which obscures the observer's approach from animals; and have features which concentrate animal activity (e.g. waterholes). Coral reef dive sites fulfil all of these desirable traits, and it is possible that these environments often represent the best habitats for viewing a high diversity and abundance of organisms within close proximity to the viewer, in physically diverse and interesting settings. While the sites studied in this research do not cover the whole spectrum of coral reef types (fringing reefs, inshore reefs, patch reefs, pinnacles, mid-shelf reefs, outer-shelf reefs, seamounts/coral atolls), and therefore the full range of potential dive sites, they are representative of the diving opportunities on the outer-shelf and seamount sites in northern section of the GBR and adjacent Coral Sea. More importantly, the five study sites selected are those that all visiting divers participating in live-aboard diving trips to the Ribbon Reef and Osprey Reef locations will visit, especially during three day trips where these make up the majority of the sites visited. While it is acknowledged that there are many other reef types that tourists visit, there was a wide range of biophysical attributes measured at the five study sites in this study, many of which also occur at other reef sites around the world (Spalding et al., 2001). Because of the similarities of attributes found on coral reef sites, the findings of this research are applicable on a much broader coral reef scale than just the northern GBR and Coral Sea.

7.2.2 <u>Certified SCUBA divers</u>

While it has been shown that visitors can have different levels of history when participating in wildlife tourism experiences (Birtles et al., in prep; Hammitt et al., 1993; Muloin, 2000; Rouphael & Inglis, 1995; Shafer et al., 1998; Valentine et al., 2004), there has been little attempt to segment populations of participants into groups based on known levels of activity and setting history. Such information is essential to understanding what types of visitors participate in such activities, and how this might influence their experiences and evaluations. This research was able to demonstrate that there are different types of certified SCUBA divers, based on known levels of Diving and Coral Reef History (DACRH) Specialization, reflected by participation, training and associated skills, and setting history.

The recreational specialization construct, noted by Bryan (1977) and used extensively by many leisure and recreation researchers, provided the tools to segment the sample of divers into definable units using a Multidimensional Recreational Specialization Index (MRSI). These divers were:

- 'Beginners' – divers who had recently started diving.
- 'Intermediates' - no longer new to the activity but with limited diving and coral reef history.
- 'Enthusiasts' - higher level-certifications and who had established diving as a regular part of their leisure with moderate exposure to coral reef settings
- 'Specialists' - professional certifications (Dive Master or Open Water SCUBA Instructor), highly engaged in the activity of diving with high exposure to coral reef settings.

The differences between all groups were significant with regard to all diving and coral reef history measurements, ownership of SCUBA related equipment, and levels of coral reef interest and knowledge. Only a relatively small portion of the divers in this study were 'beginners', and almost all divers had dived on coral reefs previous to the trip. This is different to the breakdown of participants on day-trip vessels, which predominantly attract non-divers visiting coral reefs, and many divers for their first coral reef experience (Shafer et al., 1998). For the small percentage of day-trip participants that are certified, up to 70% have less than 40 total dives, however this ranged from one to 3,000 (n=214) (Rouphael & Inglis, 1995). Because divers that are likely to be more specialised also take part in day-trips, and 'beginner' divers also take part in live-aboard trips, there is some mixing of types of participants on each of the trip types. Although the results reported here are for live-aboard diving trip participants, the findings are representative of a broad range of certified SCUBA divers. Therefore, the results of this research are applicable to a wide range of reef tourism operations, not just live-aboard diving trips.

It is possible that no wildlife tourism participants studied in the past are more specialised than the 'specialist' certified SCUBA divers that participated in the live-aboard diving trips in this study, which supports Kellert's (1996) notion that some wildlife experiences involve considerable expense, knowledge, specialised equipment, and long distance travel. As divers increase in DACRH Specialization, they also increase in specialization for coral reef environments and the marine life that lives there, reflected by high levels interest and knowledge. DACRH 'enthusiasts' and 'specialists' could even be referred to as underwater naturalists. Progression towards specialization in terms of the environment and its inhabitants is also documented for recreational fishers (Bryan, 1977), and birdwatchers (McFarlane, 1994). For regular participants in activities that focus on natural areas, a keen interest in and knowledge of the environment is highly likely.

The recreational specialization construct provided an excellent framework to segment certified SCUBA divers, possibly because SCUBA diving is an activity that is more clearly defined and structured than other recreational pursuits previously studied, for example fishing (Sutton, 2001, 2003), hiking (Watson et al., 1994), or birdwatching (McFarlane, 1994; Scott et al., 2005). This is because of the way that diving is learned with a clear series of certification levels that need to be achieved in a set order. Such a structured approach to learning and training, and thus a natural progression towards specialization within an activity, especially a tourism activity, is rarely seen. However, the utility of the recreational specialization construct might be limited when used to segment other types of wildlife tourism participants that are not trained or educated in the way that SCUBA divers are. This is because there is still little consensus among specialization researchers on how recreational specialization should be measured and characterized, which makes its wider application limited. It is likely that there is not one method that will work for all types of activities, but rather researchers should use the construct as a framework to make inquiries about participants that have clearly defined and known levels of specialization within an activity, and if appropriate the setting where the activity takes place.

Future research concerned with the level of SCUBA diver specialization in both the activity of diving and coral reef settings might use the DACRH specialization groups constructed in this thesis as a guide for developing a self-rated scale of specialization. Self-rated scales of specialization, where respondents categorise themselves, have been shown to perform as well, if not better, than multidimensional indices making them more useful to managers (Scott et al., 2005). However, this method is only likely to be reliable for participant segmentation as long as self-rated group definitions are developed from previous research and findings that show specialization does exist. The group definitions constructed in this research are likely to be useful in segmenting participants for any certified SCUBA diving activities on coral reefs.

7.2.3 Certified SCUBA divers' experiences

A major finding of this research was that the five coral reef dive sites studied provided the sample of divers with a wide variety of best experiences both within each site, and also across all five sites. Both the physical and biological attributes of coral reefs contributed almost equally to best experiences, although some attributes were more important to experiences than others. In total there were 208 different biophysical attributes listed by the divers as best experiences at all sites combined, with 118 of these being for specifically named organisms. This finding was significant because it was shown that the single coral reef sites studied provide visitors with an extraordinarily diverse range of experiences. Although previous research on certified SCUBA divers has shown that their experiences are extremely diverse on coral reefs (Birtles et al., in prep; Curnock, 1998), this has not been demonstrated for a single site. Only by using the open-ended question format as Birtles et al., (in prep) and Curnock (1998) did, was it possible to obtain such rich information, a method that very few researchers have employed. This finding is also significant because it highlights that the sample of divers had high levels of knowledge and understanding of coral reef environments, which enabled them to have such varied experiences, even at individual sites. Using the recreational specialization construct for the first time to examine participants' experiences, it was found that more specialised divers ('enthusiasts' and 'specialists') were experiencing a much wider range of attributes, both physical and biological, with many of these being specifically named organisms. In other words, the more you see the more you know, and the more you know the more you see. This was in contrast to the 'beginners' that tended to have best experiences with the most distinctive attributes at a site, many of which were also mentioned within the pre-dive briefing.

Biophysical attributes contributing to experiences

The more that visitors agree about the importance of certain attributes, the greater their value will be as an indicator of that experience (Manning & Lime, 1999). There was high consistency between all DACRH specialization groups regarding the best experiences at the sites. These included 'reef sharks', 'amazing corals', 'potato cod', 'good visibility' and the 'abundance' and 'diversity' of fish and coral, among others. Not only are a large number of divers in agreement that these are the best experiences, but these attributes could be seen at the dive sites with high frequency. This makes these attributes high in value and importance to divers' experiences, and therefore to reef-based tourism. The results reported for this study are quite similar to those found by Birtles et al., (in prep) and Curnock (1998) from the same diving locations, and provide much support that the same biophysical attributes have been regarded as best experiences for almost a decade. However, results from a study on dive tourists in the Western Caribbean do not report any findings that suggest that reef sharks were regarded as important to experiences (Williams & Polunin, 2000). Without knowing if reef sharks could be seen at the sites studied, it is difficult to determine if this particular attribute was seen but not important to visitors, or was simply not seen.

The best experiences at each site differed greatly and were closely related to the distinctive attributes measured at each site. This result demonstrated that the divers in this sample had a high ability to detect differences between coral reef dive sites in terms of the physical structure of the site, horizontal visibility of the water, diversity and abundance of marine life, the quality of the coral and fish life, and also differences with respect to particular species such as their relative abundance. Therefore, each site is experienced differently according to the attributes that occur there, although certain attributes are often best experiences overall.

Because rarer animals do not rate highly in best experience data (due to low sighting frequencies), the Animal Importance Index (AII) was designed. This index was essential in understanding the relative importance of particular animals to divers' experiences.

The rationale behind this index is based on how frequently an animal is listed by respondents as a best experience, compared to how frequently it could be seen at a site. Using the AII, it was found that 'manta rays', were the most important animals to divers' experiences when seen, followed by 'potato cod', 'reef sharks', 'cuttlefish', 'lionfish', 'turtles' and 'tuna' among others. This method for assessing relative importance to visitors' experiences is likely to be useful in many other wildlife tourism activities that are focused on multi-species viewing where rare or chance sightings of animals can be common.

It was also a major finding of this research that the biophysical attributes that were distinctive and thus contributed most to best experiences were considered by the divers to be special/unusual. Reynolds and Braithwaite (2001) describe this type of experience for a participant as one where the participant feels privileged. The reasons why attributes were special/unusual included both characteristics of the attribute (e.g. 'diversity', 'perceived rarity', 'colours', 'cryptic', 'perceived health'), and also aspects of the experience (e.g. 'first experience', 'getting close', 'not expected', 'photo opportunities', 'always wanted to see'). Given the high diversity and abundance of biophysical attributes that occur on coral reef sites, and the high diversity of biophysical attributes that were found to contribute to best experiences, it might be expected that there are many attributes that divers are yet to encounter, or continue to be amazed by in these environments. This in itself might be the attraction of diving on coral reefs. For 'beginners' coral reefs present a myriad of first experiences in a strange and exciting setting, while for more specialised divers with many years of diving and coral reef history it might be knowing that there could always be something that surprises them on each and every site.

The second most important distinctive factor of an attribute was its popularity or iconic status, mostly for biological attributes. Popular or iconic organisms, such as 'reef sharks' and 'turtles', are likely to be important to experiences wherever they occur especially when they are also distinctive for other factors such as size, behaviour, and especially abundance, which was found to be the third most important factor. The more abundant an organism was, the more it contributed to best experiences. Behaviour also played a large role in the distinctiveness of an organism, as has been shown for other wildlife tourism encounters in both marine and terrestrial settings. The inquisitive behaviour of minke whales has been shown to be a very strong element of swim-with-whale participants' best experiences (Birtles et al., 2002b), while seeing wildlife behaving naturally can be very important for terrestrial wildlife tourism participants (Moscardo et al., 2001).

Biophysical and social attributes detracting from experiences

This research also identified social and environmental impacts that divers perceived at the sites that detracted from their experiences. The most significant impact was the number of divers on a site at any one time, and was perceived by all DACRH specialization groups. This type of crowding effect has a been a major indicator of detracting experiences in a large number of tourism and recreation studies, both terrestrial (Dawson & Watson, 1999; Hollenhorst & Gardner, 1994; Muloin, 2000; Watson, 2001), and marine (Davis et al., 1997; Inglis et al., 1999; Rudd & Tupper, 2002; Shafer & Inglis, 2000; Shafer et al., 1998). A much higher percentage of more specialised divers also reported that seeing other divers come into contact with the coral was a detracting experience. These divers were also much more perceptive to environmental impacts, and reported that seeing broken, damaged, dead, or bleached coral was a major detracting experience. This result reinforces the notion that the corals are regarded very highly by the divers and that any visible damage to the coral condition is likely to be detected, especially by more specialised divers. This situation can be likened to wilderness users observing broken or trampled vegetation, which has also been shown to detract from experiences (Manning & Lime, 1999; Watson, 2001).

The effects of SCUBA divers' impacts on coral reef environments are well documented, and show much consistency among studies from various coral reef locations around the world. Only a small percentage of divers pose a significant threat to coral reefs (Rouphael & Inglis, 1995). This threat particularly impacts the aesthetic value of a site (Hawkins & Roberts, 1997; Wielgus et al., 2002), as much of the damage caused damages fragile branching corals (Hawkins & Roberts, 1992b; Rouphael & Inglis, 1995; Zakai & Chadwick-Furman, 2002). Because the coral contributes such a strong visual component to the coral reef scene, and because it has been shown in this study to both positively and negatively influence visitors' experiences, the condition of the coral is of high importance to the outcome of the experience. Shafer et al., (1998) also demonstrated that corals were the most influential attribute to visitors' enjoyment with their reef experience.

The negative impact that the fish and shark feeding/attracting activities had on divers' experiences was also of concern. While this activity is undertaken by operators to enhance and enrich experiences through guaranteed sightings of certain species and allowing divers to get very close and witness feeding behaviour, it appears that for some, this activity can detract from the naturalness of the experience. The positive and negative effects of feeding activities on both the animals and the participants have been discussed in Chapter Five, and it is suggested that this activity merits further research to understand its role in influencing experiences and how it impacts on the animals targeted.

Many divers visiting the Ribbon Reef and Osprey Reef locations reported very high levels of enjoyment, satisfaction, and their expectations being exceeded at the sites, however more specialised divers reported significantly lower ratings for these. Lower ratings of satisfaction have also been reported for wildlife tourism participants with previous history of wildlife encounters in captive and natural settings (Muloin, 2000), This was also the case for the ratings of environmental, fish, and coral quality at the Ribbon Reef sites, but not the Osprey Reef sites. The Osprey Reef sites were evaluated by all divers to be of significantly higher quality than the Ribbon Reef sites. It is suggested that where all DACRH specialization groups evaluations are high and in agreement, that these sites are of the highest value and importance to tourism. Osprey Reef is a prime example of this.

It is likely that more specialised divers place the quality of the sites and attributes seen in the context of all their previous experiences (Fenton et al., 1998). These divers also have a greater perception of impacts at the sites. Both of these considerations might explain why enjoyment and satisfaction ratings are not as high as for 'beginners'. Clearly being a new participant in a rich, diverse, abundant, and vibrant environment has a greater positive influence on experiences than for a participant that has spent decades visiting the same type of environment. This result has significant implications for the management of natural areas for different types of users. Areas that are of lower quality and have biophysical attributes that have been damaged, and/or removed are likely to be of little use where more specialised participants are concerned, while these same areas might be highly enjoyed by new participants because they do not have the cognitive history to make comparisons as suggested by David and Tisdell (1995).

7.2.4 Application of findings in a Rcereational Opportunity Spectrum (ROS) and Limits of Acceptable Change (LAC) planning approach

The LAC planning approach (Stankey et al., 1985), based on the ROS framework, was aimed at preventing adverse environmental impacts caused by human activities, and can be particularly useful in guiding management where conflicts between different users exist (Cole & McCool, 1998). In the case of certified SCUBA diving on coral reefs, this specifically relates to the maintenance of the biophysical attributes that are most important and significant to divers' experiences. This means managing the level of damage and/or removal of these attributes for a wide range of users including tourism operators and tourists, Indigenous communities, local recreation users, recreational and commercial fishing and collecting, coastal developers, and shipping (Shafer et al., 1998). The final objective of this thesis was to investigate which biophysical and social attributes might best be used as indicators of quality experiences for certified SCUBA divers.

It is suggested that the biophysical attributes that were found to contribute most highly to divers' experiences in this research are also likely to be useful indicators of wildlife tourism quality, particularly the coral attributes. This is because any damage and/or removal of these attributes are likely to significantly impact on the quality of divers' experiences. This will especially be the case for more specialised divers that are more discerning of the environmental, coral, and fish quality at a site, and are more perceptive about/of a wider range of impacts, especially to the coral condition. It is likely that sites they evaluate to be of low quality and high in impact will be of little interest to these divers. In a ROS planning framework, this will mean that different sites, based on differing levels of impacts and biophysical attributes, will be better suited to specific types of divers. If such planning is not undertaken, and more specialized divers are regularly taken to sites they consider to be of low quality, this is likely to have serious and long lasting effects to the sustainability of reef-based tourism in these and other regions. Many of the indicators of quality experiences suggested in this study also reflect indicators of quality experiences used in terrestrial environments (see Manning & Lime, 1999). Such high consistency between marine and terrestrial indicators make these useful in a LAC planning process in marine environments, partly because of their long history of use and acceptance elsewhere (Manning & Lawson, 2002; Manning & Lime, 1999).

7.3 Management implications and recommendations

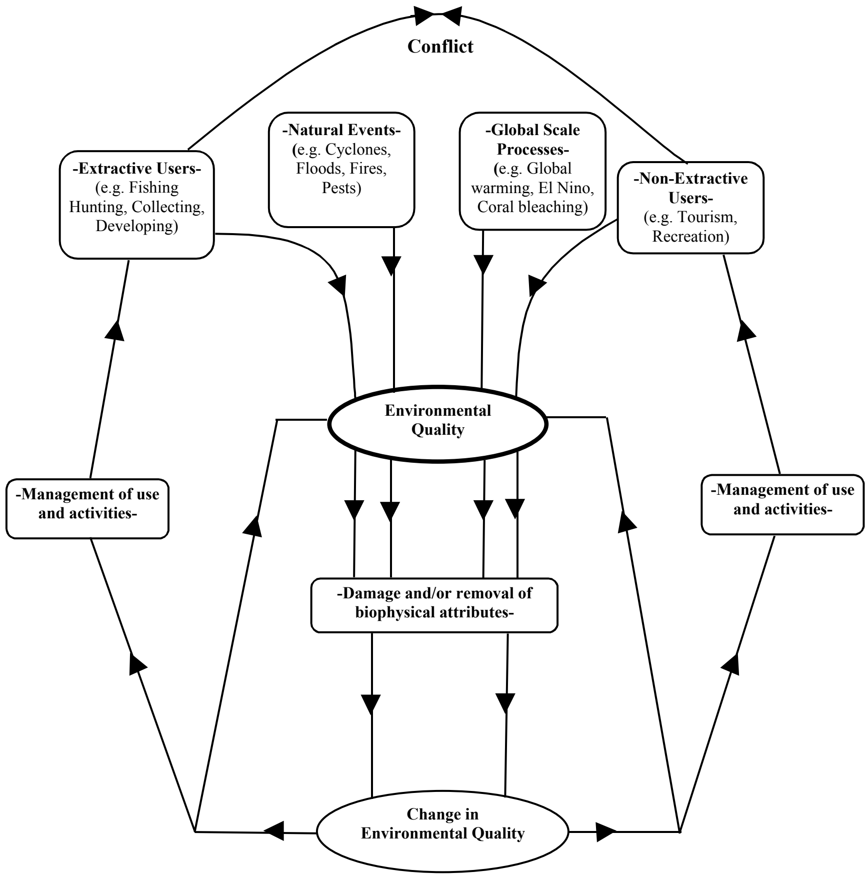
> '*Recreation research has been a search for the most effective framework for representing the value of quality recreation experiences and protecting that value through planning and management actions*' (Borrie and Birzell, 2001, p. 30).

The findings of the research presented in this thesis have important management implications for maintaining and protecting the biophysical attributes that are most significant to the wildlife tourism experience on coral reefs. This research has demonstrated that taking an experience-based approach to understanding the interaction that takes place between the participant and the environment can play a critical role in managing natural areas for their ecologically sustainable use for tourism. This is achieved by identifying those biophysical and social attributes that are essential to the maintenance and protection of quality experiences for visitors. Natural areas important to tourism should be managed for the types of visitors that go there, according to their needs, a concept inherent in the ROS and LAC frameworks (Driver et al., 1987; Stankey et al., 1985). Therefore limits regarding the use and allocation of resources may need to be set including the number and types of accessible sites and different user groups. Both of these considerations will maximise tourism numbers through correct resource allocation, while also maintaining quality experiences and protecting special values. The future potential of wildlife tourism, and its ability to provide positive outcomes, is entirely dependent on decisions being made today regarding significant attributes and the environment as a whole (Birtles et al., 2001).

This section on management implications focuses on the factors that have potential to damage and/or remove the biophysical attributes most significant to visitors' experiences. These factors are: extractive users; non-extractive users; natural events;

and global scale processes. The ways that these factors negatively impact the environmental quality and the biophysical attributes, and the conceptual links that they have to each other can be seen in Figure 7.1.

Figure 7.1. Factors affecting the environmental quality and biophysical attributes of natural areas that tourism depends on for the attraction of visitors and the experiences they have.



7.3.1 <u>Extractive users</u>

Extractive user groups like commercial and recreational fishers, hunters, collectors, and developers are any users that through their activities act to remove, or in the process of removing may inadvertently also damage biophysical attributes. These impacts are usually the immediate removal of species. Within the GBR Marine Park (GBRMP) there are specific zones (see Chapter One), where certain user groups are allowed to undertake extractive activities, and limits have been set regarding the amount they are able to take. Before July 1, 2004, there were less than 5% 'no-take' zones by area, but since this date, this has been increased to more than 33% through the Representative Areas Program (RAP) (GBRMPA, 2005c). Many of the high-use tourism sites of the GBR fall within the 'no-take' zones, and are thus afforded a higher level of protection, although this is largely dependent on education, compliance, surveillance and enforcement.

Osprey Reef in the Coral Sea, and many of the other coral reef locations around the world, are not afforded any level of protection from extractive users, making them vulnerable to use and misuse by human activities, especially commercial fisheries (Kenchington, 1990). This is where conflicts will most likely arise between extractive and non-extractive users (Davis et al., 1995; Kenchington, 1990), as seen in Figure 7.1. Because of the demonstrated value of Osprey Reef to divers' experiences and therefore the diving industry, it is recommended that Osprey Reef, and other coral reef locations that are of high value and importance to tourism that have no level of protection, be considered for Marine Protected Area (MPA) status. Reef-based tourism has often been the driving force for MPA establishment and maintenance (Arin & Kramer, 2002; Colwell, 1998; Dixon, 1993; Fenner, 2001; Spalding et al., 2001; Wilkinson, 2004a), protecting both the values of the resource and the economies which they support.

In a coral reef fishery context the types of organisms targeted are varied and include: squid, prawns, snapper, wrasse, mackerel, tuna, trevally, coral trout, and various cod species (DPI, 2002). Sharks are also heavily targeted by fisherman (Anderson & Ahmed, 1993; Gribble, Whybird, Williams, & Garrett, 2005). Sharks are taken in increasing numbers worldwide, most prized for their fins that are used primarily in shark-fin soup, considered a delicacy in several Asian countries. Once the fins are removed the rest of the animal is often returned to sea, usually alive, with no chance of survival. Not only is this cruel and inhumane practice, but is of international concern to researchers and managers. This is because aspects of sharks' reproductive characteristics (and lack of knowledge of these for many species) including slow growth rates, late maturity, and low fecundity and productivity, make current take levels unsustainable (Stevens, Bonfil, Dulvy, & Walker, 2000; USA Department of Commerce, NOAA., & National Marine Fisheries Service, 2001; WILDAID, 2001).

The practice of removing shark fins and discarding the body at sea is now banned in the GBRMP (GBRMPA, 2005b), yet illegal finning activities have been observed even during the course of this research. Eight grey reef sharks were found dead and illegally finned at Challenger Bay, a popular dive site only 0.5 km away from Pixie Pinnacle, one of the study sites used in this thesis (pers. obs). Because of the high price tag associated with shark fin products, and because reef sharks occur with high frequency and abundance at some sites, these animals and the tourism experiences they provide are under considerable threat from extractive use. At sites where they are removed, tourism is significantly and negatively impacted (Anderson & Waheed, 2002).

In a coral reef commercial and recreational collecting context, mainly for the commercial global trade in ornamental species, the target species are also varied and include: soft corals, live coral, coral rock, shrimp, small clams, clown fish, angelfish, damsels, and surgeonfish (MAC, 2005). Extractive users might also take a more destructive approach to the removal of species such as dynamite or cyanide fishing (very unlikely within the GBRMP), and in doing so affect other components of the reef community. Dynamite fishing techniques require the use of explosives that kill and destroy all life within a given area including fish, coral, and invertebrates (ICRIN, 2004). This method is used to collect numerous small reef fish for food in a short period of time. Cyanide fishing requires the use of concentrated cyanide for capturing live reef fish for the seafood and aquarium markets. Cyanide is extremely harmful and often fatal to corals and invertebrates (ICRIN, 2004).

It is clear that the target species taken and the indirect impacts of extractive use are in direct conflict with reef-based tourism. This is because the very same attributes that the extractive user groups target are also those that provide the best experiences for visitors. Because of this, it is unlikely that tourism and extractive user groups can share the same resource. In comparison to the extractive use of resources, a greater benefit and ultimately a higher economic return can be gained from the natural resource when it is used by tourism (Birtles et al., 2001). For example, one single live grey reef shark was estimated to be worth US$33,500 per year to dive tourism in the Maldives, as opposed to the dead, one-time value of US$32 to a local fisherman (Anderson & Ahmed, 1993). Furthermore, the value of tourism within the GBR Catchment Area was recently valued at $5.1 billion per annum, while commercial fishing in the same area was valued at

$149 million (Access Economics, 2005). Given that tourism is the largest and most important economic industry associated with the GBRMP World Heritage Area (Access Economics, 2005; Harriott, 2002; Productivity Commission, 2003), as it is in many other coral reef locations around the world (Anderson & Waheed, 2002; Davis, 1993; Pendleton, 1994), and that sustainable tourism depends on healthy, vibrant, and attractive coral reefs (Chadwick, 2005), the decision regarding which user groups goals are most important should not be a difficult one.

The following are recommendations for the management of extractive users and coral reef tourism:

- where possible, extractive activities should not be undertaken on tourism sites as these act to remove and/or destroy many of the attributes visitors come to see;
- where possible, important tourism sites should be afforded a high level of protection, such as the ‘no-take’ zones of the Great Barrier Reef Marine Park;
- where extractive activities and tourism co-exist, agreements should be made between the different users as to how much, and what type, of extraction is acceptable. An examination of the methods used for extraction will also be of the highest importance as some methods will cause greater and longer term damage than others;
- management of protected areas and extractive activities must take into account the biology and ecology of a wide range of species to ensure management arrangements will be effective;
- unsustainable fishing practices should be examined with high scrutiny to ensure long term ecological damage, and thus tourism value, will not ensue from these activities; and

7.3.2 Non-extractive users

While it might be expected that non-extractive users will have little to no impact on biophysical attributes because their activities are not aimed at negatively affecting natural resources, their presence, especially in elevated numbers, can nevertheless cause considerable damage to the environmental quality of a site (Wielgus et al., 2002; Zakai & Chadwick-Furman, 2002). This concept of “loving” a natural area “to death” (Fishman, 1991) has been the driving force behind attempting to estimate visitor carrying capacities (Borrie et al., 1998; Hawkins & Roberts, 1997) and reactive management frameworks (Stankey et al., 1985). The negative impacts that tourism itself can have on the environmental quality can be significant and in some reef-based communities tourism is seen as both an opportunity and a threat (Hawkins & Roberts, 1992a).

The GBRMP is a prime example of the above and has been the focus of several studies on the impacts of tourism (Edwards, 1997; Harriott, 2002; Rouphael & Inglis, 1995, 1997, 2001; Shafer et al., 1998; Sweatman, 1996). As mentioned earlier, it is well accepted that SCUBA divers and snorkellers can impact coral quality, and thus site aesthetics (Hawkins & Roberts, 1992b; Rouphael & Inglis, 1995; Zakai & Chadwick-Furman, 2002). Bad anchoring practices, and the lack of moorings can also cause considerable damage to large areas of corals (Harriott, 2002; Tratalos & Austin, 2001). Because corals were found to be such a significant reef attribute in this and other research (Birtles et al., in prep; Curnock, 1998; Pendleton, 1994; Shafer et al., 1998), reef managers need to address ways of mitigating the cumulative impacts of non-extractive user groups on the coral condition. This is because all of the above impacts act to increase the level of visible coral and reef damage. One of the most promising ways to reduce this type of damage to the coral is likely to be through education programs for the recreation and commercial user groups, and the visitors themselves (Brylske, 1999, 2000; Madlin & Fenton, 2004; Medio et al., 1997; Moscardo, 1999; Townsend, 2000).

The following are recommendations for the management of non-extractive users and coral reef tourism:

- managers should ensure that tourism operators and their crew are trained and educated to undertake tourism activities to environmental best practice standards. These messages in turn will filter down to the passengers through effective interpretative activities;
- placing limits on the number of tourism operations, and/or the number of visitors that may visit particular locations, will assist in the ecologically and economically sustainable management of tourism important sites;

- having a permit system that provides tourism operations and marine park management guidance on the activities allowed and the places these can take place will minimise the potential for environmental impacts to occur;
- providing the capacity for marine park management, or individual tourism operations, to install moorings will reduce the amount of coral damaged through poor anchoring practices; and
- management should invest great time and money in educating coral reef users at all levels from operators to visitors about sustainable and best practice uses of coral reef sites to maximise visitor experiences and minimise operational impacts.

7.3.3 Natural events

Natural events, for example tsunamis, cyclones, floods, fires, and pests can all impact negatively on the environmental quality of a site. In a coral reef context natural events are usually restricted to cyclones, tsunamis, severe storms, floods, and disease and pest outbreaks. In experiencing these, reefs can be damaged or weakened, but healthy ones generally are resilient and eventually recover. Cyclones and severe storms can have devastating effects, clearing large sections of coral reefs of delicate and branching corals (Nybakken, 1997). These events also cause large scale flooding, and river discharges during this time are the single biggest source of nutrients to inshore areas of reefs which result in a range of impacts that affect corals by promoting phytoplankton blooms and macroalgal growth which act to out-compete the coral (GBRMPA, 2005d). Flooding also increases suspended sediments that act to reduce the horizontal visibility of the water. Coral reefs also face diseases that can almost wipe out entire species (Hughes, 1994), having long lasting and flow-on effects on coral reef communities. Crown-of-thorns starfish outbreaks can be devastating to the coral condition because the animals seek out and consume live coral cover (Reef CRC, 2003). The starfish are able to impact on both small (individual coral colonies) and large scales (entire reefs). Because their feeding activities in large numbers effects coral so significantly, control measures cost the tourism industry on the GBR and the Queensland and Commonwealth Governments about AUD$3 million annually (Reef CRC, 2003). Wilkinson (2004a), acknowledges the threat imposed by the crown-of-thorns starfish is of a global scale.

The negative impacts that natural events have on coral reefs are again focussed on reducing the coral condition, especially the colour, diversity, structure, and abundance, as well as the horizontal visibility of the water; all attributes found in this research to positively influence divers' experiences. While there is little that management intervention can do in most cases to curb or alter the impacts of natural events on coral reefs, it is essential that reef managers and operators are aware of the potential for these to negatively influence the tourist experience. In extreme cases natural events might have long lasting effects on reef-based economies.

The following are recommendations for the management of natural events and coral reef tourism:

- management of tourism activities must acknowledge the potential for natural events to damage specific attributes of tourism sites. Contingency plans must be put in place for such events if tourism is to remain viable;
- management should place great emphasis on educating tourism operators and their crew about the potential impacts of natural events, how to identify their onset and how to provide high quality interpretation of these events to visitors to ensure the correct messaged are being conveyed; and
- management should also place great emphasis on educating visitors about natural events in areas that are susceptible to these, and in so doing promote truth in marketing.

7.3.4 Global scale processes

Global events are quickly becoming real threats to many natural areas of the world, particularly in the case of global warming. The effects of global warming on coral reefs are now documented every year, and come in the form of coral bleaching (Hoegh-Guldberg, 1999). Coral bleaching events can impact on coral reefs worldwide (Wilkinson, 2004b) by damaging or killing reef building corals (Spalding et al., 2001). The largest known coral bleaching and mortality event was in 1998, when an estimated 16% of the world's area of coral reef was severely damaged, with some areas such as the Indian Ocean and South East Asia more affected than others (Wilkinson, 2004a). In some cases, the bleaching so severely affected coral cover and structure that areas no longer resembled coral reefs (Wilkinson, 2004a). Because of the high importance placed on the coral structure, colour, and size by reef visitors in this and in other studies (Curnock, 1998; Pendleton, 1994; Shafer & Inglis, 2000; Shafer et al., 1998; Williams & Polunin, 2000), coral bleaching poses probably the largest and most wide spread threat to coral, coral reefs, and reef-based tourism. Indeed this has been demonstrated to be the case for coral reefs and reef-based tourism in the Philippines (Cesar, 2000), Zanzibar (Ngazy et al., 2004), and Palau (Graham et al., 2001).

The following are recommendations for the management of global scale processes and coral reef tourism:

- management of tourism activities must acknowledge the potential for global scale processes to damage specific attributes of tourism sites. Contingency plans must be put in place for such events if tourism is to remain viable;
- management should place great emphasis on educating tourism operators and their crew about the potential impacts of global scale processes, how to identify their onset and how to provide high quality interpretation of these events to visitors to ensure the correct messaged are being conveyed; and
- management should also place great emphasis on educating visitors about global scale processes that pose a threat to local areas, and in so doing promote truth in advertising.

7.3.5 <u>Implications for tour operators</u>

This research has also highlighted several implications for tour operators. Given that different types of divers perceive and evaluate reef settings differently, operators might choose sites that appeal to the type of visitors that they attract. While it is likely that ‘beginner’ divers will have quality experiences on sites that are not of the highest environmental quality, more specialised divers are less likely to be attracted to these. In Studies Three and Four, it was also clear that the pre-dive briefing plays an important role in interpreting and educating visitors about the biophysical attributes that occur at sites, and are effective in directing divers to particular attributes of interest. It is likely that visitors’ experiences in natural areas can be enriched if they are alerted to biophysical attributes in an area that can be presented as special/unusual through interesting facts, stories, or descriptions during the pre-dive briefing and interpretation presentations. This avenue of thinking will be of the highest importance at sites that receive very high annual visitor numbers, or are at risk or have already suffered, some form of site degradation. To ensure that these sites remain useful as tourism resources, specific interpretation techniques need to direct visitors to the attributes that are known to positively influence divers' experiences aided by resource assessments (Hammitt et al., 1993), while also educating divers to dive in an eco-friendly manner (Brylske, 1997, 1999; Medio et al., 1997; Townsend, 2000). Interpretation should also concentrate on ways of preparing visitors appropriately at sites that have been degraded by coral bleaching or crown-of-thorns starfish for example, so they understand the processes that have taken place. This is important because it is clear that the divers in this sample are already aware of cumulative impacts of diving activities at sites, as well as the impacts of natural and global events.

This research also found that divers' expectations for the sites they visit have a significant impact on how much the sites are enjoyed. It is important then that operators promote truth in marketing so that visitors' expectations can be easily met, if not exceeded by their actual experiences. This means being realistic about the biophysical attributes that divers are likely to encounter on individual dive sites, and therefore not overselling a site.

It is also in the operators' best interest to manage their style of operation and the visitors they accommodate in a way that causes the least possible environmental impacts to their sites. It is common sense that healthy reef sites equal healthy tourism. In areas where sites are shared amongst several operators, it will be essential that operators engage and communicate with each other to ensure that all activities are undertaken in the most sustainable manners so as not to disadvantage others. To this end it will also be of the highest importance that new and current crew are trained to a high level in the following:

- basic marine biology and ecology:
- effective interpretative techniques;
- visitor and site management;
- Marine Park management arrangements; and
- best environmental practices for marine tourism operations.

7.4 Limitations of the study

In undertaking this multidisciplinary research there were several limitations. These are as follows:

- The sample of certified SCUBA divers took part in this research voluntarily. Therefore, only those divers with an interest in describing their expectations, experiences, and evaluations of their SCUBA diving experience participated.
- It is likely that the length of the questionnaire contributed to reducing the response rate, as did the fact that it was available only in English. Therefore only respondents that could read and write proficiently enough in English participated in the study. It is also possible that seasickness and the difficulty of writing on a moving boat might have also meant than some divers refused to participate. However, the detail and richness of the data provided by the 651 respondents (with a response rate of 53.9%) that did complete the questionnaire justified this technique.
- Crew employed by the six operators that took part in this research largely undertook the sampling procedures used for Studies One, Three, and Four. Crew were instructed to distribute and explain the questionnaire to passengers before leaving port. It is assumed that this technique was adhered to throughout the sampling period. The researcher made regular personal visits to reinforce the technique and support crew with the surveys.
- It was not possible to strictly control the exact timing that respondents filled out the three sections of the questionnaire, that is, before diving had taken place, after diving at the specific dive sites, and once all diving for the trip had been completed. This meant that some participants might have completed the entire questionnaire at the end of the trip. To ensure that respondents did fill out each section at the appropriate time, the crewmember that did administer the questionnaire at the start of the trip was given a one-page instruction sheet that was read verbatim to the respondents (Appendix A). A similar set of instructions was also provided in the questionnaire (Appendix B). The instructions stressed the need to complete each section at the three stages of the trip, and the crew were asked to remind respondents at each of these stages to complete the appropriate section. The richness of information provided in each of the three sections of the questionnaires by the 651 respondents, and the differences observed between the pre-trip and post-trip

responses, provides a positive indication that in the majority of cases the questionnaire was completed as originally designed. This methodology is likely to have been as successful as it was because certified SCUBA divers willingly complete a dive log (a record of each dive) immediately after each dive. The design of the questionnaire content closely reflected the information that divers would record in their dive logs, thus making the questionnaire almost an extension of this behaviour. This method might not be suitable for tourists that do not willingly keep a record of their experiences.

- Marine scientists that had very high levels of local knowledge and history with the study sites collected the presence/absence and relative abundance data in Survey 4 of Study Two. This meant that they were able to find each of the organisms that were surveyed on the study sites with much greater ease than it might be expected a visiting diver would. This was especially the case for the more cryptic organisms. The Animal Importance Index (AII) assumes that all divers have the same opportunity to view the animals surveyed, however it is likely that the divers did not find animals like the stonefish and red flame file shell as often as the researchers did.
- The number of divers in the DACRH specialization group sample for 'beginners' in Study Four was quite low (n=18). This was because respondents that visited the Ribbon Reef location only were removed from the data set. This caused a significant location effect in the results for diving experiences and ratings of site quality between those respondents that visited the Ribbon Reef location in a single trip, and respondents that visited both the Ribbon Reef and Osprey Reef locations in one trip. Therefore, respondents who visited only the Ribbon Reef location confounded the differences observed between DACRH specialization groups. Smaller sample sizes for the 'beginner' and 'intermediate' groups occurred because fewer divers from these groups took part in the Ribbon Reef and Osprey Reef trip than they did in just the Ribbon Reef trip.

7.5 Recommendations for future research

This thesis represents one of the first studies to investigate the wildlife tourism experience in terms of the specific interactions between the participant and the environment, and how the type of participant modifies this interaction. Hopefully it will provide the foundation for future research that extends the results of the studies reported here. Based on the results of this thesis, future research should focus on several areas. These are:

- economic evaluation of biophysical attributes most significant to divers' experiences, and the tourism generated by these experiences;
- a greater understanding of the biology and ecology of significant attributes, and the impacts, both anthropogenic and natural, that threaten their existence and sustainable use by tourism;
- monitoring of significant attributes and determining at what levels of damage and/or removal the tourist experience and the ecological sustainability of the attributes is compromised;
- how interpretation can direct and enrich experiences, as well as act to manage the behaviour of SCUBA divers while underwater to minimise their impacts to significant attributes at sites; and
- replication of results in other locations important to tourism for direct comparisons.

This research has provided the first step in determining economic values for the biophysical attributes, sites, and even locations most significant to divers' experiences, and the tourism generated by these experiences. Economic valuation stems from the need to generate a better and more comprehensive informational base for policy formulation and decision making (Turner et al., 2003). This is because natural systems are viewed as multifunctional assets in the sense that the environment provides humans with a range of economically valuable functions (Turner, Pearce, & Bateman, 1994). With this information managers will be able to better appreciate the importance and value of the natural resources, especially when trying to cope with the allocation of resources among competing user groups (Cole & McCool, 1998).

There is a critical need to understand the biology and ecology of significant biophysical attributes, why and where they occur, and the impacts that threaten their existence and use by tourism (Birtles et al., 2001). At present we know little about the biology, ecology, and population dynamics of some of the most important species to divers' experiences such as reef sharks, manta rays, turtles, large cod and grouper, and corals, for example. Furthermore, we know even less about the severity of impacts that threaten their existence, including overfishing and collecting, habitat destruction, global warming, and even tourism itself. These detailed marine wildlife tourism research needs fit very well within the framework of research information needs outlined by the GBRMP Authority for the protection and management of the GBRMP (GBRMPA, 2005e). This type of information will be critical to those that make decisions regarding the future use and sustainability of coral reef resources.

Research presented in this thesis has identified the biophysical attributes that are most significant to divers' experiences. Future research needs to establish what are the socially acceptable limits to change in the condition of these attributes (GBRMPA, 2005e), past which point visitors' experiences will be significantly compromised (Cole & McCool, 1998). This represents the next step in the LAC planning process (Stankey et al., 1985). Such research needs to incorporate measurements that align both social and ecological thresholds to provide managers with the triggers needed to make decisions regarding the continued use and utility of the resources in question, by a range of non-extractive and extractive users (Borrie et al., 1998).
Future research might also concentrate on enhancing interpretive materials to enrich visitors' experiences and promote GBRMP values and messages (GBRMPA, 2005e), as well as managing visitors' in-water behaviour to minimise their cumulative impact at sites (Harriott et al., 1997; Medio et al., 1997). As mentioned earlier, this level of understanding will be of the highest importance at sites that receive very high annual visitor numbers or have already suffered some form of site degradation. Which methods are most useful for delivering this content, and how effective it can be to a wide range of participants will be of critical importance to both operators and managers aiming to provide quality wildlife tourism experiences for reef visitors.

Finally, results of this thesis should be repeated in other important coral reef dive locations. This would provide direct comparisons to other locations, and in so doing provide an understanding of the biophysical attributes that occur there, the types of certified SCUBA divers participating in diving activities, and the attributes of highest importance and value to tourism in each location. This would allow managers of coral reef areas in different locations to focus management and conservation efforts towards those specific attributes that provide visitors with the highest quality experiences. This will ensure not only the sustainability of the environment, but also the sustainability of the economically important tourism industry that depends on the quality of the environment for the attraction of visitors and the experiences they have.

7.6 Conclusions

The research presented in this thesis has provided an essential step in understanding the complexity and richness of the certified SCUBA diving experience on coral reefs for a wide range of divers. Their diverse, and very high-quality experiences are testament that the sites studied here are some of the best in the world, and that the GBR and Coral Sea reefs are truly amazing places to visit. It is hoped that the findings of this thesis will inspire and empower researchers, managers, tour operators, conservationists, and of course divers, to argue for the right to ensure that these, and other coral reef locations around the world are protected and conserved for future use, and that their existence is assured for future generations of SCUBA divers.

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APPENDIX A

One page introduction of research and its aims, and instructions for completing questionnaire. Laminated and given to crewmembers on each vessel to read when administering survey instrument.

Checklist for Crewmember administering JCU Research Questionnaires

At start of trip during Skippers/Trip directors briefing please provide information on project

This research from James Cook University in Townsville explores the diving experiences of passengers aboard 3-6 day live-aboard diving expeditions to the Ribbon Reefs and Osprey Reef

Very little is known about what visitors to the Great Barrier Reef and Osprey Reef expect and enjoy when visiting these areas

It is necessary to ensure that visitors continue to have high-quality dive experiences while also minimising the impacts to the environment. This will ensure the long-term ecological sustainability of the Great Barrier Reef and the diving industry

The information gathered in this study will assist with the planning and management of sustainable diving practices both locally and in other areas

Provide information about participation

Participation in this research is <u>entirely</u> voluntary

Information regarding individual participants is strictly confidential

Information regarding specific named boats is strictly confidential

Your participation in this research is greatly appreciated

Provide information on how to complete questionnaire

The questionnaire is split up into three sections –each section takes only a few minutes

The first section is to be filled in now before any diving has taken place

The second section refers to five specific dive sites and are to be filled in after each one has been completed. There is no particular order for these dive sites. If you do not dive or visit a particular dive site please leave it blank.

The third and final section is to be filled in after all diving has been completed at the end of the trip

Please answer *<u>all</u>* questions as best you can from your knowledge, feelings, and experiences

At the end of trip please return completed questionnaires to a crew member

Provide enough questionnaires for all passenmgers and supply pens

During trip

Please remind passengers that questionnaires need to be filled in after the following dives
Pixie Pinnacle, Cod Hole, Steve's Bommie, North Horn, Admiralty Anchor
Note: If a dive site is not visited please ask passengers to leave section blank

At end of trip please remind passengers to complete questionnaires and return to a crew member-*thank them for their participation – and thank you very much!!!!!!!*

APPENDIX B

Questionnaire

Towards sustainable high-quality diving experiences

QUESTIONNAIRE 2003-2004

JCU JAMES COOK UNIVERSITY

CRC Reef Research Centre

CHARROA
Cod Hole and Ribbon Reef Operators Association

crc Sustainable Tourism
crctourism.com.au

-Introduction-

This research is exploring the experiences of SCUBA divers on 3-6 day live-aboard diving expeditions to the Ribbon Reefs in the Cairns Section of the Great Barrier Reef Marine Park, and to Osprey Reef in the Coral Sea. Very little is known about what visitors to these areas expect and enjoy when diving on coral reef dive sites. It is important that visitors continue to have high-quality dive experiences while minimising their impacts on the environment for the long-term ecological sustainability of the diving industry.

Please answer all questions as best you can from your knowledge, feelings, and experiences. The information gathered in this study will assist with the planning and management of sustainable diving practices both locally and in other areas.

Information regarding individual participants is strictly confidential. No names, addresses or any other identifying information is recorded so your responses in this questionnaire cannot be traced to you. Your participation is of course entirely voluntary.

This questionnaire is divided into three sections. These will be spread out over your entire trip.

Section 1- Before Diving. This section is four pages long and must be completed before you make your first dive for the trip. This section explores your diving history and any expectations you may have. This section will take approximately 10 minutes.

Section 2 – Specific dive sites. This section is broken up into five specific dive sites labelled at the top of the pages. Please answer all the questions in the appropriate section after you have completed that dive. A good time to do this is when you are filling out your log-book. This section explores your enjoyment and experiences of the selected sites. (If you miss a dive site for any reason please leave it blank.) Each section will take less than five minutes.

Section 3 – End of trip. This section is two pages long and is to be completed at the end of the trip. This section explores your overall experience. Please answer all questions as best you can and then return to a crew-member. This section will take approximately five minutes. I look forward to your comments. Thank you.

This research is being undertaken with the support of local tourism operators, the *Association of Marine Park Tourism Operators* (AMPTO), the *Cod Hole and Ribbon Reef Operators Association* (CHARROA), and is funded by *James Cook University*, *CRC Reef, CRC Sustainable Tourism*, and *Undersea Explorer*. The sampling period for this research is from July 2003 to March 2004. Supervised by Dr Alastair Birtles (TOURISM) and Mr Peter Valentine (TESAG) of James Cook University, and Andy Dunstan of Undersea Explorer.

For any questions or complaints about this research please contact either:

Dean Miller
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James Cook University
Townsville, QLD 4811
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Information concerning specific named boats is *STRICTLY CONFIDENTIAL*. It will neither be published nor released to managers and other operators. Operator's support in conducting this research is greatly appreciated and we hope that the information collected will contribute to the long term sustainability of the industry

When you have completed this questionnaire, please return it to the crew of your boat

You are welcome to tear off and keep this cover page

Thank you for your participation!

Survey number

☐ ☐ ☐ ☐ c

please complete ***before diving***

about you

❑ **Female** ❑ **Male** **Year of Birth**__________

Dates of trip______________to________________ **Name of Boat**________________________________

Country of residency______________________________**(if Australia, please include postcode)**___________

1. Have you dived on the Great Barrier Reef or at Osprey Reef before this trip?

❑ **Yes** ❑ **No** If yes, how many other visits have you made?__________________________

2. Have you dived at other coral reef locations around the world? ❑ **Yes** ❑ **No**
(if yes, tick as many as apply)

❑ Red Sea ❑ Caribbean ❑ South Pacific ❑ Other Pacific ❑ South East Asia
❑ East Africa ❑ Other Indian Ocean ❑ Other____

3. How important was this diving trip in your decision to come to this part of Australia?

(please circle one number)

not at all important 1 2 3 4 5 6 7 8 9 10 extremely important

4. Why did you choose to go diving on the Great Barrier Reef and/or Osprey Reef?

____

____

5. What is special to you about diving on coral reefs in general?

____

____

6. What SCUBA diving organization were you trained by? (PADI, NAUI etc.)______________________

7. What is the highest SCUBA diving certification that you have completed? (or equivalent)

❑ Open water diver ❑ Rescue diver ❑ Instructor
❑ Advanced Open Water ❑ Dive Master ❑ Other________________________________

8. What year did you begin SCUBA diving?_____________

9. Approximately how many dives have you made?

In the last 12 months ________________dives
Grand total ________________dives
On coral reefs ________________dives

What is your previous maximum dive depth? ___________m
What is your most comfortable maximum dive depth? ___________m

10. Have you worked professionally in marine environments? ❑ **Yes** ❑ **No**
(Dive instructor, marine biologist, etc.)

(if yes please explain)____

____

11. What is the highest level of education that you have completed?

- ❑ Some high school or less
- ❑ Completed high school
- ❑ Some college or university
- ❑ Completed college or university
- ❑ Some post-graduate program or professional school
- ❑ Completed post-graduate or professional school degree

12. How do you rate your diving ability?

(please circle one number)

basic 1 2 3 4 5 6 7 8 9 10 extremely competent

13. Please select one category that best describes your level of diving development.

❑ **Beginner** ❑ **Intermediate** ❑ **Skilled** ❑ **Highly Skilled**

14. Do you own:

Diving equipment (eg. BCD, Regs)? ❑ **Yes** ❑ **No** Underwater camera? ❑ **Yes** ❑ **No**
A coral reef guide book? ❑ **Yes** ❑ **No**

15. At what level do you rate your coral reef knowledge?

(please circle one number)

basic 1 2 3 4 5 6 7 8 9 10 very advanced

16. When diving on a coral reef, what characteristics would you use to define:

High coral quality?____

Low coral quality?____

17. The following statements describe a diver's interest and knowledge of coral reef marine life. On the 5-point scale please indicate how <u>accurate</u> each statement is for <u>you</u>.

1=not at all accurate, 5= extremely accurate

I know more about coral reefs than most recreational divers	1	2	3	4	5
I know a great deal about my favourite aspects of coral reefs	1	2	3	4	5
I have seen many different coral reefs	1	2	3	4	5
I attach great importance to being able to identify coral reef organisms	1	2	3	4	5
I very often look up identification books after I complete a dive	1	2	3	4	5
I travel to diving destinations to see specific animals and habitats	1	2	3	4	5
I know the behaviour and habits of many coral reef organisms	1	2	3	4	5
I am a good judge of coral reef dive site quality	1	2	3	4	5
I go diving on coral reefs because the marine life interests me a lot	1	2	3	4	5

about your expectations for this diving trip

In the following two questions the term <u>environmental quality</u> refers to both the abundance and size of individual reef species and the overall diversity of corals, marine fish and other animals.

18. What do you expect the environmental quality of the <u>Great Barrier Reef</u> dive sites to be?

(please circle <u>one</u> number)

very low quality 1 2 3 4 5 6 7 8 9 10 very high quality

19. What do you expect the environmental quality of the <u>Osprey Reef</u> dive sites to be?

(please circle <u>one</u> number)

very low quality 1 2 3 4 5 6 7 8 9 10 very high quality

20. What three marine animals do you most <u>want</u> to see while diving <u>on this trip</u>?

1. ______________________________
2. ______________________________
3. ______________________________

21. Are there any particular marine animals that you expect to see while diving on this trip?

(Please list three and briefly explain why) ❑ **Yes** ❑ **No**

1.______________________________ Why?____
2.______________________________ Why?____
3.______________________________ Why?____

22. When diving on a coral reef in general, what three things in order of preference do you most enjoy seeing?

(1 = most important)

1. ____
2. ____
3. ____

23. While diving on the Great Barrier Reef and Osprey Reef dive sites for this trip, how common do you expect each of the following features to be?

(please circle one number for each feature, **or tick the box if feature will not be present**)

1 = rare, 5 = very common

	Not present							Not present					
Big fish (>50cm)	❑	1	2	3	4	5	Sharks	❑	1	2	3	4	5
Diverse fish life	❑	1	2	3	4	5	Diverse coral life	❑	1	2	3	4	5
Potato cod/groupers	❑	1	2	3	4	5	Large schools of fish	❑	1	2	3	4	5
Manta rays	❑	1	2	3	4	5	Other rays	❑	1	2	3	4	5
Cuttlefish and octopus	❑	1	2	3	4	5	Nudibranchs	❑	1	2	3	4	5
Turtles	❑	1	2	3	4	5	Sea snakes	❑	1	2	3	4	5
Interesting landscape	❑	1	2	3	4	5	Lots of fish	❑	1	2	3	4	5
Beautiful corals	❑	1	2	3	4	5	Crustaceans (eg. Crabs)	❑	1	2	3	4	5
Sea cucumbers	❑	1	2	3	4	5	Good visibility	❑	1	2	3	4	5
Other______________ ___________________	❑	1	2	3	4	5	Pelagic fish (eg. Tuna)	❑	1	2	3	4	5

24. What was the main source of information that you used to find out about diving on the Great Barrier Reef and Osprey Reef?

____

25. Is there anything else about yourself, diving, or your expectations that you would like to add?

____
____
____

end of section

please complete after diving **Steve's Bommie - GBR**

Date of dive____________**Time of day** ____________**Visibility (m)**________**Your max depth (m)**______

1. What were the <u>three</u> best features of this dive site?

1.________________________ Why?_____________________________________
2.________________________ Why?_____________________________________
3.________________________ Why?_____________________________________

2. Overall, how much did you enjoy this dive site?

(please circle one number)

not at all 1 2 3 4 5 6 7 8 9 10 very much

Please explain why you felt this way

____
____

3. What do you think are the most important aesthetic values of this dive site?

____
____

4. Summarise in one or two words how you felt during this dive.

____

5. Overall, how well did this dive site meet your expectations?
(please tick one box and give a brief explanation why)

❏	❏	❏	❏	❏
Fell well below my expectations	Somewhat below my expectations	Met my expectations	Somewhat above my expectations	Well above my expectations

Why did you feel this way? ____
____

6. Overall, how would you rate the coral quality at this dive site?

(please circle one number)

very low quality 1 2 3 4 5 6 7 8 9 10 very high quality

7. Overall, how would you rate the fish life at this dive site?

(please circle one number)

very low quality 1 2 3 4 5 6 7 8 9 10 very high quality

8. Overall, how would you rate the information you received in the dive brief about this dive site?

(please circle one number)

very poor 1 2 3 4 5 6 7 8 9 10 excellent

(Please list)

1.____

2.____

3.____

If yes, how did you feel about this?____

10. Was there anything specific at this site about which you would have liked more information?

____

____

11. Overall, how would you rate the human impacts at this dive site?

(please circle one number)

no impact 1 2 3 4 5 6 7 8 9 10 high impact

12. How important were the following features in contributing to your enjoyment of this dive?

(please circle one number for each feature, **or tick the box if feature was not seen**)

1=not at all important, 5=extremely important

	Not Seen							Not Seen					
Big fish (>50cm)	❑	1	2	3	4	5	Sharks	❑	1	2	3	4	5
Diverse fish life	❑	1	2	3	4	5	Diverse coral life	❑	1	2	3	4	5
Potato cod/groupers	❑	1	2	3	4	5	Large schools of fish	❑	1	2	3	4	5
Manta rays	❑	1	2	3	4	5	Other rays	❑	1	2	3	4	5
Cuttlefish and octopus	❑	1	2	3	4	5	Nudibranchs	❑	1	2	3	4	5
Turtles	❑	1	2	3	4	5	Sea snakes	❑	1	2	3	4	5
Interesting landscape	❑	1	2	3	4	5	Lots of fish	❑	1	2	3	4	5
Beautiful corals	❑	1	2	3	4	5	Crustaceans (eg. Crabs)	❑	1	2	3	4	5
Sea cucumbers	❑	1	2	3	4	5	Good visibility	❑	1	2	3	4	5
Other____________ ______________	❑	1	2	3	4	5	Pelagic fish (eg. Tuna)	❑	1	2	3	4	5

13. Did any of the following impact negatively on your experience at this dive site? ❑ **Yes** ❑ **No**

(please tick as many boxes as apply)

- ❑ Diver-coral contact
- ❑ Inexperienced divers
- ❑ Coral rubble
- ❑ Wildlife harassment
- ❑ Coral bleaching
- ❑ Bottom-time limit
- ❑ Damaged coral
- ❑ Moorings
- ❑ Divers with cameras
- ❑ Dead coral
- ❑ Not enough fish
- ❑ Maximum-depth limit
- ❑ Fish/shark feeding
- ❑ Not diverse enough
- ❑ Divers touching/petting marine life
- ❑ Too many divers
- ❑ Waste from boat
- ❑ Other______________________________

Please explain how you felt about this.

____

____

end of section

please complete after diving **Pixie Pinnacle - GBR**

Date of dive____________**Time of day** ___________**Visibility (m)**_______**Your max depth (m)**______

1. What were the three best features of this dive site?

1.__________________________ Why?_______________________________________
2.__________________________ Why?_______________________________________
3.__________________________ Why?_______________________________________

2. Overall, how much did you enjoy this dive site?

(please circle one number)

not at all 1 2 3 4 5 6 7 8 9 10 very much

Please explain why you felt this way

____
____

3. What do you think are the most important aesthetic values of this dive site?

____
____

4. Summarise in one or two words how you felt during this dive.

____

5. Overall, how well did this dive site meet your expectations?
(please tick one box and give a brief explanation why)

❑	❑	❑	❑	❑
Fell well below my expectations	Somewhat below my expectations	Met my expectations	Somewhat above my expectations	Well above my expectations

Why did you feel this way? ____
____

6. Overall, how would you rate the coral quality at this dive site?

(please circle one number)

very low quality 1 2 3 4 5 6 7 8 9 10 very high quality

7. Overall, how would you rate the fish life at this dive site?

(please circle one number)

very low quality 1 2 3 4 5 6 7 8 9 10 very high quality

8. Overall, how would you rate the information you received in the dive brief about this dive site?

(please circle one number)

very poor 1 2 3 4 5 6 7 8 9 10 excellent

(Please list)

1.____
2.____
3.____

If yes, how did you feel about this?____

10. Was there anything specific at this site about which you would have liked more information?

____

____

11. Overall, how would you rate the human impacts at this dive site?

(please circle one number)

no impact 1 2 3 4 5 6 7 8 9 10 high impact

12. How important were the following features in contributing to your enjoyment of this dive?

(please circle one number for each feature, **or tick the box if feature was not seen**)

1=not at all important, 5=extremely important

	Not Seen							Not Seen					
Big fish (>50cm)	❑	1	2	3	4	5	Sharks	❑	1	2	3	4	5
Diverse fish life	❑	1	2	3	4	5	Diverse coral life	❑	1	2	3	4	5
Potato cod/groupers	❑	1	2	3	4	5	Large schools of fish	❑	1	2	3	4	5
Manta rays	❑	1	2	3	4	5	Other rays	❑	1	2	3	4	5
Cuttlefish and octopus	❑	1	2	3	4	5	Nudibranchs	❑	1	2	3	4	5
Turtles	❑	1	2	3	4	5	Sea snakes	❑	1	2	3	4	5
Interesting landscape	❑	1	2	3	4	5	Lots of fish	❑	1	2	3	4	5
Beautiful corals	❑	1	2	3	4	5	Crustaceans (eg. Crabs)	❑	1	2	3	4	5
Sea cucumbers	❑	1	2	3	4	5	Good visibility	❑	1	2	3	4	5
Other__________ ______________	❑	1	2	3	4	5	Pelagic fish (eg. Tuna)	❑	1	2	3	4	5

13. Did any of the following impact negatively on your experience at this dive site? ❑ Yes ❑ No

(please tick as many boxes as apply)

❑ Diver-coral contact
❑ Inexperienced divers
❑ Coral rubble
❑ Wildlife harassment
❑ Coral bleaching
❑ Bottom-time limit
❑ Damaged coral
❑ Moorings
❑ Divers with cameras
❑ Dead coral
❑ Not enough fish
❑ Maximum-depth limit
❑ Fish/shark feeding
❑ Not diverse enough
❑ Divers touching/petting marine life
❑ Too many divers
❑ Waste from boat
❑ Other____________________________

Please explain how you felt about this.

____

____

end of section

please complete after diving **Cod Hole - GBR**

Date of dive_____________**Time of day** ____________**Visibility (m)**________**Your max depth (m)**______

1. What were the <u>three</u> best features of this dive site?

1.____________________________ Why?____
2.____________________________ Why?____
3.____________________________ Why?____

2. Overall, how much did you enjoy this dive site?

(please circle <u>one</u> number)

not at all 1 2 3 4 5 6 7 8 9 10 very much

Please explain why you felt this way

____
____

3. What do you think are the most important aesthetic values of this dive site?

____
____

4. Summarise in one or two words how you felt during this dive.

____

5. Overall, how well did this dive site meet your expectations?
(please tick <u>one</u> box and give a brief explanation why)

❏ Fell well below my expectations
❏ Somewhat below my expectations
❏ Met my expectations
❏ Somewhat above my expectations
❏ Well above my expectations

Why did you feel this way? ____
____

6. Overall, how would you rate the coral quality at this dive site?

(please circle <u>one</u> number)

very low quality 1 2 3 4 5 6 7 8 9 10 very high quality

7. Overall, how would you rate the fish life at this dive site?

(please circle <u>one</u> number)

very low quality 1 2 3 4 5 6 7 8 9 10 very high quality

8. Overall, how would you rate the information you received in the dive brief about this dive site?

(please circle <u>one</u> number)

very poor 1 2 3 4 5 6 7 8 9 10 excellent

(Please list)
1.______________________________
2.______________________________
3.______________________________

If yes, how did you feel about this?______________________________

10. Was there anything specific at this site about which you would have liked more information?

____
____

11. Overall, how would you rate the human impacts at this dive site?

(please circle one number)

no impact 1 2 3 4 5 6 7 8 9 10 high impact

12. How important were the following features in contributing to your enjoyment of this dive?

(please circle one number for each feature, **or tick the box if feature was not seen**)

1=not at all important, 5=extremely important

	Not Seen							Not Seen					
Big fish (>50cm)	❑	1	2	3	4	5	Sharks	❑	1	2	3	4	5
Diverse fish life	❑	1	2	3	4	5	Diverse coral life	❑	1	2	3	4	5
Potato cod/groupers	❑	1	2	3	4	5	Large schools of fish	❑	1	2	3	4	5
Manta rays	❑	1	2	3	4	5	Other rays	❑	1	2	3	4	5
Cuttlefish and octopus	❑	1	2	3	4	5	Nudibranchs	❑	1	2	3	4	5
Turtles	❑	1	2	3	4	5	Sea snakes	❑	1	2	3	4	5
Interesting landscape	❑	1	2	3	4	5	Lots of fish	❑	1	2	3	4	5
Beautiful corals	❑	1	2	3	4	5	Crustaceans (eg. Crabs)	❑	1	2	3	4	5
Sea cucumbers	❑	1	2	3	4	5	Good visibility	❑	1	2	3	4	5
Other______________	❑	1	2	3	4	5	Pelagic fish (eg. Tuna)	❑	1	2	3	4	5

13. Did any of the following impact negatively on your experience at this dive site? ❑ Yes ❑ No

(please tick as many boxes as apply)

❑ Diver-coral contact
❑ Inexperienced divers
❑ Coral rubble
❑ Wildlife harassment
❑ Coral bleaching
❑ Bottom-time limit
❑ Damaged coral
❑ Moorings
❑ Divers with cameras
❑ Dead coral
❑ Not enough fish
❑ Maximum-depth limit
❑ Fish/shark feeding
❑ Not diverse enough
❑ Divers touching/petting marine life
❑ Too many divers
❑ Waste from boat
❑ Other______________________________

Please explain how you felt about this.

____
____

end of section

please complete after diving **Admiralty Anchor-OSPREY**

Date of dive_____________ **Time of day** ____________ **Visibility (m)**________ **Your max depth (m)**______

1. What were the <u>three</u> best features of this dive site?

1.____________________________ Why?____

2.____________________________ Why?____

3.____________________________ Why?____

2. Overall, how much did you enjoy this dive site?

(please circle <u>one</u> number)

not at all 1 2 3 4 5 6 7 8 9 10 very much

Please explain why you felt this way

____

____

3. What do you think are the most important aesthetic values of this dive site?

____

____

4. Summarise in one or two words how you felt during this dive.

____

5. Overall, how well did this dive site meet your expectations?
(please tick <u>one</u> box and give a brief explanation why)

❑	❑	❑	❑	❑
Fell well below my expectations	Somewhat below my expectations	Met my expectations	Somewhat above my expectations	Well above my expectations

Why did you feel this way? ____

____

6. Overall, how would you rate the coral quality at this dive site?

(please circle <u>one</u> number)

very low quality 1 2 3 4 5 6 7 8 9 10 very high quality

7. Overall, how would you rate the fish life at this dive site?

(please circle <u>one</u> number)

very low quality 1 2 3 4 5 6 7 8 9 10 very high quality

8. Overall, how would you rate the information you received in the dive brief about this dive site?

(please circle <u>one</u> number)

very poor 1 2 3 4 5 6 7 8 9 10 excellent

9. Were there any animals/features that you expected to see on this dive but didn't? ❑ **Yes** ❑ **No**

(Please list)

1.____

2.____

3.____

If yes, how did you feel about this?____

10. Was there anything specific at this site about which you would have liked more information?

____

____

11. Overall, how would you rate the human impacts at this dive site?

(please circle one number)

no impact 1 2 3 4 5 6 7 8 9 10 high impact

12. How important were the following features in contributing to your enjoyment of this dive?

(please circle one number for each feature, **or tick the box if feature was not seen**)

1=not at all important, 5=extremely important

	Not Seen							Not Seen					
Big fish (>50cm)	❑	1	2	3	4	5	Sharks	❑	1	2	3	4	5
Diverse fish life	❑	1	2	3	4	5	Diverse coral life	❑	1	2	3	4	5
Potato cod/groupers	❑	1	2	3	4	5	Large schools of fish	❑	1	2	3	4	5
Manta rays	❑	1	2	3	4	5	Other rays	❑	1	2	3	4	5
Cuttlefish and octopus	❑	1	2	3	4	5	Nudibranchs	❑	1	2	3	4	5
Turtles	❑	1	2	3	4	5	Sea snakes	❑	1	2	3	4	5
Interesting landscape	❑	1	2	3	4	5	Lots of fish	❑	1	2	3	4	5
Beautiful corals	❑	1	2	3	4	5	Crustaceans (eg. Crabs)	❑	1	2	3	4	5
Sea cucumbers	❑	1	2	3	4	5	Good visibility	❑	1	2	3	4	5
Other__________ ______________	❑	1	2	3	4	5	Pelagic fish (eg. Tuna)	❑	1	2	3	4	5

13. Did any of the following impact negatively on your experience at this dive site? ❑ **Yes** ❑ **No**

(please tick as many boxes as apply)

- ❑ Diver-coral contact
- ❑ Inexperienced divers
- ❑ Coral rubble
- ❑ Wildlife harassment
- ❑ Coral bleaching
- ❑ Bottom-time limit
- ❑ Damaged coral
- ❑ Moorings
- ❑ Divers with cameras
- ❑ Dead coral
- ❑ Not enough fish
- ❑ Maximum-depth limit
- ❑ Fish/shark feeding
- ❑ Not diverse enough
- ❑ Divers touching/petting marine life
- ❑ Too many divers
- ❑ Waste from boat
- ❑ Other__________________________

Please explain how you felt about this.

____

____

end of section

please complete after diving **North Horn-OSPREY**

Date of dive____________Time of day ____________Visibility (m)________Your max depth (m)______

1. What were the <u>three</u> best features of this dive site?

1.__________________________ Why?____
2.__________________________ Why?____
3.__________________________ Why?____

2. Overall, how much did you enjoy this dive site?

(please circle <u>one</u> number)

not at all 1 2 3 4 5 6 7 8 9 10 very much

Please explain why you felt this way

____

____

3. What do you think are the most important aesthetic values of this dive site?

____

____

4. Summarise in one or two words how you felt during this dive.

____

5. Overall, how well did this dive site meet your expectations?
(please tick <u>one</u> box and give a brief explanation why)

❏	❏	❏	❏	❏
Fell well below my expectations	Somewhat below my expectations	Met my expectations	Somewhat above my expectations	Well above my expectations

Why did you feel this way? ____

____

6. Overall, how would you rate the coral quality at this dive site?

(please circle <u>one</u> number)

very low quality 1 2 3 4 5 6 7 8 9 10 very high quality

7. Overall, how would you rate the fish life at this dive site?

(please circle <u>one</u> number)

very low quality 1 2 3 4 5 6 7 8 9 10 very high quality

8. Overall, how would you rate the information you received in the dive brief about this dive site?

(please circle <u>one</u> number)

very poor 1 2 3 4 5 6 7 8 9 10 excellent

9. Were there any animals/features that you expected to see on this dive but didn't? ❑ **Yes** ❑ **No**

(Please list)

1.____

2.____

3.____

If yes, how did you feel about this?____

10. Was there anything specific at this site about which you would have liked more information?

____

____

11. Overall, how would you rate the human impacts at this dive site?

(please circle one number)

no impact 1 2 3 4 5 6 7 8 9 10 high impact

12. How important were the following features in contributing to your enjoyment of this dive?

(please circle one number for each feature, **or tick the box if feature was not seen**)

1=not at all important, 5=extremely important

	Not Seen							Not Seen					
Big fish (>50cm)	❑	1	2	3	4	5	Sharks	❑	1	2	3	4	5
Diverse fish life	❑	1	2	3	4	5	Diverse coral life	❑	1	2	3	4	5
Potato cod/groupers	❑	1	2	3	4	5	Large schools of fish	❑	1	2	3	4	5
Manta rays	❑	1	2	3	4	5	Other rays	❑	1	2	3	4	5
Cuttlefish and octopus	❑	1	2	3	4	5	Nudibranchs	❑	1	2	3	4	5
Turtles	❑	1	2	3	4	5	Sea snakes	❑	1	2	3	4	5
Interesting landscape	❑	1	2	3	4	5	Lots of fish	❑	1	2	3	4	5
Beautiful corals	❑	1	2	3	4	5	Crustaceans (eg. Crabs)	❑	1	2	3	4	5
Sea cucumbers	❑	1	2	3	4	5	Good visibility	❑	1	2	3	4	5
Other__________ ______________	❑	1	2	3	4	5	Pelagic fish (eg. Tuna)	❑	1	2	3	4	5

13. Did any of the following impact negatively on your experience at this dive site? ❑ **Yes** ❑ **No**

(please tick as many boxes as apply)

- ❑ Diver-coral contact
- ❑ Inexperienced divers
- ❑ Coral rubble
- ❑ Wildlife harassment
- ❑ Coral bleaching
- ❑ Bottom-time limit
- ❑ Damaged coral
- ❑ Moorings
- ❑ Divers with cameras
- ❑ Dead coral
- ❑ Not enough fish
- ❑ Maximum-depth limit
- ❑ Fish/shark feeding
- ❑ Not diverse enough
- ❑ Divers touching/petting marine life
- ❑ Too many divers
- ❑ Waste from boat
- ❑ Other________________________

Please explain how you felt about this.

____

____

end of section

1. Overall, how would you rate your satisfaction with the dive sites this week?

(please circle one number)

not at all satisfied 1 2 3 4 5 6 7 8 9 10 extremely satisfied

Briefly explain why you felt this way

____

____

2. In order of preference, please number which of the following dive sites were your favourites?
(1=most favourite, 5= least favourite)

Pixie Pinnacle	_____	*Admiralty Anchor*	_____	*Steve's Bommie*	_____
Cod Hole	_____	*North Horn*	_____	*Other*____________________	

3. Why did you choose number 1 in the above question as your favourite?

____

____

4. What were the three best features on the dive sites on this trip?

1.____________________________ Why?____
2.____________________________ Why?____
3.____________________________ Why?____

5. With respect to this weeks diving overall, rate how common the following features were?
(please circle one number for each feature, **or tick the box if feature was not seen**)

1 = rare, 5 = very common

	Not present							Not present					
Big fish (>50cm)	❑	1	2	3	4	5	Sharks and rays	❑	1	2	3	4	5
Diverse fish life	❑	1	2	3	4	5	Diverse coral life	❑	1	2	3	4	5
Potato cod/groupers	❑	1	2	3	4	5	Large schools of fish	❑	1	2	3	4	5
Manta rays	❑	1	2	3	4	5	Other rays	❑	1	2	3	4	5
Cuttlefish and octopus	❑	1	2	3	4	5	Nudibranchs	❑	1	2	3	4	5
Turtles	❑	1	2	3	4	5	Sea snakes	❑	1	2	3	4	5
Interesting landscape	❑	1	2	3	4	5	Lots of fish	❑	1	2	3	4	5
Beautiful corals	❑	1	2	3	4	5	Crustaceans (eg. Crabs)	❑	1	2	3	4	5
Sea cucumbers	❑	1	2	3	4	5	Good visibility	❑	1	2	3	4	5
Other____________ ________________	❑	1	2	3	4	5	Pelagic fish (eg. Tuna)	❑	1	2	3	4	5

6. <u>Overall</u>, how well did the dive sites meet your expectations?
(please tick one box and give a brief explanation why)

❑	❑	❑	❑	❑
Fell well below my expectations	Somewhat below my expectations	Met my expectations	Somewhat above my expectations	Well above my expectations

Why did you feel this way? ____

7. Overall, how would you rate the <u>Great Barrier Reef</u> dive sites in terms of environmental quality? (environmental quality defined in section one)

(please circle <u>one</u> number)

very low quality 1 2 3 4 5 6 7 8 9 10 very high quality

8. Overall, how would you rate the <u>Osprey Reef</u> dive sites in terms of environmental quality? (environmental quality defined in section one)

(please circle <u>one</u> number)

very low quality 1 2 3 4 5 6 7 8 9 10 very high quality

9. Overall, how would you rate the coral quality on the <u>Great Barrier Reef</u>?

(please circle <u>one</u> number)

very low quality 1 2 3 4 5 6 7 8 9 10 very high quality

10. Overall, how would you rate the coral quality on <u>Osprey Reef</u>?

(please circle <u>one</u> number)

very low quality 1 2 3 4 5 6 7 8 9 10 very high quality

11. Overall, how would you rate the fish life on the <u>Great Barrier Reef</u>?

(please circle <u>one</u> number)

very low quality 1 2 3 4 5 6 7 8 9 10 very high quality

12. Overall, how would you rate the fish life on <u>Osprey Reef</u>?

(please circle <u>one</u> number)

very low quality 1 2 3 4 5 6 7 8 9 10 very high quality

13. Overall, how would you rate the <u>Great Barrier Reef</u> in terms of human impacts on the environment?

(please circle <u>one</u> number)

no impact 1 2 3 4 5 6 7 8 9 10 high impact

14. Overall, how would you rate <u>Osprey Reef</u> in terms of human impacts on the environment?

(please circle one number)

no impact 1 2 3 4 5 6 7 8 9 10 high impact

15. Overall, how would you rate the <u>Great Barrier Reef</u> in terms of natural beauty?

(please circle one number)

not at all beautiful 1 2 3 4 5 6 7 8 9 10 very beautiful

16. Overall, how would you rate <u>Osprey Reef</u> in terms of natural beauty?

(please circle one number)

not at all beautiful 1 2 3 4 5 6 7 8 9 10 very beautiful

17. Overall, how would you rate the sea conditions during your dive trip? (please tick one box)

❏ Very rough ❏ Rough ❏ OK ❏ Calm ❏ Very calm

18. Overall, was there anything specific about which you would have liked more information?

____

____

____

Is there anything else that you would like to add?

____

____

____

If you would like further information on this research and are willing to participate in a follow up study please leave your name and email address below.

____

____

thank you for your help with this research

APPENDIX C

List of all coral species recorded at each of the study sites by Dr Douglas Fenner. An X represents the species being sighted at the study site that heads the column.

Family	Species	SB	PP	CH	AA	NH
Acroporidae	*Acropora abrotanoides*				X	
Acroporidae	*Acropora aculeus*	X	X			
Acroporidae	*Acropora aspera*			X		
Acroporidae	*Acropora osaria*			X		
Acroporidae	*Acropora bifurcata*					
Acroporidae	*Acropora carduus*					
Acroporidae	*Acropora carolineana*		X			
Acroporidae	*Acropora cerealis*	X	X	X	X	X
Acroporidae	*Acropora clathrata*			X		
Acroporidae	*Acropora cytherea*			X		
Acroporidae	*Acropora digitifera*			X	X	X
Acroporidae	*Acropora divaricata*	X	X		X	
Acroporidae	*Acropora echinata*				X	
Acroporidae	*Acropora elseyi*	X	X			
Acroporidae	*Acropora osariae*					
Acroporidae	*Acropora florida*	X		X		
Acroporidae	*Acropora osaria*		X	X		
Acroporidae	*Acropora gemmifera*		X	X		
Acroporidae	*Acropora globiceps*					
Acroporidae	*Acropora grandis*			X	X	
Acroporidae	*Acropora granulosa*	X		X	X	X
Acroporidae	*Acropora horrida*		X			
Acroporidae	*Acropora humilis*	X	X	X	X	
Acroporidae	*Acropora hyacinthus*	X	X	X		X
Acroporidae	*Acropora latistella*	X			X	
Acroporidae	*Acropora listeri*		X	X		
Acroporidae	*Acropora loripes*	X	X	X	X	X
Acroporidae	*Acropora microphthalma*		X	X		
Acroporidae	*Acropora millepora*		X	X		
Acroporidae	*Acropora monticulosa*					X
Acroporidae	*Acropora moretonensis*	X				
Acroporidae	*Acropora nasuta*			X		X
Acroporidae	*Acropora palifera*	X		X	X	
Acroporidae	*Acropora paniculata*	X	X			
Acroporidae	*Acropora polystoma*					
Acroporidae	*Acropora robusta*			X		
Acroporidae	*Acropora osaria*					
Acroporidae	*Acropora samoensis*	X				
Acroporidae	*Acropora sarmentosa*	X	X	X		
Acroporidae	*Acropora selago*	X	X	X		
Acroporidae	*Acropora spathulata*	X	X	X		
Acroporidae	*Acropora subglabra*	X				
Acroporidae	*Acropora subulata*					
Acroporidae	*Acropora tenuis*	X	X	X	X	X
Acroporidae	*Acropora valenciennesi*	X		X		
Acroporidae	*Acropora valida*					
Acroporidae	*Acropora verweyi*					
Acroporidae	*Acropora yongei*	X		X		
Acroporidae	*Astreopora cuculata*					X
Acroporidae	*Astreopora gracilis*		X			
Acroporidae	*Astreopora myriophthalma*		X	X	X	
Acroporidae	*Astreopora ocellata*					
Acroporidae	*Astreopora randalli*	X	X		X	X
Acroporidae	*Astreopora suggesta*				X	
Acroporidae	*Montipora aequituberculata*	X				
Acroporidae	*Montipora confusa*					
Acroporidae	*Montipora corbettensis*			X		
Acroporidae	*Montipora danae*					
Acroporidae	*Montipora foliosa*		X			
Acroporidae	*Montipora foveolata*					X

Species list continued

Acroporidae	*Montipora hispida*		X	X		
Acroporidae	*Montipora hoffmeisteri*		X			
Acroporidae	*Montipora informis*		X	X		
Acroporidae	*Montipora tuberculosa*	X	X		X	
Acroporidae	*Montipora turgescens*					
Acroporidae	*Montipora verrucosa*		X	X	X	
	Total Genera	3	3	3	3	3
	Total Species	24	28	31	17	11
Agariciidae	*Coeloseris mayeri*			X	X	X
Agariciidae	*Gardineroseris planulata*	X	X			X
Agariciidae	*Leptoseris explanata*		X		X	X
Agariciidae	*Leptoseris hawaiiensis*					X
Agariciidae	*Leptoseris incrustans*		X			X
Agariciidae	*Leptoseris mycetoseroides*		X		X	X
Agariciidae	*Leptoseris striata*	X				
Agariciidae	*Leptoseris yabei*	X				X
Agariciidae	*Pachyseris gemmae*					
Agariciidae	*Pachyseris speciosa*	X	X		X	X
Agariciidae	*Pavona runcates*	X			X	X
Agariciidae	*Pavona cactus*	X				
Agariciidae	*Pavona clavus*				X	
Agariciidae	*Pavona decussata*		X	X		
Agariciidae	*Pavona duerdeni*	X		X	X	
Agariciidae	*Pavona explanulata*	X	X		X	X
Agariciidae	*Pavona maldivensis*	X			X	
Agariciidae	*Pavona minuta*				X	
Agariciidae	*Pavona varians*	X	X	X	X	X
Agariciidae	*Pavona venosa*			X		
	Total Genera	4	4	2	4	5
	Total Species	10	8	5	11	11
Astroceniidae	*Stylocoeniella armata*					
Astroceniidae	*Stylocoeniella guentheri*	X	X			
	Total Genera	1	1	0	0	0
	Total Species	1	1	0	0	0
Dendrophylliidae	*Dendrophyllia green*		X			
Dendrophylliidae	*Rhizopsammia verrilli*	X	X			
Dendrophylliidae	*Tubastraea coccinea*	X	X			
Dendrophylliidae	*Tubastraea micranthus*	X	X			
Dendrophylliidae	*Tubastrea diaphana*	X	X			
Dendrophylliidae	*Turbinaria peltata*	X	X			
Dendrophylliidae	*Turbinaria reniformis*			X		
Dendrophylliidae	*Turbinaria stellulata*					
	Total Genera	4	5	1	0	0
	Total Species	5	6	1	0	0
Euphylliidae	*Euphyllia ancora*	X				
Euphylliidae	*Physogyra lichentensteini*	X	X	X		X
Euphylliidae	*Plerogyra sinuosa*	X				
	Total Genera	3	1	1	0	1
	Total Species	3	1	1	0	1
Faviidae	*Barabattoia amicorum*					
Faviidae	*Cyphastrea decadia*	X				
Faviidae	*Diploastrea heliopora*	X	X	X		
Faviidae	*Echinopora gemmacea*	X				
Faviidae	*Echinopora hirsuitissima*	X		X		X
Faviidae	*Echinopora horrida*	X			X	
Faviidae	*Echinopora runcates*		X	X	X	
Faviidae	*Echinopora mammiformis*	X	X	X		
Faviidae	*Favia matthaii*					
Faviidae	*Favia pallida*	X		X		X
Faviidae	*Favia rotundata*	X	X			
Faviidae	*Favia stelligera*	X	X	X	X	X
Faviidae	*Favia runcates*		X			
Faviidae	*Favites abdita*	X		X		
Faviidae	*Favites flexuosa*				X	
Faviidae	*Favites halicora*		X		X	
Faviidae	*Favites pentagona*					

Species list continued

Faviidae	*Goniastrea aspera*	X				
Faviidae	*Goniastrea edwardsi*		X	X	X	
Faviidae	*Goniastrea minuta*					
Faviidae	*Goniastrea pectinata*	X	X		X	X
Faviidae	*Goniastrea retiformis*			X	X	X
Faviidae	*Leptastrea bewickensis*					X
Faviidae	*Leptastrea inaequalis*	X	X			X
Faviidae	*Leptastrea pruinosa*					X
Faviidae	*Leptastrea purpurea*	X	X		X	
Faviidae	*Leptastrea transversa*		X	X	X	X
Faviidae	*Leptoria ylindr*		X	X	X	X
Faviidae	*Montastrea annuligera*	X				
Faviidae	*Montastrea curta*	X		X	X	X
Faviidae	*Montastrea magnistellata*	X	X			X
Faviidae	*Oulastrea ylindri*	X	X			
Faviidae	*Oulophyllia crispa*					X
Faviidae	*Platygyra daedalea*	X		X		
Faviidae	*Platygyra lamellina*					
Faviidae	*Platygyra pini*	X				
Faviidae	*Plesiastrea versipora*	X				X
	Total Genera	11	9	9	7	8
	Total Species	21	15	13	12	14
Fungiidae	*Cycloseris costulata*	X				
Fungiidae	*Cycloseris vaughani*					
Fungiidae	*Heliofungia actiniformis*	X	X			
Fungiidae	*Fungia concinna*	X				
Fungiidae	*Fungia fungites*	X	X			
Fungiidae	*Fungia granulosa*		X			
Fungiidae	*Fungia horrida*	X	X		X	
Fungiidae	*Fungia paumotensis*	X	X	X		
Fungiidae	*Fungia scutaria*					X
Fungiidae	*Ctenactis crassa*		X			
Fungiidae	*Ctenactis echinata*	X				
Fungiidae	*Herpolitha limax*	X	X			
Fungiidae	*Herpolitha weberi*					
Fungiidae	*Halomitra pileus*		X			
Fungiidae	*Sandalolitha ylindr*	X				X
Fungiidae	*Sandalolitha robusta*	X				
Fungiidae	*Podabacia crustacea*	X				
Fungiidae	*Podabacia motuporensis*				X	X
	Total Genera	7	5	1	2	3
	Total Species	11	8	1	2	3
Hydrocorals	*Millepora dichotoma*			X	X	X
Hydrocorals	*Millepora exaesa*	X	X	X	X	X
Hydrocorals	*Millepora ylindric*	X				
	Total Genera	1	1	1	1	1
	Total Species	2	1	2	2	2
Merulinidae	*Hydnophora exesa*	X				
Merulinidae	*Hydnophora microconos*	X		X		X
Merulinidae	*Hydnophora rigida*		X	X	X	
Merulinidae	*Merulina ampliata*				X	X
Merulinidae	*Merulina scabricula*		X			
Merulinidae	*Scapophyllia ylindrical*	X				
	Total Genera	3	2	1	2	2
	Total Species	3	2	2	2	2
Mussidae	*Cynarina lacrymalis*					
Mussidae	*Scolymia vitiensis*	X	X			
Mussidae	*Acanthastrea brevis*		X		X	X
Mussidae	*Acanthastrea echinata*	X			X	
Mussidae	*Acanthastrea hemprichii*					
Mussidae	*Lobophyllia corymbosa*				X	
Mussidae	*Lobophyllia hemprichii*	X	X		X	X
Mussidae	*Lobophyllia pachysepta*	X	X		X	X
Mussidae	*Lobophyllia robusta*	X	X			
Mussidae	*Symphyllia agaricia*			X	X	
Mussidae	*Symphyllia "hassi"*					

Species list continued

Mussidae	*Symphyllia radians*	X				
Mussidae	*Symphyllia recta*	X		X		
	Total Genera	4	3	1	3	2
	Total Species	7	5	2	6	3
Oculinidae	*Galaxea astreata*					
Oculinidae	*Galaxea fascicularis*	X	X		X	X
Oculinidae	*Galaxea longisepta*					
	Total Genera	1	1	0	1	1
	Total Species	1	1	0	1	1
Pectiniidae	*Echinomorpha nishihirai*					
Pectiniidae	*Echinophyllia aspera*					X
Pectiniidae	*Echinophyllia orpheensis*				X	
Pectiniidae	*Oxypora crassispinosa*	X	X			
Pectiniidae	*Oxypora lacera*		X		X	
Pectiniidae	*Mycedium elephatotus*	X	X		X	X
Pectiniidae	*Pectinia alcicornis*					
Pectiniidae	*Pectinia paeonia*	X				
	Total Genera	3	2	0	2	2
	Total Species	3	3	0	3	2
Pocilloporidae	*Pocillopora damicornis*	X	X	X	X	
Pocilloporidae	*Pocillopora eydouxi*	X				X
Pocilloporidae	*Pocillopora meandrina*	X	X	X		
Pocilloporidae	*Pocillopora verrucosa*	X	X	X	X	X
Pocilloporidae	*Seriatopora aculeata*			X		
Pocilloporidae	*Seriatopora caliendrum*			X		
Pocilloporidae	*Seriatopora hystrix*		X	X	X	X
Pocilloporidae	*Stylophora pistillata*	X		X	X	X
	Total Genera	2	2	3	3	3
	Total Species	5	4	7	4	4
Poritidae	*Alveopora spongiosa*	X	X			
Poritidae	*Goniopora somaliensis*	X				
Poritidae	*Porites (s.) monticulosa*				X	
Poritidae	*Porites (synaraea) rus*	X	X		X	
Poritidae	*Porites cylindrica*				X	
Poritidae	*Porites vaughani*			X	X	X
	Total Genera	3	2	1	1	1
	Total Species	3	2	1	4	1
Siderastreidae	*Coscinaraea columna*		X		X	
Siderastreidae	*Psammocora contigua*	X				
Siderastreidae	*Psammocora nierstraszi*	X	X	X	X	
Siderastreidae	*Psammocora profundacella*	X				X
	Total Genera	1	2	1	2	1
	Total Species	3	2	1	2	1
	STUDY SITE	**SB**	**PP**	**CH**	**AA**	**NH**
	Families Total (15)	**15**	**15**	**12**	**12**	**13**
	Genera Total (55)	**51**	**43**	**25**	**31**	**33**
	Species Total (205)	**102**	**87**	**67**	**66**	**56**

Note: SB=Steve's Bommie, PP=Pixie Pinnacle, CH=Cod Hole, AA=Admiralty Anchor, NH=North Horn.

APPENDIX D

List of all fish species recorded at each of the study sites by Dean Miller, as well as known maximum total length. An X represents the species being sighted at the study site that heads the column.

Family	Common Name	Species	Max size (cm)	SB	PP	CH	AA	NH
Acanthuridae	Ornate Surgeonfish	*Acanthurus dussumieri*	*50*	X	X	X		
Acanthuridae	Elongate surgeonfish	*Acanthurus mata*	*50*	X	X	X	X	X
Acanthuridae	Whitemargin Unicornfish	*Naso annulatus*	*100*	X	X	X		
Acanthuridae	Sleek Unicornfish	*Naso hexcanthus*	*75*	X	X	X		
Acanthuridae	Orange-spine Unicornfish	*Naso lituratus*	*45*	X	X	X		
Acanthuridae	Elongate Unicornfish	*Naso lopezi*	*50*	X	X	X		
		Total Genera		2	2	2	1	1
		Total Species		6	6	6	1	1
Apogonidae	Tiger Cardinal Fish	*Cheilodipterus macrodon*	*22*	X	X	X		
		Total Genera		1	1	1	0	0
		Total Species		1	1	1	0	0
Aulostomidae	Trumpet fish	*Aulostomus chinensis*	*80*	X		X	X	X
		Total Genera		1	0	1	1	1
		Total Species		1	0	1	1	1
Balistidae	Orange-Lined Triggerfish	*Balistapus undulatus*	*30*	X				
Balistidae	Clown Triggerfish	*Balistoides conspicillum*	*50*	X		X	X	
Balistidae	Titan Triggerfish	*Balistoides viridescens*	*75*	X	X	X	X	X
Balistidae	Red Tooth Triggerfish	*Odonus niger*	*40*	X				
Balistidae	Yellow Margin Trigger Fish	*Pseudobalistes flavimarginatus*	*60*				X	
		Total Genera		2	1	1	2	1
		Total Species		4	1	2	3	1
Belonidae	Crocodile Longtom	*Tylosaurus crocodilus crocodilus*	*130*		X			
		Total Genera		0	1	0	0	0
		Total Species		0	1	0	0	0
Blennidae	Bicolour Blenny	*Ecsenius bicolour*	*11*	X		X	X	X
Blennidae	Piano fangblenny	*Plagiotremus*	*13*			X		
Blennidae	Filamentous Blenny	*Cirripectes filamentosus*	*9*	X	X			
		Total Genera		1	1	2	1	1
		Total Species		1	1	2	1	1
Bothidae	Panther Sole	*Bothus pantherinus*	*30*			X		
		Total Genera		0	0	1	0	0
		Total Species		0	0	1	0	0
Caesionidae	Sciscortail fusileers	*Caesio caerulaurea*	*25*	X	X	X	X	X
Caesionidae	Blue and Gold fuslieers	*Caesio teres*	*30*	X	X	X	X	
Caesionidae	Neon Fusilier	*Pterocaesio tile*	*25*	X	X	X	X	X
Caesionidae	3 Lined Fusilier	*Pterocaesio trilineata*	*15*	X	X	X	X	X
		Total Genera		2	2	2	2	2
		Total Species		4	4	4	4	3
Carangidae	Giant Trevally	*Caranx ignobilis*	*170*	X	X		X	
Carangidae	Bluefin Trevally	*Caranx melampygus*	*100*	X	X	X		X
Carangidae	Bigeye Trevally	*Caranx sexfasciatus*	*78*	X	X		X	X
Carangidae	Rainbow Runner	*Elagatis bipinnulatus*	*80*	X				X
Carangidae	Double spotted Queenfish	*Scomberoides lysan*	*70*					X
Carangidae	Black spotted dart	*Trachinotus bailloni*	*54*				X	X
Carangidae	Snub Nose Dart	*Trachinotus blochii*	*65*					X
		Total Genera		2	1	1	2	4
		Total Species		4	3	1	3	6
Carcharinidae	Silvertip Whaler	*Carcharhinus albimarginatus*	*300*				X	X
Carcharinidae	Grey Reef Whaler	*Carcharhinus amblyrhincos*	*225*			X	X	X
		Total Genera		0	0	1	1	1
		Total Species		0	0	1	2	2

Species list continued

Chaetodontidae	Saddled Butterflyfish	*Chaetodon ephippium*	*23*	X	X	X	X	X
Chaetodontidae	Klein's Butterflyfish	*Chaetodon kleini*	*13*	X	X	X		
Chaetodontidae	Bluespot Butterflyfish	*Chaetodon plebius*	*13*	X	X	X		
Chaetodontidae	Rainfords Butterflyfish	*Chaetodon rainfordi*	*15*	X	X	X	X	X
Chaetodontidae	Longer-nose Butterflyfish	*Forcipiger longirostris*	*22*	X	X	X	X	X
Chaetodontidae	Pyramid Butterflyfish	*Hemitaurichthys polylepis*	*18*			X	X	X
Chaetodontidae	Longfin Bannerfish	*Heniochus acuminatus*	*25*	X	X	X	X	X
Chaetodontidae	Humphead Bannerfish	*Heniochus varius*	*18*	X	X	X	X	X
		Total Genera		3	3	3	3	3
		Total Species		7	7	8	6	6
Cirrhitidae	Blackside Hawkfish	*Paracirrhites forsteri*	*23*	X	X	X	X	X
Cirrhitidae	Dwarf Hawkfish	*Cirrhitichthys falco*	*7*	X	X			
		Total Genera		2	2	1	1	1
		Total Species		2	2	1	1	1
Congridae	Spotted Garden Eel	*Heteroconger hassi*	*40*				X	
		Total Genera		0	0	0	1	0
		Total Species		0	0	0	1	0
Dasyatidae	Khuls Stingray	*Dasyatis khulii*	*70*			X	X	
		Total Genera		0	0	1	1	0
		Total Species		0	0	1	1	0
Diodontidae	Porcupinefish	*Diodon hystrix*	*71*	X				
		Total Genera		1	0	0	0	0
		Total Species		1	0	0	0	0
Echeneidae	Remora	*Echeneis naucrates*	*100*					X
		Total Genera		0	0	0	0	1
		Total Species		0	0	0	0	1
Fistulariidae	Smooth Flutemouth	*Fistularia commersonii*	*150*	X	X	X	X	X
		Total Genera		1	1	1	1	1
		Total Species		1	1	1	1	1
Haemulidae	Many spotted sweetlip	*Plectorhinchus chaetodontoides*	*60*	X	X	X	X	X
Haemulidae	Diagonally banded sweetlip	*Plectorinchus lineatus*	*50*			X		
		Total Genera		1	1	1	1	1
		Total Species		1	1	2	1	1
Hemigaleidae	Whitetip reef shark	*Triaenodon obesus*	*210*	X	X	X	X	X
		Total Genera		1	1	1	1	1
		Total Species		1	1	1	1	1
Hemiscyllidae	Epaulette shark	*Hemiscyllium ocellatum*	*107*	X				
		Total Genera		1	0	0	0	0
		Total Species		1	0	0	0	0
Holocentidae	Whitetip Soldierfish	*Myripristis vittata*	*20*	X	X	X	X	X
Holocentidae	Sabre Squirrelfish	*Sargocentron spiniferum*	*45*	X		X	X	X
		Total Genera		2	1	2	2	2
		Total Species		2	1	2	2	2
Gobisocidae	One-Stripe Clingfish	*Discrotrema sp.*	*3*		X			
		Total Genera		0	1	0	0	0
		Total Species		0	1	0	0	0
Gobidae	Shrimp Goby	*Amblyeleotris sp.*	*8*	X	X	X	X	
Gobidae	Whip Goby	*Bryaninops yongei*	*4*	X	X			
Gobidae	Blueband Goby	*Valenciennea strigata*	*18*				X	
		Total Genera		2	2	1	2	0
		Total Species		2	2	1	2	0
Labridae	Axil Pigfish	*Bodianus icolour*	*20*	X		X		
Labridae	Diana's Hogfish	*Bodianus icol*	*25*	X		X		
Labridae	Maori wrasse	*Cheilinus icolour*	*229*	X	X	X	X	X
Labridae	Harlequin tuskfish	*Choerodon fasciatus*	*30*	X	X	X	X	X
Labridae	Slingjaw Wrasse (terminal)	*Epibulus insidiator*	*35*	X		X	X	X
Labridae	Bird Wrasse	*Gomphosus varius*	*32*	X	X	X		
Labridae	Tubelip Wrasse	*Labrichthys unilineatus*	*18*	X		X		
Labridae	Bicolour Cleaner Wrasse	*Labroides icolour*	*14*			X		

Species list continued

Labridae	Striped Cleaner Wrasse	*Labroides dimidiatus*	*12*	X	X	X	X	X
Labridae	Rockmover Wrasse	*Novaculichthys taeniourus*	*30*			X		
Labridae	Moonwrasse	*Thalassoma lunare*	*25*	X	X	X		
		Total Genera		8	5	9	4	4
		Total Species		9	5	11	4	4
Lethrinidae	Long-Nosed Emporer	*Lethrinus olivaceus*	*100*		X			
		Total Genera		0	1	0	0	0
		Total Species		0	1	0	0	0
Lutjanidae	Green Jobfish	*Aprion virescens*	*100*					X
Lutjanidae	Red Bass	*Lutjanus bohar*	*75*	X	X	X	X	X
Lutjanidae	Blackspot Snapper	*Lutjanus fulviflamma*	*35*	X				
Lutjanidae	Yellowmargined Seaperch	*Lutjanus fulvis*	*40*	X				
Lutjanidae	Bigeye Seaperch	*Lutjanus lutjanus*	*30*	X				
Lutjanidae	Moses Perch	*Lutjanus russelli*	*45*	X		X	X	X
Lutjanidae	Midnight Sea perch	*Macolor macularis*	*55*	X		X	X	X
Lutjanidae	Black and White Sea perch	*Macolor niger*	*55*	X	X	X	X	X
		Total Genera		2	2	2	2	3
		Total Species		7	2	4	4	5
Microdesmidae	Fire Dartfish	*Nemateleotris magnifica*	*8*	X	X	X	X	X
		Total Genera		1	0	0	1	0
		Total Species		1	0	0	1	0
Mobulidae	Manta Ray	*Manta birostris*	*670*				X	
		Total Genera		0	0	0	1	0
		Total Species		0	0	0	1	0
Mullidae	Yellowfin Goatfish	*Mulloidichthys vanicolensis*	*38*	X				
Mullidae	Dash-dot goat fish	*Parupeneus barberinus*	*50*	X	X	X	X	X
Mullidae	Goldsaddle Goatfish	*Parupeneus cyclostomus*	*50*	X				
		Total Genera		2	1	1	1	1
		Total Species		3	1	1	1	1
Muraenidae	Giant Moray	*Gymnothorax javanicus*	*220*			X		X
Muraenidae	Whitemouth Moray	*Gymnothorax meleagris*	*100*				X	
		Total Genera		0	0	1	1	1
		Total Species		0	0	1	1	1
Nemipteridae	Big-eye Bream	*Monotaxis grandoculis*	*60*	X	X	X	X	X
Nemipteridae	Bridled Monocle Bream	*Scolopsis bilineatus*	*23*	X	X	X	X	X
		Total Genera		2	2	2	2	2
		Total Species		2	2	2	2	2
Orectolobidae	Tassled wobbegong	*Eucrossorhinus dasypogon*	*250*	X				
		Total Genera		1	0	0	0	0
		Total Species		1	0	0	0	0
Ostraciidae	Striped Boxfish	*Ostracion solorensis*	*11*			X		
		Total Genera		0	0	1	0	0
		Total Species		0	0	1	0	0
Pinguipedidae	Speckled Sandperch	*Parapercis hexophtalma*	*23*	X	X	X	X	
		Total Genera		1	1	1	1	0
		Total Species		1	1	1	1	0
Plotosidae	Striped Catfish	*Plotosus lineatus*	*32*			X		
		Total Genera		0	0	1	0	0
		Total Species		0	0	1	0	0
Pomacentridae	Scisortail Seargent Majors	*Abudefduf sexfasciatus*	*17*		X			
Pomacentridae	Golden Damsel	*Amblyglyphideoden aureus*	*12*		X	X		X
Pomacentridae	Barrier Reef anmeone fish	*Amphiprion akindynos*	*12*	X	X	X	X	X
Pomacentridae	Orange fin Anemonefish	*Amphiprion chystopterus*	*16*	X				
Pomacentridae	Tomato Anenomefish	*Amphiprion frenatus*	*8*	X				
Pomacentridae	Clown Anemonefish	*Amphiprion percula*	*8*	X				
Pomacentridae	Pink Anenomefish	*Amphiprion perideraion*	*10*	X		X	X	X
Pomacentridae	Half and half chromis	*Chromis iomelas*	*7*	X	X	X	X	X
Pomacentridae	Blue-Green Chromis	*Chromis viridis*	*9*	X	X	X		

Species list continued

Pomacentridae	Three Spot Dascyllus	*Dascyllus trimaculatus*	*13*	X		X	X	X
		Total Genera		3	5	4	2	5
		Total Species		8	5	6	4	5
Pomacanthidae	2 Spined Angelfish	*Centropyge bispinosus*	*10*	X	X	X		
Pomacanthidae	Bicolour angelfish	*Centropyge bicolour*	*15*	X	X	X		X
Pomacanthidae	Regal Angelfish	*Pygoplites diacanthus*	*26*	X	X	X	X	X
		Total Genera		2	2	2	1	2
		Total Species		3	3	3	1	2
Priacanthidae	Crescent-Tail Big Eyes	*Priacanthus hamrur*	*40*				X	X
		Total Genera		0	0	0	1	1
		Total Species		0	0	0	1	1
Pseudochromidae	Royal Dottyback	*Pseudochromis paccagnellae*	*7*	X	X	X	X	X
		Total Genera		1	1	1	1	1
		Total Species		1	1	1	1	1
Scaridae	Humphead Parrot Fish	*Bolbometapon muricatum*	*120*			X	X	X
Scaridae	Bicolour Parrotfish	*Cetoscarus icolour*	*80*					X
Scaridae	Steephead Parrotfish	*Chlorurus microrhinos*	*70*				X	X
Scaridae	Yellowfin Parrotfish	*Scarus flavipectoralis*	*30*			X	X	X
Scaridae	Swarthy Parrotfish	*Scarus niger*	*35*	X	X	X	X	X
Scaridae	Bullethead Parrotfish	*Scarus sordidus*	*40*	X	X	X	X	X
		Total Genera		1	1	2	3	4
		Total Species		2	2	4	5	6
Scombridae	Shark Mackeral	*Grammatorcynus bicarinatus*	*130*	X	X	X	X	X
Scombridae	Dog Tooth Tuna	*Gymnosarda unicolor*	*180*					X
		Total Genera		1	1	1	1	2
		Total Species		1	1	1	1	2
Scorpaenidae	Zebra Lionfish	*Dendrochirus zebra*	*18*	X				
Scorpaenidae	Ragged-Fin Firefish	*Pterois antennata*	*20*	X	X			
Scorpaenidae	Red Firefish	*Pterois volitans*	*38*	X	X	X	X	X
Scorpaenidae	False Stonefish	*Scorpaenopsis diabolus*	*30*				X	
Scorpaenidae	Reef Stonefish	*Synanceia verrucosa*	*35*	X				
		Total Genera		3	1	1	2	1
		Total Species		4	2	1	2	1
Serranidae	Whitelined Rockcod	*Aethaloperca leucogrammicus*	*52*	X	X	X		
Serranidae	Redmouth Rockcod	*Aethaloperca rogaa*	*60*			X		
Serranidae	Blue-Spotted Rockcod	*Cephalopholis cyanostigma*	*35*					
Serranidae	Coral Rock Cod	*Cephalopholis miniata*	*41*	X	X	X	X	X
Serranidae	Peacock Rockcod	*Cephalopholis argus*	*40*	X	X	X	X	X
Serranidae	Six Spot Rockcod	*Cephalopholis sexmaculata*	*35*	X	X	X		
Serranidae	Flagtail Rockcod	*Cephalopholis urodeta*	*27*	X	X	X		
Serranidae	Flowery Cod	*Epinephelus fuscoguttatus*	*90*	X	X	X		X
Serranidae	Potato Cod	*Epinephelus tukula*	*200*			X		X
Serranidae	Sixline Soapfish	*Grammistes sexlineatus*	*27*	X	X			
Serranidae	Threadfin Anthias	*Nemanthias carberryi*	*12*	X	X	X	X	X
Serranidae	Chinese Footballer	*Plectropomus laevis*	*100*				X	X
Serranidae	Coral Trout	*Plectropomus leopardus*	*75*	X	X	X	X	X
Serranidae	Redfin Anthia	*Pseudoanthias dispar*	*9.5*	X	X			
Serranidae	Squarespot Anthias	*Pseudoanthias pleurotaenia*	*20*				X	
Serranidae	Purple Anthia	*Pseudoanthias squamipinnis*	*12*	X	X			
Serranidae	Coronation Trout	*Variola louti*	*80*	X	X	X		
		Total Genera		8	8	6	4	4
		Total Species		12	12	11	6	7
Siganidae	Coral rabbitfish	*Siganus carallinus*	*28*	X	X	X		X
		Total Genera		1	1	1	0	1
		Total Species		1	1	1	0	1
Sphyraenidae	Chevron Barracuda	*Sphyraena qenie*	*90*	X	X	X	X	X
		Total Genera		1	1	1	1	1
		Total Species		1	1	1	1	1
Sphyrnidae	Scalloped Hammerhead	*Sphyrna lewini*	*420*					X
		Total Genera		0	0	0	0	1
		Total Species		0	0	0	0	1

Species list continued

Syngnathidae	Banded Pipefish	*Corythoichthys intestinalis*	*16*	X	X			
Syngnathidae	Shultz's Pipefish	*Corythoichthys shultzi*	*16*	X	X	X	X	X
		Total Genera		1	1	1	1	1
		Total Species		2	2	1	1	1
Synodontidae	Reef Lizardfish	*Synodus variegatus*	*29*	X	X	X	X	X
		Total Genera		1	1	1	1	1
		Total Species		1	1	1	1	1
Tetraodontidae	Star Puffer	*Arothron stellatus*	*90*	X			X	X
Tetraodontidae	Blackspotted Puffer	*Arothron nigropunctatus*	*25*	X	X	X	X	X
Tetraodontidae	Black Saddled Toby	*Canthigaster valentini*	*9*	X	X	X	X	X
		Total Genera		2	2	2	2	2
		Total Species		3	2	2	3	3
Zanclidae	Moorish Idol	*Zanclus cornutus*	*25*	X	X	X	X	X
		Total Genera		1	1	1	1	1
		Total Species		1	1	1	1	1
		STUDY SITE		**SB**	**PP**	**CH**	**AA**	**NH**
		Families Total (46)		**34**	**31**	**35**	**34**	**33**
		Genera Total (100)		**68**	**59**	**65**	**57**	**60**
		Species Total (146)		**103**	**79**	**92**	**74**	**75**

Note: SB=Steve's Bommie, PP=Pixie Pinnacle, CH=Cod Hole, AA=Admiralty Anchor, NH=North Horn.

APPENDIX E

List of all other marine organism species recorded at each of the study sites by Dean Miller, as well as known maximum total length. An X represents the species being sighted at the study site that heads the column.

Phylum	Family	Common Name	Species	Max size (cm)	SB	PP	CH	AA	NH
Annelida	Serpulidae	Xmas Tree worm	*Spirobranchus giganteus*	*15*	X	X	X	X	X
			Total Genera		1	1	1	1	1
			Total Species		1	1	1	1	1
	Terebellidae	Spaghetti worm	*Reteterebella queenslandica*	*20*	X	X	X	X	X
			Total Genera		1	1	1	1	1
			Total Species		1	1	1	1	1
Chordata	Clavelinidae	Ascidians	*Clavelina spp*	*16*	X	X			
			Total Genera		1	1	0	0	0
			Total Species		1	1	0	0	0
	Didemnidae	Ascidians	*Atriolum robustum*	*16*	X	X			
	Didemnidae	Ascidians	*Didemnum molle*	*16*	X	X	X		
	Didemnidae	Ascidians	*Diplosoma similis*	*16*	X	X			
	Didemnidae	Ascidians	*Lissoclinum patella*	*16*	X	X			
			Total Genera		4	4	1	0	0
			Total Species		4	4	1	0	0
	Styelidae	Ascidians	*Polycarpa aurata*	*16*	X	X	X	X	X
	Styelidae	Ascidians	*Polycarpa pigmentata*	*16*	X	X	X		
			Total Genera		1	1	1	1	1
			Total Species		2	2	2	1	1
Cnidaria	Actiniidae	Bulb Tentacle Sea Anemone	*Entacmaea quadricolor*	*30*	X	X			
			Total Genera		1	1	0	0	0
			Total Species		1	1	0	0	0
	Discosomatidae	Corallimorph	*Amplexidiscus fenestrafer*	*22*	X				
			Total Genera		1	0	0	0	0
			Total Species		1	0	0	0	0
	Stichodactylidae	Magnificent Sea Anemone	*Heteractis magnifica*	*30*	X				
	Stichodactylidae	Haddens Sea Anemone	*Stichodactyla haddoni*	*30*	X	X			
			Total Genera		2	1	0	0	0
			Total Species		2	1	0	0	0
	Thalassianthidae	Adhesive sea anemone	*Cryptodendrum adhaesivum*	*30*	X				
			Total Genera		1	0	0	0	0
			Total Species		1	0	0	0	0
	Antipathidae	wire coral	*Stichopathes sp.*	*110*	X	X			
			Total Genera		1	1	0	0	0
			Total Species		1	1	0	0	0
Crustacea	Alpheidae	Burrowing shrimp	*Alpheus sp.*	*15*	X	X	X	X	
			Total Genera		1	1	1	1	0
			Total Species		1	1	1	1	0
	Diogenidae	Hermit Crab	*Dardanus guttatus*	*15*	X	X	X	X	X
			Total Genera		1	1	1	1	1
			Total Species		1	1	1	1	1
	Odontodactylidae	Peacock Mantis	*Odontodactylus scyllarus*	*15*	X	X			
			Total Genus		1	1	0	0	0
			Total Species		1	1	0	0	0
	Palaemonidae	Amemone shrimp	*Periclimenes brevicarpalis*	*5*	X				

Species list continued

	Palaemonidae	Glass Shrimp	*Periclimenes venustus*	*5*	X				
			Total Genera		2	0	0	0	0
			Total Species		1	0	0	0	0
	Palinuridae	Painted Cray	*Panulirus marginatus*	*40*		X			
			Total Genera		0	1	0	0	0
			Total Species		0	1	0	0	0
	Porcellanidae	Porclean crabs	*Neopetrolisthes maculata*	*5*	X				
			Total Genera		1	0	0	0	0
			Total Species		1	0	0	0	0
	Stenopodidae	Banded Coral Shrimp	*Stenopus hispidus*	*10*	X	X	X	X	X
			Total Genera		1	1	1	1	1
			Total Species		1	1	1	1	1
Echinodermata	Acanthasteridae	Crown-of-thorns	*Acanthaster planci*	*90*		X			
			Total Genera		0	1	0	0	0
			Total Species		0	1	0	0	0
	Amphiuridae	Brittlestar	*Amphiura sp*	*30*	X	X	X	X	X
			Total Genera		1	1	1	1	1
			Total Species		1	1	1	1	1
	Comasteridae	Crinoids	*Comantheria briareus*	*25*	X	X	X	X	X
	Comasteridae	Crinoids	*Lamprometra almate*	*25*	X	X	X	X	X
	Comasteridae	Crinoids	*Oxycomanthus bennetti*	*25*	X	X	X	X	X
	Comasteridae	Crinoids	*Stephanometra sp.*	*25*	X	X	X	X	X
			Total Genera		4	4	4	4	4
			Total Species		4	4	4	4	4
	Diadematidae	Urchin	*Diadema savignyi*	*28*	X	X			
	Diadematidae	Urchin	*Echinothrix diadema*	*28*	X	X			
			Total Genera		0	0	0	0	0
			Total Species		0	0	0	0	0
	Echinometridae	Urchin	*Echinometra mathaei*	*15*	X				
	Echinometridae	Urchin	*Echinostrephus aciculatus*	*15*	X	X			
			Total Genera		2	2	0	0	0
			Total Species		2	2	0	0	0
	Holothuriidae	Leopard Spot	*Bohadschia argus*	*40*			X		
			Total Genera		0	0	1	0	0
			Total Species		0	0	1	0	0
	Ophiocomidae	Brittle stars	*Ophiomastix variabilis*	*30*	X	X	X	X	X
			Total Genera		1	1	1	1	1
			Total Species		1	1	1	1	1
	Ophiodiasteridae	Starfish	*Fromia sp.*	*15*	X	X			
	Ophiodiasteridae	Linkia Starfish	*Linckia laevigata*	*40*	X		X		
			Total Genera		2	1	1	0	0
			Total Species		1	1	1	0	0
	Oreasteridae	Large Starfish	*Choriaster granulatus*	*40*	X				
			Total Genera		1	0	0	0	0
			Total Species		1	0	0	0	0
	Stichopodidae	Pineapple Sea Cucumber	*Thelenota ananas*	*40*	X	X	X	X	
	Stichopodidae	Sea Cucumber	*Thelenota anax*	*40*			X		
			Total Genera		1	1	1	1	0
			Total Species		1	1	2	1	0
	Synaptidae	Toothpaste Sea Cucumber	*Synaptula lamberti*	*15*	X				
			Total Genus		1	0	0	0	0
			Total Species		1	0	0	0	0
Mollusca	Chromodorididae	Chromodoris	*Chromodoris elizabethina*	*10*	X	X			
	Chromodorididae	Chromodoris	*Chromodoris lochi*	*10*	X	X			
	Chromodorididae	Chromodoris	*Chromodoris magnifica*	*10*	X	X			
			Total Genera		1	1	0	0	0

Species list continued

			Total Species		3	3	0	0	0
	Phyllidiidae	Phyllidia	*Phyllidia pustulosa*	*10*	X	X	X	X	X
			Total Genera		1	1	1	1	1
			Total Species		1	1	1	1	1
	Polyceridae	Green Nudibranch	*Nembrotha kubaryana*	*10*	X				
			Total Genera		1	0	0	0	0
			Total Species		1	0	0	0	0
	Gryphaeidae	Honeycomb oyster	*Hyotissa hyotis*	*21*	X	X			
			Total Genera		1	1	0	0	0
			Total Species		1	1	0	0	0
	Limidae	Red Flame File Shell	*Lima hians*	*15*	X	X			
			Total Genera		1	1	0	0	0
			Total Species		1	1	0	0	0
	Notodorididae	Notodoris	*Notodoris minor*	*12*	X				
			Total Genera		1	0	0	0	0
			Total Species		1	0	0	0	0
	Octopodidae	Octopus	*Octopus Cyanea*	*40*	X			X	
			Total Genera		1	0	0	1	0
			Total Species		1	0	0	1	0
	Pseudoceratidae	Flatworm	*Pseudobiceros bifurcus*	*10*		X			
	Pseudoceratidae	Flatworm	*Pseudobiceros hancockanus*	*10*	X	X			
	Pseudoceratidae	Flatworm	*Pseudobiceros sapphirinus*	*10*	X				
	Pseudoceratidae	Flatworm	*Pseudoceros dimidiatus*	*10*	X	X			
			Total Genera		2	2	0	0	0
			Total Species		3	3	0	0	0
	Sepiidae	Cuttlefish	*Sepia latimanus*	*50*	X	X			
			Total Genera		1	1	0	0	0
			Total Species		1	1	0	0	0
	Spondylidae	Thorny Oyster	*Spondylus varians*	*21*	X	X			
			Total Genera		1	1	0	0	0
			Total Species		1	1	0	0	0
	Tridacnidae	Crocus Giant Clam	*Tridacna crocea*	*110*			X	X	X
	Tridacnidae	Giant Clam	*Tridacna gigas*	*110*			X	X	
			Total Genera		0	0	1	1	1
			Total Species		0	0	2	2	1
Porifera	Ianthellidae	Elephant ear sponge	*Ianthella basta*		1				
			Total Genera		1	0	0	0	0
			Total Species		1	0	0	0	0
Reptilia	Cheloniidae	Green Turtle	*Chelonia mydas*	*110*	X	X	X		
			Total Genera		1	1	1	0	0
			Total Species		1	1	1	0	0
			STUDY SITE		**SB**	**PP**	**CH**	**AA**	**NH**
			Families Total (42)		**36**	**28**	**16**	**13**	**10**
			Genera Total (58)		**47**	**36**	**19**	**16**	**13**
			Species Total (66)		**49**	**40**	**22**	**17**	**13**

Note: SB=Steve's Bommie, PP=Pixie Pinnacle, CH=Cod Hole, AA=Admiralty Anchor, NH=North Horn.

APPENDIX F

Sighting frequency (SF), relative mean abundance, habitat, and depth range, for 'standard' and 'specific' organisms monitored at Steve's Bommie (n=21).

Organism	Standard (S) or Specific (SP)	SF	Mean abundance and range	±1 SE	Habitat	Depth range (m)
Fish						
Fusiliers	SP	100.0	1285.7 (550-3000)	184.5	Open water	6-20
Anthias	SP	100.0	845.2 (250-1500)	109.2	Open water/Coral	0-25
Bigeye seaperch	SP	100.0	201.9 (80-500)	26.02	Coral	21-30
Goldsaddle goatfish	SP	100.0	103.3 (10-200)	16.0	Coral	21-30
Trevally	S	100.0	80.4 (20-200)	11.8	Open water	5-25
Anemonefish	S	100.0	60.0	-	Anemone	0-25
Barracuda	S	52.4	4.8 (1-10)	2.1	Open water	6-20
Titan triggerfish	S	52.4	2.1 (1-6)	0.5	Coral rubble	11-25
Red bass	S	47.6	17.3 (3-50)	5.5	Open water	6-25
Shark mackerel	S	42.9	3.1 (1-10)	0.9	Open water	6-20
Stonefish	SP	42.9	2.0 (1-5)	0.4	Coral rubble	6-10
Coral trout	S	33.3	5.1 (2-10)	1.2	Coral	11-25
Lionfish	S	23.8	2.2 (1-3)	0.4	Coral	6-15
Moray eels	S	23.8	1.4 (1-3)	0.4	Cave/wall	16-25
Maori wrasse	S	23.8	1.0 (1)	0	Coral	16-25
Potato cod	S	9.5	1.0 (1)	0	Open water	26-30
Bumphead parrot fish	S	0	-	-	-	-
Tuna	S	0	-	-	-	-
Invertebrates						
Corallimorphs	SP	100.0	11.0 (11)	0	Rock	11-15
Porcelain crab	SP	100.0	1.3 (1-2)	0.1	Anemone	0-5
Red flame file shell	SP	100.0	1.0 (1)	0	Cave	11-15
Nudibranchs	S	66.7	1.9 (1-5)	0.3	Rock/sponge	11-25
Cuttlefish	S	28.6	1.5 (1-2)	0.2	Coral	11-20
Octopus	S	23.8	1.4 (1-2)	0.2	Coral rubble	6-15
Mantis shrimp	SP	19.0	1.3 (1-2)	0.3	Coral rubble	11-15
Crown of thorns starfish	S	0	-	-	-	-
Reptiles						
Turtles	S	57.1	1.3 (1-2)	0.1	Open water/Sponge	6-25
Sea snakes	S	0	-	-	-	-
Shark and rays						
Reef sharks	S	42.9	1.9 (1-3)	0.2	Sand	26-30
Wobbegong shark	SP	14.3	1.3 (1-2)	0.3	Cave	11-20
Rays	S	9.5	2.0 (2)	0	Sand	26-30
Manta rays	S	0	-	-	-	-

- Organisms ranked by type of organism in alphabetical order (fish, invertebrates, reptiles, sharks and rays). Within each of these rankings, organisms are ranked by sighting frequency and then by relative mean abundance.
- Sighting frequency is calculated as the number of surveys an organism was sighted in divided by the total number of surveys undertaken at that site over the sample period, expressed as a percentage.
- Relative mean abundance is calculated only for surveys when an organism was sighted

APPENDIX G

Sighting frequency (SF), relative mean abundance, habitat, and depth range, for 'standard' and 'specific' organisms monitored at Pixie Pinnacle (n=20).

Organism	Standard (S) or Specific (SP)	SF	Mean abundance and range	± 1SE	Habitat	Depth range (m)
Fish						
Fusiliers	SP	100.0	902.5 (500-1800)	91.4	Open water	6-20
Anthias	SP	100.0	252.5 (190-300)	12.8	Open water/Coral	0-20
Sergeant majors	SP	100.0	116.3 (60-140)	12.1	Open water	0-5
Anemonefish	S	100.0	15.0	-	Anemone	0-20
Barracuda	S	95.0	21.2 (4-60)	4.1	Open water	6-20
Lionfish	S	90.0	2.9 (1-9)	0.5	Coral	6-20
Trevally	S	75.0	9.8 (1-25)	2.0	Open water	0-15
Coral trout	S	55.0	2.3 (1-4)	0.3	Coral	11-25
Titan triggerfish	S	55.0	1.6 (1-2)	0.2	Coral rubble	11-25
Red bass	S	45.0	6.3 (3-10)	1.0	Open Water	11-25
Shark mackerel	S	45.0	2.6 (1-5)	0.5	Open water	6-20
Maori wrasse	S	40.0	1.4 (1-2)	0.2	Coral	21-30
Coronation trout	SP	15.0	1.7 (1-2)	0.3	Coral	16-25
Potato cod	S	10.0	1.0 (1)	0	Open water	26-30
Moray eels	S	5.0	1.0 (1)	0	Cave	21-25
Bump head Parrotfish	S	0	-	-	-	-
Tuna	S	0	-	-	-	-
Invertebrates						
Gorgonian fans	SP	100.0	11.0 (11)	0	Cave	11-20
Red flame file shell	SP	100.0	2 .0 (2)	0	Cave	16-25
Nudibranchs	S	80.0	2.4 (1-10)	0.6	Sponge/wall	6-30
Mantis shrimp	SP	40.0	1.1 (1-2)	0.1	Coral rubble	11-20
Octopus	S	15.0	1.0 (1)	0	Coral rubble	6-15
Cuttlefish	S	0	-	-	-	-
Crown of thorns starfish	S	0	-	-	-	-
Reptiles						
Turtles	S	5.0	1.0 (1)	0	Open water	11-15
Sea snakes	S	0	-	-	-	-
Sharks and rays						
Reef sharks	S	15.0	1.0 (1)	0	Sand	26-30
Rays	S	5.0	1.0 (1)	0	Sand	26-30
Manta rays	S	0	-	-	-	-

- Organisms ranked by type of organism in alphabetical order (fish, invertebrates, reptiles, sharks and rays). Within each of these rankings, organisms are ranked by sighting frequency and then by relative mean abundance.
- Sighting frequency is calculated as the number of surveys an organism was sighted in divided by the total number of surveys undertaken at that site over the sample period, expressed as a percentage.
- Mean abundance is calculated only for surveys when an organism was sighted

APPENDIX H

Sighting frequency (SF), relative mean abundance, habitat, and depth range, for 'standard' and 'specific' organisms monitored at the Cod Hole (n=38).

Organism	Standard (S) or Specific (SP)	SF	Mean abundance and range	± 1SE	Habitat	Depth range (m)
Fish						
Anemonefish	S	100.0	47.0	-	Anemone	6-25
Red bass	S	97.4	27.8 (2-100)	3.8	Open water	0-20
Potato cod	S	81.6	3.0 (1-10)	0.4	Sand/Open water	6-30
Coral trout	S	68.4	4.8 (1-15)	0.7	Coral/Open water	11-25
Maori wrasse	S	65.8	1.4 (1-4)	0.2	Open water	6-20
Flowery cod	SP	60.5	1.7 (1-4)	0.2	Open water/sand	6-20
Titan triggerfish	S	57.9	1.7 (1-5)	0.2	Sand	6-15
Moray eels	S	39.5	1.0 (1)	0	Cave/coral	6-15
Diagonally-banded sweetlips	SP	18.4	122.0 (2-300)	84.0	Open water	6-10
Shark mackerel	S	15.8	3.8 (1-10)	1.4	Open water	6-10
Barracuda	S	13.2	17.0 (5-50)	8.3	Open water	6-20
Bumphead parrot fish	S	13.2	1.2 (1-2)	0.2	Coral/Open water	11-15
Trevally	S	10.5	23.3 (3-50)	11	Open water	15-25
Lionfish	S	10.5	1.5 (1-3)	0.5	Coral	11-20
Tuna	S	0	-	-	-	-
Invertebrates						
Nudibranchs	S	31.6	1.3 (1-2)	0.1	Sponge/coral rubble	6-20
Octopus	S	13.2	1.4 (1-2)	0.2	Coral rubble	11-15
Cuttlefish	S	10.5	1.3 (1-2)	0.3	Coral/sand	11-15
Crown of thorns starfish	S	0	-	-	-	
Reptiles						
Turtles	S	7.9	1.0 (1)	0	Open water	11-20
Sea snakes	S	0	-	-	-	-
Sharks and rays						
Reef sharks	S	92.1	2.5 (1-6)	0.3	Sand/Open water	11-30
Rays	S	21.1	1.0 (1)	0	Sand	11-25
Manta rays	S	2.6	1.0 (1)	0	Open water	11-16

- Organisms ranked by type of organism in alphabetical order (fish, invertebrates, reptiles, sharks and rays). Within each of these rankings, organisms are ranked by sighting frequency and then by relative mean abundance.
- Sighting frequency is calculated as the number of surveys an organism was sighted in divided by the total number of surveys undertaken at that site over the sample period, expressed as a percentage.
- Mean abundance is calculated only for surveys when an organism was sighted

APPENDIX I

Sighting frequency (SF), relative mean abundance, habitat, and depth range, for 'standard' and 'specific' organisms monitored at Admiralty Anchor (n=37).

Organism	Standard (S) or Specific (SP)	SF	Mean abundance and range	± 1SE	Habitat	Depth range (m)
Fish						
Garden eels	SP	100.0	150.0	-	Sand	26-30
Anemonefish	S	100.0	12.0	-	Anemone	6-20
Coral trout	S	73.0	3.6 (1-10)	0.4	Open water/coral	11-25
Titan triggerfish	S	59.5	1.9 (1-8)	0.3	Coral rubble/sand	16-25
Red bass	S	54.1	8.0 (1-20)	1.1	Open water	6-25
Barracuda	S	29.7	7.0 (1-20)	1.9	Open water	11-25
Lionfish	S	27.0	2.3 (1-4)	0.4	Coral	6-25
Maori wrasse	S	27.0	1.4 (1-4)	0.3	Coral/Open water	6-25
Moray eels	S	27.0	1.2 (1-2)	0.1	Coral	21-25
Trevally	S	18.9	11.6 (2-30)	3.5	Open water	6-20
Bumphead parrotfish	S	16.2	19 (4-40)	4.8	Coral/Open water	0-15
Shark mackerel	S	13.5	3.4 (1-10)	1.7	Open water	6-20
Potato Cod	S	10.8	2.0 (1-4)	0.7	Open water/sand	21->30
Tuna	S	10.8	1.3 (1-2)	0.3	Open water/wall	21->30
Invertebrates						
Nudibranchs	S	10.8	1.0 (1)	0	Sponge	11-15
Octopus	S	8.1	1.3 (1-2)	0.3	Coral rubble	6-20
Crown of thorns starfish	S	0	-	-	-	-
Cuttlefish	S	0	-	-	-	-
Reptiles						
Turtles	S	8.1	1.0 (1)	0	Open water/wall	11-20
Sea snakes	S	0	-	-	-	-
Sharks and rays						
Reef sharks	S	91.9	3.1 (1-10)	0.4	Sand/Open water	21->30
Rays	S	16.2	1.0 (1)	0	Sand	21-30
Manta rays	S	5.4	3.0 (1-5)	2.0	Open water	11-15
Silvertip reef sharks	S	5.4	1.5 (1-2)	0.5	Open water	31->30

- Organisms ranked by type of organism in alphabetical order (fish, invertebrates, reptiles, sharks and rays). Within each of these rankings, organisms are ranked by sighting frequency and then by relative mean abundance.
- Sighting frequency is calculated as the number of surveys an organism was sighted in divided by the total number of surveys undertaken at that site over the sample period, expressed as a percentage.
- Mean abundance is calculated only for surveys when an organism was sighted

APPENDIX J

Sighting frequency (SF), relative mean abundance, habitat, and depth range, for 'standard' and 'specific' organisms monitored at North Horn (n=52).

Organism	Standard (S) or Specific (SP)	SF	Mean abundance and range		± 1 SE	Habitat	Depth range (m)
Fish							
Anemonefish	S	100	7.0		-	Anemone	11-30
Potato cod	S	76.9	1.9	(1-5)	0.2	Open water/Coral	26>30
Red bass	S	55.8	9.6	(1-30)	1.5	Open water	11-30
Maori wrasse	S	55.8	3.8	(1-12)	0.7	Open water	0-10
Coral trout	S	55.7	7.2	(1-10)	0.6	Open water/Coral	11-30
Moray eels	S	40.4	1.2	(1-2)	0.1	Coral	16-25
Tuna	S	36.5	3.9	(1-15)	0.9	Open water	11-30
Barracuda	S	34.6	24.6	(5-100)	5.7	Open water	11-30
Titan triggerfish	S	34.6	1.9	(1-8)	0.4	Coral	11-30
Trevally	S	26.9	18.8	(5-100)	6.4	Open water/Wall	11->30
Shark mackerel	S	19.2	5.4	(1-10)	1.0	Open water	11-25
Bumphead parrotfish	S	15.4	41.6	(1-300)	37.0	Coral	0-11
Lionfish	S	0	-		-	-	-
Invertebrates							
Nudibranchs	S	3.8	1.0	(1)	0	Sponge	16-20
Cuttlefish	S	1.9	1.0	(1)	0	Coral	11-15
Crown of thorns starfish	S	0	-		-	-	-
Octopus	S	0	-		-	-	-
Reptiles							
Turtles	S	11.5	1.0	(1)	0	Open water	0-30
Sea snakes	S	0	-		-	-	-
Sharks and rays							
Reef sharks	S	100	23.4	(1-58)	1.6	Open Water	6->30
Silvertip reef sharks	SP	15.4	1.8	(1-4)	0.4	Open water	26->30
Hammerhead sharks	SP	15.4	1.4	(1-3)	0.3	Open water	>30
Manta rays	S	0	-		-	-	-
Rays	S	0	-		-	-	-

- Organisms ranked by type of organism in alphabetical order (fish, invertebrates, reptiles, sharks and rays). Within each of these rankings, organisms are ranked by sighting frequency and then by relative mean abundance.
- Sighting frequency is calculated as the number of surveys an organism was sighted in divided by the total number of surveys undertaken at that site over the sample period, expressed as a percentage.
- Mean abundance is calculated only for surveys when an organism was sighted