Visitor impacts on marine protected areas in New Zealand

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Visitor impacts on marine protected areas in New Zealand

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ABSTRACT

The establishment of marine protected areas in New Zealand has accelerated in recent times. The first marine protected area was established in 1975. Four more were established during the 1980s and 15 in the 1990s. Public interest and hence visitor numbers have grown to a point where serious concerns are being expressed about potential negative impacts of visitors on the conservation values within these areas.

A survey of New Zealand and international literature was made to identify negative impacts associated with visitors, plus any useful lessons from international research that would be relevant to the New Zealand situation.

Most studies looked at visitor impacts on the coastal area in general rather than on marine protected areas specifically; and compared with international literature, visitor impacts on marine protected areas have been little studied in New Zealand.

The review showed that there are some significant problems associated with visitors to marine reserves in New Zealand. These include damage to intertidal and subtidal reefs and changes to fish behaviour through interactions with visitors feeding them.

Managers of each marine protected area need to identify and assess visitor impacts in their area, and monitor the situation in order to adopt timely management responses. They also need to monitor the success or otherwise of the visitor management techniques they employ.

It is suggested that further research is required to assess the biological significance of visitor impacts on marine protected areas in New Zealand. There is also a need to instigate and maintain long-term research to assess the impacts of various visitor activities and hence their sustainability.

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1. Introduction

The Department of Conservation (DOC) is charged with protecting the intrinsic, natural and cultural values of the terrestrial and marine areas it manages, while fostering recreational opportunities that provide contact with these values. The Department's over-riding protection goal is to ensure that the intrinsic natural and historic values of the areas managed by the Department are not compromised by the impacts of visitor activities (Department of Conservation 1996).

The marine areas managed by the Department include marine reserves, and other marine protected areas (MPAs) such as marine mammal sanctuaries. Only marine reserves established under the Marine Reserves Act 1971 provide full legal protection of New Zealand's marine habitat, and flora and fauna.

Marine Reserves are established under the provisions of the Marine Reserves Act 1971 '*for the purpose of preserving, as marine reserves for scientific study of marine life, areas of New Zealand that contain underwater scenery, natural features, or marine life, of such distinctive quality, or so typical, or beautiful, or unique, that their continued preservation in the national interest*' (Section 3(1) of the Marine Reserves Act 1971). Subject to the primary purpose, the public has freedom to access marine reserves and is encouraged to visit them '*so that they may enjoy in full measure the opportunity to study, observe and record marine life in its natural habitat*.'

The dilemma exists that marine reserves (and MPAs to a limited extent) are set up to protect and preserve marine communities, but visitor use of these areas may have a deleterious impact on these communities. One of the major challenges facing conservation managers is how to balance visitor access and potential negative impacts against the protection and security of biota (Cessford 1995).

Not all visitor use is negative. There may also be positive benefits for conservation in general and increased support and awareness of marine protection in particular. For example, Cessford (1995) found that visiting protected sites could stimulate a greater pro-conservation attitude in people.

Regardless of this, serious concerns are being expressed about potential negative impacts from visitors on the actual resources and values targeted under marine reserve and marine protected area status. Understanding visitor impacts and their management are key needs identified by DOC managers in, for example, the Marine Reserves Information Paper (Department of Conservation 1995), the Visitor Strategy (Department of Conservation 1996), proceedings from a DOC workshop on the physical impacts of visitors on natural and historic resources (Cessford & Dingwall 1997, Cessford 1997) and the Strategic Business Plan (Department of Conservation 1998a).

In New Zealand the greatest legislative protection is given to marine reserves and this report focuses on these.

The aim of this report is to assist managers to identify and assess the positive and negative impacts of visitors to marine protected areas. This is done by providing:

- A review of the range of visitor impacts and management actions from international studies on coastal environments (Section 3).
- A review of the range of visitor impacts and management actions from New Zealand studies on coastal environments (Section 4).
- A review of the characteristics of visitors to marine reserves in New Zealand (Section 5).
- Current management actions for marine reserves in New Zealand (Section 6);
- Relevant variables to consider when developing monitoring or management options (Section 7).
- Recommendations for future management of visitor impacts on marine reserves in New Zealand (Section 8).
- Recommendations for future research on visitor impacts on marine reserves in New Zealand (Section 9).

Sections 3, 4 and 5 provide information which will help managers to identify impacts that may require monitoring. Sections 3, 4, 7 and 8 assist with determining appropriate management actions.

While this report focuses on marine reserves the analysis is also valid for visitor impacts in other MPAs and coastal environments within New Zealand. There may, however, be more limited management options available to managers of these environments as they are covered by different legislation than marine reserves.

An initial literature search revealed that international research specifically conducted on visitor impacts on MPAs was limited, and focused more broadly on coastal environments. Impacts caused by visitor activities on the coastal environment will be similar to, if not the same as, those on MPAs. Management techniques used to manage those impacts may also be implemented in MPAs. For this reason the literature search was broadened to review international and national research investigating visitor impacts on the coastal environment as well as visitor impacts on MPAs.

Therefore, although marine protected areas generally have boundaries seaward of the Mean High Water Springs (MHWS), this report will include some discussion on visitor impacts on areas landward of that mark (e.g. sand dune systems), as these form part of the coastal environment and, in some cases, will form part of a reserve complex where a land reserve may adjoin a marine reserve.

This discussion will be kept brief as visitor impacts to sandy beaches and coastal dunes have been reviewed in a concurrent study conducted for DOC (Stephenson 1999). In addition, there have been two recent publications which are relevant to the impacts of humans on seabirds. Claridge (1997) reviewed the impacts of visitors to seabird breeding islands in Australia, and provided comprehensive guidelines for managing visitors. Walls (1999) reviewed the impacts of visitors on freshwater avifauna in New Zealand. The report covers a number of New Zealand coastal bird species, and provides an excellent guide to impact issues and management recommendations, and recommends further research requirements.

Similarly, visitor impacts on areas beyond the marine protected area boundaries or beyond the 12 nautical mile limit are identified but not covered in detail in the present report. There may be visitor impacts on these areas, especially on larger marine animals, such as marine mammals, seabirds, and sharks. These types of impacts may need to be investigated as the requirement arises.

The review searched library catalogues and online databases such as CAB abstracts, Aquatic Fisheries and Sciences abstracts, Biological abstracts, and Zoological record; and focused on literature from 1975 until June 1999, as relevant literature prior to 1975 is scarce. General searches of the worldwide web were also undertaken. In addition, DOC staff and other experts in the field were consulted.

Reviewing New Zealand and international experience of visitor impacts on the coastal environment will increase our understanding of the various recreational impacts on the coast and on MPAs. This, in turn, will help managers predict impacts prior to their occurrence and implement appropriate management practices to mitigate impacts, therefore ensuring sustainable use of the marine resources in any particular marine protected area. It is envisaged that this review will also raise the awareness about marine reserve values and management issues facing managers, researchers, and the public.

2. Definitions

2.1 VISITORS

For the purpose of this report, 'visitors' are defined as: 'members of the public making recreational visits to marine protected areas'. The term is used in a broad sense and includes local, national and international visitors, eco-tourists (both individual travellers and people on commercial trips), and people in dive parties and other activities. (see list in Table 1).

2.2 VISITOR IMPACTS

Visitor impacts are defined as: 'impacts on the natural conservation values of the coastal environment and marine protected areas arising from the presence and activities of visitors'.

The report does not look into visitor impacts on other visitors (e.g. visitor perceptions and satisfactions, use conflicts, interference between user groups—such as commercial versus general public); visitor impacts on facility or service amenities (e.g. carparks, toilet facilities); visitor impacts on historic or cultural values (e.g. ship wrecks, areas of traditional Maori significance); or risks to visitors by the various recreational activities of other visitors (e.g. risks to swimmers in areas where boating activities are high). However, these issues are important for managers to take into consideration when planning marine reserves and preparing management plans.

TABLE 1. EXAMPLES OF THE TYPES OF VISITORS TO MARINE PROTECTED AREAS, AND THE TYPES OF ACTIVITIES UNDERTAKEN WITHIN MARINE PROTECTED AREAS, NOT LISTED IN ANY ORDER OF IMPORTANCE. COMPILED FROM VARIOUS VISITOR SURVEYS (SEE TABLE 5). INTERFERENCE WITH THE PRESERVATION OF MARINE LIFE IS NOT ALLOWED IN MARINE RESERVES.

TYPE OF VISITORS	VISITOR ACTIVITIES
Individuals Family/social groups Scuba diving clubs/ other clubs Scuba diving training groups Visitors using other commercial operations Students attending university field courses School groups	Swimming Snorkelling Diving Picnics/barbecues Exploring the intertidal reefs and fossicking Walking Boating e.g. motor, sailing, canoeing Sunbathing Walking dogs Horse riding Underwater photography Water-skiing Bird-watching Surfing Feeding fish[1] Curio collecting[2] Legal extraction[3] Illegal extraction

[1] Feeding fish is not specifically controlled for in marine reserves, but it is illegal to kill other reserve organisms to feed the fish.

[2] Illegal activity in marine reserves.

[3] Although, taking marine life in marine reserves is prohibited, legal extraction may be provided for in both marine reserves and other marine protected areas under specific regulations.

This report does not review other human impacts to the coast such as non-point-source pollution (e.g. sediment run-off); point source pollution (e.g. sewage outfalls); littering; pollution from boats (petrol, oil spills and other waste); urban development; or coastal developments (e.g. boat ramps, jetties or marinas); vehicle strandings or dumpings (infrequent unlawful incursions into protected areas, but a real pollution threat which managers may have to budget for and remove). These types of impacts may effect the marine environment of MPAs, and may also be important issues to consider when planning MPAs or determining management strategies for them.

2.3 COASTAL ENVIRONMENT

The coastal environment is defined as: 'An environment in which the coast usually is a significant element or part. The extent of the coastal environment will vary from place to place depending on how much it affects, or is affected by, coastal processes and the management is concerned. It includes at least three distinct but inter-related parts: the coastal marine area, the active coastal zone, and the land back-drop' (Department of Conservation 1998b).

2.4 MARINE PROTECTED AREAS (MPAs)

Marine protected areas (MPAs) are defined by the World Conservation Union (IUCN) as: 'areas of the marine environment which are specifically dedicated to the protection and maintenance of marine biological diversity and managed through legal or other effective means' (IUCN 1994).

For the purpose of this report MPAs are defined as: 'areas of the New Zealand marine environment which are granted *full or nearly full protection status* and are *managed, or partially managed,* by DOC'.

Currently (June 1999) there are 20 marine protected areas in New Zealand (see Figure 1 and Table 2). Of these, there are fifteen marine reserves and two marine mammal sanctuaries managed by DOC. This report concentrates on visitor impacts on marine reserves established under the Marine Reserves Act 1971.

Marine mammal sanctuaries are established under the Marine Mammal Protection Act 1978 for the sole purpose of protecting marine mammals. Issues relating to visitor impacts on marine mammals are identified and discussed in detail Constantine (1999), which provides a comprehensive review of the impacts of tourism on marine mammals. For this reason, visitor impacts on marine mammals or marine mammal sanctuaries are not specifically covered in this report, and readers are directed to Constantine (1999).

The remaining three marine protected areas—Tawharanui and Mimiwhangata marine parks, and the Sugar Loaf Islands Marine Protected Area—are managed by different agencies, with varying levels of involvement by DOC.

Mimiwhangata and Tawharanui marine parks were established under the former Harbours Act 1950 and the former Fisheries Act 1983. Mimiwhangata Marine Park is managed by the Ministry of Fisheries and DOC. DOC provides on-site interpretation at Mimiwhangata Marine Park and helps with fishing regulations compliance and law enforcement (Piet Nieuwland, Conservation Officer, DOC, pers. comm.).

Tawharanui Marine Park is managed by the Auckland Regional Council and the Ministry of Fisheries. Through fishing regulations the marine area is nearly fully protected and therefore it is effectively a marine reserve. For this reason it has been included in the report.

The Sugar Loaf Islands were declared a marine protected area under a special Act of Parliament in 1991. Management of the Sugar Loaf Islands Marine Protected Area is shared by Ministry of Fisheries and DOC. Specific Fisheries Regulations and fisheries resources, as defined under the Fisheries Act 1996, are the responsibility of the Ministry of Fisheries, while the foreshore, seabed, sea water, bird life and marine mammals are the responsibility of DOC.

Marine areas set aside as foreshore reserves or wildlife management reserves established under the Wildlife Act 1953 and the Reserves Act 1977 do not provide full or nearly full protection to the coastal environment, so are not discussed in this report. Nor does the report look specifically at visitor impacts on any other types of marine protected areas managed under any other legislation. For example, restricted fishing areas created under fishing regulations (Fisheries Act 1996), or Taiapure (provided for in the Maori Fisheries Act 1989) and Mataitai reserves created under customary fishing regulations (Treaty of Waitangi (Fisheries Claims) Settlement Act).

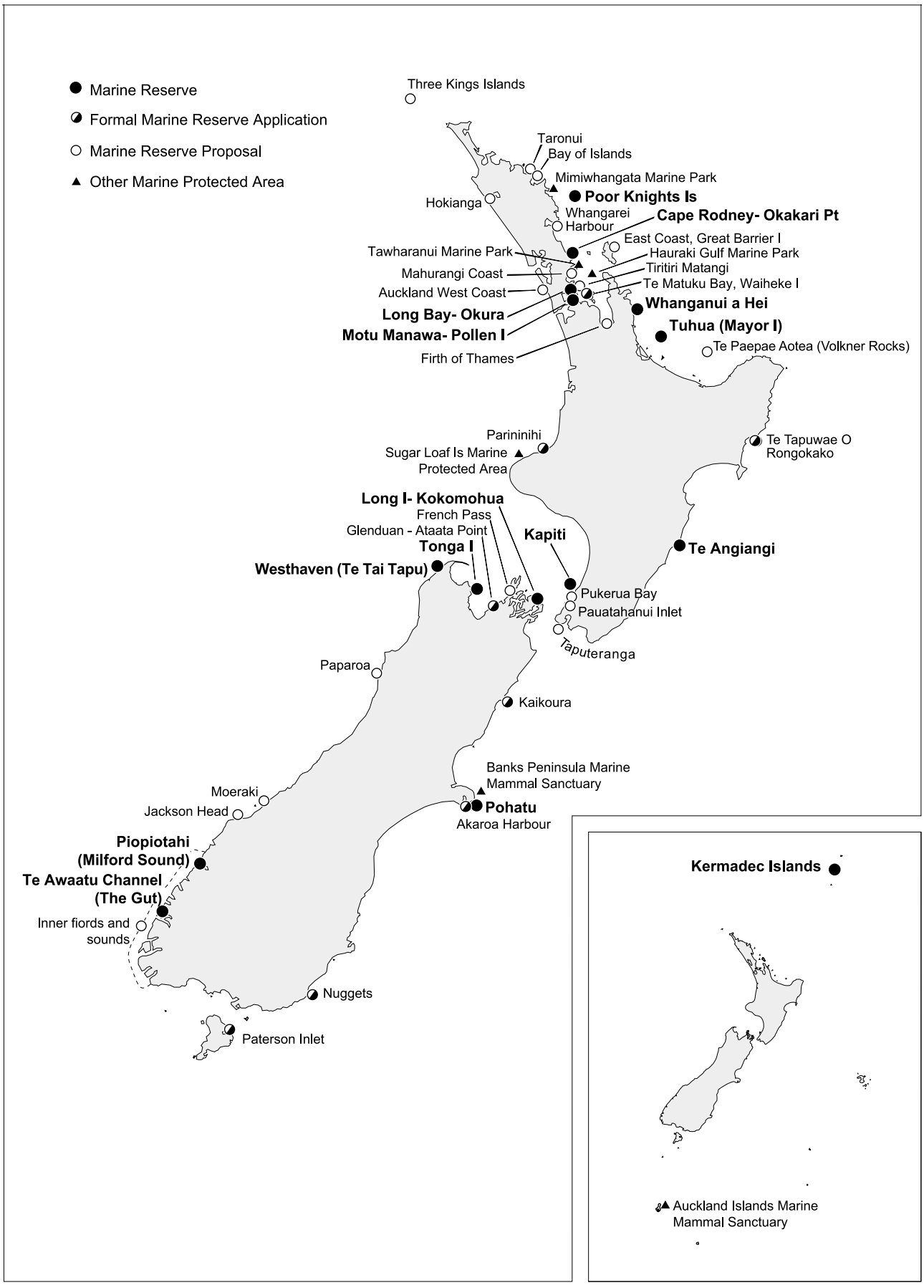

Figure 1. Marine reserves, proposals and investigations as at June 1999.

TABLE 2. MARINE PROTECTED AREAS IN NEW ZEALAND AS AT JUNE 1999. DATES IN PARENTHESES SHOW THE YEAR OF ESTABLISHMENT.

RESERVE TYPE	AREA
Total Marine Reserves (15)[1]	**761 177 hectares**
Cape Rodney to Okakari Point, North Auckland (1975)	518 ha
Poor Knights Islands, Northland (1981)	2410 ha
Kermadec Islands (1990)	748 265 ha
Wanganui-a-Hei (Cathedral Cove), Coromandel (1992)	840 ha
Tuhua (Mayor Island), Bay of Plenty (1992)	1060 ha
Kapiti, Waikanae (1992)	2167 ha
Long Island - Kokomohua, Marlborough Sounds (1993)	619 ha
Tonga Island, Able Tasman National Park (1993)	1835 ha
Te Awaatu Channel - The Gut, Doubtful Sound (1993)	93 ha
Piopiotahi, Milford Sound (1993)	690 ha
Westhaven (Te Tai Tapu), Karamea, West Coast (1994)	536 ha
Long Bay - Okura, Auckland (1995)	980 ha
Motu Manawa - Pollen Island, Auckland (1995)	500 ha
Te Angiangi, Hawkes Bay (1998)	446 ha
Pohatu, Banks Peninsula (1999)	218 ha
Total Marine Parks and Marine Protected Areas (3)	**3150 hectares**
Tawharanui Peninsula Marine Park, North Auckland (1981) [2]	350 ha
Mimiwhangata Marine Park, Northland (1983) [3]	2000 ha
Sugar Loaf Islands Marine Protected Area, New Plymouth (1991) [4]	800 ha
Total Marine Mammal Sanctuaries (2) [1]	**335 111 hectares**
Banks Peninsula, Canterbury (1988)	113 560 ha
Auckland Islands (1993)	221 551 ha
Total Marine Reserves and Marine Protected Areas (20)	**1 099 438 hectares**
Percentage Marine Reserves of the Territorial Sea [5]	**4.76 %**
Percentage Marine Reserves of the EEZ [6]	**0.19 %**
Percentage Marine Protected Areas of the EEZ	**0.27 %**

1 Marine reserves and marine mammal sanctuaries are administered by the Department of Conservation.

2 Tawharanui Peninsula Marine Park is administered by the Auckland Regional Council and the Ministry of Fisheries (created under provisions of the Fisheries Act 1983 and Harbours Act 1950).

3 Mimiwhangata Marine Park is administered by the Ministry of Fisheries (created under provisions of the Fisheries Act 1983 and Harbours Act 1950).

4 Management of Sugar Loaf Islands Marine Protected Area is shared by several different agencies. Specific Fisheries Regulations and fisheries resources, as defined under the Fisheries Act 1996, are the responsibility of the Ministry of Fisheries. Foreshore, seabed, seawater, birdlife and marine mammals remain the responsibility of the Department of Conservation (Sugar Loaf Islands Marine Protected Area Act 1991).

5 Territorial Sea—12 nautical miles (160 000 km^2 = 16 million hectares, *from Department of Conservation 1995*).

6 EEZ—Exclusive Economic Zone (4 053 049 km^2 = 405 million hectares, *from Blezard 1980*).

3. Review of international research on visitor impacts on the coastal environment: 1975 to June 1999

Humans have always used the coastal environment, with impacts that vary according to the type of activity and the type and sensitivity of the environment (French 1997).

Internationally there is an increasing awareness of the conflicts between recreational use of marine resources and conservation (French 1997). Marine-based tourism is growing at a significant rate worldwide (Davis & Tisdell 1995). Coastal tourism increased 20-fold between 1950 and 1995, and is expected to double by 2010 (Platt McGinn 1999). A number of conferences and reviews have discussed the issues of tourism and conservation of coastal resources (e.g. Great Barrier Reef Marine Park Authority 1978, 1981; Baker et al. 1983; Salm & Clark 1984; Strahan 1990; Miller & Auyong 1991a, b, c; Agardy 1993; Miller 1993; Andereck 1995).

Recognition of the conflicts between conservation and tourism in protected areas is also well known (Salm 1985, Gordon 1993, Kenchington 1993, Davis & Tisdell 1995, Davis et al. 1995, Gubbay 1995). There are many instances of reported damage to protected coastal areas from human activities. For example, over 75 000 dives were made annually at only four sites in the Ras Mohammed Marine Park in Egypt (Thorsell & Wells 1992). At these sites coral damage was marked, compared with non-dived areas. Damage caused by divers is now the main cause of coral mortality in the Park (Medio et al. 1997).

Sand dunes and coral reefs are probably the most tourist-damaged habitats found on the world's coasts (French 1997). Because coral reefs occur in warm, shallow, clear waters, and contain a very diverse range of fauna, they are very popular recreational areas (French 1997). Coral reefs are particularly vulnerable to human impacts, damage may include coral breakage from anchors, trampling, and boat grounding, and boat washes stirring up sediment which smothers coral (Hawkins & Roberts 1992, 1993).

Coastal studies conducted in Australia were reviewed by Fairweather (1990). Most studies concentrated on coral reef and rocky shore systems. Seagrasses, mangroves and estuaries received some attention, but very little work had been done on sandy beaches, mudflats or saltmarshes. This bias appears to be reflected in the international literature generally (also see Tables 3 & 4).

The impacts of recreational activities on coastal environments are listed in Appendix 1, and explained in more detail in sections 3.1–3.8.

TABLE 3. EXAMPLES OF VISITOR IMPACT STUDIES ON COASTAL HABITATS.

DISTURBANCE TYPE	HABITAT	RESULTS/EFFECT	LOCATION	REFERENCE
Trampling	Dunes	Reduction of vegetation, plant communities varied in their vulnerability to trampling	England	Boorman & Fuller 1977
		Formation of bare patches	Denmark	Hylgaard 1981
		Reduction of flora and fauna	NE USA	McDonnell 1981
		Reduction of vegetation	NE USA	Nickerson & Thibodeau 1983
		Reduction of vegetation and species	NE USA	Carlson & Godfrey 1989
	Soft shores	Reduction of floral and faunal diversity and floral cover, dunes were most vulnerable, coastal grasslands intermediate and saltmarsh most resistant to trampling	Denmark	Anderson 1995
		Shift in composition of the benthic fauna of saltmarshes	England	Chandrasekara & Frid 1996
		Severe damage to eelgrass at medium and high use	South Island, New Zealand	Miller, S. 1998
	Coral reefs	Extensive physical damage to coral communities	Great Barrier Reef, Australia	Woodland & Hooper 1977
		Corals broken, damage to living tissue and recovery affected	Great Barrier Reef, Australia	Liddle & Kay 1987
		Corals more vulnerable on reef flats, and morphology of coral most important feature relating to trampling resistance	Great Barrier Reef, Australia	Kay & Liddle 1989
		Sediment re-suspension affected coral growth and survivorship	Australia	Neil 1990
		Coral colonies smaller, bare rock and rubble patches increased	Egypt	Hawkins & Roberts 1993
	Rocky shores	Lower densities of algal species and small bivalves at the highest impact site	California, USA	Beauchamp & Gowing 1982
		Short-term immediate effects included fauna dislodged and crushed, algal cover reduced. Wave action on exposed rocky shores may have greater impact then trampling	South Africa	Bally & Griffiths 1989
		Decreased algal cover, *Hormosira banksii* most vulnerable	SE Australia	Povey & Keough 1991
		Significant changes to community structure	NW USA	Brosnan 1992
		Fauna dislodged and crushed, decrease in algal cover, change in community composition. Foliose algae more susceptible then turfing algae, and barnacles more susceptible then mussel mats	NW USA	Brosnan & Crumrine 1994
		Reduction of algal cover, animals exposed to repeated dislodgement may cease to right themselves	North Island, New Zealand	Brown 1996

		Reduction in abundance and diversity, formation of bare patches	England	Fletcher & Frid 1996
		Reduction in *Hormosira* mats, variation between sites in sensitivity to trampling, no linear relationship between trampling intensity and damage to *Hormosira*	S Australia	Keough 1996
		Reduction in coraline turf and *Hormosira* mats, enhancement of some mollusc species	SE Australia	Keough & Quinn 1998
		Reduction of turf dwelling animals, polychaetes particularly susceptible even to low levels of trampling. Three months after trampling ended infaunal densities recovered to control values, except for polychaetes	North Island, New Zealand	Brown & Taylor 1999
		Trampling intensity had variable effects on algal cover. Season, location, indirect effects of reduction in coralline algae and recruitment of *Hormosira banksii* influence recovery after disturbance	South Island, New Zealand	Schiel & Taylor 1999
Harvest/ trampling	Rocky shores	Reduction of a few species populations, changes in species abundance's (e.g. barnacles, coralline algae, polychaete worm)	California, USA	Ghazanshahi et al. 1983
		Reduction of target species population size structures, and reduction of reproductive potential especially for invertebrates	NE Australia	Catterall & Poiner 1987
		Significant difference between harvested and non-harvested sites in density, biomass, and size structure of bull kelp	Chile	Castilla & Bustamante 1989
		Switch in dominant gastropod species	Chile	Durán & Castilla 1989
		Collected species were less abundant, decrease in mean individual size	Victoria, Australia	Keough et al. 1993
		Density of all study species reduced, under-rock communities substantially changed	California, USA	Addessi 1994
		Exploitation of large limpets and disturbance of oyster-catchers resulted in a community dominated by small limpets	California, USA	Lindberg et al. 1998
		Selective removal of target inter-tidal species resulted in various changes in micro-algae abundance, cascade effects could lead to broader community changes	SE Australia	Sharpe & Keough 1998

Diving	Coral reefs	Physical damage to reef communities	Egypt	Hawkins & Roberts 1992
		Coral degradation and reduced cover in heavily dived sites	Caribbean	Dixon et al. 1993
		Significant damage to corals, both direct mechanical and through secondary damage from infection, disease, overgrowth etc	Egypt	Prior et al. 1995
		Mechanical damage highest to branching corals	Great Barrier Reef, Australia	Rouphael & Inglis 1997
	Rocky reefs	A higher percentage of larger red coral colonies were damaged	Fiordland, New Zealand	Miller, K. 1995
		Decrease in bryozoan density, colony height, and colony diameter	Mediterranean	Sala et al. 1996
		Decreased densities of bryozoans in exposed positions, reduced mean size, and bryozoan colonies restricted to cryptic positions. Greatest impacts to communities one year after the start of diving disturbance	Mediterranean	Garrabou et al. 1998
		Decline in colony abundance, population of larger red coral colonies had dropped over 40% in 4 years, presumed to be linked to divers	Fiordland, New Zealand	Miller, K. 1998
		Initial results suggest that large numbers of divers may affect the usually wave-protected kelp forests which may cause alterations in community structure	North Carolina, USA	Schaeffer & Foster 1999
Anchor damage/ boat moorings/ boating	Soft shores	Seagrass beds took up to two years to recolonize after propeller-induced disturbance	Florida, USA	Zieman 1976
		Depending on the type of mooring used large areas of seagrass beds could be destroyed	W Australia	Walker et al. 1989
	Coral reefs	Anchor chains caused severe physical damage to staghorn corals	Florida, USA	Davis 1977
	Rocky reefs	Damage to benthic communities from the mooring chain	North Island, New Zealand	Jeffs 1993
Off-road vehicles	Dunes	Destruction of vegetation	NE USA	Godfrey & Godfrey 1980
	Beaches	Reduction in ghost crabs populations and smaller size structure	Virginia, USA	Steiner & Leatherman 1981
		Reduction in ghost crabs populations	North Carolina, USA	Wolcott & Wolcott 1984

TABLE 4. EXAMPLES OF HUMAN IMPACT STUDIES ON MARINE ANIMALS (EXCLUDING MARINE MAMMALS).

DISTURBANCE TYPE	HABITAT/SPECIES	RESULTS/EFFECT	LOCATION	REFERENCE
Presence	Soft-shore/Birds	Disruption to breeding pelicans and gulls, resulting in reduced breeding success rates	California, USA	Anderson & Keith 1980
		Disruption to breeding gulls, resulting in reduced breeding success rates and increased intraspecific predation	Gulf of California, Mexico	Hand 1980
		Disturbance impacts were greater on species using the front side of the beach	NE USA	Pfister et al. 1992
		Terns became more tolerant to humans presence over time if visits were regular and predicatble	Australia	Dunlop 1996
		New Zealand dotterel chicks spent less time feeding, and were restricted to less disiable areas, when people were present in their habitat	New Zealand	Lord et al. 1997
		Wetland birds varied in response to approach by humans	SE USA	Rodgers & Smith 1997
	Rocky/Birds	Disturbance to cormorants led to nest dissertion, nest predation by gulls, and reduction in late-nesting	Canada	Ellison & Cleary 1978
		Habitutaion of some wader species to humans	UK	Scott et al. 1996
		Little blue penguins heart rates increased in response to human noises and lights	New Zealand	Eagles 1998
		Habitutaion of some wader species to continued benign human presence	UK	Fitzpatrick & Bouchez 1998
Boating	Rocky/Fish	Fish behaviour altered by operation of glass-bottom boat. Possible impacts on bird behaviour noted	North Island, New Zealand	Jeffs 1993
Diving	Rocky/Fish	Feeding of fish by divers may have altered the behaviour of some species of fish	North Island, New Zealand	Cole 1994
		Feeding and handling of stingrays were found to be significantly altering stingray behaviour and causing injury	Caribbean	Shackley 1998

3.1 HARVESTING

The affect on marine species and communities of recreational fishing, selective gathering of organisms for bait, food, aquaria, and for scientific study, and inadvertent or intentional killing is well established (e.g. Kingsford et al. 1991, Visser & Njuguna 1992, Underwood 1993a, Quinn et al. 1996, Hall 1999). A wide variety of taxa including crabs, seaweed, ascidians, various gastropod species, fish, sea urchins, octopus, and bivalves are exploited (Underwood 1993a). Underwood (1993a) pointed out that many non-target organisms are destroyed as a result of the collection method. The removal of target species and non-target species can have a cascading effect and lead to changes in community structures (Kingsford et al. 1991, Keough 1996, Quinn et al. 1996, Lindberg et al. 1998, Sharpe & Keough 1998).

Intertidal shellfish collection by humans is a form of selective predation and can have both direct and indirect deleterious effects on intertidal communities (Ghazanshahi et al. 1983, Catterall & Poiner 1987, Durán & Castilla 1989, Kingsford et al. 1991, Keough et al. 1993, Underwood 1993a, Sharpe & Keough 1998). This has also been demonstrated for MPAs where there has been insufficient policing of the area (e.g. Keough et al. 1993, Sharpe & Keough 1998). An overview of the impacts of collecting intertidal shellfish is provided by Sharpe & Keough (1998), along with a number of relevant references. Direct impacts of removing many large individuals include the reduction in the abundance as well as a decrease in the mean size of individuals within a population. This may affect future reproductive output of the population. Species diversity within and between communities may also be affected by shellfish harvest (Sharpe & Keough 1998).

Indirect effects are more difficult to assess, but may be more important than direct effects, since they reflect changes to the whole community (Underwood 1991). The impacts of intertidal shellfish collection may be more far-reaching than merely a reduction in the abundance of the target species, and can lead to broader community changes in the long term, particularly if shellfish collection occurs regularly (Sharpe & Keough 1998).

Castilla & Bustamante (1989) investigated the consequences of human exploitation on the intertidal macroalga *Durvillaea antarctica*. A comparison between protected and non-protected areas revealed a significant difference in density, biomass, and size structure of the algae. Kingsford et al. (1991) found that people are potentially important in determining the abundance and species composition of fish and sedentary invertebrates associated with rocky reefs, and recommended effectively policed MPAs as the best means of protection for the coastal environment.

Direct effects of harvesting on shores are reduced densities and altered size structure of target species populations, particularly molluscs and fish. Indirect effects on other species and ecological mechanisms include loss of habitat and release from competition or predation. Impacts are most severe around metropolitan areas and areas popular with visitors (Keough 1996).

3.2 TRAMPLING

Negative effects of recreational traffic on marine ecosytems have been well documented (Liddle 1991, 1997).

A number of studies have investigated the impact of trampling on coral reefs (e.g. Woodland & Hooper 1977, Liddle & Kay 1987, Kay & Liddle 1989, Hawkins & Roberts 1993). Some coral reef communities are fragile and very susceptible to damage by trampling, with foliaceous and branching corals growing in sheltered reef flats being the most vulnerable (Hawkins & Roberts 1993). Sediments stirred up by walkers and exposure of damaged tissue to infection may also effect the survival of corals (Liddle & Kay 1987, Niel 1990). The amount of damage sustained by corals is related to the number of people who pass over a given area and the composition of the coral assemblage (Woodland & Hooper 1977, Kay & Liddle 1989, Hawkins & Roberts 1993). The initial phases of trampling cause the most damaging impacts (Kay & Liddle 1989, Hawkins & Roberts 1993).

Even low levels of trampling can be detrimental to dune communities; reducing vegetative cover, and even destablising dunes (Boorman & Fuller 1977, Hylgaard 1981, McDonnell 1981, Nickerson & Thibodeau 1983, Carlson & Godfrey 1989, Liddle 1997). Management techniques such as elevated walkways, fencing off sensitive areas, and educating visitors have proven very successful in allowing high visitation rates while preserving the environment (Carlson & Godfrey 1989).

Other soft shores are susceptible to trampling. Anderson (1995) found that coastal grasslands and saltmarsh are less vulnerable than dunes to trampling; although the total number of plant species and amount of vegetation cover in all habitats is reduced by trampling.

The susceptibility of saltmarsh benthic fauna to human trampling depends on the intensity of trampling disturbance and on the nature of the habitat (Chandraskara & Frid 1996). Although the passage of one person across a saltmarsh may leave a trail discernible for several weeks, the amount of damage sustained to biota may not be high or very long lasting. Loss of vegetation and destruction of habitat are also caused by trampling on saltmarshes, mangroves, and, to a lesser extent, mudflats and sandflats (French 1997). Indirect mortality of soft-shore fauna may result from burial through compaction of sediments, collapsing burrows, or exposure to the surface and avian predation (Chandraskara & Frid 1996).

The flora and fauna of rocky shores generally appear to be more robust then those of soft shores, although organisms may be crushed when use is high (Liddle 1997). Studies have shown that the flora and fauna of rocky shores can be significantly affected by trampling and community structures may be altered (e.g. Beauchamp & Gowing 1982, Ghazanshahi et al. 1983, Bally & Griffiths 1989, Povey & Keough 1991, Brosnan 1992, Addessi 1994, Brosnan & Crumrine 1994, Porter 1994, Fletcher & Frid 1996, Keough 1996, Keough & Quinn 1998). Keough & Quinn (1998) pointed out the complexity of variables influencing the effects of trampling and natural variation on communities. Levels of disturbance may differ between sites and recovery from trampling may also vary.

3.3 OFF-ROAD VEHICLES

Off-road vehicles (ORVs) also have a negative impact on dune systems and beaches, in terms of structure and biota (Godfrey & Godfrey 1981, Steiner & Leatherman 1981, Wolcott & Wolcott 1984, Brown & McLachlan 1990). Off-road vehicles can destroy vegetation, reduce numbers of organisms, and disturb wildlife. Watson et al. (1996) surveyed the use of dunefields in South Africa by fishers and ORV drivers. They found a significant area and seasonal overlap with beach users and breeding birds and suggested that without appropriate management there might be a high impact on the flora and fauna.

3.4 BOATING ACTIVITIES

Anchoring can be particularly damaging in some marine habitats. As boats swing on their anchors with shifting winds and changing tides, their anchor chains abrade the benthic communities. The resultant level of damage depends on the sensitivity of the community. Davis (1977) described the extent of anchor damage to coral reefs in Florida. Rogers et al. (1990) discussed anchor damage in Virgin Islands National Park. They detailed methods for documenting damage to coral reefs and sea grass beds using photography and mapping techniques, and suggested protective measures to minimise damage, including the installation of moorings, designation of 'no anchoring' areas, education, and enforcement of regulations.

Damage can also occur around moorings. Walker et al. (1989) found that depending on the type of mooring used, large areas of sea grass beds could be destroyed. Damage can also occur where diver use is concentrated around moorings and anchors (Dixon et al. 1993).

Propeller wash and boat groundings can also cause significant damage to coastal benthic communities, depending on vessel size (Zieman 1976; Rogers et al. 1990).

3.5 DIVING—CORAL REEFS

A number of studies have investigated the impact of divers and snorkellers on corals (e.g. Hawkins & Roberts 1992, Davis & Tisdell 1995, Prior et al. 1995, Rouphael & Inglis 1997). Investigations showed that snorkelling and scuba diving can have a considerable impact on corals (Liddle 1997), and studies have confirmed that diver impact is a major management issue within MPAs (Medio et al. 1997).

Coral damage may be caused by divers intentionally (by curio collecting) or accidentally (by kicking, finning, trampling, holding, kneeling, standing, and re-suspension of sediments) (Hawkins & Roberts 1992). Hawkins & Roberts (1992) also found that divers can cause significant damage to the communities on coral reefs and diver-damaged reefs can occur very rapidly in heavily used areas. The reef damage appeared to stabilise after the initial rapid deterioration phase, with subsequent use having less impact. There was also some evidence that the differences between heavily dived sites and less dived sites may be relatively unimportant biologically. However, they were unable to determine if the communities could accommodate any more damage or whether there were any long-term effects.

Damage to coral may flow through to other organisms associated with that habitat. Lewis (1998) studied the effect of coral damage on the abundance of fish. The author found that many of the fish species appeared to be unaffected by the habitat damage. The fish that were negatively affected were species that associate closely with live coral. Significant declines in abundances of these species occurred almost immediately after coral damage.

Davis & Tisdell (1995) reviewed the impacts of recreational scuba diving and carrying capacity of MPAs, and identified the conflicts between recreation and conservation that may occur in MPAs. They suggested that although obvious damage is caused by diving, biological degradation or loss of biodiversity may not be significant. However, they did suggest that overcrowding at dive sites may lead to excessive deterioration of those sites. This usage (whether immediate or cumulative) may reduce amenity value, and may reduce the ecosystem functioning at particular dive sites. The authors concluded that critical thresholds are difficult to define, and pointed out the need for further research to identify social and biological thresholds, and the need to design and implement management strategies to reduce the conflicts between recreation and conservation.

Davis et al. (1995) discussed the impacts of recreational diving on MPAs, using Julian Rocks Aquatic Reserve, NSW, Australia, as a case study. Their focus was mainly on the intensity of use by divers and the economic value of the reserve to the diving community. They also considered possible management responses to intensive diver pressure. Their suggested management responses included:

- Installation of small boat moorings.
- Staggering dive times.
- reducing the number of divers using the most popular sites.
- On-going diver training (more experienced divers made significantly fewer uncontrolled contacts with the substrate than less experienced divers).
- Provision of diver care codes that direct more diver activity to alternative sites (here they also suggest establishing artificial reefs).

Davis et al. (1995) concluded that monitoring programmes are essential to detect changes over time. The use of a GIS database mapping marine habitats, mooring sites, dive pressure sites, and sea floor features provides a powerful tool to measure the effects of changing usage patterns and assists in management decisions.

Dixon et al. (1993) suggested that localised overuse within MPAs is commonly observed before larger-scale degradation begins and this could serve as an 'early warning system' for managers.

The impact of recreational diving on coral reefs in the Red Sea near the Sharm el Sheikh resort was investigated by Prior et al. (1995). Inexperienced divers were found to cause more damage than experienced divers. Although they were unable to clearly demonstrate whether mechanical damage or secondary damage to coral communities (e.g. increased susceptibility to fungal attack and disease, reduction of habitat to other organisms) was ecologically significant, there was evidence of cumulative degradation which could lead to irreversible damage. Prior et al. (1995) recommended encouraging inexperienced divers to use less sensitive sites and use of dive trails, and that education be upgraded (e.g. using videos, brochures and pre-dive briefings) to inform divers of care codes and engender conservation awareness.

Medio et al. (1997) investigated the rates of damage to coral resulting from scuba diving at the Ras Mohammed National Park, and set out to assess the effectiveness of environmental education in reducing these. They found that diver behaviour could be influenced by education. Following an environmental briefing there was a change in both the voluntary and involuntary contacts that divers had with the substratum, and in the type of substratum contacted by divers during voluntary contacts. Most intentional impacts were made by divers' hands, and unintentional contact by divers' fins. Divers using cameras and/or videos have been found to be amongst the worst offenders for having contact with the substrate (Prior et al. 1995). In response to these findings the Ras Mohammed Park managers initiated a training programme for dive-guides and instructors. The importance of public awareness and of the active participation of those in commercial ventures in public awareness initiatives (dive courses, tourist operators) has also been pointed out by Kenchington (1985), Salm (1985) and McCawley & Teaff (1994).

Rouphael & Inglis (1997) found that the topography of a coral reef was not an important influence on the type or amount of diver-damage incurred. Scuba divers caused more damage at reefs with a large cover of branching corals than at sites dominated by other growth forms. Other factors such as waves, currents, ecological characteristics of the site (including abundance and attractiveness of specific features) may also influence how often divers make contact with the substratum.

As establishing MPAs has not been initially successful at protecting coral reefs from human impacts, restoration has been suggested as an alternative strategy for rehabilitating damaged reefs (Rinkevich 1995).

3.6 DIVING—ROCKY REEFS

Sala et al. (1996) and Garrabou et al. (1998) demonstrated that intense diving can lead to the regression of bryozoan (*Pentapora facialis*) populations. Divers have an unintentional abrasive impact on the bryozoan colonies with two main consequences. Firstly there is a loss of colonies—the whole colony is detached from the substrate. Secondly, colonies are restricted to cryptic positions; that is, exposed colonies suffer greater mortality. Garrabou et al. (1998) found that the bryozoans were not able to recolonize quickly enough to compensate losses.

The diver disturbance on southern Monterey Bay giant kelp forests was investigated (Schaeffer & Foster, Unpublished report 1999). It is estimated that 60 000 divers visit the kelp forests every year. Initial results from the study suggested that large numbers of divers can affect the usually wave-protected kelp forests, which could lead to alterations in community structure. The authors suggested that impacts could be mitigated through more environmentally aware diving promotion, better training, and designation of ecologically resilient shore entry and exit points, and underwater training areas.

In general, damage to benthic communities from intentional or unintentional contact by divers depends on the amount of contact, the fragility of the organisms, the rates at which the organisms can recover, diver education and diver training. Damage to the habitat may have flow-on affects to other components of the environment.

3.7 WILDLIFE DISTURBANCE

Worldwide, the number of people wanting to experience wildlife in its natural environment is growing rapidly, particularly in the case of marine mammals (Orams 1996, Davis et al. 1997, Constantine 1999). Effects of humans on marine mammals were reviewed by Bejder (1995) and Constantine (1999) and are not covered in any detail here. Impacts include disturbance through human presence, contact, boating activities, noise, and feeding marine mammals—all of which may alter natural behaviours, change habitat use, affect reproduction and even pose a risk to people; e.g. if animals become aggravated or demanding of food (Constantine 1999).

There has not been as much research on the impacts of human interactions with other large marine animals, although there are a number of tourist operations involving manta rays, stingrays, sharks and whale sharks.

Shackley (1998) found that the stingray population off the coast of Grand Cayman in the western Caribbean was beginning to show major behavioural changes such as altered feeding habits and shoaling behaviour; and many individuals had skin abrasions from handling. On a busy day, up to 500 divers and snorkellers were observed in the water stroking and feeding the rays. It is estimated that the stingrays receive 80 000 to 100 000 visitors per year. Shackley (1998) suggested urgent long-term monitoring be set up and that possible restrictions on visitor numbers may be necessary to manage the impacts on the stingrays.

Many shark tourist operations involve feeding sharks to attract them. There may be negative impacts on the sharks; but also of concern is that inshore feeding of sharks could endanger divers and conflict with other recreational users of the marine environment (Burgess 1999). There is a relatively new tourist operation of swimming and diving with whale sharks off the coast of Western Australia. There is very little information on the effect of this tourism on the sharks, although there has been some monitoring (Davis et al. 1997). Davis et al. described the ecological, experimental and economic elements of whale shark tourism. They discussed management concerns and demonstrated how management can significantly improve both the protection of the sharks and the experience of the tourists.

Other interactions include feeding of fish which may alter natural behaviours and change species interactions, e.g. divers feeding potato cod and moray eels at dive spots on the Great Barrier Reef (Mellor 1990, Alder & Haste 1995).

The negative impacts of humans on seabirds have been widely documented (e.g. Ellison & Cleary 1978, Anderson & Keith 1980, Hand 1980, Erwin 1980, Pfister et al. 1992, Watson et al. 1996, Rodgers & Smith 1997 and many others). Impacts include:

- Changes in habitat utilisation.
- Loss of eggs/burrows.
- Nest desertion—reduced survival of chicks.
- Desertion of colony by all or part of breeding population.
- Disruption of migratory birds, disruption of roost sites.
- Feeding disruptions, habitat destruction (e.g. burrows).
- Disruption of breeding activities.
- Disruption at sea (e.g. resting/feeding flocks, shag roost/nest sites, loss of individuals such as penguins being hit by boats).

Particular species may be more susceptible to human disturbance, depending on what habitat they utilise. For example, the impacts of human disturbance were found to be greater for species occupying front-beach habitat rather then the back dunes (Pfister et al. 1992).

Seabird species differ in their sensitivity to disturbance and react to human disturbance in a variety of ways. Some species of coastal birds may become habituated to humans (Scott et al. 1996). These authors found that oystercatchers (*Haematopus ostralegus*) and redshanks (*Tringa totanus*) showed a significant difference in disturbability at sites with higher visitor pressure. At such sites the birds allowed observers to approach more closely before flying away. Similar results have been found by Dunlop (1996) and Fitzpatrick & Bouchez (1998). Muir & Chester (1993) use Michaelmas Cay in Australia as a case study to review visitor management strategies for seabird nesting islands. Claridge (1997) provides a comprehensive review of the vulnerability of Australian seabirds (many of which also occur in New Zealand) to human activities, and provides excellent guidelines for managing visitor interactions with seabirds.

Myrberg (1980, 1990) reviewed the effects of human-produced noise on the behaviour and related processes of marine animals. Most research concentrates on marine mammals and fish, as comparatively little research has been conducted for other groups (Myrberg 1990). Deleterious effects on the hearing of fishes may occur even at moderate noise levels (Myrberg 1990). Impacts may include disruption to individual and species recognition, disruption of territory defence, and affects on ability to search for prey, and to avoid predators (Myrberg 1990).

3.8 SUMMARY

- Many types of human activity (including non-consumptive) can have negative impacts on the coastal environment.
- Harvesting, trampling, diving and boating have similar impacts on the coastal marine area.
- The direct effects of these impacts on coastal environments are reduced densities and altered size structure of species populations, particularly molluscs and fish.
- Indirect effects on other species and ecological processes include loss of habitat and changes in competition and predation.
- Damage to communities from intentional or unintentional human impact depends on a number of variables, including: the degree and intensity of contact, the fragility or sensitivity of the organisms or environment, and the rates at which the organisms can recover.
- Other more subtle impacts include behavioural changes.
- Education can significantly alter people's behaviour and therefore reduce or minimise impacts to the coastal environment.

4. Review of New Zealand research on visitor impacts on the coastal environment: 1975 to June 1999

Literature searches revealed that there has been little research in New Zealand on visitor impacts on the coastal environment or marine protected areas (also see Tables 3 & 4.).

In 1991 DOC prepared an annotated bibliography on coastal recreation in New Zealand (Department of Conservation 1991). The bibliography has 210 references, which contain information on coastal recreation in New Zealand for the period 1975 to 1991. Only 17 of the 210 references included some information on the impact of recreational activities on the coastal environment, or the impact of visitors on one another. Of these 17, only a few identified and investigated visitor impacts on the coastal environment. These were: Healy (1978), Muir (1982), Friends of the Shoreline (1988), Harris (1988), and Clarke (1990). None of the studies was conducted in an MPA.

Healy (1978) and Harris (1988) reported on the impact of four-wheel drive vehicles, trail bikes and horses on the stability and vegetation cover on sandy beaches, and lower foredunes, and noted that major damage was caused by these activities. Muir (1982) investigated the broad use of, and recreational activities on, the coastline, and evaluated the potential of the area as a leisure resource in Poverty Bay. Visitor numbers, activities and effects of usage on the Castlecliff Coastal Reserve near Wanganui were described by Friends of the Shoreline (1988). Management recommendations for reducing the impact of unacceptable activities were provided. Clarke (1990) assessed recreational activities at Pauatahanui Inlet and the zones in which they occurred, with reference to potential conflicts and threats to the ecology of the area.

Devlin et al. (1995) and Peebles (1995) produced a review and synthesis of research literature, and an extensive bibliography related to outdoor recreation in New Zealand. These volumes include a few references related to recreational activities, social impacts and physical impacts on coastal marine areas. Of these, only the research conducted by Jeffs (1993) on the impacts of a glass-bottomed boat at the Cape Rodney to Okakari Point Marine Reserve is directly related to investigating human impacts on an MPA. This study was briefly outlined in Devlin et al. (1995). Ward & Beanland (1996) also reviewed the study by Jeffs (1993) as part of a critical review of research into the impacts of tourism in New Zealand.

In 1996, DOC held a workshop to scope visitor impacts on conservation areas managed by the Department, and to develop an action plan for research into those impacts (Cessford 1997; Cessford & Dingwall 1997). The workshop documents give background information on the overall types and effects of visitor impacts on conservation values, although they only provide a few specific issues related to coastal environments. The literature search revealed

that there has been little attempt to determine threshold levels or carrying capacities of visitor use, or examine use or impact relationships in detail within New Zealand, let alone in New Zealand MPAs.

Recent studies investigating visitor impacts on the coastal environment are detailed in Sections 4.1–4.7, and are also listed in Tables 3 & 4.

4.1 HARVESTING

Noticeable impacts of legal recreational fishing have been reported for Mimiwhangata Marine Park (Dart & Darby (1982), Commission for the Environment (1982) and Grace (1981, 1985)). The detrimental impacts of recreational take of several fish species, and the exploitation of kina within Mimiwhangata Marine Park are detailed in Grace (1981, 1985). Similar impacts were found at Tawharanui Marine Park. The Auckland Regional Council's management plan (Auckland Regional Council 1992) states that monitoring surveys indicate that the quality of marine life in the 'no take' area was improving, but not as dramatically as was experienced at the Cape Rodney to Okakari Point Marine Reserve. This has been attributed to the numerous instances of people fishing inside the marine park and the inadequate enforcement of fishing regulations.

4.2 TRAMPLING

Impacts of human trampling on eelgrass, *Zostera novazeandica*, and the associated macrofauna inhabiting Harwood sandflat in Otago Harbour, were investigated during 1997/98 (Miller, S. 1998). The sandflats are used regularly by people walking across them, horse riding, driving four-wheel farm bikes and dragging their dinghies across at low tide. People have even been seen playing golf on the sandflats. Four-wheel bike tracks were still present several months after they first appeared. Heavy trampling (greater than 10 passes in one area) resulted in decline of the above ground biomass of eelgrass and the beginning of trench formation. Horse riding and four-wheel biking ripped up rhizomes and roots, leading to the formation of large bare patches into which eelgrass had not re-colonised by the end of the study in 1998. A number of recommendations were made in the report, including restriction of human and boat access to selected areas in the harbour; the creation of marked pathways, setting aside of areas for boat launching and mooring, and increased education about the importance and vulnerability of eelgrass ecosystems. Restoration of eelgrass beds was also suggested.

The effect of visitors on the rocky intertidal reefs in the Cape Rodney to Okakari Point Marine Reserve was examined by Brown (1996). Trampling was found to have reduced the height of coralline turf which, in turn, appeared to have caused a reduction in abundances of the faunal inhabitants associated with the turf. Established patches of the dominant algal turf *Hormosira banksii* showed extensive reduction in percentage cover immediately after trampling, even at the lowest rate of five steps per trampling session. Vegetation did not recover

during the year-long monitoring period. Brown (1996) highlighted the fact that simply declaring a marine reserve is not sufficient to ensure the inhabitants and habitats of the reserve are protected from human disturbance, and suggested that if visitor numbers continued to increase, restrictions on public access to near-pristine or less-disturbed areas might be needed. Details and recommendations on methods and equipment for monitoring visitor impacts on rocky intertidal reefs were provided.

The results of further trampling experiments on coralline turf and its associated fauna in the Cape Rodney to Okakari Point Marine Reserve were presented in Brown & Taylor (1999). Trampling of coralline turf resulted in the immediate reduction in density of total animals, and in abundance of the five commonest taxa. Most taxa recovered after three months once trampling ceased. However, recovery times may not be as fast in areas where periods of intense trampling occur. Coralline algae grow slowly and may not fully recover before the next visitor season. Although the long-term effect of this impact was not investigated, it is suggested that the reduction of these taxa may have flow-on effects to other constituents of the community and may have long-term effects on the community structure of the rocky shore. The authors recommended that the effective management of protected coastal areas and marine reserves in particular may require the total exclusion of humans from some parts of the MPA.

Schiel & Taylor (1999) found that trampling intensity had variable effects on the dominant algal (*Hormosira banksii*) cover of rocky intertidal platforms in southern New Zealand. As few as 10 tramples produced discernible changes in percentage cover. However, recovery could be high provided there was sufficient time without further disturbance. Season, location, indirect effects of reduction in coralline algae and recruitment of *H. banksii* influence recovery after disturbance. The authors suggested that as numbers of visitors increased, communities on southern New Zealand intertidal platforms may be dramatically changed.

A report to DOC which investigates the effect of human recreational activities on rocky intertidal reefs on New Zealand's north-eastern coast and, in particular, within Cape Rodney to Okakari Point Marine Reserve, is currently being prepared. The report is expected to provide management recommendations for visitor use within marine reserves.

4.3 OFF-ROAD VEHICLES

Vehicle impacts on sandy beaches and coastal dunes have recently been reviewed in a study conducted for DOC (Stephenson 1999). This review summarises previous research, mostly outside New Zealand, into vehicle impacts on the biota of sandy beaches and coastal dunes covering the period 1988–97. These impacts are not discussed here, although the results of New Zealand and international studies are similar (e.g. Healy 1978, Harris 1988).

4.4 BOATING ACTIVITIES

The impacts of a commercial glass-bottomed boat operation in Goat Island Bay, Cape Rodney to Okakari Point Marine Reserve were reported in Jeffs (1993). Results from this study suggested that fish behaviour was modified by the boat's operation (and other vessels). Fish tended to move away from other boats, which may be related to the speed at which they were operated. Fish species reacted in a different ways to the glass-bottomed boat, and in the case of snapper (*Pargrus auratus*), for individuals of different sizes. For example, butterfish (*Odax pullus*) and silver drummer (*Kyphosus sydneyanus*) were observed to have the highest 'fright' responses, some plankton feeders (e.g. sweep, *Scorpis lineolatus*) were attracted to the material stirred up by the boat, and some benthic species were largely unaffected by the passage of the boat. However, it was considered unlikely that there would be any significant long-term impacts on the natural ecology of the area, especially compared with other activities such as uncontrolled fish feeding, other boat traffic, and the discharge of polluted water from a nearby stream.

The type of boat operating in the reserve did not have any observed effect on the behaviour of different bird species. Although there did not appear to be a negative impact on bird behaviour, the author suggested that, as a precautionary measure, the commercial boat should avoid areas of importance to birds.

Jeffs (1993) found that the boat's mooring chain had abraded sessile communities and seaweed from an approximately 5 m strip of rocky platform. Although the damage was obvious, it was restricted to a small area and the situation could easily be remedied by shortening the chain or using rope for attaching the buoy.

4.5 DIVING

Following concerns that recreational divers may be having a deleterious impact on red coral populations in Te Awaatu Marine Reserve, Fiordland, a survey of the population structure was undertaken in order to establish a baseline survey for future monitoring (Miller, K. 1995). It was found that the percentage of damaged red coral colonies increased with colony size, and that most damaged colonies were found on the southern site where densities were higher and most diving occurred. Results from the second survey indicated that populations of red corals in Te Awaatu Marine Reserve had declined by about 40% between 1995 and 1998, although overall damage rates appeared to have dropped (Miller, K. 1998). This may be a consequence of most damage having already occurred.

Preliminary growth studies showed that corals can grow up to 2 cm per year (Miller, K. 1998). However, this was based on only one year's study and growth among colonies was found to be highly variable with some colonies even shrinking. Therefore, recovery rates cannot be estimated at this time. Miller, K. (1998) recommended that regular monitoring of the reserve continue to determine the effects of recreational diving on red coral colonies and gauge

colony growth rates. Diver education to help minimise colony damage was recommended, along with studies to examine reproduction and recruitment and investigate natural types and rates of damage, and to gather more detail on actual diver damage.

4.6 WILDLIFE DISTURBANCE

Although not primarily studying effects of fish feeding on fish behaviour, Cole (1994) found that divers feeding fish in the Cape Rodney to Okakari Point Marine Reserve may have altered fish behaviour there. Snapper (*Pagrus auratus*) were found to be more positively diver-oriented in the middle section of the reserve where most of the public activity was focused. Evidence of altered behaviour within the reserve for other fish species such as blue maomao (*Scorpis violaceus*) and parore (*Girella tricuspidata*) was also found. Cole (1994) suggested that diver-responsiveness of different fish species related to their feeding habits. He found that the macro-carnivores were most diver-responsive. He also suggested that the increase in abundance of these fish in popular dive areas within the reserve may affect the abundance or population size structure of their prey.

There have been a number of studies of human interactions with seabirds in New Zealand, mostly concentrating on shore birds and those that nest on the mainland (e.g. Dowding 1993, Robertson 1993, Barlow, 1995, Lord et al. 1997, Eagles 1998, Wright 1998). Walls (1999) has provided an excellent guide to impact issues relating to a number of bird species that occur in the coastal environment, plus management and future research recommendations. For this reason, visitor impacts on seabirds are not covered in detail here.

The impacts of humans on the endangered New Zealand dotterel (*Charadrius obscurus)* were investigated by Lord et al. (1997). Chicks spent less time feeding, and were restricted to less desirable areas, when people were present in their habitat. The presence of people may threaten the ability of dotterel chicks to consume enough food. The report recommended restricting people's access to feeding areas during breeding seasons to help increase chick fledging success.

Eagles (1998) found that little blue penguins (*Eudyptula minor*) were sensitive to human voices and torch lights. This may have adverse effects on populations regularly visited by humans. The report recommended that these disturbances be mitigated wherever possible and suggested that restrictions on the type of lighting and level of noise permitted be implemented in areas where human interactions with penguins are likely to occur.

Wright (1998) investigated the impacts of ecotourism on yellow-eyed penguins (*Megadyptes antipodes*) on the Otago Peninsula. The presence of humans affected the frequency of yellow-eyed penguin landings to the study beach. The study concluded that if people used the hide provided by DOC to view yellow-eyed penguins there would be little short-term effect on the penguins.

4.7 SUMMARY

- Only a few studies have investigated visitor impacts on the coastal environment in New Zealand and only three studies have specifically investigated visitor impacts on MPAs in New Zealand.
- Results of studies conducted in New Zealand are consistent with those conducted outside New Zealand. Composition and abundance of marine life can be altered by fossicking, and taking and trampling, and fish behaviour may be altered by hand feeding.
- Results from these studies demonstrate that visitors are having negative impacts on marine reserves.
- Although the biological significance of these impacts may not have been demonstrated, the studies have provided some management recommendations for amelioration of visitor impacts.

5. General characteristics of visitors to marine reserves in New Zealand

New Zealanders make great use of the coast for recreation, and the coastal environment is also recognised as a major attraction for international visitors (Statistics New Zealand 1993). The number of visitors to New Zealand is increasing (Statistics New Zealand 1993, Tayor & Smith 1997). For example, the number of visitors to the Kaikoura Peninsula has risen rapidly over the last 10 years (Dave Schiel, Senior Lecturer, Canterbury University, pers. comm.). As visitor numbers increase, the recreational pressures on the New Zealand coastal environment will continue to increase.

Visitor surveys conducted at marine protected areas reflect the growing number of visitors to the coast, especially in those reserves close to large metropolitan areas (e.g. Sutton 1994, 1995, 1996; Brown 1996). These surveys have also shown that the wide variety of coastal recreational activities that are undertaken on the coast are also undertaken within MPAs (see Tables 1 & 5). Increasing popularity of marine reserves can be expected as people learn more about them and about the natural values of the coast; and as local community infrastructure and services increase (Cocklin & Flood 1992).

Only a few surveys have been conducted or monitoring programmes established to specifically assess the extent and range of activities of recreational visitors to marine protected areas in New Zealand (see Table 5). Some surveys were conducted as part of proposals for the establishment of marine reserves (e.g. Department of Conservation 1989, 1994a). Access issues have a significant effect on whether or not visitors to MPAs have been monitored. Some MPAs, such as Cape Rodney to Okakari Point Marine Reserve have one main access point (in this case, via the road from Leigh), making monitoring visitors fairly easy. Others, such as Kapiti Marine Reserve, are visited mainly by boaties launching from a number of sites (Bruce Dix, Conservation Officer, Department of Conservation, pers. comm.), making monitoring difficult. Other MPAs are difficult to monitor because of their remote location (e.g. Long Island Marine Reserve in the Marlborough Sounds and Kermadec Islands Marine Reserve).

The limited number of surveys conducted show that a wide range of visitors use marine protected areas and that, in general, the majority of visitors originate from the vicinity of the reserve and from the closest large metropolitan area (Lands and Survey 1984; Auckland Regional Authority 1988; Auckland Regional Council 1992, 1993; Cocklin & Flood 1992).

The first marine reserve in New Zealand was Cape Rodney to Okakari Point Marine Reserve, established in 1975, which has now been operational for more than 20 years. It is a major attraction in the Auckland Conservancy, visited by an increasing number of people each year and has become one of the most popular coastal destinations in New Zealand (Sutton 1996, Department of Conservation 1997, Enderby & Enderby 1998).

TABLE 5. VISITORS TO MARINE PROTECTED AREAS IN NEW ZEALAND AS AT JUNE 1999. INFORMATION COLLATED FROM PERSONAL COMMUNICATION WITH CONSERVANCY STAFF AND RELEVANT PUBLISHED SURVEYS.

ARA—Auckland Regional Authority
ARC—Auckland Regional Council
DOC—Department of Conservation
MR—Marine reserve
MP—Marine Park
?—Unknown
Arrows denote symbolically the proportion of increasing or decreasing visitor numbers. Dash for no change.

CONSERVANCY	MARINE PROTECTED AREA	VISITOR SURVEYS, MONITORING, OR IMPACT STUDIES WITHIN THE MPA (EXCLUDING SOCIAL IMPACT STUDIES)	VISITOR NUMBERS INCREASING OR DECREASING	VISITOR NUMBERS	COMMENTS
Northland	Poor Knights Islands MR Established 1981—18 y	None	↓	?	No formal counts Evidence from compliance work suggests that the number of visitors (boaties) has reduced subsequent to the total closure to fishing in mid 1998 (Keith Hawkins, Conservation Officer, Department of Conservation pers. comm.)
	Mimiwhangata MP Established 1983—16 y	Visitor survey: (Lands & Survey 1982)	?	?	No formal counts The Lands and Survey (1982) survey estimated about 100 boat visits to the area during the summer 1981/82
Auckland	Cape Rodney to Okakari Point MR Established 1975—24 y	Visitor survey: (Lands & Survey 1984) Visitor monitoring: (Sutton 1994, 1995, 1996) Visitor impact studies: (Jeffs 1993, Brown 1996, Brown & Taylor 1999)	↑	100 000+ annually	The estimated visitor numbers for the summer period of 1983/84 were 14 000 (Lands & Survey 1984). Estimated number of visitors annually to the marine reserve was 114 000 in 1993, and 122 000 in 1994 (Sutton 1994, 1995) and continues to be over 100 000 per year (Department of Conservation 1997), with up to 3000 visitors per day during the summer peak periods (Brown & Taylor 1999). Main use is focused around the centre of the reserve (Brown 1996)
	Tawharanui MP Established 1981—18 y	Visitor surveys: (Auckland Regional Authority 1988, Auckland Regional Council 1992)	↑	100 000 annually	Usage levels at the park increased 9% in the period between 1988 and 1991 (from 57 000 to 78 000 visitors per year). In 1991 the number of visitors per day during peak periods was about 3000. The 97/98 figures were estimated at 95 000 visitors per annum. Numbers have been increasing at about 1% per year over the last few years (Eric Hamilton, Park Ranger, Auckland Regional Council, pers. comm.). Main use of the area is concentrated on the beach and dunes (Eric Hamilton, Park Ranger, Auckland Regional Council, pers. comm.).

Auckland	Kermadec Islands MR Established 1990—9yrs.	None	?	?	No formal counts or estimates.
	Long Bay - Okura MR Established 1995—4 y	Visitor monitoring: (Auckland Regional Council 1993)	↑	1 000 000+ annually	From car park monitoring it has been estimated that there can be 40 000 visitors on a summers day and one million visitors annually to Long Bay beach (Auckland Regional Council 1993). Total visitors (including boaties) to the marine reserve now probably exceeds 1.5 million per year (Chris Roberts, Conservation Officer, Department of Conservation, pers. comm) Main use of the area is concentrated on about 25% of the beach (Eric Hamilton, Park Ranger, Auckland Regional Council, pers. comm.).
	Motu Manawa - Pollen Island MR Established 1995—4 y	None	?	?	No formal counts or estimates.
Waikato	Te Wanganui-a-Hei (Cathedral Cove) MR Established 1992—7 y	Visitor monitoring: Unpub. report, Waikato Conservancy visitor monitoring programme	↑	100 000+ annually	Estimates from counters at Cathedral Cove show the increase in visitors to the area rise from approximately 19 000 per year in 1992 to over 135 000 per year in 1998 Compliance officers collect information on visitors and activities during their work (Peter Carter, Conservation Officer, Department of Conservation, pers. comm.)
Bay of Plenty	Tuhua (Mayor Island) MR Established 1992—7 y	None	↑	?	No formal counts Compliance officers have noted an increase in visitors (boaties). However, this may reflect the general increase in recreational use of this coast and not necessarily be due to the presence of the marine reserve (Allan Jones, Conservation Officer, Department of Conservation, pers. comm.)
East Coast/ Hawkes Bay	Te Angiangi MR Established 1998—1 y	Visitor survey: (DOC 1994b)	-	1000+ annually	Prior to the establishment of the reserve, a survey to estimate types and levels of activities was conducted during summer in 1992. The average number of visitors to the area was 54/day Over the peak summer period, 1998/99, observers estimated approximately 20–25 boats/day being launched at the reserve, and about 20–25 people/day snorkelling, and about 50–60 people/day on the beach. It is estimated that use over the winter period would be very low with only about 10–20 people/week visiting the reserve (Pat Bonis, Conservation Officer, Department of Conservation, pers. comm.)

Wanganui	Sugar Loaf Islands Marine Protected Area Established 1991—8 y	None	?	1000+ annually	No formal counts Types of activities and levels of use of the area were estimated from a 1989 Taranaki Regional Council recreational survey of region (Fechney 1997). Number of dives per year estimated for 1989 were 1500, and recreational fishing effort is estimated to have been 800 boat trips annually
Wellington	Kapiti MR Established 1992—7 y	None	?	?	No formal counts Prior to the establishment of the reserve, information on the use of the area had been gathered (Baxter 1987, Department of Consevation 1989). Baxter (1987) estimated up to 30 people/day visited the Kapiti area over summer in 1986
Nelson/ Marlborough	Long Island - Kokomohua MR Established 1993—6 y	None	↓	?	No formal counts Evidence from compliance work suggests that numbers of visitors (boaties) has dropped due to the marine reserve establishment and therefore closure to fishing. (Andrew Baxter, Conservation Officer, Department of Conservation, pers. comm.)
	Tonga Island MR Established 1993—6 y	None	↑	?	No formal counts Estimated that numbers of visitors are increasing as popularity of that coast in general increases (Andrew Baxter, Conservation Officer, Department of Conservation, pers. comm.)
	Westhaven (Te Tai Tapu) MR Established 1994—5 y	None	?	?	No formal counts or estimates
West Coast	None	N/A	N/A	N/A	N/A
Canterbury	Pohatu MR Established 1999—0 y	None	?	?	No formal counts or estimates
Otago	None	N/A	N/A	N/A	N/A
Southland	Te Awaatu Channel - The Gut MR Established 1993—6 y	Visitor impact study: (Miller 1995, 1998)	?	?	No formal counts or estimates
	Piopiotahi MR Established 1993—6 y	None	?	?	No formal counts or estimates

Cocklin & Flood (1992) found that most of the visitors to Cape Rodney to Okakari Point Marine Reserve either lived in the vicinity or were from Auckland. Other visitors came from Hamilton, Wellington, Taranaki, Napier and even Christchurch. Most visitors to the Reserve were day-trippers, with the sole purpose of visiting the marine reserve, and most people surveyed visited the marine reserve in the summer months only (Cocklin & Flood 1992). A survey conducted over summer 1983/84 estimated visitor numbers to be about 14 000 (Lands and Survey 1984). More than 100 000 people now visit Cape Rodney to Okakari Point Marine Reserve each year (Department of Conservation 1997), with up to 3000 visitors per day during the summer peak periods (Brown & Taylor 1999). Visitors tend to concentrate in only a small, central, part of the reserve (Lands and Survey 1984, Brown 1996). In excess of 1200 visitors have been be counted on the intertidal reef on a summer's day during low tide (Brown 1996). Visitor numbers are extremely variable, dependant on the season, holiday periods and weather conditions (Brown 1996).

Long Bay Marine Reserve situated next to Long Bay Regional Park in Auckland, has only been established since 1995. Being sited next to a popular regional park, in safe sheltered waters, has meant this area already had a large number of visitors before it became a marine reserve. Car counter estimates of visitor numbers to the area show a dramatic increase in people from 40 000/yr in 1983, to 80 000/yr in 1985 and 1 000 000/yr in 1991 (Auckland Regional Council 1993). Visitors to this marine reserve are now estimated to be in excess of 1.5 million annually (Chris Roberts, Conservation Officer, Department of Conservation, pers. comm.). As expected, the highest visitor numbers occur over summer—around 40 000 per day at peak times (Auckland Regional Council 1993; Brenda Green, Auckland Regional Council, pers. comm.).

Since the establishment of Te Whanganui-a-Hei Marine Reserve in 1992, visitors to the area have been steadily increasing (DOC unpublished internal visitor monitoring report). There are now more than 135 000 visitors per year to the reserve, with numbers at their highest over summer. One survey indicated that many visitors were from overseas (Dunn 1996).

Newly established marine reserves and those situated further away from large populations, or reserves that are only accessible by boats, presently have low numbers of visitors (see Table 5). Some marine reserves have, in fact, had a reduction in the number of visitors, e.g. the Poor Knights Islands and Long Island marine reserves (see Figure 1). Before the total closure to fishing was implemented at the Poor Knights Islands Marine Reserve, 70% of boats (approximately 20 boats/day during peak summer times) were visiting the islands for angling (Keith Hawkins, Conservation Officer, Department of Conservation, pers. comm.). Now about half that number of boats visit the area, and these are mainly dive charters (Keith Hawkins, Conservation Officer, Department of Conservation, pers. comm.).

This reduction in visitor numbers when the designation of an area changes to marine reserve may be temporary as other types of recreation become established and as the marine reserve gains greater publicity. The Cape Rodney to Okakari Point Marine Reserve at Leigh was established at a relatively undeveloped and isolated location, but over time it has become a very popular destination, largely because of the interest generated by the improvement in

marine life (Cocklin et al. 1998). In addition, commercial ventures may start up specifically to take visitors to marine reserves and, as a consequence, bring in more visitors. For example, dive charters were established at Te Whanganui-a-Hei Marine Reserve (Dunn 1996), and Tuhua Marine Reserve (Allan Jones, Conservation Officer, Department of Conservation, pers. comm.). Increasing numbers of visitors to marine reserves have also been noted at Tuhua and Tonga Island Marine Reserves where numbers reflect the general increase in use of the coast (Andrew Baxter, Conservation Officer, Department of Conservation, pers. comm.).

In summary:

- Most marine reserves in New Zealand have been established for less than 10 years.
- The number of visitors varies among marine reserves in New Zealand.
- Visitor numbers generally increase over time.
- Reserves in the Auckland region receive the highest number of visitors per annum.
- Visitors tend to focus on specific areas within reserves based on access and popular sites.
- A wide variety of recreational activities are undertaken in reserves; most visits are made during the summer months.
- Daily visitor numbers fluctuate depending on the weather conditions, tide, and holiday times.

6. Relevant variables to consider when developing monitoring or management options for marine reserves

Managers need to ensure that uses of marine reserves are consistent with the conservation objectives and purpose of the reserve and that unacceptable negative environmental impacts are avoided. The same is true for other marine protected areas. Adverse effects of human activity within reserves must be minor and of a temporary nature, and must not compromise components of the structure or functioning of the ecosystems within the marine reserve.

Visitor impacts may be cumulative and subtle, but with time they may have a dramatic effect on the coastal environment. As the number of visitors to a marine reserve increases, the conflict between resource use and resource protection will also increase.

Each marine reserve will have its own suite of variables related to habitat and species types, visitor patterns and pressures. Studies outside New Zealand have shown that ecological work directed at providing information for management of one area has not always provided simple messages that can be applied to management in other areas (e.g. Davis et al. 1995, Garrrabou et al. 1998). Keough (1996) noted that his research and other studies on the southern Australian coast have shown that not only are natural ecosystems variable from place to place, but so are the ecological processes and, more importantly, the responses to human disturbances. Some impacts may be very obvious, but perhaps not biologically significant (Davis & Tisdell 1995). Impacts vary from the obvious (e.g. death of organisms and habitat loss) to more subtle changes, that are difficult to quantify and assess (e.g. behavioural disturbances and changes in assemblage structures). It may be difficult to distinguish between long-term anthropogenic and natural changes or variability.

Kuss et al. (1990) emphasised that visitor impacts at all reserve sites must be considered separately, as many contributing factors make each site a specific and unique case. However, certain visitor impacts will occur in most marine reserves. Many of the management techniques used to control or mitigate these impacts at one reserve will apply also to the others, or could be adapted slightly to suit specific issues within particular reserves.

Critical features of any natural community subjected to disturbance are its ability to withstand damage and to recover from it. These will depend not only on the nature of the community itself but also on the type, magnitude and frequency of disturbance (Underwood 1989).

Information on visitor numbers combined with environmental impact data is a basic requirement for good management.

Managers should evaluate potential visitor impacts and incorporate management options to address these in the planning stages of marine reserve proposals. Where possible, areas could be incorporated into the proposed reserve that naturally restrict human access (e.g. preserve some less accessible coastal areas to reduce human impacts to foreshore and ensure greater protection of marine life).

To evaluate visitor impacts on marine reserves managers need to:

- Identify the species or communities of high conservation value, or which are likely to be affected by visitor activities, such as fragile communities and unique ecosystems or species assemblages of national or international importance (e.g. Fiordland, Poor Knights Islands, Kermadec Islands (Grange, 1990, Fahy et al. 1990, Shaw & Maingay 1990)). (See Box 1 for further detail.)
- Assess the likely visitor usage of the reserve, and usage of different sites of interest in the reserve.
- Evaluate the potential impacts arising from human activities (e.g. identify the types of activities that are likely to disturb marine life, damage natural habitats, effect natural behaviours; or introduce undesirable plants or animals. See Box 2 for further details on the introduction of species to marine reserves).
- Conduct initial surveys to assess the present situation and determine the initial management responses required. A manager may decide that although a particular impact on a habitat or community within a reserve may be less than desirable, an area might be 'sacrificed' without significant damage to the whole, to achieve other conservation objectives such as visitor education.
- Initiate research or monitoring programmes if required (e.g. regularly check the most popular sites in the reserve for signs of visitor pressure such as anchor abrasion; monitor visitor numbers). This allows managers to develop appropriate and timely responses to avoid unacceptable environmental impacts. It will also keep knowledge of the condition of the reserve up-to-date.
- Design a monitoring programme to assess the effectiveness of any visitor management techniques implemented (see Box 3 for further details on monitoring).

It is difficult to provide an objective and scientifically based set of criteria to specify what levels of visitor disturbance in a marine system should require management intervention. The level of acceptable change will vary according to the type of activity and the perceived importance of an area, and the vulnerability of the community or ecosystem.

Management techniques may need to be implemented when visitor activities:

- Impact on the natural habitat of marine life.
- Impact on the key elements or features of the reserve environment.
- Impact on the diversity, integrity and quality of the underwater scenery.
- Have the potential to introduce unwanted plant or animal species.
- Begin to reduce the value of scientific research in the reserve through disturbance of existing projects or future opportunities to study marine life in its natural habitat.

Box 1—Degree of visitor impact

The degree of visitor impact depends on a number of factors including:

Ecosystem tolerance

- The type of coastal environment/sensitivity of the environment, (e.g. mangroves, dunes, exposed rocky shores, sand flats).
- The vulnerability of particular species (e.g. a species' susceptibility to disturbance. Disturbance may cause species to alter their behaviour, species may be easily disrupted during breeding, and some animals are likely to be more vulnerable to human impact at certain times of the year or breeding cycle).
- The varying tolerance of different species to various impacts (recovery rates, habituation).
- The fragility of particular communities. Some species are sensitive to physical damage, (e.g. sponges, gorgonians, sea pens, bryozoans, hydroids, corals etc. For example: red and black corals found throughout Fiordland; endemic bryozoan beds off Tasman Bay and sponge/hydroid communities off Spirits Bay (Grange et al. 1981, Bradstock & Gordon 1983, O'Shea & Cryer 1998)).
- Status of a species (e.g. populations or species at risk—endangered, threatened or rare—are more vulnerable to human impact (Kuss et al. 1990). The only known colony of the endangered black coral (*Aphanipathes fruticosa*) in New Zealand was damaged at Kapiti Island by a boat anchor (Grange 1994). The rare endemic bryozoan, the scarlet alcyonidium, has only been found in the Cape Rodney to Okakari Point Marine Reserve (Gordon 1994). The spotted black groper (*Epinephalus daemelii*) and the Kermadec damselfish (*Parma kermadecensis*) are two of several threatened coastal fishes found in the Kermadec Islands Marine Reserve (Paulin & Roberts 1994)).

Visitor activity

- The type of usage, e.g. diving, fossicking amongst rocks on the intertidal reefs.

Intensity of use

- The overall number of visitors to the reserve (this will be effected by the proximity of major populations, the length of time the reserve has been operating, means of access e.g. boat access only, sealed or non-sealed roads, the available facilities and quality e.g. good car-parking, toilets).
- What periods are most utilised (time of day, season, year).
- The frequency of use (daily, every summer).
- Where most visits occur in a marine reserve, (e.g. people may focus on one particular reef or dive site).
- Special events, (e.g. sea week, where an influx of visitors is concentrated over a short period of time).

Box 2—Recognition of potential hazards: intentional or unintentional introductions of species to marine reserves

Over 140 species of exotic marine organisms have been accidentally translocated into New Zealand coastal waters (Cranfield et al. 1998). Most introductions probably arrived on hulls of ships and via ballast water. Ports, harbours and breakwaters, and sheltered bays where vessels moor are the areas most susceptible to invadion (Cranfield et al. 1998). The types of introduced organisms include seaweeds, estuarine grasses, and several animal groups. Impacts of adventive species include competitive exclusion of native species and/or habitat modification (Battershill et al. 1998, Cranfield et al. 1998).

There are already exotic organisms in marine protected areas. For example, species found in Auckland reserves include the Pacific oyster (*Crassostrea gigas*), the small brown seaweed *Colpomenia durvillaei*, the bryozoan *Bowerbankia imbicata*, the bivalve *Limaria orientalis*, and, most recently discovered, the Australian bridled goby (*Arenigobius bifrenatus*) (Dromgoole & Foster 1983; Gordon & Mawatari 1992; Adams 1994; Greene 1996; Willis et al. 1999; Bob Creese, Director Leigh Marine Laboratory, Auckland University, pers. comm.).

There have been recorded instances of dispersal of exotic species among sites within New Zealand—e.g. *Undaria*, the Japanese brown algae, has spread via ships' hulls to various ports (Hay 1990, Miller et al. 1997) and via mussel ropes from the Marlborough Sounds to a site on Stewart Island close to a proposed marine reserve (Lindsay Chadderton, Conservation Officer, Department of Conservation, pers. comm.). The potential threat of further introductions and of perhaps more aggressive species is real, and the possibility of these organisms being translocated to other marine protected areas is also real.

Mammalian predators and other pests and weeds may be introduced to areas adjacent to marine protected areas. Although not directly affecting the conservation values of marine protected areas, these introduced pests and weeds may have impacts on the coastal environment and biota (such as nesting sea birds).

Box 3—Assessing the impact of visitors

There are some impacts from any level of recreational activity. These may be insignificant at low levels, but depending on the type and intensity of use, and the type of environment or community, a point is reached where management is needed to control or minimise damage.

Visitor impacts may be difficult to quantify because they can be subtle and occur gradually over a long period within a context of considerable natural variation and there may be no historical reference points. For example, Keough (1996) found that there was an initial rapid decline of *Hormosira* mats after trampling, but during one summer, even areas with no human trampling declined after severe desiccation during extreme low tides on sunny days. The greatest impact on algal cover that monitoring season resulted from a natural event.

Impacts evolve simultaneously with the increase in visitor numbers but not necessarily in a linear fashion (Keough 1996). Therefore, long-term monitoring programmes are important. Benchmarks need to be established to determine when individuals or communities are being disturbed and when or whether that disturbance has potential to harm individuals, populations, or ecosystems.

Little attention had been given to the design of surveys that assess the effects of visitors on the coast (Kingsford et al. 1991). However, there is an increasing number of papers that discuss the sampling and design issues related to detection of ecological impacts on coastal environments (e.g. Clarke & Green 1988; Underwood & Kennelly 1990; Fairweather 1991; Underwood 1991, 1992, 1993b, 1994; Green 1993; Osenberg & Schmitt 1994; Oliver 1995; Glasby & Underwood 1996; Schmitt & Osenberg 1996; Berlow & Navarrete 1997; Keough & Quinn 1998; Kingsford & Battershill 1998; New 1998). Kingsford & Battershill (1998) is particularly useful as it provides a comprehensive source of approaches to studying coastal environments and detecting impacts, with the emphasis on coastal environments in New Zealand (and temperate waters of the east coast of Australia). This book provides a guide to the design of impact studies, and many examples of specific impacts are given throughout. Guidelines for survey and monitoring are also being developed by DOC.

7. Recommended techniques and options for managing visitor impacts on marine reserves

A number of articles and publications discuss visitor management options and provide guidelines for managing and mitigating visitor impacts on marine protected areas (e.g. Salm & Clark 1984, Woodley 1992, Alder 1993, Gubbay 1995, Oliver 1995, Cho 1998). Although not specifically aimed at managing visitor impacts on the coastal environment, two other useful references, Graefe et al. (1990) and Department of Conservation (1994b), describe a number of methods by which managers can evaluate visitor impacts, and provide a selection of approaches and management techniques. Many of these may be applied to the marine context.

As marine reserves become popular and visitor numbers increase, controls on recreational use are likely to become a more familiar part of reserve management (Gubbay 1995).

Management options for controlling and mitigating visitor impacts on marine reserves include:

- Modifying visitor behaviours through education.
- Regulating types of activities (e.g. commercial operations, boating activities).
- Encouraging minimal impact uses (e.g. board walks, interpretation trails, moorings).
- Reducing the use of specific sites.
- Restricting access.
- Promoting compliance of the marine reserve regulations.
- Identifying areas where damage can be repaired and undertaking restoration.

These options are explained in greater detail below.

7.1 PROMOTE ENVIRONMENTAL CARE

Marine environmental education is an essential tool for managing marine resources (Alcock 1994). Studies have shown that improved public education can reduce the amount of damage done by the public in coastal areas. A study in California found that many people were unaware of conservation problems or the need to care for the coastal environment, or were ignorant of, or ignored laws. However, following an education programme, visitor damage to intertidal areas was reduced (Ghazanshahi et al. 1983). Good signage also increased people's awareness of conservation regulations (van Herwerden & Griffiths 1991).

Diver education was found to be very important (Rouphael & Inglis 1997). The probability of divers coming into contact with the substratum is determined by a range of personal attributes that influence their behaviour in the water and the sea conditions at the time of the dive. In particular, the technical competence of

divers and the types of activities they pursue (e.g. photography, training, exploration), and their awareness of the environmental consequences of their actions all affect the liklihood that they will damage the environment (Davis et al. 1995, Rouphael & Inglis 1997). Diver education programmes have been very effective in reducing physical damage to the environment (Rouphael & Inglis 1997, Medio et al. 1997).

The more people know about and understand responsible use of the coastal environment, the less likelihood there is of inadvertent abuse of the environment (and a greater likelihood of reducing the frequency of offending in marine reserves).

All marine reserves in New Zealand have educational material. This includes on-site signage, brochures and environmental care codes (See Table 6).

7.2 REGULATE COMMERCIAL OPERATIONS

Commercial operators are subject to:

- The general management and offence provisions of the Marine Reserves Act 1971.
- Provisions under the Marine Reserves Act 1971 that allow the Director General (DOC) to 'take steps as may be necessary to ensure the continued welfare of any reserve in the interest of scientific study of marine life and for the enjoyment of the reserve by the public' (section 11). Such steps may include restrictions on the number of commercial operators, visitors, or stipulating conditions as may be necessary to meet the Act's requirements.
- Section 24 of the Act which enables regulations to be made to give full effect to the Act and its administration.

Regulations can be used to limit commercial operations in marine reserves. These regulations enable the Department to have more control over the type and number of commercial activities, and therefore greater power to mitigate adverse effects.

7.3 ENCOURAGE MINIMUM IMPACT USE

7.3.1 Provide underwater trails

Underwater trails can be used to provide focal points in desired locations, and they provide educational and cautionary information. Green (1982) discusses the types and uses of underwater interpretation, and provides some designs for self-guided underwater trails.

Problems encountered with the installation of underwater trails include the difficulty of keeping the markers clear of encrusting organisms and the tendency to concentrate visitors in certain areas, sometimes increasing damage around the trail.

7.3.2 Provide moorings

Boat moorings can be used to prevent anchor damage, and focus activities in desired locations.

TABLE 6. MARINE PROTECTED AREAS MANAGEMENT AS AT JUNE 1999.

CONSERVANCY	MARINE PROTECTED AREA	MANAGEMENT COMMITTEE OR CONSERVATION MANAGEMENT DOCUMENT	COMPLIANCE AND LAW ENFORCEMENT (CLE)	ADVOCACY[1]
Northland	Poor Knights Islands[2] Established 1981	Marine Issues Advisory Committee A conservation management plan is in preparation	Warranted DOC staff Honorary rangers	✓
	Mimiwhangata[3] Established 1983	None	MinFish officers Honorary rangers	✓
Auckland	Cape Rodney to Okakari Point[2] Established 1975	Leigh Reserve Complex Draft Conservation Management Plan (DOC 1997)	Draft CLE Plan Warranted DOC staff Honorary rangers	✓
	Tawharanui Peninsula[4] Established 1981	Tawharanui Regional Park Management Plan (ARC 1992)	ARC Park rangers Honorary Fisheries officers	✓
	Kermadec Islands[2] Established 1990	None	Royal NZ Air Force Warranted DOC staff	✓
	Long Bay - Okura[2] Established 1995	None	CLE Plan Warranted DOC staff ARC Park rangers Honorary rangers	✓
	Motu Manawa - Pollen Island[2] Established 1995	None	Warranted DOC staff	✓
Waikato	Te Wanganui-a-Hei (Cathedral Cove)[2] Established 1992	Te Wanganui-a-Hei Marine Reserve Committee A conservation management plan is in preparation	Draft CLE Plan Warranted DOC staff Honorary rangers	✓
Bay of Plenty	Tuhua (Mayor Island)[2] Established 1992	None	Draft CLE Plan Warranted DOC staff MinFish officers	✓
East Coast/ Hawkes Bay	Te Angiangi[2] Established 1998	Te Anagiangi Marine Reserve Committee	CLE Plan Warranted DOC staff Honorary rangers	✓
Wanganui	Sugar Loaf Islands[5] Established 1991	Sugar Loaf Islands Conservation Management Plan (Fechney 1997)	MinFish officers Warranted DOC staff	✓
Wellington	Kapiti[2] Established 1992	Kapiti Marine Reserve Conservation Management Plan (DOC 1998a)	Draft CLE Plan Warranted DOC staff Honorary rangers	✓
Nelson/ Marlborough	Long Island - Kokomohua[2] Established 1993	Long Island Advisory Committee	CLE Plan Warranted DOC staff	✓
	Tonga Island[2] Established 1993	None	CLE Plan Warranted DOC staff	✓
	Westhaven (Te Tai Tapu)[2]	None	Warranted DOC staff	✓
Canterbury	None	N/A	N/A	N/A

Canterbury	Pohatu Established 1999	Pohatu Marine Reserve Advisory Committee	Warranted DOC staff	✓
Otago	None	N/A	N/A	N/A
Southland	Te Awaatu Channel - The Gut[2] Established 1993	None	Warranted DOC staff	✓
	Piopiotahi[2] Established 1993	None	Warranted DOC staff	✓

[1] Advocacy includes brochures, signs, care codes etc.
[2] Marine reserves. Marine reserves are managed by the Department of Conservation (DOC).
[3] Mimiwhangata Marine Park. Mimiwhangata Marine Park is managed by the Ministry of Fisheries (MinFish) and DOC.
[4] Tawharanui Peninsula Marine Park. Tawharanui Peninsula Marine Park is managed by the Auckland Regional Council (ARC), ex Auckland Regional Authority (ARA) and the Ministry of Fisheries.
[5] Sugar Loaf Islands Marine Protected Area. Management of Sugar Loaf Islands Marine Protected Area is shared by two agencies. Specific Fisheries Regulations and fisheries resources, as defined under the Fisheries Act 1996, are the responsibility of the Ministry of Fisheries. The foreshore, seabed, seawater, birdlife and marine mammals remain the responsibility of the Department of Conservation.

There are some problems associated with moorings. These include:
- Determining control of usage (e.g. who uses them and when, especially when moorings may be sponsored by commercial interests).
- Cost of up-keep.
- Possible habitat damage from mooring chains.
- Concentrating visitors around the mooring site, thus increasing the possible damage around these areas.

7.4 REDUCE THE USE OF SPECIFIC SITES

Marine reserve managers can reduce the use of specific sites by steering visitors towards alternative sites.

7.5 RESTRICT ACCESS

Freedom of access of the public to marine reserves is an important feature of the Marine Reserves Act 1971. But that freedom is '*subject to the provisions of this Act and to the imposition of such conditions and restrictions as may be necessary for the preservation of marine life or for the welfare in general of the reserves*' (MRA, 1971). Regulation 12 of the Marine Reserve Regulations 1983 can also be used to exclude the public from areas within a marine reserve closed for scientific study. Therefore, restrictions on public access may be imposed where necessary to protect marine life for scientific study.

Restricting access to parts of a reserve, or zoning, can be used to:
- Provide focal points in desired locations.
- Provide selective control of different sites.
- Protect biota over other goals.
- Separate incompatible activities (e.g. diving, boating, swimming, research).
- Allow areas to recuperate.
- Provide protection at various times of life cycles (e.g. breeding times).

Zoning may also be required to keep incompatible recreational activities apart, such as separating speed boating and water skiing from dive schools.

Access can also be restricted by passive means, such as reducing access points, and not providing facilities.

7.6 PROMOTE COMPLIANCE WITH THE MARINE RESERVE REGULATIONS

Enforcement is an essential component in the management of MPAs, not only to stop intentional illegal activities but also to reduce unintentional misuse of reserves (Underwood 1993a, Causey 1995, Keough 1996). The level of enforcement required may vary significantly from site to site. Education, peer pressure and enlisting the help of user groups (e.g. engaging honorary rangers and passing on the conservation message through dive club instructors) can be the most effective form of enforcement and can generate public support and visitor compliance (Causey 1995).

Illegal activities, intentional and unintentional (ignorance of the regulations), do occur in New Zealand MPAs. For example, during the peak summer season at Long Bay Regional Park there are, on average, three incidents per day of people disregarding the marine reserve no-take regulations (Meg Ramsey, Park Ranger, Auckland Regional Council, pers. comm.). Oysters have also been taken illegally from the marine reserve (Greene 1996). Another example concerns the illegal taking of paua and kina from Te Angiangi Marine Reserve (Debbie Freeman Conservation Officer, Department of Conservation, pers. comm.). On their own these incidents may not be biologically significant, but in reserves with high visitor numbers the total impact of such actions could be significant.

All marine reserves are required to have a compliance and law enforcement plan of action (CLE Plan); however, not all have such plans in place (see Table 6). Warranted DOC staff and, in many cases, honorary rangers, patrol the reserves. However, the level and standard of policing varies and depends on training and motivation of individuals and the amount of resources allocated for the job (Anderton 1995; Steve Anderton, Conservation Officer, Department of Conservation, pers. comm.).

7.7 RESTORATION

Natural recovery of the environment from human impacts can be achieved through protective measures or 'active management' where species may be 'seeded' into the habitat (Brown & McLachlan (1990)—dune restoration, Schiel & Foster (1992)—restoration of kelp forests, Rinkevich (1995)—rehabilitation of damaged coral reefs, Miller, S. (1998)—restoration of eelgrass, Anderson & Devlin (1999)—restoration of a multi-species seabird colonies). Although some species may be actively restored, this may be difficult or impossible for other species (Schiel & Foster 1992).

8. Current management of visitor impacts on marine reserves in New Zealand

At present, integrated management objectives for all established marine reserves are detailed in each Conservancy Conservation Management Strategy. Some marine reserves have specific Conservation Management Plans and/or management committees (see Table 6). Compliance Law Enforcement Plans are also required as part of the reserve management, and are developed by Conservancies to co-ordinate compliance promotion and law enforcement responses within marine reserves (see Table 6).

Educational material is used to increase people's awareness and understanding of the coastal environment, and to promote sensitive use. All existing marine reserves have signage, information boards, and promotional and educational pamphlets (see Table 6). Other methods used to promote environmental care include talks, summer programmes, and liaison with dive clubs and other key interest groups.

Visitor impact issues are becoming more widely recognised by marine reserve managers and many of these issues are beginning to be addressed (see Appendix 2). Box 4 provides a case study of the visitor impact issues and visitor management being undertaken by marine reserve managers at the Cape Rodney to Okakari Point Marine Reserve.

Box 4—Case study of visitor management in a marine reserve in New Zealand. Cape Rodney to Okakari Point Marine Reserve (Established 1975), Auckland Conservancy, Department of Conservation

Management of the reserve is directed by the Leigh Reserve Complex Draft Conservation Management Plan (Department of Conservation 1997). Compliance and law enforcement is directed by the Draft Compliance Law Enforcement Plan. Warranted DOC staff and honorary rangers patrol the reserve.

The main management issues concerning visitor impacts on the reserve are increasing visitor numbers, trampling on intertidal reef platforms, fish feeding, anchor and mooring damage (Department of Conservation 1997; Chris Roberts, Conservation Officer, Department of Conservation, pers. comm.).

Visitor numbers have increased dramatically over time, placing increasing pressure on the reserve resources (Department of Conservation 1997). However, managers anticipate that visitor numbers will self-regulate to the level of the facilities provided, and not continue to grow (Department of Conservation 1997). The Conservancy will continue monitoring visitor numbers (using a car counter) to periodically assess the situation (Department of Conservation 1997).

Recent research found that visitors were having an impact on species abundance and, possibly, community structures on the most popular intertidal reef in the reserve. (Brown 1996). It was suggested that the Department might need to consider restricting access to the reefs if visitor numbers continued to increase (Brown 1996). Brown & Taylor (1999) suggest this may also be necessary for other MPAs in New Zealand.

The rights of public access are subject to the general management sections of the Marine Reserves Act 1971, and regulations of the Marine Reserves Regulations 1983 and as such, restrictions or conditions on public access to the reserve may be imposed the Department (Department of Conservation 1997). Although trampling on the popular intertidal reefs has been identified as a problem, the Draft Conservation Management Plan (Department of Conservation 1997) does not specifically address the issue.

The issue of altered natural behaviour of fish through hand-feeding is being managed by discouraging people from doing it through education and liaison with dive clubs (Department of Conservation 1997).

The Department seeks to discourage anchoring in high-use areas by provision of at least six moorings (Department of Conservation 1997).

Further management strategies recommended by DOC include a proposal to promulgate Marine Reserve Regulations through which controls on commercial ventures can be implemented, promoting public awareness and education about the reserve, monitoring visitors to ascertain the level of public knowledge and understanding of the reserve rules, and encouraging relevant research (Department of Conservation 1977).

Most of the research that has been conducted in the reserve has concentrated on population processes or individual species, and not on visitor impacts on the ecology of the marine reserve (Department of Conservation 1997). The Draft Conservation Management Plan (Department of Conservation 1997) states that Departmental research contracts should focus on studies that will enable better management of the marine reserve and its visitors, and that the Department will continue to encourage university research into visitor impacts.

Currently there is no research being undertaken by the Department to assess or monitor visitor impacts on the Cape Rodney to Okakari Point Marine Reserve. In addition, there has not been a formal evaluation of how the management strategies outlined in the Draft Conservation Management Plan (Department of Conservation 1997) are working, or may work, to mitigate visitor impacts.

9. Recommendations for future research

Many suggestions for further research on the impacts of visitors can be found in the literature studied in this review, in the proceedings of a workshop scoping the impacts of visitors on natural and historic resources in New Zealand (Department of Conservation 1995, Cessford 1997) and arising from specific DOC conservancy requests. These suggestions relate to the assessment of visitor usage of marine reserves, identification of specific visitor impacts at particular sites, extending our basic knowledge of the effects of visitor impacts and the reactions of organisms and communities to those impacts, and the testing of specific mitigation and management techniques. Much of this research will go hand-in-hand with obtaining information on both the biology of various species under threat of impact, and monitoring changes within reserves to separate anthropogenic influences from natural perturbations.

There is an obvious lack of research into visitor impacts on marine reserves in New Zealand (refer Table 5); however, this does not mean that all marine reserves or MPAs should have a complete research and monitoring programme in place.

To be prudent, however, managers should conduct a preliminary assessment of the likely impacts for each marine reserve. In order to respond in a timely fashion, managers should have at least a preliminary assessment for each reserve of:

- Existing and likely visitor impacts.
- Levels of impacts presently occurring.
- Likely increase in reserve uses and hence potential impacts.

The literature search revealed the lack of visitor impact studies on MPAs in New Zealand, and that there is a need for baseline surveys to assess visitor impacts. There is also a need to instigate and maintain long-term monitoring to assess the impacts of various visitor activities and hence their sustainability.

It is recommended that DOC:

- Design a check list to assist MPA managers to make an initial assessment of the level of visitors and level of visitor impacts.
- Design guidelines for monitoring visitor numbers for the various situations that can be expected in MPAs. For example: one access point, many access points, remote MPA.
- Design guidelines for monitoring visitor impacts, identifying the most likely types of impacts and the research methods best suited for monitoring them.
- Design guidelines to evaluate the effectiveness of mitigation or management responses.

Based on the literature search, DOC reports (Department of Conservation 1995, Cessford 1997) and the specific DOC conservancy requests, the following topics are suggested for further research.

9.1 SUGGESTED RESEARCH TOPICS

9.1.1 Anchor damage

What damage is caused by anchoring in New Zealand coastal environments? Which environments are most sensitive? Are moorings a good alternative? Do they reduce the environmental impacts associated with anchoring or do they create other problems? For example, at the Cape Rodney to Okakari Point Marine Reserve a mooring chain was substantially damaging a small area the marine habitat (Jeffs 1993). Are there design solutions that will make moorings conservation friendly (e.g. sub-surface floating buoys to keep the chain vertical and off the sea floor, thus preventing it from dragging and scouring the habitat)? The allocation of moorings between public and commercial use may also need to be addressed.

9.1.2 Fish feeding

This activity can change population and species structures and behaviour; e.g. increased numbers of carnivorous fish around feeding sites. Such changes can affect scientific studies; for example, behavioural and population studies of specific fish species. Other projects may benefit from the 'friendliness' of the fish, e.g. using tamed fish to take blood samples from. Does fish feeding by visitors pose any significant threat to the viability and ecological values of a marine reserve? Do the educational and public awareness benefits of fish feeding outweigh the negative effects or limitations on scientific study?

9.1.3 Anti-fouling paints

Are these leaching off boat hulls? Do high numbers of small vessels have more impact than small numbers of large vessels? Anti-fouling paints are likely to be of particular concern in MPAs near marinas or when marinas or other facilities are established within an MPA.

9.1.4 Pollution

This may become a problem in areas where boating increases or is concentrated in particular areas with poor water circulation. For example, Long Bay Marine Reserve has very high visitor numbers, including many small boats. Pollution from these small vessels may become a problem during summer months (although determining pollution source may be difficult, as run-off and urban development will be contributing to the general levels of pollution in the area).

9.1.5 Propeller wash from larger vessels

For example, inter-island ferries in the Marlborough Sounds (Davidson 1997) and large tourist vessels turning in Fiordland.

9.1.6 Spread or introduction of weed and pest species

Are there any potential weed or pest problems? How can introductions be avoided? Can any be remedied if they occur?

9.1.7 Underwater caves

What are the impacts of divers on underwater caves? What do divers do to them? Do they effect air quality etc.?

9.1.8 Bird disturbance

What are the impacts of visitors on seabirds? For example, effects of boating on flush flight distances, zoning and buffer recommendations.

9.1.9 Conservation awareness

Analysis of the cost and benefits of recreational use of marine reserves is needed, e.g. visitors feeding the fish and altering fish populations and behaviour in one part of a reserve versus the positive spin-offs of improving people's attitudes towards conservation.

10. Conclusions

1. There are proven negative impacts of visitors on the coastal environment. Harvesting, trampling, diving, and boating all have similar impacts. The direct effects are reduced densities and altered size structure of populations of species. Indirect effects on other species and ecological mechanisms include loss of habitat and changes in competition and predation. Other more subtle impacts include behavioural changes and reduction in species health.
2. The critical features of any community subjected to disturbance are its ability to withstand damage and to recover from it. These will depend not only on the nature of the community itself but also on the type, magnitude and frequency of disturbance.
3. There have been few studies specifically investigating visitor impacts on the coastal environment in New Zealand, and there have only been three studies specifically investigating visitor impacts on MPAs in New Zealand, all in marine reserves. The results of studies conducted in New Zealand are consistent with and reflect international studies.
4. The significant problems associated with visitors to marine reserves in New Zealand that have been identified so far include: damage to intertidal and subtidal reef systems, and changes to fish behaviour through visitors feeding them.
5. The number of visitors to the coast is increasing. The number of visitors to marine protected areas in New Zealand is also generally increasing. Reserves in the Auckland region receive the highest number of visitors per annum. Visitors tend to focus on specific areas within reserves, based on access and popular sites. Summer is the peak visitor season.
6. There are a number of management techniques available to control and mitigate visitor impacts. These include: provision of facilities (e.g. moorings, underwater trails, boardwalks), restricting visitor activities, restricting visitor numbers and access, providing education and law enforcement. Education can significantly alter people's behaviour and thus reduce or minimise impacts.
7. Marine reserve managers must identify and assess visitor impacts, and then monitor the situation so that they can respond in a timely fashion. The success or otherwise of visitor management techniques employed must also be monitored.
8. Further research is required to assess the biological significance of visitor impacts on MPAs in New Zealand. There is also a need to instigate and maintain long-term research to assess the impacts of various visitor activities and hence their sustainability.

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Appendix 1

Potential non-extractive visitor impacts on coastal environments and examples of management response

These impacts may also occur in MPAs. Extractive impacts (e.g. curio collecting, legal and illegal extraction) can occur in all coastal environments.
Management responses can include:
Modifying the type of use and visitor behaviour.
Modifying the location of use within an the area.
Modifying the timing of use.
Modifying visitor expectations.
Increasing the resistance of the resource.
Reducing use of specific sites.
Maintaining or rehabilitating the resource.
Limiting the use of the entire area (Department of Conservation 1994b).

Note, In the following table:
[1] off-road vehicles includes dune buggies, motor bikes, four-wheel drive trucks, cars, buses etc.
MHWS = Mean High Water Springs.
MLWS = Mean Low Water Springs.

COASTAL HABITAT	POTENTIAL VISITOR ACTIVITIES	POTENTIAL ENVIRONMENTAL IMPACTS	EXAMPLES OF MANAGEMENT RESPONSES
Dunes *Above MHWS*	Off-road vehicles [1] Presence/approach (e.g. picnics, walking, walking with dogs) Horse riding Noise Littering/rubbish	Loss of vegetation Blow-outs Dune instability Loss of shore nesting birds nests/eggs (e.g. New Zealand dotteral, *Charadrius aquilonius)* Disruption of shore roosts, resting birds, nesting, breeding birds Disruption of resting marine mammals (e.g. New Zealand sea lion, *Phocarctos hookeri*)	Restrict access Provide access ways e.g. board-walks, paths Dune enhancement, reconstruction, restoration Advocacy/education/education to improve behaviour, care-codes, supervision and enforcement of controlling regulations
Beaches *MLWS - MHWS*			
Sand	Off-road vehicles [1] Presence/approach (e.g. walking, walking with dogs) Launching boats Horse riding Noise Littering/rubbish	Damage to invertebrate populations (e.g. toheroa *Paphies ventricosum*) Disruption of feeding birds (e.g. variable oystercatcher, *Haematopus unicolour*) Indirect mortality of infauna may result from burial through compaction of sediments, collapsing burrows, or individuals becoming exposed to the surface and avian predation	Restrict access Advocacy/education to improve behaviour, care-codes, supervision and enforcement of controlling regulations Provide access ways e.g. boats ramps
Sand/gravel	Off-road vehicles [1] Presence/approach (e.g. walking, walking with dogs) Launching boats Horse riding Noise Littering/rubbish	Disruption of feeding birds Damage to invertebrate populations Indirect mortality of infauna may result from burial through compaction of sediments, collapsing burrows, or individuals becoming exposed to the surface and avian predation	Restrict access Advocacy/education to improve behaviour, care-codes, supervision and enforcement of controlling regulations
Gravel/boulder	Presence/approach (e.g. walking, walking with dogs) Intertidal exploration (e.g. fossicking under rocks) Noise Littering/rubbish	Disruption of feeding birds Damage to invertebrate populations	Restrict access Advocacy/education to improve behaviour, care-codes, supervision and enforcement of controlling regulations
Salt marsh *MLWS - MHWS*	Off-road vehicles [1] Presence/approach (e.g. walking, walking with dogs) Horse riding Littering Noise Littering/rubbish	Reduction or loss of vegetation Habitat damage Damage to invertebrate populations Disruption of shore roosts, resting birds, nesting, breeding birds	Restrict access Provide board walks Advocacy/education to improve behaviour, care-codes, supervision and enforcement of controlling regulations

mud flats *MLWS – MHWS*	Off-road vehicles [1] Presence/approach (e.g. walking, walking with dogs) Horse riding Littering/rubbish Noise	Habitat damage Damage invertebrate populations Disruption of feeding birds Damage to vegetation	Restrict access Advocacy/education to improve behaviour, care-codes, supervision and enforcement of controlling regulations
sand flats *MLWS – MHWS*	Off-road vehicles [1] Presence/approach (e.g. walking, walking with dogs) Horse riding Littering/rubbish Noise	Habitat damage Damage to invertebrate populations Disruption of feeding birds Damage to vegetation (e.g. eelgrass, *Zostera novazealandica*)	Restrict access Advocacy/education to improve behaviour, care-codes, supervision and enforcement of controlling regulations
Mangroves *MLWS – MHWS*	Off-road vehicles [1] Presence/approach (e.g. walking, walking with dogs) Littering/rubbish Noise	Habitat damage Damage to invertebrate populations Damage to vegetation	Restrict access Provide board walks Advocacy/education to improve behaviour, care-codes, supervision and enforcement of controlling regulations
Hard shore platforms *MLWS – MHWS*	Presence/approach (e.g. walking, walking with dogs) Intertidal exploration (e.g. fossicking under rocks) Littering/rubbish	Reduction or loss of algal cover (e.g. Neptune's necklace, *Hormosira banksii*) Damage or destruction of all or part of intertidal species (e.g. repeated dislodgement, crushing) Disruption of resting/breeding marine mammals (e.g. New Zealand fur seal, *Arctocephalus fosteri*) Disruption of feeding birds	Restrict access Advocacy/education to improve behaviour, care-codes, supervision and enforcement of controlling regulations
Offshore *MLWS – diving depths (approx. 30m)*			
Soft sediments	Anchoring Diving Littering/rubbish	Habitat damage, (e.g. flippers, anchoring) Diver-induced behavioural changes (e.g. fish feeding) Damage or destruction of all or part of subtidal benthic species (e.g. repeated dislodgement) Water quality—stirring up sediments and benthos	Restrict access Provide secure moorings Provide self guided underwater trails Advocacy/education to improve behaviour, care-codes, supervision and enforcement of controlling regulations
Rocky	Anchoring Diving Littering/rubbish	Habitat damage (e.g. flippers, anchoring) Diver-induced behavioural changes (e.g. fish feeding) Damage or destruction of all or part of subtidal benthic species (e.g. repeated dislodgement)	Restrict access Provide secure moorings Provide self guided underwater trails Advocacy/education to improve behaviour, care-codes, supervision and enforcement of controlling regulations

Offshore *Below diving depths – 12 nautical miles offshore*			
Soft sediments	Littering/rubbish	Habitat damage	Advocacy/education to improve behaviour, care-codes, supervision and enforcement of controlling regulations.
Rocky	Littering/rubbish	Habitat damage	Advocacy/education to improve behaviour, care-codes, supervision and enforcement of controlling regulations
Offshore surface waters *Coast to 12 nautical miles offshore*	Boating Oil-spills Littering/rubbish	Disturbance of flocking birds/resting or feeding birds Disruption of roost sites (e.g. shag roost sites in overhanging trees, cliffs) Disturbance of larger marine animals (e.g. marine mammals, sharks) Accidental deaths of seabirds (e.g. little blue penguins, *Eudyptula minor*, hit by boats)	Restrict access Advocacy/education to improve behaviour, care-codes, supervision and enforcement of controlling regulations

Appendix 2

Examples of visitor impacts on marine reserves in New Zealand

ILLEGAL HARVEST

Unintentional (ignorance of the regulations) and intentional harvesting has occured in a number of marine reserves, e.g. Cape Rodney to Okakari Point Marine Reserve, Long Bay Marine Reserve, Te Angiangi Marine Reserve (Greene 1996; Steve Anderton, Conservation Officer, Department of Conservation, pers. comm.; Debbie Freeman, Conservation Officer, Department of Conservation pers. comm.; Meg Ramsey, Park Ranger, Auckland Regional Council pers. comm.). Illegal take of paua and kina appears to be occurring primarily at night in Te Angiangi Marine Reserve (Debbie Freeman, Conservation Officer, Department of Conservation, pers. comm.).

TRAMPLING

An intertidal study at Cape Rodney to Okakari Point Marine Reserve revealed that visitors traversing and exploring rocky reefs and platforms are inadvertently damaging marine life and may be changing the structure of these ecosystems (Brown 1996, Brown & Taylor 1999). Anecdotal evidence suggests that the diversity of species on the very popular Echinoderm reef is significantly reduced compared with other less used intertidal platforms in the reserve (Bob Creese, Director Leigh Marine Laboratory, Auckland University, pers. comm.).

Trampling of the *Hormosira*/eelgrass beds on the rocky reef intertidal platforms at Te Angiangi Marine Reserve, particularly by school visits, is a serious issue (Debbie Freeman, Conservation Officer, Department of Conservation, pers. comm.).

OFF-ROAD VEHICLES

At Te Angiangi Marine Reserve, regulations allow vehicles (including cars, tractors, four-wheel bikes etc.) to drive along the sandy beach within the marine reserve. Information signs at the boundaries of the marine reserve request that vehicles do not drive across the rocky reef intertidal platforms. However, there

is evidence that vehicles are driven through the *Hormosira/*eelgrass beds (Debbie Freeman, Conservation Officer, Department of Conservation, pers. comm.).

BOATING ACTIVITIES

Anchor damage

Fiordland red and black coral—boat anchors may be damaging red corals and other assembledges (Miller, K. 1995, 1998); possible damage at the Poor Knights Island Marine Reserve (Ray Pierce, Conservation Officer, Department of Conservation, pers. comm.) and the Cape Rodney to Okakari Point Marine Reserve (Chris Roberts, Conservation Officer, Department of Conservation, pers. comm.).

Mooring damage

Cape Rodney to Okakari Point Marine Reserve (Jeffs 1993; Chris Roberts, Conservation Officer, Department of Conservation, pers. comm.), Poor Knights (Andrew Jeffs, Manager Aquaculture Research, NIWA, pers. comm.).

Diving

Divers may be damaging red and black corals in the Fiordland marine reserves (Miller, K. 1995, 1998). Possible diver damage is occurring at the Poor Knights and Cape Rodney to Okakari Point marine reserves (Ray Pierce, Conservation Officer, Department of Conservation, pers. comm.; Chris Roberts, Conservation Officer, Department of Conservation, pers. comm.).

Wildlife disturbance

Feeding fish is a very popular activity at the Cape Rodney to Okakari Point Marine Reserve. This practice may be changing the behaviour of certain fish species (Cole 1994, Department of Conservation 1997) and affecting fish health (Andrew Jeffs, Manager Aquaculture Research, NIWA, pers. comm.).