Scientific and biodiversity values of marine reserves

A review

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Trevor J. Willis

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A review

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Abstract

New Zealand's 'Marine Protected Areas Policy' is currently being implemented, and requires background information concerning the scientific and biodiversity values of marine reserves. This review determines the current state of knowledge, discusses the value of marine reserves for scientific research and biodiversity conservation, assesses trends in scientific productivity in marine reserves, places New Zealand work into an international context, and suggests future research priorities. Marine reserves in New Zealand have the primary function of protecting spatially delimited areas from the effects of fishing. Their success is generally measured by the recovery of exploited species within their boundaries, which is reliant on consistently conducted monitoring time series. Estimates of recovery have now been obtained from several reserves, showing that snapper (*Pagrus auratus*), blue cod (*Parapercis colias*), and rock lobster (*Jasus edwardsii*) all respond positively to protection, although the speed and magnitude of recovery tends to be variable and site-specific. Recovery of these predators has been linked to changes in reef habitats through trophic cascades, effects on small cryptic reef fishes, and effects on assemblages in nearby soft-sediment habitats. New Zealand's contribution to the study of marine reserves has slowed in recent years, reflecting reduced funding for marine ecological research nationwide, changes in composition and research emphasis in scientific personnel, but also reluctance in some regions to approve manipulative experimental work within marine reserves. Whilst direct effects of marine reserves on fisheries are uncertain and difficult to demonstrate, the use of unfished areas to act as controls for the effects of fishing on almost all aspects of marine ecological study is a potentially powerful, but as yet only partially realised, research tool. In addition to providing unfished areas for estimating population parameters of fished species, marine reserves could provide spatial references for the state of fished stocks, controls for effects-of-fishing studies, inform models of ecosystem structure, and provide the opportunity for detecting previously unrealised linkages between habitats and species. Continued progress in this area will benefit from a unified approach to research involving long-term partnerships between management, researchers, and funding agencies. The review concludes with recommendations on how this may be achieved, and suggests priorities for future research to further utilise marine reserves in understanding the marine environment.

Keywords: marine reserves, value, research, science, New Zealand

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1. Introduction

The New Zealand Marine Reserves Act (1971) states specifically that one of the reasons marine reserves are to be established shall be '... for the purpose of scientific study'. This was a legacy of the pioneering efforts of staff of the University of Auckland's Leigh Marine Laboratory, and after the establishment of the Cape Rodney–Okakari Point Marine Reserve (also known as Goat Island or Leigh Marine Reserve), the laboratory became a centre of activity in southern hemisphere reef ecology. Scientific endeavour did not, however, focus on the marine reserve itself until the late 1980s, and few formal peer-reviewed papers were published before the 1990s, in New Zealand or elsewhere.

Marine reserves are areas of marine habitat that are permanently closed to all fishing or any type of human disturbance (apart from permitted activities). They tend to engender controversy during their establishment, at least partly because their goals are often not clearly expressed (Agardy et al. 2003), because fishery professionals and environmental advocates present conflicting information about their usefulness (Polunin 2002; Russ 2002; Kaiser 2005), or because the conclusions drawn from the science to date (Willis et al. 2003e; Sale et al. 2005) remain contentious.

The field of marine reserve science exploded internationally in the 1990s, with a steady climb in the numbers of empirical papers documenting positive responses, especially by exploited species, to the effects of protection. After 1995, a burgeoning theoretical literature (Willis et al. 2003e) began to cause the field to gain traction in policy and environmental arenas. That science was (and to a large extent still is) generally directed at determining the effects of marine reserves as spatial management tools for maintaining or enhancing local fisheries (Roberts & Polunin 1991; Agardy 1994; Rowley 1994; Russ & Alcala 1996; Bohnsack 1998; Gell & Roberts 2003). Here, instead, I review New Zealand research that has benefitted, or has the potential to benefit, from utilising marine reserves. The research can be divided into three general categories:

- Biological studies that benefit from a lack of human-induced disturbance in a marine reserve to understand biological parameters (Cole 1994; Kelly et al. 1999; Willis et al. 2001; Parsons et al. 2003; Giacalone et al. 2006; Barrett et al. 2009b; Hart & Chute 2009).
- Studies that use reserves as an experimental manipulation (Macpherson et al. 2000; Willis & Millar 2005; Freeman & MacDiarmid 2009).
- Studies that compare reserve and fished areas to understand the ecosystem effects of fishing (Babcock et al. 1999; Shears & Babcock 2002; Willis & Anderson 2003; Langlois et al. 2005; Guidetti 2006; Langlois et al. 2006). One might expand this to encompass all forms of anthropogenic disturbance, but in practice, most other forms of human-induced impact at the spatial scales protected by reserves (e.g. physical disturbance to the substratum by anchoring or diver activity) are not excluded under marine reserve regulations. Some Fiordland marine reserves have no-anchoring areas within them (e.g. Te Tapuwae o Hua (Long Sound) and Hawea (Clio Rocks) Marine Reserves; see Fig. 1 for locations of reserves mentioned throughout this review), but these areas were mostly established to protect specific features independently of the reserves.

Arguably, all ecological research in the marine environment where fishing occurs can be thought to have some degree of bias relative to natural ecosystems because of disturbance and removal of biomass by fishing. A recent review (Sale et al. 2005) lamented the science gaps that impeded the use of marine reserves for fishery management purposes. Here, I attempt to make the case that marine reserves are a potentially powerful tool for filling in science gaps in several fields—including fishery science. In addition, I review the substantial body of empirical work produced in New Zealand since publication of the seminal paper by Cole et al. (1990), and critically review the various monitoring programmes in place at various marine reserves throughout the country (Fig. 1).

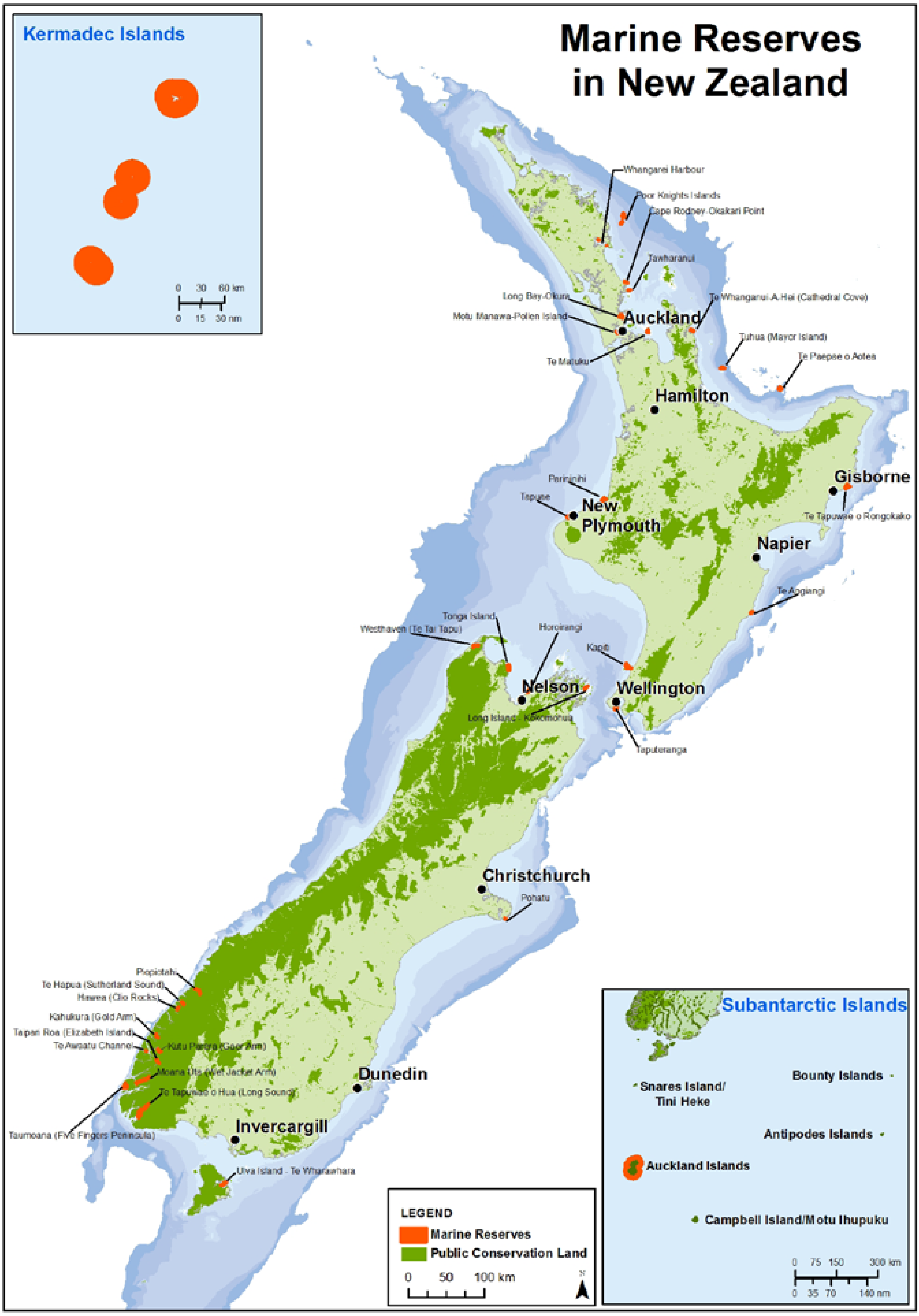

Figure 1. New Zealand Marine Reserves as at September 2013.

This review deliberately avoids dealing with the efficacy or otherwise of marine reserves as fishery management tools (or, more correctly, as fishery enhancement tools), and all that entails. The subject has been extensively (not to say, exhaustively) reviewed and debated (Roberts & Polunin 1991; Rowley 1994; Bohnsack 1996; Murray et al. 1999; Jamieson & Levings 2001; Russ 2002; Shipp 2003; Willis et al. 2003e; Hilborn et al. 2004; Kaiser 2005; Field et al. 2006) and no resolution is likely to be forthcoming any time soon.

Much of the published literature on the effects of marine reserves comes from work done in tropical environments. Not only are the habitats and species often different from those found in temperate zones, but the management and socio-economic considerations generally differ too. In many tropical regions, local economies are strongly dependent on neighbouring artisanal fisheries, and are subject to limited centralised management (e.g. Ferse et al. 2010). With few exceptions (South Africa, South America and parts of the Mediterranean zone), temperate zones have relatively minor artisanal fisheries, and fishery management is usually somewhat stronger.

Discussion of reserve effects in this review assumes that the reserve is a no-take one and that there is compliance with regulations. The benefits of 'paper parks' have been shown to be few, with key targeted species generally not responding within areas where protection consists of restrictions that do not eliminate fishing mortality (Denny & Babcock 2004; Denny et al. 2004; Kritzer 2004; Shears et al. 2006; Guidetti et al. 2008).

The review ends with a series of specific recommendations with regard to some possible future directions for research in New Zealand's marine reserves, with suggestions for ways to maximise benefits from existing programmes.

2. Research in New Zealand marine reserves

Lists of research documentation were compiled from a variety of sources. Postgraduate research theses from the University of Auckland[1], Victoria University of Wellington, and Otago University were searched for through the online library catalogues of the respective universities. Current research staff at these universities were contacted to ensure lists were complete. There were no contributions found from Auckland University of Technology, Massey University, University of Waikato, University of Canterbury or Lincoln University.

A list of unpublished reports was produced from an earlier compilation by Nick Shears (Shears 2006), and augmented with more recent reports listed on the Department of Conservation (DOC) website, or passed on by DOC staff, and direct contact with the authors.

Published, peer-reviewed articles were obtained from the Thompson ISI Web of Science® database using the search term 'marine reserve or marine reserves' in the Topic field, and 'New Zealand' in the address field. The resulting list was then edited, excluding work done elsewhere by authors domiciled in New Zealand, and papers that appeared in the search only by virtue of mentioning marine reserves in the discussion, or having had supplementary key-words added by journal or ISI staff. Earlier published work from the University of Auckland's Leigh Marine Laboratory was added by examining a complete list of Leigh Marine Laboratory publications[2] and selecting studies based on the author's own knowledge and that of laboratory staff.

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1 The complete output of marine science theses from the University of Auckland was obtained from http://www.library.auckland.ac.nz/subjects/marine/theses/leightheses-589--79.htm (viewed 3 May 2012).

2 Available from http://www.marine.auckland.ac.nz/uoa/home/about/our-research/publications-16 (viewed 3 May 2012).

2.1 Peer-reviewed literature

Until quite recently, the most basic question pertinent to marine reserves—do exploited species recover within reserves?—had not been answered with any great scientific rigour (Jones et al. 1993; Babcock 2003; Willis et al. 2003e). Historically, it had been assumed that the effects of fishing were minimal, that exploited species were too mobile to accumulate in small unfished areas and that marine conservation in general had only marginal scientific credibility (Babcock 2003). This was reflected in the publication rate of papers with a focus on no-take reserves prior to 1990 (Fig. 2), but a major consideration is that there was only one no-take marine reserve in New Zealand until 1992. The study by Cole et al. (1990) was one of the first worldwide to demonstrate some of the possible changes that could be brought about by not fishing in the coastal marine environment, and helped to interest many in the field.

New Zealand's contributions to the international marine reserve literature were few through the 1990s (McCormick & Choat 1987; Cole et al. 1990; MacDiarmid & Breen 1993; Cole 1994; Rowley 1994) until Dr Russ Babcock obtained support from DOC to establish a multifaceted research programme based on the northern Hauraki Gulf marine reserves, and later, the Poor Knights Islands. With three PhD programmes focusing on rock lobster (Kelly et al. 1999; Kelly et al. 2000; Kelly et al. 2002; Kelly & MacDiarmid 2003), reef fishes (Willis & Babcock 2000; Willis et al. 2000; Willis et al. 2001; Willis et al. 2003d), and reef invertebrate and algal assemblages (Shears & Babcock 2002, 2003; Shears et al. 2004), Babcock was able to draw together the data to document one of the world's first examples of a marine reserve causing a trophic cascade by reinstating top reef predators (Babcock et al. 1999).

Spin-off projects from this work included a slew of methodological studies, tagging projects on fish and lobster, and investigations seeking new evidence for trophic effects on other taxa. These studies are examined in more detail in Section 3.

At the time of writing, there have been 167 peer-reviewed papers resulting from work in New Zealand marine reserves (Table 1, Appendix 1), of which 58 deal directly with the ecological effects of no-take marine reserves. This total does not include work done at sites that became marine reserves some time after a study was conducted (e.g. Kingsford et al. 1989). Forty-nine of the 167 were published after 1998 (Fig. 2) and 34 utilised the Cape Rodney–Okakari Point Marine Reserve in the research, either alone or with data from other northern New Zealand reserves.

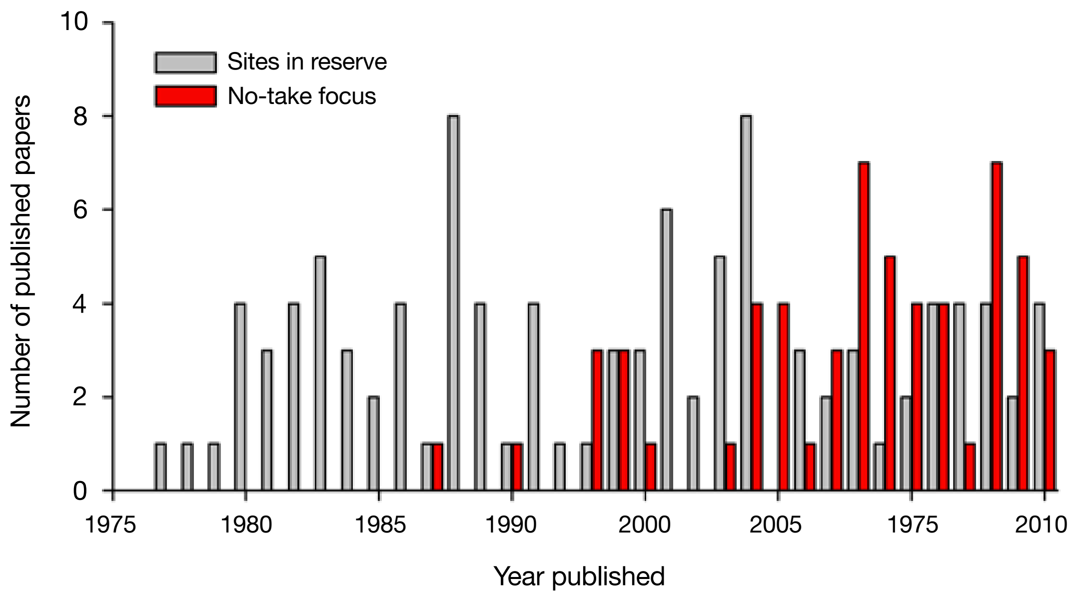

Figure 2. Number of peer-reviewed papers published by year for which the research was carried out in New Zealand marine reserves, and the number in which a no-take status was critical to the research.

Table 1. New Zealand marine reserves and research. Since some documents examine multiple reserves, the total number of documents is less than the sum of the site-level subtotals. Note that this list excludes areas not protected under the Marine Reserves Act (1971).

RESERVE	REGION	DATE GAZETTED	No. OF PEER-REVIEWED RESEARCH PUBLICATIONS	No. OF THESES	No. OF UNPUBLISHED REPORTS
Cape Rodney–Okakari Point (CROP, Leigh, Goat Island)	Northland	1975	119	127*	22
Poor Knights Islands	Northland	1981, 1998†	17	4	8
Kermadec Islands	Subtropical	1990	6‡		1
Kapiti Island	Wellington	1992	1	1	6
Te Whanganui A Hei (Hahei)	Coromandel	1992	8	3	22
Tuhua (Mayor Island)	Bay of Plenty	1992	3		10
Long Island-Kokomohua	Marlborough	1993	4		8
Tonga Island	Nelson	1993	5		7
The Gut (Doubtful Sound)	Fiordland	1993	3	1	11
Piopiotahi (Milford Sound)	Fiordland	1993		1	5
Westhaven (Te Tai Tapu)	Nelson	1994			1
Long Bay-Okura	Auckland	1995			18
Motu Manawa-Pollen Island	Auckland	1995	1	1	1
Te Angiangi	Hawke's Bay	1997	1	1	10
Pohatu	Canterbury	1999	1		3
Te Tapuwae o Rongokako	Gisborne	1999	3	1	7
Auckland Islands/Motu Maha	Subantarctic	2003			
Ulva Island/Te Wharawhara	Stewart Island	2004			6
Hawea (Clio Rocks)	Fiordland	2005		1	2
Kahukura (Gold Arm)	Fiordland	2005			2
Kutu Parera (Gaer Arm)	Fiordland	2005	1	1	2
Moana Uta (Wet Jacket Arm)	Fiordland	2005	1	1	2
Taipari Roa (Elizabeth Island)	Fiordland	2005	1		1
Taumoana (Five Fingers Peninsula)	Fiordland	2005		1	2
Te Hapua (Sutherland Sound)	Fiordland	2005			
Te Tapuwae o Hua (Long Sound)	Fiordland	2005	1	1	2
Te Matuku	Auckland	2005			
Horoirangi	Nelson	2006			5
Parininihi	Taranaki	2006			6
Te Paepae o Aotea (Volkner Rocks)	Bay of Plenty	2006			1
Whangarei Harbour	Northland	2006			
Tapuae	Taranaki	2008			
Taputeranga	Wellington	2008		1	2
Total			**167**	**136**	**170§**

* Includes theses done prior to reserve establishment.

† Signifies when the Poor Knights Islands Marine Reserve was gazetted as a no-take marine reserve (1 September 1998). A more complete bibliography of Poor Knights Islands publications is available in Sim-Smith & Kelly (2008).

‡ This figure is not comprehensive. It omits a number of taxonomic and descriptive papers from various expeditions to the Kermadec Islands that formed the basis for the islands being designated a marine reserve, but are not related to the islands' marine reserve status.

§ Includes three reports on the greater Fiordland Marine Area that sampled some reserves incidentally, and three general reports to DOC dealing with design and database issues for marine reserve monitoring.

The increase in publication rate over the last 10 years has little to do with the establishment of 22 new marine reserves since 1995, but reflects continued output from the Babcock group. As can be seen from Table 1, more recently established reserves have received little attention in the published literature.

2.2 University theses

Only three of New Zealand's universities (Auckland, Victoria, and Otago) have established student research programmes related to marine reserves (Appendix 2).

The proximity and historical connections of the University of Auckland's Leigh Marine Laboratory to the Cape Rodney–Okakari Point Marine Reserve means that most student research conducted within a reserve area (either prior to or after reserve establishment) comes from that reserve. Victoria University's Island Bay Marine Lab has produced a number of theses based on field work done around the south coast of Wellington, including within what is now Taputeranga Marine Reserve. Only two completed theses to date deal with marine reserves: the baseline surveys of Taputeranga Marine Reserve by Pande (2001), subsequently published by Pande & Gardner (2009) and that of Struthers (2004) at Kapiti Island. Very recently, research programmes have been started on the Wellington south coast, centred on the new Taputeranga Marine Reserve (J.P.A. Gardner, Victoria University, pers. comm. 2010). At the time of writing, Otago University has produced 27 theses from work in Fiordland[3], most of which were completed prior to the establishment of the larger Fiordland reserve network in 2005. One recent PhD thesis (L. Jack, pers. comm.) incorporates marine reserves into its design, but no current work is specifically aimed at marine reserves *per se*.

Creese & Jeffs (1993) listed 72 theses in marine sciences from the University of Auckland and assessed the importance of the Cape Rodney–Okakari Point Marine Reserve to the theses based on the Leigh laboratory. My reanalysis of all marine science theses from the University of Auckland (n = 416) illustrates the importance assumed by the Leigh reserve area in marine reserve research from the 1980s onward (Fig. 3).

After a twenty-year period of sustained usage, marine reserves have been studied in markedly fewer Auckland University theses in the last 5 years (Fig. 3). Two main factors appear to have contributed to this decline. The first stems from changes in academic staff in 2003 and, therefore, changes in research focus at Leigh Marine Laboratory. The second is changes in the permitting process implemented by DOC's Auckland Conservancy in recent years (Anon., pers. comm. 2010) that have encouraged researchers to redirect studies to alternative locations in the vicinity. After 2004, only three theses (all PhDs) were completed that relied on no-take status. Two of these were initiated in 2002 prior to changes in the permitting process, and research for the third was conducted at the Te Tapuwae o Rongokako Marine Reserve near Gisborne. Thus, no new student research has been completed on Auckland or Northland Conservancy marine reserves in the last 5 years.

The 133 thesis studies done in marine reserves were assessed in a similar fashion to that used by Creese & Jeffs (1993), and assigned one of three categories: essential, where the study could not have taken place without a no-take reserve (study focus was either the reserve itself, or exploited species that were accessible in sufficient numbers only within a reserve); advantageous, where reserve status provided protection for experimental apparatus or manipulations, or the possibility of incidental fishing mortality may have impacted upon study species; and no particular advantage, where reserve status held little or no relevance to the study. The latter category comprised 60 (45%) of the theses (Table 2), which documented studies that were either laboratory-based, or utilised the proximity of the Leigh Marine Laboratory to the reserve but could have equally been based outside the reserve (if the increased logistical and time costs of travelling away from the laboratory are ignored). The remaining 73 theses (65%) derived benefit from the presence of the reserve, and 33 of those studies (25% of the total) could not have been conducted without marine reserves (Table 2).

[3] See http://marineinfo.otago.ac.nz/publications/search/Fiordland/ (viewed 30 Nov 2010).

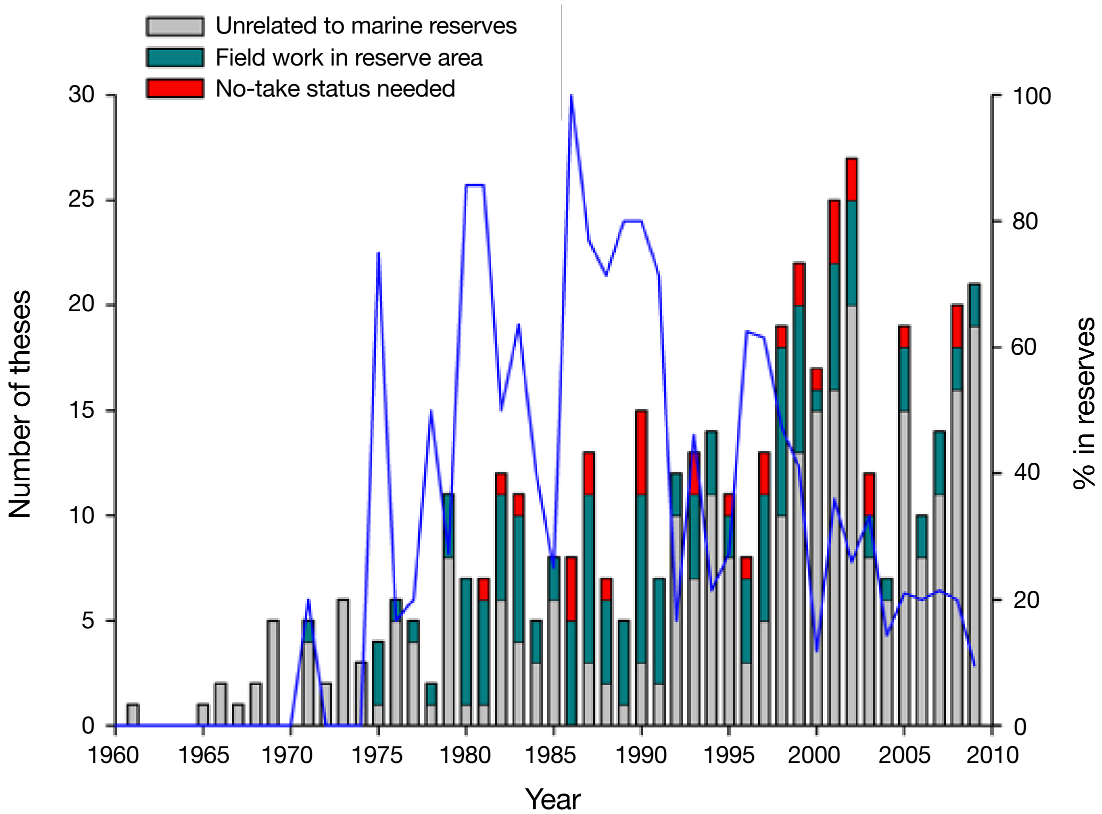

Figure 3. Number of graduate research theses (MSc and PhD combined) in marine science from the University of Auckland (1960–2009) and their relatedness to marine reserves. Field work in reserve area = at least part of the research was conducted within a marine reserve; "No-take status needed" = research that was wholly or partly dependent on the no-take area to succeed (included work that either focused specifically on the effects of marine reserves, or relied on the availability (for study) of exploited species within a reserve). Blue line = the percentage of theses in each year for which research was conducted within marine reserves.

Table 2. The importance of no-take status to thesis research conducted in marine reserves at the University of Auckland.

MARINE RESERVE	IMPORTANCE OF RESERVE TO RESEARCH		
	ESSENTIAL	ADVANTAGEOUS	OF NO PARTICULAR ADVANTAGE
Cape Rodney–Okakari Point (CROP)	31	38	58
Tawharanui Marine Park	4		
Te Whanganui A Hei	3		
Poor Knights Islands	1	2	1
Te Tapuwae o Rongokako	1		
Te Angiangi	1		
Motu Manawa-Pollen Island			1
Total	**33***	**40**	**60**

* Thesis research conducted at both the Tawharanui Marine Park and Hahei Marine Reserve was also conducted at Cape Rodney–Okakari Point Marine Researve. Research for one thesis was done at both Te Angiangi and Te Tapuwae o Rongokako Marine Reserves.

2.3 Unpublished reports

The unpublished, or 'grey', literature is the primary data source for almost all data pertaining to monitoring of marine reserves. Some is redundant, i.e. the latest report in a monitoring time series tends to report the previously collected data with that from the latest survey (e.g. Haggitt & Mead 2009b), and as will be seen in section 2.4, some is unreliable. While sometimes the 'grey' literature is the only source of information for a particular reserve (Table 1), I consider that the analysis and interpretation of unpublished reports should probably be put aside once the data have been published in a peer-reviewed journal. While not 100% guaranteed, the chances are high that the published analysis and interpretation have undergone careful examination by experts in the field, whereas an unpublished report most likely has not. The advantage of these reports, however, is that the raw data are often available for scrutiny, which occurs only rarely in published papers.

I compiled a list of 183 reports (including DOC publications, see Appendix 3), of which 13 were concerned with forms of protection other than marine reserve (e.g. cable zones and partially protected areas like Mimiwhangata Marine Park). Most were part of a series of reports and updates on Cape Rodney–Okakari Point and Te Whanganui A Hei Marine Reserves, followed closely by Long Bay-Okura Marine Reserve (Table 1), which has been repeatedly sampled as part of a series of intertidal shellfish surveys funded through the Ministry of Fisheries and a large estuarine project funded by the Auckland Regional Council. Intertidal estuarine reserves (Motu Manawa-Pollen Island, Te Matuku Bay and Westhaven (Te Tai Tapu)) have received little attention, as have some of the more remote (and hence expensive to study) locations (Kermadec Islands, Auckland Islands/Motu Maha, and the Fiordland marine reserves). Tuhua (Mayor Island) Marine Reserve has been the subject of a long-term study by students of the Bay of Plenty Polytechnic.

The bulk of this literature is baseline and monitoring studies funded by DOC, reflecting the commitment to matters marine initiated by Blue Package[4] funding in the 1990s.

2.4 Monitoring in New Zealand marine reserves

> *Counting fish is just as easy as counting trees, except they are invisible and they move* (attributed to John Shepherd).

2.4.1 What is 'monitoring'?

'Monitoring', in the context of marine reserves, is a form of observational research that documents variability in natural systems by comparing them with manipulated systems over time. By definition, it implies a long-term (>5 year) dataset collected using consistent methods (Magurran et al. 2010). The value of monitoring data increases disproportionately with time (e.g. Magnuson 1990), i.e. a ten-year dataset is worth much more than twice a five-year dataset, because the level of inference that can be drawn from longer time series is so much greater. Despite the opinions of some people, environmental monitoring of any type is a form of scientific research that is not exempt from the basic tenets of experimental design (Underwood 1991, 1993).

2.4.2 Comments on survey designs for monitoring

When the primary objective of a monitoring programme is to observe the long-term effects of an area-based manipulation (in this case, the cessation of fishing in a delimited area), achieving that objective depends on whether observed changes in space or time are actually due to the manipulation. An ideal design has been referred to as a 'beyond-BACI' design (Underwood 1991)

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[4] A block of funding administered by DOC that was dedicated to marine reserve research and education.

where BACI stands for Before After Control Impact. Sampling should be conducted in both impact and control sites, before and after the impact occurs. This is often difficult to implement in environmental impact assessments as it is not always known *a priori* when and where an impact might occur. A beyond-BACI design suggests that temporal variability be accounted for by replicated sampling episodes in time before the 'impact' (here, reserve establishment), to differentiate the magnitude of an effect from that of natural fluctuations in time.

Thus far, it has been difficult to implement a monitoring programme in New Zealand that samples more than once (if at all) before reserve establishment, although some studies have been initiated either immediately prior to, or concurrent with, reserve closure (Davidson 2001; Freeman & Duffy 2003; Denny et al. 2004). It is notable that DOC has been attempting to initiate 'before' monitoring surveys at several locations where new reserves have been recently established. These areas are usually surveyed only once and, unfortunately therefore, the surveys are often referred to as 'baselines'—a term that implies that the fished environment was in a state of stasis. If this were so, one pre-protection survey would be more than adequate for researchers to confidently describe subsequent change. However, factors other than fishing combine to cause considerable temporal variability—witness the variability seen in control datasets of some existing monitoring programmes (Willis & Millar 2005; Davidson et al. 2007; Haggitt & Mead 2009a; Russ & Alcala 2010), and it becomes clear why I reiterate earlier calls (Guidetti 2002; Willis et al. 2003e) for a commitment to pre-reserve biological monitoring that is replicated in time.

Random? Fixed? Stratified? Replicated?

The number of survey approaches to marine reserve studies is nearly as varied as the number of marine reserves, reflecting that there is perhaps no single right way to conduct a survey. The generally accepted approach is the use of hierarchical designs that replicate samples within sites that are themselves replicated with regard to the treatment of interest (Underwood 1993; Kingsford & Battershill 1998). There are good reasons why such a design—operating as it does at different spatial scales—is appropriate. The most important is that the abundance of animals and plants tends to vary on multiple spatial scales (Archambault & Bourget 1996; Benedetti-Cecchi 2001; Anderson & Millar 2004), and capturing different levels of variability gives much more confidence to the interpretation of the question of how (and by how much) populations respond to marine reserve protection.

Two current monitoring programmes (Young et al. 2006; Wing & Jack 2007) use survey designs that do not replicate samples at the site level. Cole (2003) suggested that, for the sake of increasing precision, a design that eliminated replication within sites, and redistributed the same sampling effort across the main treatments (reserve sites v. non-reserve sites) might increase precision (reduce variance) and, therefore, give a much more powerful test of the main effect. This is mathematically true. However, this approach eliminates the ability to determine how much variation occurs at the site level and could lead to incorrect interpretations. For example, imagine that we sampled lobsters in a reserve with a hierarchical design and found that the reserve mean number of individuals per given area was somewhat higher than that of the fished area and that the among-site variability was very high. Further, on closer examination, we found that extremely high densities of lobsters at only one site were responsible for the observed difference. An unreplicated design might similarly find a reserve-v.-fished area difference, but we would have no simple means of determining why our reserve variance was so high. As noted by Cole (2003), the unreplicated approach is also not especially efficient considering that sampling is generally conducted by scuba divers.

The ideal means of allocating sites in space to treatments is via true randomisation, where locations are chosen *a priori* and sampling conducted by reference to Global Positioning System (GPS) coordinates that were randomly generated before the sampling. This has two main advantages: the field worker does not bias sampling by always choosing nice-looking dive sites, and the design has a strong theoretical integrity in that the samples should be (if truly randomly selected) a representative selection of all possible sites in each treatment area. This is fine if the geography and proportional representation of habitats is exactly the same in all treatment areas—but they rarely are, except maybe in deepwater trawl surveys. The danger, then, of a truly randomised design in coastal surveys, is that the design might be unbalanced with respect to habitat. This has occurred in the randomised design of Young et al. (2006), where a large proportion of the control sites were allocated to sandy sea floor (N.T. Shears, University of Auckland, pers. comm. 2010), giving the completely spurious result of significantly higher reef fish density inside the reserve.

A more effective approach is the stratification of sampling by habitat. For example, the spiny lobster (*Jasus edwardsii*) monitoring programmes at the Cape Rodney–Okakari Point and Te Whanganui A Hei Marine Reserves, initiated by Kelly et al. (2000) and continued by Haggitt & Mead (2009a, b), utilise knowledge of the distribution of lobster habitat, gleaned on initial surveys, to allocate sampling sites only within appropriate habitat. Spiny lobsters are known to depend on reef environments that offer them shelter. A spatial comparison of lobster density that failed to take their very specific habitat requirements into account would give a misleading picture if, for example, the sites used as controls for a reserve lacked good shelter. Thus, the assessment of reserve effects is based not on a sampling design that encompasses the whole reserve, but asks 'within this habitat, are lobster densities different in the marine reserve?' which eliminates the problem of habitat-dependent spatial confounding.

On the down side, the lobster and fish surveys at Te Whanganui A Hei, like some other surveys (Wing & Jack 2007), are now based on fixed sites, in which exactly the same locations are surveyed on each sampling occasion. Unlike for a random or random-stratified design, there no longer exists the possibility of sampling any representative location in the study area (that is, of choosing any subset of all possible sampling sites in a given area or treatment) and, therefore, the only inferences that can be drawn concern changes at the fixed sites, not in the reserve at large. Another problem is that, for patchily-occurring phenomena (e.g. localised recruitment events), there is no chance of ever detecting them if these phenomena do not occur at any of the fixed sites. Sample locations for the initial fish surveys at Te Whanganui A Hei up to 2002 were allocated haphazardly over the reef and exact sites were generally not repeat-sampled on consecutive surveys (Willis et al. 2003a), and the move to fixed sites cannot be regarded as a step forward.

General design pitfalls

Generally, a good monitoring design will attempt to either factor in variables likely to affect the study species, or use randomisation techniques to render their effects nil. Often, the latter is the more cost-effective option. For example, rather than expressly incorporating a wide range of potential biases in a monitoring programme designed to determine the response of reef fishes to protection, sampling could be randomised such that any potential but uncontrolled confounding elements are evenly divided among treatments. Surveys need to take into account that these confounding factors may operate at different spatial and temporal scales. It is known that reef fishes may change their activity levels (and thus their apparent density) throughout the day with changes in the weather, tidal flow intensity and light levels, and with the tide (Kingsford & MacDiarmid 1988); or their activity may change at scales of tens of minutes or even minutes (Willis et al. 2006; McClanahan et al. 2007) as a result of their relative mobility. A survey that starts, for example, at the western end of an area and works its way east may suffer bias if the weather changes during the survey. The results may indicate a difference between western and eastern sites that might, in fact, be an artefact of certain species changing their behaviour during the survey and seeking shelter in swell or wave action part way through it. At smaller scales, if a survey first sampled the sites closest to a boat ramp each morning and then sampled progressively more distant sites, a false spatial difference may appear that actually reflects changes in activity levels during the day.

Given the natural, small-scale spatial variability in marine environments, a sampling design is needed that accounts for habitat heterogeneity (Garcia-Charton & Perez-Ruzafa 1999; Garcia-Charton et al. 2004) as habitat is one of the main drivers of the distribution of the exploited species (Garcia-Charton et al. 2004; Kendall et al. 2004; Freeman et al. 2009) that are the main indicators of a functioning marine reserve. While habitat and depth are the most common drivers of spatial variability, current patterns also vary in space as well as time. Due consideration should be given to all forms of spatio-temporal variability when designing a monitoring programme.

Consistency in survey design, including timing

Despite the previous emphasis on spatial and short-term temporal variability, monitoring programmes are primarily designed to determine change over longer time scales. Consistency in the way subsequent surveys are run is critical to valid inference. For example, both spiny lobsters (MacDiarmid 1991) and snapper (Willis et al. 2003d) are known to exhibit marked seasonal fluctuations in density in coastal waters, and reef fishes in northern waters are subject to recruitment pulses from subtropical populations that occur seasonally and vary in intensity among years (Choat et al. 1988; Francis & Evans 1993). Surveys that vary the timing of sampling among years will not provide valid estimates of change.

Just how crucial the timing of surveying can be is illustrated by studies on snapper in the Cape Rodney–Okakari Point Marine Reserve. After a tagging study found that many snapper were resident in the reserve (Willis et al. 2001), Willis et al. (2003b) postulated that the lower snapper densities in winter and spring were likely to be made up primarily of resident fish, with the regular summer peaks in density being attributed to the addition of migratory fish that depart as the water temperature drops. Thus, they proposed, the density of snapper seen during the spring surveys represents the true reserve population, unaugmented by transients. Willis et al. (2003b) therefore recommended that if survey frequency was to be reduced, a true measure of temporal variation in snapper density would be given by continuing the spring surveys, because the summer populations are subject to considerable variation that may depend mostly on the strength of onshore migration. Despite this advice, all subsequent surveys have been done carried out in summer, and so it is likely that all data collected since 2003 probably provide no information about temporal variation in snapper density in the reserve.

Inconsistency in survey design and methods also has repercussions. In pre-2003 surveys, '… sites were selected to encompass the variability in habitat types as well as geographic coverage of the areas' (Willis et al. 2003b), such that samples were often taken on open sand habitat. However, from April 2003 onward, the baited underwater video (BUV) sampling was conducted adjacent to reefs at all sites (D. Egli, Leigh Marine Laboratory, pers. comm. 2010). Since snapper are almost always found in greater densities near reefs than on open ground, the apparent leap in relative density between May 2002 and April/May 2003 was most likely an artefact of the change in the distribution of the sample locations.

Shears (2006) has highlighted also that changes made to the survey design at the Tuhua (Mayor Island) Marine Reserve have resulted in a large proportion of non-reserve control sites being placed on open sand habitat. Subsequent reports highlighting a sudden and large 'reserve effect' on reef fishes should, therefore, be treated with scepticism.

These examples are presented to illustrate how the value of monitoring surveys can be reduced if insufficient attention is paid to maintaining consistency in survey design. In extreme cases, small changes can potentially invalidate large portions of a time-series dataset, thereby wasting large amounts of time and resources. That is not to say that any monitoring design, once implemented, should be inviolate. Reluctance to endanger a time series should not overcome the need to alter a survey design where the basic requirements of spatial replication and elimination of confounding factors have not been met. A consistent time series of data from a flawed survey design has even less value than one produced from a good design that has been altered. There is no single correct way to design a monitoring survey, but—as with any experimental design—there are many ways to get it wrong. It is commonly and wrongly assumed that environmental monitoring is a simple and straightforward exercise; considerable attention must be paid to the logical framework of experimental design (e.g. Underwood 1991, 1993; Kingsford & Battershill 1998; Willis et al. 2003e) if monitoring is to be successful.

Consistency in methodology

The success of long-term monitoring depends critically on consistency in sampling methodology. Changes during a programme devalue the data, and variations in different regions make larger-scale comparisons very difficult.

For example, counts of reef fishes in different locations are conducted using varying transect widths and lengths, which can have a significant effect on the comparability of data collected at different reserves (Cheal & Thompson 1997). While reserve monitoring studies in northern New Zealand are generally conducted using 25 m (length) × 5 m (width) × 5 m (height) transects (Willis et al. 2003c), surveys at Tonga Island use 30 × 2 × 2 m transects because of frequently poor water visibility (Davidson et al. 2007), and at Ulva Island – Te Wharawhara surveys have been done using 50 × 5 × 2.5 m transects (Wing 2006) although some prior work at the same site used 50 × 5 × 5 m transects (M. Carruthers, DOC Southland, pers. comm.). These variable dimensions mean it is very difficult to make direct comparisons of fish densities between (and sometimes within) locations, since recorded density is not necessarily a function of transect area (Kulbicki et al. 2010). That is, the count of a particular species in a 50 × 5 m transect may not be twice that of a 25 × 5 m transect. Kulbicki et al. (2010) attribute this to the attraction/repulsion effect of a diver to different species of fish, where the highest counts are made at the beginning and end of transects.

While it has been argued that longer transects are more likely to detect rare species, a greater number of shorter transects can be sampled in a similar period of time so that the same area is covered. Longer transects are also believed to provide more precise counts, in the statistical sense, because the average count per replicate will be higher. Although it is true that a higher mean will give the appearance of greater precision (and, therefore, reduced variances), long transects are much more difficult to constrain within particular habitat types, raising the possibility that variance will in fact be inflated due to real, but unaccounted-for, within-transect variability. Only one study has examined the effects of varying transect dimensions on New Zealand demersal reef fish counts. McCormick & Choat (1987) found that increasing transect length tended to underestimate true densities of the red moki (*Cheilodactylus spectabilis*), without any appreciable gain in statistical precision. The transect dimensions that might be regarded as optimal for multispecies (assemblage level) counts that include the suite of benthic, demersal and schooling planktonic species have not been determined.

Concluding remarks

Commendably, more effort is being made to rectify the shortcoming of a lack of 'before' data as new reserves are created, e.g. at Taputeranga Marine Reserve at Wellington (Pande & Gardner 2009). In one region (Nelson/Marlborough), multiple reserves are monitored using a hierarchical, replicated experimental design by the same contractor, using the same methods, and with support over a long time period. The Long Island–Kokomohua Marine Reserve monitoring programme is possibly the best example of its type in the country, and is on par with the best in the world (Edgar & Barrett 1999; Edgar et al. 2009). At the same time, the design and methodology of many sampling programmes around the country seem to be placed solely in the hands of the researcher or contractor running a given programme. This has resulted in:

- A wide variety of methodologies implemented, reducing the scope for larger-scale comparisons
- some idiosyncratic sampling designs that often fail to fulfil the aims of monitoring in any rigorous fashion
- and changes to long-term studies mid-stride, when new workers take over existing programmes

It would be counterproductive to enshrine one particular approach in perpetuity, thereby prohibiting the use of new methodologies and analytical techniques, and there are sometimes good reasons for varying elements of a survey at a particular location (e.g. a reduced transect width may be needed where water visibility is consistently poor). However, the existing piecemeal approach resulting from a lack of nation-wide coordination makes for a loss of value; a more unified approach among reserves would give greater predictive value to syntheses of data collected at different locations.

Given the relative paucity of funding available for long-term monitoring studies, developing appropriate measures for dealing with changing methods and approaches (Magurran et al. 2010) may be a challenge. It is, however, worth investing in the development of a series of guidelines with the aim of establishing national standards of methodology and design for monitoring marine reserves. Variations from those guidelines would need to be justified. The overall value of the national dataset is likely to offset the costs involved.

It would be unfortunate if monitoring studies were seen as useful only as a means of establishing that recovery does occur within reserves. Monitoring data, in tracking the degree of recovery of fished species in marine reserves, provide the basis upon which any ecosystem-level studies rest. Without good data on the direct effects of reserves, indirect effects, population dynamics and mechanisms for recovery cannot be determined.

2.4.3 Trends in biological indicators

Notwithstanding the above comments, the research-driven monitoring programmes in New Zealand marine reserves might be generally regarded as successful. Studies have confirmed that the best indicator of a reserve functioning as intended is an increase within the reserve in density of exploited species. Since fishing is the main activity controlled by the implementation of a reserve, this may be regarded, with hindsight, as patently obvious. However, prior to the establishment of New Zealand's first reserve, it was not generally believed that it would happen. In fact, Gordon & Ballantine (1976), writing at the time the Leigh reserve was gazetted, make only a passing mention of the fact that 'Censusing … would be useful in monitoring changes in populations'. Research on recovery of snapper and spiny lobster in northern New Zealand has previously been summarised by Babcock (2003). Here, I summarise the results of studies on those two key, fished species and one other.

*Spiny lobster (*Jasus edwardsii*)*

The first study to examine changes in lobster numbers within the Cape Rodney–Okakari Point Marine Reserve registered a dramatic change, with densities more than doubling between 1976 and 1983 (MacDiarmid & Breen 1993). No control sites were included in this survey, and it wasn't until the publication of follow-up studies that were replicated at the reserve level (Kelly et al. 2000) that the observed changes could be definitively attributed to protection. Shortly afterward, Davidson et al. (2002) estimated that lobster density in the Tonga Island Marine Reserve had increased by 22% in the 5 years since it was established, representing an annual density increase of 4.4% while the adjacent fished areas declined by 2.9% per annum. At Te Tapuwae o Rongokako Marine Reserve near Gisborne (an area where lobster are generally more common), Freeman et al. (2009) reported that densities had increased from 20 animals/ha to 180 animals/ha in 5 years, whereas fished densities remained stable. Not all marine reserves have exhibited such a marked response: Willis et al. (2009) detected no difference at all between six Fiordland reserves and their (putatively) fished controls after 4 years of protection. It is not clear why this should be, but the authors offered five possible explanations: (1) lack of time since reserve establishment, (2) low levels of fishing in the surrounding fiord areas, (3) lack of compliance, (4) low statistical power associated with low densities, since surveys were not stratified by lobster habitat, and (5) low statistical power caused by seasonal influxes of lobsters to all parts of Fiordland, which increased the means and variance in both reserve and fished areas.

*Snapper (*Pagrus auratus*)*

Because snapper are flighty when divers are around once they are beyond their juvenile stage, it was not until BUV methods were used (Willis & Babcock 2000) that the magnitude of snapper recovery could be estimated. Surveys of three coastal reserves (with controls) using BUV showed that legal-size (> 270 mm) snapper were 14.3 times more abundant inside reserves compared with fished areas. Biannual surveys showed that density fluctuated markedly in both reserve and fished areas with season, peaking generally in late summer, and at a low when coastal water temperatures were low in September/October (Willis et al. 2003d). The opportunity to survey prior to and after fishery closure at the Poor Knights Islands showed that initial recolonisation of mobile fishes like snapper can be extremely rapid, with the number of legal-size fish rising 300% in the first year after protection, and rising further to be 8.3 times the density of control sites (which remained stable) after 3 years (Denny et al. 2004). Earlier opinions that snapper were too mobile to accumulate in marine reserves have been shown to be misplaced, with long-term residency of some individuals demonstrated over quite small home ranges (Willis et al. 2001; Parsons et al. 2003).

*Blue cod (*Parapercis colias*)*

At the Long Island-Kokomohua Marine Reserve in the Marlborough Sounds, the density of blue cod was significantly higher (125%) than in fished areas after 6 years of protection and fish were, on average, 80 mm longer (Davidson 2001). Northern New Zealand is probably too warm for blue cod, and densities are generally low relative to points south. Nonetheless, both the Cape Rodney–Okakari Point Marine Reserve and Te Whanganui A Hei (Cathedral Cove) Marine Reserves experienced increases in blue cod density relative to fished areas by a factor of c. 2.5 (Willis 2001). Based on a meta-analysis of data from a variety of sources, Pande et al. (2008) detected statistically significant (but unquantified) increases in both blue cod and lobster numbers within New Zealand marine reserves.

Concluding remarks

The one generality (other than that both fish density and mean size tend to increase within reserves) to come from the various studies done in different locations is that the recovery rate, density and population structure of the fish species varies a good deal from place to place. The reasons for this variability in recovery rates are unclear, but may be related to local habitat availability or quality, the availability of recolonising individuals from the greater population, habitat linkages between reserves and source populations, large-scale temporal variability in recruitment, or the degree of local compliance with reserve regulations. There is much work to be done in determining which, if any, of these factors control rates of recovery from fishing, but planning of future reserves would benefit from knowledge that provided the ability to predict relative recovery rates.

2.4.4 Understanding the biology of targeted species—a cautionary tale for meta-analysts

A common approach in the search for generalities about marine reserve effects is the use of meta-analysis to provide an estimate of an ‘average’ expected response to marine reserve protection (e.g. Cote et al. 2001; Halpern & Warner 2002; Guidetti & Sala 2007; Pande et al. 2008). Meta-analyses incorporate data from a variety of studies where, for example, fish densities have been estimated inside and outside reserves, and calculate a log response ratio as an estimate of effect size. The implication of these analyses (and the way in which they are often used) is that a general estimate of reserve response can be calculated that will predict the response of areas given reserve status in the future. This meta-analytical approach appears to have been deemed necessary in the absence of adequate time series of monitoring data with which to build more meaningful predictive models.

The difficulty with this approach lies not in the approach itself, but in the disparate sources of the input data. Often, data obtained from poorly designed surveys are adopted uncritically (Stewart 2010), and the meta-analysis thus hides the flaws in its constituent studies. Analysts can minimise this problem by critically appraising the quality of the studies used. Furthermore, many of the studies do not distinguish among the species used in the analysis, preferring the use of guilds (groups of species that are believed to be functionally similar). Thus, variation in the response of individual species is frequently not examined. This is problematic, because the effects for a particular species are likely to vary from place to place.

For example, a logistic model of snapper biomass accumulation in marine reserves over time provides reasonable fit to data from the Cape Rodney–Okakari Point and Te Whanganui A Hei Marine Reserves (Fig. 4). However, snapper density in the Tawharanui Marine Park is well below that expected for the reserve's age, whereas at the Poor Knights Islands Marine Reserve, snapper biomass has accumulated much more quickly than expectations based on coastal areas (Fig. 4). It should be clear that a model that successfully describes the response of snapper to reserve protection in northern New Zealand cannot be built without significantly more information about processes. Critics might argue that reserve size has not been accounted for here, and it hasn't, but the difference in size between these reserves is not so great as to explain the observed difference in rate of recolonisation. Variation in compliance with no-take regulations is likely to play a part in the low biomass at Tawharanui, but the Poor Knights Islands' very rapid increase in snapper is most likely to be a function of its position: offshore continental shelf island surrounded by deep water. Any meta-analysis that included the Poor Knights Islands' data would likely produce an unrealistically high estimate of predicted recovery for a coastal location.

As an aside, no claim is made here that a logistic model is necessarily the best means of representing the accumulation of fish biomass in marine reserves; the example is merely illustrative. Russ & Alcala (2010) recently used a similar model to describe the build-up of fish biomass in two Philippine marine reserves based on a 26-year time series and achieved a good fit to the data. Their models, however, indicated markedly different rates of recovery and carrying capacities of the two reserves despite the data being pooled from five different families of fish, as opposed to a single species.

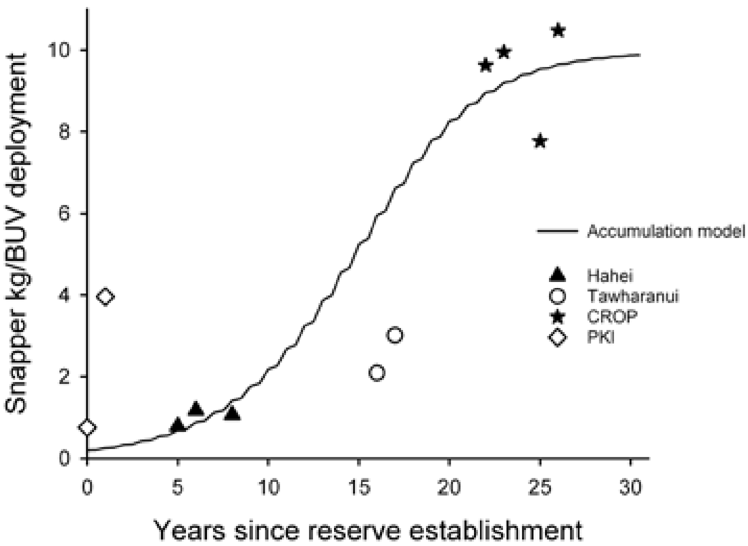


Figure 4. Theoretical logistic model of snapper (*Pagrus auratus*) recolonisation of northern New Zealand marine reserves over time, with measured relative biomass (data collected on winter surveys) from four marine reserves. The model assumes seasonal variation in snapper recolonisation rate in line with observed data. BUV = baited underwater video. Data from Willis & Millar (2005) and Denny et al. (2004).

Meta-analysis is a technique that synthesises data from disparate studies to provide generalities. It usually cannot predict the specific unless applied correctly (Stewart 2010), and has very limited predictive value unless the constituent studies are performed rigorously. The now-classic example in marine reserve research (Halpern & Warner 2002) is very highly cited, partly because it is simply wrong (Russ & Alcala 2004; Russ et al. 2005; Claudet et al. 2008). The authors claimed that marine reserve effects were 'rapid and lasting', when all long-term empirical studies (and some other meta-analyses) indicate they are more likely to be variable and dynamic (e.g. Willis et al. 2003d; Russ et al. 2005; Guidetti & Sala 2007; Pande et al. 2008; Babcock et al. 2010; Russ & Alcala 2010).

3. The value of marine reserves

3.1 Scientific research

At the global scale, attempts to use reserves for scientific research that are not directed at determining the effects of the reserves themselves are few relative to the effort put into modelling potential effects of reserves on fisheries, or deciding where to site reserves. In New Zealand, there are, however, a large number of studies that used reserves tacitly—e.g. the ecological studies done from the Leigh Marine Laboratory over the years, and now a growing number of studies that have utilised reserves to attempt to understand ecological mechanisms (Babcock et al. 1999; Shears & Babcock 2002, 2003; Langlois et al. 2005; Langlois et al. 2006). The main benefits (realised and potential) of marine reserves to scientific study are considered below.

3.1.1 Safety of *in situ* experiments and apparatus

Much of the research conducted in New Zealand marine reserves to date, especially the earlier work, was biological or ecological work that had little to do with the reserve status; rather, by being in a reserve, the studies were less likely to be disrupted by the public. Especially pertinent was the ability to set up intertidal or subtidal experimental plots or manipulations that would remain undisturbed. Indeed, much of the support for the Cape Rodney–Okakari Point Marine Reserve provided by the University of Auckland's Leigh Marine Laboratory during the early 1970s was based on the standpoint that research would be less likely to be interfered with in a reserve (Creese & Jeffs 1993). At the time, the popularity of the reserve as a tourist destination was unanticipated, and the many visitors that now inundate the reserve during holiday periods and summer weekends means that this function has probably been negated—at least in the central area where visitor access is easiest.

3.1.2 Access to depleted species

One of the most basic, and perhaps under-appreciated, uses of marine reserves is the ease of access for researchers to species that have been depleted by fishing elsewhere. Simply having an unexploited and undisturbed population available for study can yield insights into population dynamics and behaviour that would not otherwise be possible. Indeed, this was one of the principles driving the original Marine Reserves Act (1971), and one of the main reasons for the lobbying by university staff from the Leigh Marine Laboratory for the establishment of the Cape Rodney–Okakari Point Marine Reserve in 1976 (Gordon & Ballantine 1976). It should be repeated here that until the late 1990s, the oft-supposed recolonisation response of exploited species to protection had not been rigorously demonstrated (Kelly et al. 2000; Willis et al. 2000; Davidson 2001; Davidson et al. 2002; Willis et al. 2003d).

Selected examples from the Cape Rodney–Okakari Point Marine Reserve

By virtue of the presence of the adjacent marine laboratory, more research has been conducted at the Cape Rodney–Okakari Point Marine Reserve than at all other New Zealand marine reserves combined. From the late 1970s, a variety of students and staff at the University of Auckland's

Leigh Marine Laboratory used this reserve for various ecological studies (Creese & Jeffs 1993). Much of the work done during the 1970s and early 1980s was reviewed in a series of papers published in the *New Zealand Journal of Marine and Freshwater Research* (Andrew 1988; Creese 1988; Jones 1988; Kingsford 1988; Schiel 1988), a high proportion of it done within the reserve.

After early efforts to map the Cape Rodney–Okakari Point Marine Reserve habitats by a group led by Dr Tony Ayling in 1976, the earliest published effort to determine species responses to protection was conducted by McCormick & Choat (1987), who surveyed red moki (*Cheilodactylus spectabilis*)—a species previously much targeted by spear fishers—and found that its density was 2.3 times greater within the reserve than outside. This was the first indication that protection was having some effect, and the study was followed by the whole-assemblage approach of Cole et al. (1990), which supported McCormick & Choat's result, and recorded trends for higher abundances of blue cod and snapper within the reserve.

Various studies in the heyday of experimental marine ecology in New Zealand entailed manipulative experiments in the Cape Rodney–Okakari Point Marine Reserve, all of which benefitted from the security the reserve provided to experimental plots and apparatus (see section 3.1.1). For example, the effects of predation on encrusting communities by sea urchins and leatherjackets were determined through a series of experiments where grazers were denied access to the substratum (Ayling 1981), and Andrew & Choat (1982) excluded predatory fish from plots to determine the effects of fish predation on sea urchins. This latter study was the precursor of the trophic cascade work discussed in section 3.1.3. Several other caging studies were also conducted that required minimal disturbance to plots or cages (Choat & Kingett 1982; Stocker 1986).

The first, and to date only, *in situ* study of blue cod ecology was an MSc project (Mutch 1983). Mutch established that large males tend to have quite limited home ranges on reefs, which they defend against conspecifics. No study since has examined blue cod behavioural dynamics at such small scales. Studies of general demography and population biology of fished species also may rely on reserve status. Hooker & Creese (1995) and Neil (1997) utilised the unfished reserve populations of two species of paua (*Haliotis iris* and *H. australis*), heavily exploited elsewhere, to study reproductive biology and follow population trends. *Haliotis iris* was found to have different breeding patterns and much slower growth in the reserve relative to southern populations. Since both these species are relatively uncommon in northern waters, it is highly likely that any attempt to conduct such a study outside reserve boundaries would be curtailed rapidly with the loss of the individuals under study.

The PhD study of MacDiarmid (1989, 1991, 1994) drew heavily on the availability of an unexploited lobster population. His studies on cohabitation recorded aggregations of up to 105 individuals, differentiated patterns between juveniles and adults, and between sexes, and found size-based links in reproductive behaviour during mating (MacDiarmid 1994). Such work would have been very difficult to do with an exploited population. Subsequent work utilised the same advantages to show, using acoustic telemetry, that large lobsters foraged seasonally on soft sediment habitats outside the marine reserve (Fig. 5), and often returned to the original shelter from which they departed (Kelly et al. 1999). Such fine-scale homing behaviour had not been previously demonstrated.

Natural and unnatural behaviour

There is evidence that fishing changes the behaviour of marine species—especially fishes—and that removing fishing can cause resident species to reinstate more natural behaviour (Cole 1994; Kulbicki 1998). In many species, this means that the flight response common to frequently hunted animals all but disappears, and individuals become more 'apparent' to observers relative to exploited populations. This phenomenon confers both benefits and disadvantages to research, depending on the question being addressed or style of research. One large research programme that utilised the relative tameness of snapper at the Cape Rodney–Okakari Point Marine Reserve was based on *in situ* measurements of hormonal responses to stress in fish (Pankhurst & Sharples 1992). Ned Pankhurst (Griffith University, Australia, pers. comm. 2010) credits his group's early

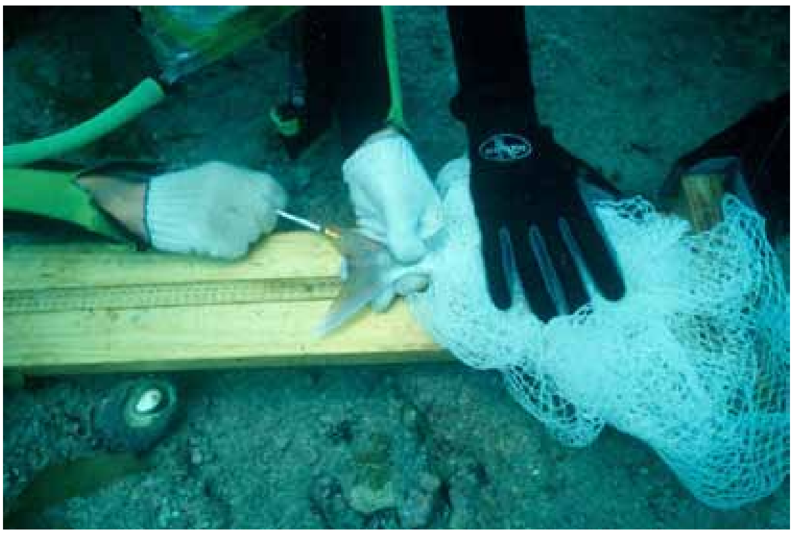
Figure 5. Large rock lobster (*Jasus edwardsii*) aggregated on sand bottom outside the Cape Rodney–Okakari Point Marine Reserve. A tagged individual is visible in the centre of the group. *Photo: S. Kelly*

work at Leigh Marine Laboratory with paving the way to conduct 'real-time wild fish physiology'. In a current review, Pankhurst (2012) describes the method as providing '...the least ambiguous description of endocrine states in terms of the effects of capture and sampling on target variables.'

Similarly, the approachability of snapper at the reserve meant that Willis et al. (2001) could use visually identifiable elastomer tags (Willis & Babcock 1998), implanted into the caudal fin (Fig. 6), to identify individuals repeatedly over several years. This study (benefitting also from the fact that the subjects were not caught by fishers during the research) found that individual snapper may occupy fixed or very limited home ranges for periods of years. This result challenged the accepted wisdom that snapper were generally migratory, and unlikely to exhibit marked site fidelity, which had underlain previous tagging programmes (Gilbert & McKenzie 1999). Despite working on soft-sediment systems, Gilbert & McKenzie (1999) found that snapper did not mix randomly as expected, but rather showed fidelity to the areas where they had been originally tagged, albeit at considerably larger spatial scales. Subsequent work using acoustic tagging with real-time tracking showed that the home range diameter of a resident snapper on reef habitat may be as little as 190 m (Fig. 7) and that only limited movements occurred, and persisted over periods of months (Parsons et al. 2003).

On the negative side, changes in behaviour of resident animals within reserves can confound studies that use reserves to compare fished and unfished populations (Cole 1994; Kulbicki 1998; Willis et al. 2000). The very behavioural change that made *in situ* physiology and tagging studies

Figure 6. *In situ* tagging of snapper (*Pagrus auratus*) using injected elastomer tags at Goat Island, Cape Rodney–Okakari Point Marine Reserve. *Photo: R.C. Babcock*



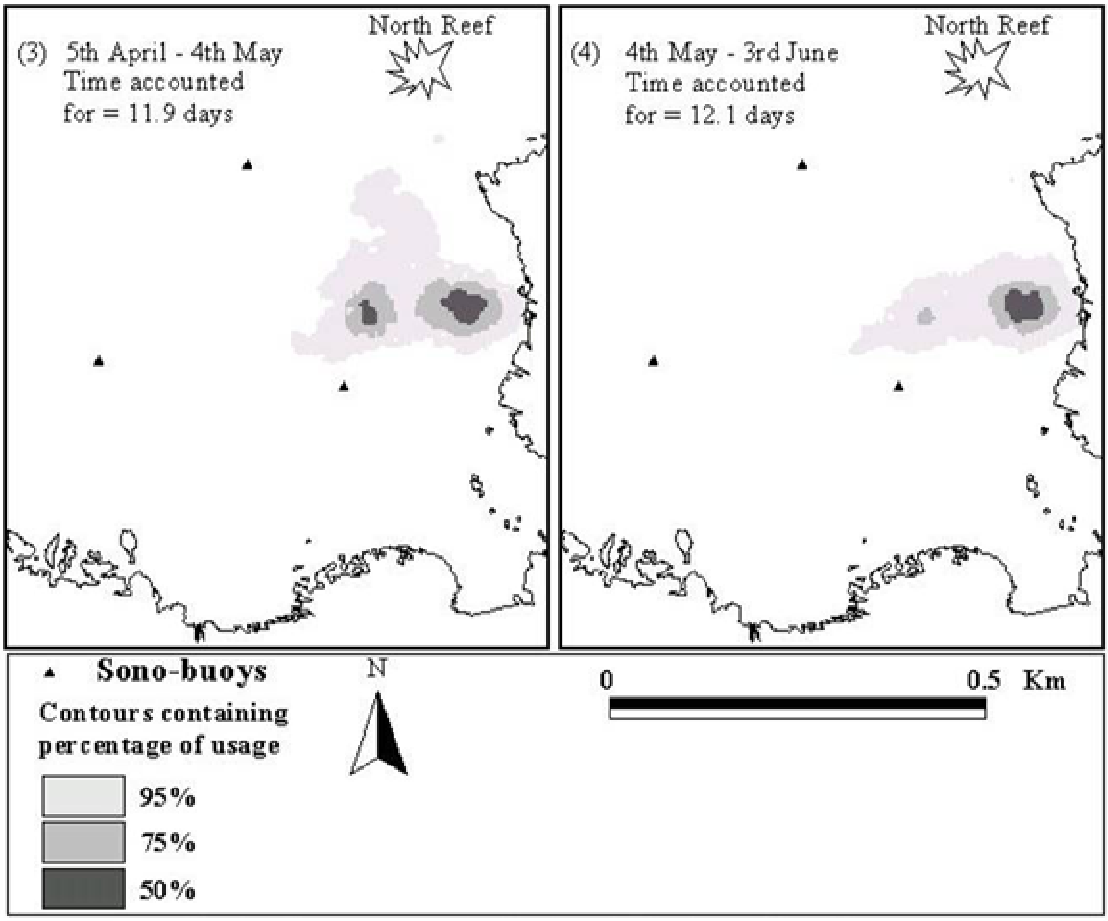


Figure 7. Short-term space utilisation, as a percentage, by a snapper (415 mm fork length) west of Goat Island, Cape Rodney–Okakari Point Marine Reserve (figure reproduced from Parsons et al. 2003).

possible—diver positivity (being attracted to divers)—rendered invalid any assessment of snapper density based on traditional underwater visual census (UVC) transects in reserves and fished areas, since large density differences may have been solely due to varying levels of detectability. To complicate matters, there is probably a third subset of fishes at Leigh: those that are diver neutral. These fish are found inside the reserve but away from the centre where human activities are concentrated and are probably the fish closest to exhibiting natural behaviour. It is likely that this variation in snapper behaviour prevented Cole et al. (1990) from detecting increases in reserve densities at Cape Rodney–Okakari Point, and led directly to the development of BUV as a sampling tool for carnivorous fishes (Willis & Babcock 2000; Willis et al. 2000).

Fishes in marine reserves can become artificially more apparent, to unnatural levels, where visitors enjoy fish feeding activities in the reserve (Cole 1994; Milazzo et al. 2005). When this happens, predatory reef fishes can exhibit extremely diver-positive behaviour and aggregate in high densities. The combination of an unnaturally high concentration of conspecifics and the expectation of food from the diver or snorkeller appears to create high levels of aggression, such that any disturbance to the substratum can prompt mob attacks on any perceived food source. At Ustica Island in Italy, such attacks occur regularly on damselfish (*Chromis chromis*) nests (Milazzo et al. 2006) and it has been suggested that local nesting success is likely to be affected (Fig. 8). A similar phenomenon has been observed at Nursery Cove, a regularly dived site at the Poor Knights Islands, where demoiselle (*Chromis dispilus*) nests were attacked by the Sandager's wrasse (*Coris sandageri*) and banded wrasse (*Notolabrus fucicola*) following accidental diver disturbance of the substratum (TJW 1999, pers. obs).

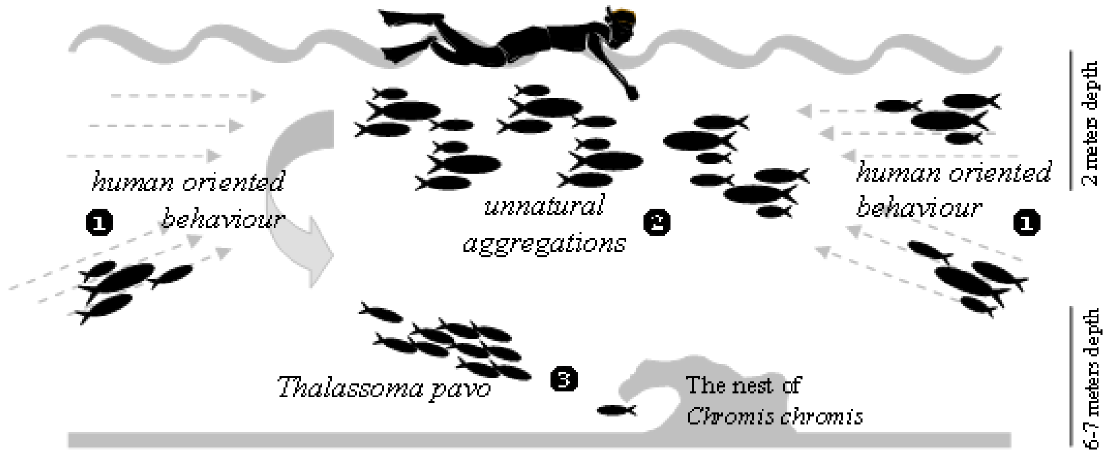


Figure 8. Sequence of events leading to human-induced predation of *Chromischromis* eggs by *Thalassoma pavo* at Ustica Marine Reserve, Italy (figure reproduced with from Milazzo et al. 2006). A similar phenomenon has been observed at the Poor Knights Islands.

3.1.3 Marine reserves as reference points for environmental and fishery management

Marine reserves are, by definition, spatially delimited areas with no fishing in their boundaries. While some other forms of anthropogenic disturbance are also limited or prohibited in reserves by legislation, it is undoubtedly fishing activity that is responsible for the greatest portion of disruption to ecosystem function, be it by direct disturbance to seafloor habitat through the use of contact fishing gears (Jennings & Kaiser 1998; Collie et al. 2000; Thrush & Dayton 2002), or the removal of biomass of predators and the flow-on effects on trophic structure (Babcock et al. 1999; Shears & Babcock 2003; Willis & Anderson 2003; Guidetti 2006; Salomon et al. 2008; Edgar et al. 2009). Marine reserves do not become isolated from larger-scale environmental variability brought about by terrestrial sediment inputs, changes to current patterns or water chemistry, or any regional-scale alterations caused by climate change. They thus provide spatially delimited controls for the effects of fishing.

Although this review explicitly excludes the fishery management applications, potential or realised, of marine reserves, the research opportunities presented by the availability of well policed no-take marine reserves are extremely relevant to fisheries research and marine environmental management in general. Indeed, over 10 years ago, Dayton and co-authors (Dayton et al. 1998; Dayton et al. 2000) mentioned the baseline value of marine reserves and the potential for determining parameters like growth, fecundity, larval transport, settlement biology, recruitment and habitat integrity. This potential has received further treatment by other authors (Macpherson et al. 1997; Macpherson et al. 2000; Schroeter et al. 2001; Willis & Millar 2005; Barrett et al. 2009b; Freeman & MacDiarmid 2009). These and other examples are described below.

Indirect management applications

NATURAL MORTALITY (*M*)

The instantaneous rate of natural mortality of fishes is one of the most difficult population parameters to estimate at the population level (Vetter 1988). Loss of post-settlement juveniles of reef fishes has been frequently estimated using experimental means (e.g. Caley et al. 1996; Hixon & Carr 1997; Forrester & Steele 2000), but most population dynamics models assume that variation in *M* after recruitment is negligible. Vetter (1988) shows, however, that variation in *M* can be considerable, and this variation can have important impacts on fishery models (e.g. Mertz & Myers 1997). The best method of estimating *M* would be based on data collected where both the species of interest and its predators are unexploited (Macpherson et al. 2000), but studies attempting this obtained spatially and temporally variable estimates of *M* (Macpherson et al. 2000; Attwood 2003; Bevacqua et al. 2010) and called into question the applicability of natural mortality estimates calculated from protected areas to fished areas (Macpherson et al. 2000; Diaz et al. 2005). There are still refinements that can be made to the approach, however, not least of which is modelling the importance of relative predator density to *M*.

FISHING MORTALITY (*F*)

Fishing mortality is often indirectly estimated as total mortality (*Z*) minus estimated natural mortality, i.e. $F = Z - M$ (e.g. Attwood 2003; Bevacqua et al. 2010). In a no-take marine reserve, *F* can be assumed to be zero (see above), meaning that fishing mortality can be calculated by estimating *Z* in fished areas and subtracting reserve estimates of *M*. Again, this assumes that *M* in marine reserves is not different to that of fished areas. Willis & Millar (2005) exploited the seasonal migrations of snapper to estimate seasonal fishing mortality outside reserves. They assumed that increases in autumn density relative to spring within reserves represented the magnitude of the seasonal onshore migration, which in the absence of fishing would be expected to be the same in fished areas. Fishing mortality, therefore, was given by the difference between this quantity and the observed seasonal fluctuation outside the reserves. This returned estimates of summer fishing mortality that were generally > 90% for the shallow coastal areas studied. Obviously, fishing mortality of this magnitude throughout the fishery would quickly cause collapse, but the estimates were limited by being based on data only from coastal reserves—areas where fishing effort is greatest.

DENSITY-DEPENDENCE

Marine reserves can be used to estimate the degree of density-dependence of various parameters (e.g. in mortality, growth, behaviour) in marine populations by exploiting the reserve area as a treatment in a large-scale density manipulation. Little effort has been expended in this direction thus far either in New Zealand or elsewhere, although it is clear that density-dependent effects do occur (see 'Predator-prey interactions and ecosystem dynamics' below).

GROWTH PARAMETERS

Estimating growth in fished populations is always subject to the potential confounding effects of fishing selectivity and removals. Fishing tends to selectively remove larger individuals from a population, so unexploited areas are more likely to contain the full size range of the species under study. This facilitates the study of age- or size-specific growth in protected populations. Hart & Chute (2009) sampled sea scallops (*Placopecten magellanicus*) in areas closed to fishing and found that they were able to track cohorts for longer than usual. Conducting growth studies in reserves using mark-recapture techniques may also be desirable (e.g. Bevacqua et al. 2010), as they are likely to achieve a higher return rate and be more cost effective than equivalent studies in fished areas. Fishing may affect growth indirectly (e.g. through habitat modification by fishing gear), or act directly on a population through damage to non-retained individuals (Freeman & MacDiarmid 2009) or selective removal of faster-growing individuals (Hauser et al. 2002).

SMALL-SCALE MOVEMENTS AND MIGRATION RATES

The build-up of exploited species biomass in marine reserves depends on the movement patterns of each species. A vagrant species will not respond to small-scale spatial protection. The size of an effective reserve thus needs to take into account the distances that target species move as part of their home range. Information on movement rates is also important for fishery management as it is essential to understanding population mixing and structure, and the area over which predators may be expected to affect prey assemblages, and to predicting how locally depleted fisheries might recover. Marine reserves have already been successfully utilised to study movement and migration rates. In New Zealand, studies have examined the movements of blue cod (Cole et al. 2000), rock lobster (MacDiarmid et al. 1991; Kelly & MacDiarmid 2003; Freeman et al. 2009) and snapper (Willis et al. 2001; Parsons et al. 2003; Egli & Babcock 2004). Elsewhere, many studies have utilised protected areas in the same way (e.g. Zeller & Russ 1998; Meyer et al. 2000; Zeller et al. 2003; McGarvey 2004; Meyer & Holland 2005; Kerwath et al. 2007; Barrett et al. 2009b).

Direct management applications

SPATIAL REFERENCE FOR THE STATE OF FISHED POPULATIONS

Stock assessments in fisheries generally rely on catch data, through fishery catch returns expressed as catch-per-unit-effort (CPUE) or via fishery-independent surveys. However, because effort is difficult to standardise, catch can be misreported, and fishers tend to target areas of high abundance, CPUE can give a misleading picture of the state of a stock (Hilborn & Walters 1992; Hutchings & Myers 1994). Fishery-independent surveys are not subject to these problems, but they tend to use the same gear for sampling as the fishery does for harvesting, and hence they are subject to the same biases in gear selectivity and changes in catchability. In what should prove to be a seminal (but so far sadly overlooked) study, Schroeter et al. (2001) used marine reserves to monitor populations of the sea cucumber *Parastichopus parvimensis* at the outset of a fishery, and showed that fishing reduced densities by 33–83%, despite there being little change in fishery CPUE. Similarly, Attwood (2003) utilised three marine reserves to produce biomass and mortality estimates for galjoen (*Dichistius capensis*) in South Africa.

Wilson et al. (2010) suggest a management strategy in which decisions are based on data from marine protected areas (MPAs) (e.g. for stock assessment), and McGilliard et al. (2011) propose a control rule-based management system that utilises a density ratio of fish outside-to-inside reserves as an indicator of stock status. Both methods are some way from providing a definitive means of assessing stocks, but are the first steps in developing a framework that uses marine reserves in an effective way to inform management.

Far from providing major problems for assessments (Field et al. 2006), MPAs should be useful in generally reducing some of the uncertainty inherent in fisheries models. If reserve-based frameworks do not replace more traditional assessment methods, they will, at least, provide empirically grounded reference points to test the accuracy of more traditional approaches.

EFFECTS-OF-FISHING STUDIES

In the very substantial literature on the physical and biological effects of fishing on the sea floor, few studies use unfished controls to provide rigorous estimates of the effects of contact fishing. This is because there are so few places that have not been fished (Halpern et al. 2008). Without areas protected for long periods, a variety of studies have utilised various approaches to suggest that the effects are nonetheless negative and strong (Thrush et al. 1995; Jennings & Kaiser 1998; Thrush & Dayton 2002). There remains the likelihood that the intensity of changes brought about by fishing may yet be shown to be much greater than currently documented if long-term closures can be used as references (Handley et al. in review).

Marine reserves can also be used to examine the collateral effects of fishing on exploited populations. For example, Freeman & MacDiarmid (2009) showed that the incidence of tail fan necrosis in rock lobster, caused by bacterial infection from repeated handling, was very low within a reserve, but occurred frequently in animals less than minimum legal size in fished areas. Estimates of mortality or reduction in growth rates from such damage would provide estimates of unaccounted loss to fishery productivity brought about by handling. Similarly, marine reserves could be used to estimate capture-related mortality of released undersize fish by comparing their relative densities in fished and unfished areas.

One of the main limitations to the use of marine reserves for the estimation of biological and fishery parameters is the representativeness of existing reserves. Habitats, productivity, the physical environment, and the behaviour of a given species may vary across the geographical range of a population. For management decisions made at the stock level, calculations must be made from reserves that represent the entire area occupied by the stock. Willis & Millar (2005) estimated seasonal snapper fishing mortality at over 90% using three coastal marine reserves in northern New Zealand, but could not make stock-level estimates because no marine reserves exist in offshore areas. Mortality estimates were, therefore, limited to a 'worst-case' situation in zones subject to very high fishing pressure.

PREDATOR-PREY INTERACTIONS AND ECOSYSTEM DYNAMICS

Correlative and manipulative studies of the effects of predators on their natural prey are generally fraught with methodological biases and confounding effects. One of the most effective experimental means of determining predator effects is to use cages or enclosures that prevent predators from accessing prey. However, some considerable thought and effort is needed to make results interpretable (Kennelly 1991; Steele 1996). Marine reserves are now being treated as a form of large-scale manipulation of predator density to examine effects on a variety of taxa (Shears & Babcock 2002; Willis & Anderson 2003; Langlois et al. 2006; Pederson & Johnson 2006).

The best-known example in New Zealand waters is the trophic cascade first described by Babcock et al. (1999) at the Cape Rodney–Okakari Point Marine Reserve. Over many years (Shears & Babcock 2003), increasing densities of rock lobster, snapper and blue cod within the reserve reduced the density of the sea urchin *Evechinus chloroticus* to the point that the urchin no longer controlled growth of the kelp *Ecklonia radiata*. Within a few years of reductions in urchin density being detected (1993–2001), most of the urchin-grazed 'barrens' disappeared, indicating that fished predators exerted strong top-down control over community structure. Subsequent studies suggested that predation effects were also felt on small cryptic reef fishes (Willis & Anderson 2003) and benthic infauna of adjacent soft sediments (Langlois et al. 2005).

Such effects are not limited to New Zealand. Long-term changes in reef communities have also been documented in temperate Australia (Barrett et al. 2009a; Edgar et al. 2009) as well as in coral reef communities (Dulvy et al. 2004), and it is being increasingly recognised that such interactions can take considerable time to manifest (Shears & Babcock 2003; Russ & Alcala 2004; Pederson et al. 2008; Edgar et al. 2009; Babcock et al. 2010; Russ & Alcala 2010).

Marine reserves could potentially reduce or eliminate the need for caging experiments in the study of predator effects, and expand the scale on which ecosystem effects of varying predator densities are measured from experimental (metres) to hundreds of metres or even kilometres. There are undoubtedly many other direct and indirect interactions in both reef and soft-sediment systems that remain to be documented, and it is most likely through studies in no-take marine reserves that these will be detected.

Remarks

The reliability of data obtained from reserve studies for determining ecosystem function depends largely on how well the no-take rule is complied with. There are now empirical data to demonstrate what should be apparent: a fished reserve is not really a reserve at all (Denny & Babcock 2004; Denny et al. 2004; Shears et al. 2006; Guidetti et al. 2008). If the primary effect of a reserve is to stop fishing, but fishing continues, then reserve status makes no material difference. It is a flaw of many (perhaps most) reviews of reserve effects that compliance levels have not been considered (probably because they are not available) when response ratios have been calculated (Kritzer 2004). That said, obtaining direct estimates of compliance through surveillance is difficult and labour intensive. However, new indirect methods developed in a fisheries context, such as the randomised response technique (Blank & Gavin 2009), are becoming available to acquire information that could provide at least relative estimates of reserve compliance.

Where the recovery of fished species has been reliably documented, it may be assumed that reserve protection is sufficiently effective to regard the glass as at least half-full: although we cannot claim perfect accuracy, species demography, mortality estimates, assemblage structure and other such parameters estimated from reserves must be more likely to reflect 'natural' conditions than those estimated from exploited areas. Information gleaned on ecosystem processes in this way will be very informative. The unknown then will be how well parameter estimates for individual species generated within marine reserves can be applied to fished populations (Macpherson et al. 2000).

The emphasis of much of the scientific literature, both in New Zealand and overseas, has been directed at establishing the fishery and/or ecosystem effects of marine reserves or MPAs. Here, I suggest a more fruitful approach is to treat reserves as an experimental treatment, and use them as a tool for determining ecosystem function in the absence of fishing impacts.

3.2 Biodiversity values of marine reserves

Biodiversity is a term usually taken to mean the natural suite of species that would be expected to inhabit a particular habitat. In its simplest form, it may refer to the number of species in a system, although sheer species richness is not necessarily an indicator of ecosystem health. The concepts of structural and functional biodiversity as used by Thrush & Dayton (2002) refer to the general integrity of a given ecosystem, and it is in that sense that I use the term here.

There have been no studies of biodiversity *per se* in New Zealand marine reserves, since most work has been directed at either establishing the existence of a response to the cessation of fishing, or the potential flow-on effects of increases in predator numbers (although each type of study provides components of future syntheses of ecosystem structure). In addition, the large-scale studies of Shears et al. (2008b) on reef environments provide a preliminary assessment that can be used as a reference point in time.

As discussed in earlier sections, the structure and function of rocky reef systems of New Zealand is only slowly being understood. The relative importance of top-down control, environmental variables such as sediment inputs (especially those from terrestrial sources), disease, and bottom-up (primary productivity) sources of system control are still relatively unknown, even though we do know that the weight of each will vary from place to place (Shears et al. 2008a). While it is clear that an appropriately policed no-take policy will remove the impact of fishing from within a reserve's boundaries, thus allowing more natural processes and biological interactions to take place, a marine reserve is not immune from impacts that arise from beyond the boundaries or from large-scale changes in the environment.

I should draw a distinction at this point between forms of physical disturbance and the habitats they act upon. Reef environments are generally subject to very small-scale anthropogenic disturbances, through the anchoring of vessels (Milazzo et al. 2004a), trampling of intertidal reef (Brown & Taylor 1999; Milazzo et al. 2004b), damage by divers (Hawkins et al. 1999; Di Franco et al. 2009) or deployment of passive fishing gears such as crayfish pots or gillnets. Only the last of these is prevented in marine reserves and, with the exception of fragile rock wall invertebrate communities, is unlikely to cause lasting damage. Soft sediment habitats, on the other hand, are subject to physical disturbances caused by a variety of contact fishing gears. These range in severity of impact from trawls that destroy epifauna but leave the underlying substratum intact (Collie et al. 2000) to dredges that dig into the sea floor, resuspend sediments and effectively homogenise large areas of habitat (Thrush et al. 2006).

Thrush et al. (2006) argued that areas of sea floor homogenised by fishing suffer biodiversity losses. The corollary of this is that previously heavily fished areas placed under protection should, as biogenic habitat structure develops with time, exhibit a recovery in biodiversity (Hewitt et al. 2005; Hewitt et al. 2008). It should be borne in mind that the changes observed after protection has been implemented depend largely on the relative intensity of the impacts the reserve was exposed to when it was fished (and that applies equally to rocky reef environments). In areas that are fished only sporadically, biodiversity might, in fact, decrease in marine reserves relative to fished areas at intermediate spatial scales (hundreds of metres to kilometres). This may occur if the predictions of the Intermediate Disturbance Hypothesis (Grime 1973; Connell 1978) hold true: that occasional disturbance will create patches of 'new' habitat available for coloniser species not otherwise present. Soft sediment habitats are under-represented in marine reserves worldwide (Caveen et al. 2012), and there is much scope to utilise reserves to tease out the relative effects of biological and physical disturbance on ecosystem function.

3.3 Concluding remarks

Fishing is a pervasive activity that is now being shown to have impacts on every marine ecosystem on the globe (Halpern et al. 2008). Does this mean that truly natural marine ecosystems no longer exist? If this is true, our understanding of marine ecology, from the scale of regional ecosystem dynamics to the behaviour of individuals, may be affected. Although marine reserves have been implemented only at small spatial scales in areas accessible to researchers (the Kermadec Islands and Auckland Islands Marine Reserves are large, but remote), they offer the opportunity to acquire an enhanced understanding of natural processes not obtainable by other means. Although the science gaps do need filling to understand how marine reserves may act as direct supplements to fishery management (Sale et al. 2005), the potential for using reserves to fill much larger gaps in our knowledge should not be underestimated.

One difficulty highlighted some time ago (Creese & Jeffs 1993) was a burgeoning bureaucracy associated with obtaining permits to conduct research in marine reserves. While DOC has previously supported 'interventionist' studies such as the snapper angling and tagging programmes at Leigh (Millar & Willis 1999; Willis et al. 2000; Willis et al. 2001), some studies that are not directly supported or implemented by DOC have met with resistance at the conservancy level.[5] Conversations with university staff in the course of this review have indicated that some have already suspended all attempts to conduct further work in marine reserves as a direct result of the time-consuming and expensive permitting process. The phenomenon is by no means consistent among conservancies—some actively support research programmes in their marine reserves and base their permitting decisions on weighing the potential benefits of the research against the likelihood of any lasting disturbance.

The most valuable research is often manipulative, meaning that researchers must interfere with (and occasionally sacrifice) organisms to complete a research project. For most research (e.g. tagging studies), the likelihood of any mortalities occurring is low, and naturally steps should be taken by the researchers to minimise any disturbance. However, to quote Lenin: 'to make an omelette, one must be willing to break a few eggs.' Some types of study are contingent upon the collection of specimens (e.g. trophic studies via gut and stable isotope analyses, or sampling of small cryptic fishes), and attempts by reserve management to prevent any sort of disturbance in reserves fails to recognise that most research activities produce disturbances that are undetectable beyond the short term, run counter to the intention of the Marine Reserves Act (1971) and will result in lost opportunities to add to knowledge.

Notwithstanding the above, there have also probably been instances of manipulative research conducted in marine reserves that could have been successfully completed outside them. In the interests of minimising disturbance to reserves systems, such applications should not be granted. Careful examination of the aims in a peer-review setting, involving independent researchers outside of DOC, should go some way to resolving disputes.

There are inconsistencies in permitting standards, monitoring methodology and survey design among reserves in different areas. While it is not the purpose of this review to make recommendations on management policy, varying standards in permitting policy have direct effects in the quantity and quality of scientific studies for which researchers will seek to use marine reserves. While observational studies (such as monitoring of target populations, or habitat surveys) are of great value and are readily granted permits, such studies do not generally provide insight into ecological processes. Well-designed manipulative and experimental work can provide deeper understanding of both ecological processes and their interactions with human impacts (Underwood 1990, 1996), and this underpins and informs biodiversity and fishery management. Such work should be encouraged by all conservancies to provide breadth in geographical scope and hence generality to observed patterns and processes.

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5 Confidential communications to the author by staff from University of Auckland and NIWA, 2010).

It is recognised that some marine reserves possess a local management committee that is at least partially responsible for decisions, and assists with buy-in from local communities. I note that the Fiordland Marine Guardians already, to some extent, act in a similar fashion to the scientific working group postulated above in working with national and local government agencies. The Guardians, however, have only two 'academic' members, and need (and seek) advice from researchers in the field from time to time.

4. New Zealand's place in the world of marine reserve research

By global standards, New Zealand possesses an extensive network of coastal marine reserves and appears to have a generally high level of compliance with reserve regulations. Because of this, research was based on rigorously collected empirical data and, in the international scientific context, New Zealand led the field in the 1990s. Students and researchers had the opportunity to demonstrate reserve effects to a global audience, because at the time many effects had been only theorised. Furthermore, broader-scale studies that used multiple marine reserves (e.g. Kelly et al. 2000; Willis et al. 2003d; Shears et al. 2008a) strengthened the insights obtained and therefore increased the relevance of the work both nationally and internationally. Consequently, New Zealand work featured in high profile international journals, and this success engendered further research effort either through applying existing techniques to new locations (e.g. Denny & Babcock 2004; Denny et al. 2004), expanding the level of detail at which the biology and behaviour of exploited species were evaluated (Parsons et al. 2003; Egli & Babcock 2004) or addressing new hypotheses about the functioning of reef ecosystems (Willis & Anderson 2003; Langlois et al. 2005; Salomon et al. 2008; Shears & Ross 2010).

Whereas many countries with few or only recently established no-take reserves have a long history of development of theoretical models, but with little empirical data with which to test the models, New Zealand has effective no-take reserves, some excellent empirical data from particular reserves, but practically no theoretical work built upon it. Thus, New Zealand has an empirical base—or the potential to develop an empirical base—that matches or exceeds that of any other country, but lacks the nationwide coordination and resourcing of research to realise its full potential.

One of the distinct disadvantages preventing New Zealand researchers from leading the world in marine reserve research is the lack of significant funding for long-term studies. By global standards, the work completed thus far has been done on shoestring budgets that are usually available only under 12 month contracts, which match the financial years of government agencies. Exceptions arise only when three-year doctoral scholarships have been awarded, either by DOC or under the Foundation for Research, Science and Technology (FRST) postdoctoral programme. Among the main funding agencies, there appears to be a perception that DOC is responsible for any research activity involving marine reserves, precluding any consideration of proposals by the Ministry of Fisheries, Ministry for the Environment, or similar agencies that are in a far stronger position than DOC to fund large-scale research programmes. Having previously led the world in establishing the positive effects of no-take marine reserves, New Zealand is beginning to fall behind as better-funded countries establish new reserves along with substantial commitments to research. Few papers have been published from New Zealand-based research in the last 3 years, and most of these have arisen from earlier work at Leigh Marine Laboratory.

5. Summary and recommendations

5.1 Research summary

Research concerning marine reserves generally falls under one of four main subject areas:

1. Direct Effects Direct effects of marine reserves on fished populations within their boundaries. This is fundamental information, resulting from monitoring studies, that determines whether a reserve is successful, and underpins all other research conclusions. To date, most work has been focused on species commonly targeted by both commercial and recreational fisheries, especially blue cod (Davidson 2001; Willis 2001; Pande et al. 2008), snapper (Willis et al. 2003d), and rock lobster (Cole et al. 1990; Kelly et al. 2000; Davidson et al. 2002; Freeman et al. 2009). Other fished species may well merit attention in some areas (e.g. hapuku (*Polyprion oxygeneios*) in Fiordland; golden snapper (*Centroberyx affinis*) and pink maomao (*Caprodon longimanus*) at the Poor Knights Islands; or kingfish (*Seriola lalandi*) at various locations in central and northern New Zealand), but these may require the development of specialised census methods. Reserve populations of non-target species have been examined in various unpublished reports, but are generally not reported in the published literature (but see Cole et al. 1990), probably because 'reserve effects' are not apparent in the data.

2. Biological studies of fished species Biological studies of fished species, aimed at understanding the mechanism(s) of reserve recolonisation, seasonal changes in density, and movement patterns (Kelly et al. 1999; Cole et al. 2000; Willis et al. 2001; Parsons et al. 2003; Egli & Babcock 2004).

3. Indirect effects Indirect effects of marine reserves on non-target taxa, brought about by increased predation. The now-classic case of elevated predation on the sea urchin *Evechinus chloroticus* by lobster and fish predators (Cole & Keuskamp 1998; Babcock et al. 1999; Shears & Babcock 2002) spawned a series of studies seeking predator effects on other taxa, including small fishes (Willis & Anderson 2003) and in soft-sediment communities near to reefs (Langlois et al. 2005; Langlois et al. 2006). These led to examination of interactions between disease in 'keystone' species and fishing (Shears & Ross 2010), or examination of community trophic structure (Guest et al. 2009) and the effects of habitat changes on nutrient flows (Salomon et al. 2008).

4. Use of marine reserves for fisheries management Use of marine reserves for fisheries management. Such studies seek to determine whether populations protected within marine reserves may supplement fished populations outside their boundaries, either via net emigration, commonly known as 'spillover', or through relatively high gamete production owing to the preservation of larger spawning individuals (Roberts & Polunin 1991; Rowley 1994). There are numerous models attempting to simulate these processes, but very few data showing that meaningful export of biomass occurs, or that increased local gamete production contributes to recruitment at the population level.

To these, we may now add:

5. Marine reserves as controls While thus far infrequently specified, the studies listed under point 3 above rely on using marine reserves as controls for understanding the effects of fishing on ecosystem structure. More specific applications include using reserves as reference points for fishery parameters (Willis & Millar 2005; Freeman & MacDiarmid 2009). It is predicted that in time, marine reserves will be used routinely as baselines for understanding individual species biology, especially in the context of behaviour, and as controls for understanding population dynamics in the absence of fishing.

5.2 Interactions between research and management

Marine reserves are a potentially powerful but underutilised tool for scientific research. Their usefulness does, however, depend on a partnership between the researcher and managing agency, requiring the latter to carefully examine the merit of research when making permitting decisions and to bear in mind the paucity of research funding available in New Zealand when implementing permitting charges. Although the Marine Reserves Act (1971) specifically states that reserves shall be implemented for scientific research, most New Zealand reserves have been little utilised for such. This is most likely a reflection of the distribution of interested researchers, but also may be due to a general shift in the perception of marine reserves as being solely conservation areas. Where this occurs, there is likely to be resistance to permitting research activities that cause real or perceived perturbations to reserve ecosystems. One possible solution is the designation of 'research priority' reserves, where the burden of 'no disturbance' is less strictly interpreted or balanced against the predicted research outcomes, or the persistence of the effects of the disturbance are considered when research permits are considered. The Cape Rodney–Okarari Point Marine Reserve is an obvious candidate for such a designation.

There is a need to seek ways of obtaining government support for long-term ecological and biological study using marine reserves for increasing our knowledge of population dynamics and ecosystem processes, including seeking synergies among funding agencies and research providers. Earlier scientific productivity during the 1990s and 2000s was at least partly attributable to funding from the Blue Package administered by DOC. More consistent funding is needed from more than a single source. Awareness should be raised within funding agencies of the potential for marine reserves to act as the nearest thing we have to controls for studying the effects of fishing. All agencies need to recognise marine reserve research as critical to understanding mechanisms and changes in marine environments, especially for understanding marine ecosystem function, the effects of fishing on population and community dynamics, and predicting the effects of climate change.

The application of ecological research to management benefits from generality—the ability to make predictions about trends, irrespective of location. It has become clear from this review that marine reserve research has been concentrated on northern areas, and that marine reserves south of the Hauraki Gulf are underutilised for research. It is unknown whether patterns and processes observed in northern New Zealand marine reserves can be generalised to other areas. Support is needed for researchers to take advantage of reserves in other biological systems.

It would also be advantageous if marine reserves were replicated so as to be representative of entire regions, thereby encompassing the range of exploited populations. For example, the estimates of snapper fishing mortality calculated by Willis & Millar (2005) were limited to coastal areas (where marine reserves are generally situated) and the authors could not provide estimates for the entire stock. In general terms, replicating reserves within biogeographic zones will increase the rigour and generality of studies documenting fishing-related changes in habitats (Shears et al. 2008a).

Throughout this review, I have assumed that marine reserves are completely no-take and permanent. It has been demonstrated that little fishing effort is required to alter the population densities of top predators (e.g. Jennings & Polunin 1996) and, indeed, even parks where only recreational fishing occurs do not appear to have benefitted target species (Denny & Babcock 2004; Denny et al. 2004). For most research applications, permanent reserves would be indicated, given the time it can take for ecological changes to manifest (Shears & Babcock 2003; Babcock et al. 2010). That said, if it was desired to manipulate, say, fish and lobster densities over shorter time frames, a case could be made for implementing regional-scale networks of temporary closures. Such a programme could give great insights into recolonisation dynamics and help to understand local fishery productivity, but its success would rely on the establishment of long-term partnerships among researchers, management agencies and fishers.

5.3 Future research directions

Some suggested priorities for research, based on gaps identified in this review, include:

- Strengthen support for existing long-term monitoring programmes, and seek to fund programmes on a multi-year, rather than an annual, basis. Attempt to implement new programmes around proposed reserves such that a time-series dataset (incorporating seasonal variation) is available before a reserve is gazetted. Monitoring is a form of research that provides the basis for all other research outcomes in marine reserves, in that it provides information on the direction and magnitude of trends in the relative density of fished species, and rates of change in habitats. If fished species do not respond to protection, or it cannot be determined if protection is effective, studies of trophic cascades, for example, cannot be interpreted.
- Estimate compliance with marine reserve regulations at selected reserves. At present, it is difficult to determine if observed recovery rates within reserves are reasonable estimates, or whether recolonisation levels may be much higher but for poaching within reserves. For example, varying levels of non-compliance among reserves will confound any attempt to determine whether population recovery is consistent in different areas.
- Estimate the distribution of fishing effort and catch in non-reserve areas near marine reserves. Reserve assessments are generally based on the ratio of reserve density to fished density. Varying effort in fished areas can, therefore, have important effects upon the interpretation of monitoring surveys. In addition, estimates of spillover, though infrequently attempted in New Zealand, have elsewhere been based on density gradients of fished species at increasing distances from reserve boundaries (e.g. Francini-Filho & Moura 2008; Forcada et al. 2009; Halpern et al. 2009). These studies generally account for variation in fishing effort, and it is only recently that more rigorous approaches have been implemented (Kelly et al. 2002; Goni et al. 2008; Stobart et al. 2009; Goni et al. 2010).
- Determine the effects of increased tourism on popular marine reserves. The 'naturalness' of reserve areas can be compromised by the activities of visitors, be it by fish feeding (Cole 1994; Milazzo et al. 2005; Milazzo et al. 2006), or simply by people trampling organisms on intertidal reefs (Brown & Taylor 1999). Elsewhere, it has been shown that dive tourism has the potential to modify habitats, especially where inexperienced divers physically disturb slow-growing sessile reef fauna (Sala et al. 1996; Garrabou et al. 1998; Rouphael & Inglis 2002; Coma et al. 2004; Di Franco et al. 2009). Studies of diver impacts are warranted in areas where fragile invertebrate faunas are vulnerable to physical disturbance, such as the Poor Knights Islands and Fiordland (Miller et al. 2004).
- Develop the theoretical basis for marine reserve recovery, using existing long-term datasets. For example, it is still uncertain, for many species, whether recovery of unfished populations in particular areas is driven primarily by recruitment or immigration from the wider population. For snapper, it appears that immigration is the key driver of recovery rates (Willis et al. 2001; Denny et al. 2004) and the appearance of large lobsters in recently established reserves points to immigration as a key mechanism for that species. Variation in recovery rates and densities at different reserves, therefore, may be explainable by local habitat characteristics, by the dynamics of the wider population, by climate variability or by local background densities that dictate the availability of immigrants.
- Conduct further investigations into reserve effects in soft-sediment systems, and the linkages between them and reef habitats. Soft-sediment habitats are subject to potentially much greater effects of fishing, as they are regularly disturbed in some areas by dredging and, to a lesser extent, trawling. Marine reserves that encompass soft-sediment habitats may provide controls and/or undisturbed experimental sites for determining the effects of fishing. Studies from Leigh have demonstrated that reef-associated predators forage on adjacent sandy habitat (Kelly et al. 1999; Langlois et al. 2005; Langlois et al. 2006), but the extent to which reefs receive nutrient subsidies from sediment habitats is unknown.

- Determine the relative impacts of fishing and other perturbations to predict the potential contribution of marine reserves to conserving biodiversity. Arguably, marine reserves protect habitats only from the effects of fishing. Other small-scale anthropogenic impacts such as anchoring and diving are permitted to continue, and reserves are not immune to large-scale perturbations from pollution, sedimentation and climate change.
- Extend the capacity to construct ecosystem models through trophic modelling and empirical investigations into ecosystem structure (e.g. through stable isotope studies). Ecosystem models constructed to date in New Zealand are based on many supposed interactions in areas where data are lacking (e.g. Pinkerton et al. 2008). Further work on trophic interactions, especially predator-prey dynamics, will inform future modelling, ultimately supporting an ecosystem-based approach to fisheries and marine environmental management.
- Develop lines of enquiry aimed at gauging different ways reserves might be used as 'reference points' for population parameters (Barrett et al. 2009b; Wilson et al. 2010; McGilliard et al. 2011), and at what size and spatial scale to represent dynamics across a breeding population. Monitoring surveys could provide population density estimates to estimate the success of fishery management measures, and studies in undisturbed populations could give unbiased biological parameters in the absence of fishing. Of critical importance will be to determine to what extent marine populations are density-dependent, so that we can estimate to what extent studies of unfished populations can be applied to fished stocks.

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Willis, T.J.; Millar, R.B.; Babcock, R.C. 2003d: Protection of exploited fish in temperate regions: high density and biomass of snapper *Pagrus auratus* (Sparidae) in northern New Zealand marine reserves. *Journal of Applied Ecology 40*: 214–227.

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Wilson, J.R.; Prince, J.D.; Lenihan, H.S. 2010: A management strategy for sedentary nearshore species that uses marine protected areas as a reference. *Marine and Coastal Fisheries 2*: 14–27.

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Appendix 1

Research publications from New Zealand marine reserves

Peer-reviewed publications from studies conducted in New Zealand marine reserves (including prior to reserve establishment). 'No-take needed?' indicates whether the main aims of the study were achievable without a no-take area. 'Reserve focused?' indicates whether the study was directed at specifically determining marine reserve effects. Review = previously published data from one or more reserves were used. Clio = Hawea (Clio Rocks), CROP = Cape Rodney–Okakari Point Marine Reserve, Elizabeth Island = Taipari Roa (Elizabeth Island), Five Fingers = Taumoana (Five Fingers Peninsula), Gaer Arm = Kutu Parera (Gaer Arm), Gold Arm = Kahukura (Gold Arm), Long Bay = Long Bay - Okura, Long Island = Long Island-Kokomohua, Long Sound = Te Tapuwae o Hua (Long Sound), PKI = Poor Knights Islands Marine Reserve, Milford = Piopiotahi (Milford Sound), Pollen Island = Motu Manawa (Pollen Island), Hahei = Te Whanganui A Hei Marine Reserve, The Gut = Te Awaru Channel (The Gut), Tuhua = Tuhua (Mayor Island), Wet Jacket = Moana Uta (Wet Jacket Arm),

PUBLICATION	NO-TAKE NEEDED?	RESERVE FOCUSED?	RESERVES USED IN STUDY
Anderson, M.J.; Willis, T.J. 2003: Canonical analysis of principal coordinates: a useful method of constrained ordination for ecology. *Ecology 84*: 511–525.	Yes	No	PKI
Anderson, T.J. 1997: Habitat selection and shelter use by *Octopus tetricus*. *Marine Ecology Progress Series 150*: 137–148.	No	No	CROP
Anderson, T.J.; Babcock, R.C. 1999: Subcutaneous electromagnetic tagging of benthic octopus: a preliminary evaluation. *Marine and Freshwater Research 50*: 225–227.	No	No	CROP
Andrew, N.L. 1986: The interaction between diet and density in influencing reproductive output in the echinoid *Evechinus chloroticus* (Val). *Journal of Experimental Marine Biology and Ecology 97*: 63–79.	No	No	CROP
Andrew, N.L. 1988: Ecological aspects of the common sea urchin, *Evechinus chloroticus*, in northern New Zealand—a review. *New Zealand Journal of Marine and Freshwater Research 22*: 415–426.	No	No	REVIEW
Andrew, N.L.; Choat, J.H. 1982: The influence of predation and conspecific adults on the abundance of juvenile *Evechinus chloroticus* (Echinoidea, Echinometridae). *Oecologia 54*: 80–87.	No	No	CROP
Andrew, N.L.; Choat, J.H. 1985: Habitat related differences in the survivorship and growth of juvenile sea urchins. *Marine Ecology Progress Series 27*: 155–161.	No	No	CROP
Andrew, N.L.; MacDiarmid, A.B. 1991: Interrelations between sea urchins and spiny lobsters in northeastern New Zealand. *Marine Ecology Progress Series 70*: 211–222.	No	Yes	CROP
Andrew, N.L.; Stocker, L.J. 1986: Dispersion and phagokinesis in the echinoid *Evechinus chloroticus* (Val). *Journal of Experimental Marine Biology and Ecology 100*: 11–23.	No	No	CROP
Ayling, A.L. 1978: The relation of food availability and food preferences to the field diet of an echinoid *Evechinus chloroticus* (Valenciennes). *Journal of Experimental Marine Biology and Ecology 33*: 223-235.	No	No	CROP
Ayling, A.M. 1981: The role of biological disturbance in temperate subtidal encrusting communities. *Ecology 62*: 830–847.	No	No	CROP

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PUBLICATION	NO-TAKE NEEDED?	RESERVE FOCUSED?	RESERVES USED IN STUDY
Ayling, A.L. 1983: Growth and regeneration rates in thinly encrusting Demospongiae from temperate waters. *Biological Bulletin 165*: 343–352.	No	No	CROP
Babcock, R.C.; Kelly, S.; Shears, N.T.; Walker, J.W.; Willis, T.J. 1999: Changes in community structure in temperate marine reserves. *Marine Ecology Progress Series 189*: 125–134.	Yes	Yes	CROP, Tawharanui
Babcock, R.C.; Shears, N.T.; Alcala, A.C.; Barrett, N.S.; Edgar, G.J.; Lafferty, K.D.; McClanahan, T.R.; Russ, G.R. 2010: Decadal trends in marine reserves reveal differential rates of change in direct and indirect effects. *Proceedings of the National Academy of Sciences of the United States of America 107*: 18256–18261.	Yes	Yes	CROP
Ballantine, W.J.; Langlois, T.J. 2008: Marine reserves: the need for systems. *Hydrobiologia 606*: 35–44.	Yes	Yes	REVIEW
Barnett, C.W.; Pankhurst, N.W. 1996: Effect of density on the reproductive behaviour of the territorial male demoiselle *Chromis dispilus* (Pisces: Pomacentridae). *Environmental Biology of Fishes 46*: 343–349.	No	No	CROP
Barr, N.G.; Rees, T.A.V. 2003: Nitrogen status and metabolism in the green seaweed *Enteromorpha intestinalis*: an examination of three natural populations. *Marine Ecology Progress Series 249*: 133–144.	No	No	CROP
Bassett, D.K.; Jeffs, A.G.; Montgomery, J.C. 2008: Identification of predators using a novel photographic tethering device. *Marine and Freshwater Research 59*: 1079–1083.	No	Yes	CROP
Beentjes, M.P.; Francis, M.P. 1999: Movement of hapuku (*Polyprion oxygeneios*) determined from tagging studies. *New Zealand Journal of Marine and Freshwater Research 33*: 1–12.	No	No	PKI
Bradstock, M.G.; Gordon, D.P. 1983: Coral-like bryozoan growths in Tasman Bay and their protection to conserve commercial fish stocks. *New Zealand Journal of Marine and Freshwater Research 17*: 159–163.	No	No	Separation Point (no-trawl area, but not no-take)
Brown, P.J.; Taylor, R.B. 1999: Effects of trampling by humans on animals inhabiting coralline algal turf in the rocky intertidal. *Journal of Experimental Marine Biology and Ecology 235*: 45–53.	Yes	No	CROP
Butler, M.J.; MacDiarmid, A.B.; Booth, J.D. 1999: The cause and consequence of ontogenetic changes in social aggregation in New Zealand spiny lobsters. *Marine Ecology Progress Series188*: 179–191.	No	Yes	CROP
Choat, J.H.; Andrew, N.L. 1986: Interactions amongst species in a guild of subtidal benthic herbivores. *Oecologia 68*: 387–394.	No	No	CROP
Choat, J.H.; Ayling, A.M. 1987: The relationship between habitat structure and fish faunas on New Zealand reefs. *Journal of Experimental Marine Biology and Ecology 110*: 257–284.	No	No	CROP, PKI, Hahei
Choat, J.H.; Ayling, A.M.; Schiel, D.R. 1988: Temporal and spatial variation in an island fish fauna. *Journal of Experimental Marine Biology and Ecology 121*: 91–111.	No	No	PKI
Choat, J.H.; Kingett, P.D. 1982: The influence of fish predation on the abundance cycles of an algal turf invertebrate fauna. *Oecologia 54*: 88–95.	No	Yes	CROP
Choat, J.H.; Schiel, D.R. 1982: Patterns of distribution and abundance of large brown algae and invertebrate herbivores in subtidal regions of northern New Zealand. *Journal of Experimental Marine Biology and Ecology 60*: 129–162.	No	No	CROP

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Appendix 1 continued

PUBLICATION	NO-TAKE NEEDED?	RESERVE FOCUSED?	RESERVES USED IN STUDY
Cole, R.G. 1994: Abundance, size structure, and diver-oriented behavior of three large benthic carnivorous fishes in a marine reserve in northeastern New Zealand. *Biological Conservation 70*: 93–99.	Yes	Yes	CROP
Cole, R.G. 1999: Trophic relationships between fishes and benthic organisms on northeastern New Zealand reefs. *Vie Et Milieu-Life and Environment 49*: 201–212.	Yes	Yes	REVIEW
Cole, R.G. 2001: Patterns of abundance and population size structure of herbivorous fishes at the subtropical Kermadec Islands and in mainland New Zealand. *New Zealand Journal of Marine and Freshwater Research 35*: 445–456.	No	No	Kermadecs, CROP
Cole, R.G.; Ayling, T.M.; Creese, R.G. 1990: Effects of marine reserve protection at Goat Island, northern New Zealand. *New Zealand Journal of Marine and Freshwater Research 24*: 197–210.	Yes	Yes	CROP
Cole, R.G.; Babcock, R.C. 1996: Mass mortality of a dominant kelp (Laminariales) at Goat Island, north-eastern New Zealand. *Marine and Freshwater Research 47*: 907–911.	No	No	CROP
Cole, R.G.; Babcock, R.C.; Travers, V. 2001: Distributional expansion of *Carpophyllum flexuosum* onto wave-exposed reefs in north-eastern New Zealand. *New Zealand Journal of Marine and Freshwater Research 35*: 17–32.	No	No	CROP
Cole, R.G.; Creese, R.G.; Grace, R.V.; Irving, P.; Jackson, B.R. 1992: Abundance patterns of subtidal benthic invertebrates and fishes at the Kermadec Islands. *Marine Ecology Progress Series 82*: 207–218.	No	No	Kermadecs
Cole, R.G.; Keuskamp, D. 1998: Indirect effects of protection from exploitation: patterns from populations of *Evechinus chloroticus* (Echinoidea) in northeastern New Zealand. *Marine Ecology Progress Series 173*: 215–226.	Yes	Yes	CROP
Cole, R.G.; Syms, C. 1999: Using spatial pattern analysis to distinguish causes of mortality: an example from kelp in north-eastern New Zealand. *Journal of Ecology 87*: 963–972.	No	No	CROP
Cole, R.G.; Syms, C.; Davey, N.K.; Gust, N.; Notman, P.; Stewart, R.; Radford, C.A.; Carbines, G.; Carr, M.H.; Jevs, A.G. 2007: Does breathing apparatus affect fish counts and observations? A comparison at three New Zealand fished and protected areas. *Marine Biology 150*: 1379–1395.	Yes	Yes	CROP, Tonga Island, Long Island
Cole, R.G.; Villouta, E.; Davidson, R.J. 2000: Direct evidence of limited dispersal of the reef fish *Parapercis colias* (Pinguipedidae) within a marine reserve and adjacent fished areas. *Aquatic Conservation: Marine and Freshwater Ecosystems 10*: 421–436.	Yes	Yes	Long Island
Connell, S.D.; Jones, G.P. 1991: The influence of habitat complexity on postrecruitment processes in a temperate reef fish population. *Journal of Experimental Marine Biology and Ecology 151*: 271–294.	No	No	CROP
Craig, J.; Anderson, S.; Clout, M.; Creese, B.; Mitchell, N.; Ogden, J.; Roberts, M.; Ussher, G. 2000: Conservation issues in New Zealand. *Annual Review of Ecology and Systematics 31*: 61–78.			REVIEW
Creese, R.G. 1988: Ecology of molluscan grazers and their interactions with marine algae in northeastern New Zealand —a review. *New Zealand Journal of Marine and Freshwater Research 22*: 427–444.	No	No	REVIEW
Creese, R.G.; Jeffs, A. 1993: Biological research in New Zealand marine reserves. Pp. 15–22 in Battershill, C.N.; Schiel, D.R.; Jones, G.P.; Creese, R.G.; MacDiarmid, A.B. (Eds): Proceedings of the Second International Temperate Reef Symposium, 7–10 January 1992, Auckland. NIWA Marine, Auckland.	Yes	Yes	REVIEW

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PUBLICATION	NO-TAKE NEEDED?	RESERVE FOCUSED?	RESERVES USED IN STUDY
Creese, R.G.C.; Cole, R.G. 1995: Marine conservation in New Zealand. *Pacific Conservation Biology 2*: 55–63.	Yes	Yes	REVIEW
Davidson, R.J. 2001: Changes in population parameters and behaviour of blue cod (*Parapercis colias*; Pinguipedidae) in Long Island Kokomohua Marine Reserve, Marlborough Sounds, New Zealand. *Aquatic Conservation: Marine and Freshwater Ecosystems 11*: 417–435.	Yes	Yes	Long Island
Davidson, R.J.; Chadderton, W.L. 1994: Marine reserve site selection along the Abel Tasman National Park coast, New Zealand—consideration of subtidal rocky communities. *Aquatic Conservation: Marine and Freshwater Ecosystems 4*: 153–167.	Yes	Yes	Tonga Island
Davidson, R.J.; Villouta, E.; Cole, R.G.; Barrier, R.G.F. 2002: Effects of marine reserve protection on spiny lobster (*Jasus edwardsii*) abundance and size at Tonga Island Marine Reserve, New Zealand. *Aquatic Conservation: Marine and Freshwater Ecosystems 12*: 213–227.	Yes	Yes	Tonga Island
Denny, C.M. 2005: Distribution and abundance of labrids in northeastern New Zealand: the relationship between depth, exposure and pectoral fin aspect ratio. *Environmental Biology of Fishes72*: 33–43.	No	No	CROP
Denny, C.M.; Babcock, R.C. 2004: Do partial marine reserves protect reef fish assemblages? *Biological Conservation 116*: 119–129.	Yes	Yes	PKI
Denny, C.M.; Willis, T.J.; Babcock, R.C. 2004: Rapid recolonisation of snapper *Pagrus auratus*: Sparidae within an offshore island marine reserve after implementation of no-take status. *Marine Ecology Progress Series 272*: 183–190.	Yes	Yes	PKI
Doherty, P.J. 1979: A demographic study of a subtidal population of the New Zealand articulate brachiopod *Terebratella inconspicua*. *Marine Biology 52*: 331–342.	No	No	CROP
Duffy, C.A.J.; Abbott, D. 2003: Sightings of mobulid rays from northern New Zealand, with confirmation of the occurrence of *Manta birostris* in New Zealand waters. *New Zealand Journal of Marine and Freshwater Research 37*: 715–721.	No	No	PKI
Easton, L.M.; Lewis, G.D.; Pearson, M.N. 1997: Virus-like particles associated with dieback symptoms in the brown alga *Ecklonia radiata*. *Diseases of Aquatic Organisms 30*: 217–222.	No	No	CROP
Egli, D.P.; Babcock, R.C. 2004: Ultrasonic tracking reveals multiple behavioural modes of snapper (*Pagrus auratus*) in a temperate no-take marine reserve. *ICES Journal of Marine Science 61*: 1137–1143.	Yes	Yes	CROP
Feary, D.A.; Clements, K.D. 2006: Habitat use by triplefin species (Tripterygiidae) on rocky reefs in New Zealand. *Journal of Fish Biology 69*: 1031–1046.	No	No	CROP
Francis, M.P. 1996: Geographic distribution of marine reef fishes in the New Zealand region. *New Zealand Journal of Marine and Freshwater Research 30*: 35–55.	No	No	various
Francis, M.P.; Evans, J. 1993: Immigration of subtropical and tropical animals into north-eastern New Zealand. Pp. 131–136 in Battershill, C.N.; Schiel, D.R.; Jones, G.P.; Creese, R.G.; MacDiarmid, A.B. (Eds): Proceedings of the Second International Temperate Reef Symposium, 7–10 January 1992, Auckland. NIWA Marine, Auckland.	No	No	PKI
Francis, M.P.; Worthington, C.J.; Saul, P.; Clements, K.D. 1999: New and rare tropical and subtropical fishes from northern New Zealand. *New Zealand Journal of Marine and Freshwater Research 33*: 571–586.	No	No	PKI

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PUBLICATION	NO-TAKE NEEDED?	RESERVE FOCUSED?	RESERVES USED IN STUDY
Franke, E.S.; Babcock, R.C.; Styan, C.A. 2002: Sexual conflict and polyspermy under sperm-limited conditions: in situ evidence from field simulations with the free-spawning marine echinoid *Evechinus chloroticus*. *American Naturalist 160*: 485–496.	No	No	CROP
Freeman, D.J.; MacDiarmid, A.B. 2009: Healthier lobsters in a marine reserve: effects of fishing on disease incidence in the spiny lobster, *Jasus edwardsii*. *Marine and Freshwater Research 60*: 140–145.	Yes	Yes	Te Tapuwae o Rongokako
Freeman, D.J.; MacDiarmid, A.B.; Taylor, R.B. 2009: Habitat patches that cross marine reserve boundaries: consequences for the lobster *Jasus edwardsii*. *Marine Ecology Progress Series 388*: 159–167.	Yes	Yes	Te Tapuwae o Rongokako
Gardner, J.R.A.; Curwen, M.J.; Long, J.; Williamson, R.J.; Wood, A.R. 2006: Benthic community structure and water column characteristics at two sites in the Kermadec Islands Marine Reserve, New Zealand. *New Zealand Journal of Marine and Freshwater Research 40*: 179–194.	No	No	Kermadecs
Gordon, D.P. 2009: New bryozoan taxa from a new marine conservation area in New Zealand, with a checklist of Bryozoa from Greater Cook Strait. *Zootaxa 1987*: 39–60.	Yes	No	Taputeranga
Haggitt, T.R.; Babcock, R.C. 2003: The role of grazing by the lysianassid amphipod *Orchomenella aahu* in dieback of the kelp *Ecklonia radiata* in north-eastern New Zealand. *Marine Biology 143*: 1201–1211.	No	No	CROP
Heltzel, P.S.; Babcock, R.C. 2002: Sexual reproduction, larval development and benthic planulae of the solitary coral *Monomyces rubrum* (Scleractinia : Anthozoa). *Marine Biology 140*: 659–667.	No	No	CROP
Hewitt, J.E.; Thrush, S.E.; Halliday, J.; Duffy, C. 2005: The importance of small-scale habitat structure for maintaining beta diversity. *Ecology 86*: 1619–1626.	No	Yes	Tonga Island
Hooker, S.H.; Creese, R.G. 1995: Reproduction of paua, *Haliotis iris* Gmelin 1791 (Mollusca, Gastropoda), in north-eastern New Zealand. *Marine and Freshwater Research 46*: 617–622.	No	Yes	CROP
Jack, L.; Wing, S.R. 2010: Maintenance of old-growth size structure and fecundity of the red rock lobster *Jasus edwardsii* among marine protected areas in Fiordland, New Zealand. *Marine Ecology Progress Series 381*: 213–222.	Yes	Yes	Fiordland, various
Jack, L.; Wing, S.R.; McLeod, R.J. 2009: Prey base shifts in red rock lobster *Jasus edwardsii* in response to habitat conversion in Fiordland marine reserves: implications for effective spatial management. *Marine Ecology Progress Series 381*: 213–222.	Yes	Yes	The Gut, Gaer Arm, Elizabeth Island
Jones, G.P. 1980: Growth and reproduction in the protogynous hermaphrodite *Pseudolabrus celidotus* (Pisces, Labridae) in New Zealand. *Copeia 4*: 660–675.	No	No	CROP
Jones, G.P. 1981: Spawning site choice by female *Pseudolabrus celidotus* (Pisces, Labridae) and its influence on the mating system. *Behavioral Ecology and Sociobiology 8*: 129–142.	No	No	CROP
Jones, G.P. 1983: Relationship between density and behavior in juvenile *Pseudolabrus celidotus* (Pisces, Labridae). *Animal Behaviour 31*: 729–735.	No	No	CROP
Jones, G.P. 1984: The influence of habitat and behavioral interactions on the local distribution of the wrasse, *Pseudolabrus celidotus*. *Environmental Biology of Fishes 10*: 43–57.	No	No	CROP
Jones, G.P. 1984: Population ecology of the temperate reef fish *Pseudolabrus celidotus* Bloch and Schneider (Pisces, Labridae). 1. Factors influencing recruitment. *Journal of Experimental Marine Biology and Ecology 75*: 257–276.	No	No	CROP

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PUBLICATION	NO-TAKE NEEDED?	RESERVE FOCUSED?	RESERVES USED IN STUDY
Jones, G.P. 1984: Population ecology of the temperate reef fish *Pseudolabrus celidotus* Bloch and Schneider (Pisces, Labridae). 2. Factors influencing adult density. *Journal of Experimental Marine Biology and Ecology 75*: 277–303.	No	No	CROP
Jones, G.P. 1988: Ecology of rocky reef fish of northeastern New Zealand—a review. *New Zealand Journal of Marine and Freshwater Research 22*: 445–462.	No	No	REVIEW
Jones, G.P.; Andrew, N.L. 1990: Herbivory and patch dynamics on rocky reefs in temperate Australasia—the roles of fish and sea urchins. *Australian Journal of Ecology 15*: 505–520.	No	No	CROP
Jones, G.P.; Cole, R.G.; Battershill, C.N. 1993: Marine reserves: do they work? Pp. 29–45 in Battershill, C.N.; Schiel, D.R.; Jones, G.P.; Creese, R.G.; MacDiarmid, A.B. (Eds): Proceedings of the Second International Temperate Reef Symposium, 7–10 January 1992, Auckland. NIWA Marine, Auckland.	Yes	Yes	REVIEW
Jones, G.P.; Thompson, S.M. 1980: Social inhibition of maturation in females of the temperate wrasse *Pseudolabrus celidotus* and a comparison with the blennioid *Tripterygion varium*. *Marine Biology 59*: 247–256.	No	No	CROP
Kelly, S.; MacDiarmid, A.B. 2003: Movement patterns of mature spiny lobsters, *Jasus edwardsii*, from a marine reserve. *New Zealand Journal of Marine and Freshwater Research 37*: 149–158.	Yes	Yes	CROP
Kelly, S.; MacDiarmid, A.B.; Babcock, R.C. 1999: Characteristics of spiny lobster, *Jasus edwardsii*, aggregations in exposed reef and sandy areas. *Marine and Freshwater Research 50*: 409–416.	No	Yes	CROP
Kelly, S.; Scott, D.; MacDiarmid, A.B. 2002: The value of a spillover fishery for spiny lobsters around a marine reserve in northern New Zealand. *Coastal Management 30*: 153–166.	Yes	Yes	CROP
Kelly, S.; Scott, D.; MacDiarmid, A.B.; Babcock, R.C. 2000: Spiny lobster, *Jasus edwardsii*, recovery in New Zealand marine reserves. *Biological Conservation 92*: 359–369.	Yes	Yes	CROP, Hahei, Tawharanui, Tuhua
Kingett, P.D.; Choat, J.H. 1981: Analysis of density and distribution patterns in *Chrysophrys auratus* (Pisces: Sparidae) within a reef environment: an experimental approach. *Marine Ecology Progress Series 5*: 283–290.	No	Yes	CROP
Kingsford, M.J. 1988: The early life-history of fish in coastal waters of northern New Zealand—a review. *New Zealand Journal of Marine and Freshwater Research 22*: 463–479.	No	No	CROP, PKI
Kingsford, M.J. 1989: Distribution patterns of planktivorous reef fish along the coast of northeastern New Zealand. *Marine Ecology Progress Series 54*: 13–24.	No	Yes	CROP, PKI
Kingsford, M.J.; MacDiarmid, A.B. 1988: Interrelations between planktivorous reef fish and zooplankton in temperate waters. *Marine Ecology Progress Series 48*: 103–117.	No	No	PKI
Langlois, T.J.; Anderson, M.J.; Babcock, R.C. 2005: Reef-associated predators influence adjacent soft-sediment communities. *Ecology 86*: 1508–1519.	Yes	Yes	CROP
Langlois, T.J.; Anderson, M.J.; Babcock, R.C. 2006: Inconsistent effects of reefs on different size classes of macrofauna in adjacent sand habitats. *Journal of Experimental Marine Biology and Ecology 334*: 269–282.	Yes	Yes	CROP
Langlois, T.J.; Anderson, M.J.; Babcock, R.C.; Kato, S. 2006: Marine reserves demonstrate trophic interactions across habitats. *Oecologia 147*: 134–140.	Yes	Yes	CROP, Tawharanui
Langlois, T.J.; Anderson, M.J.; Brock, M.; Murman, G. 2006: Importance of rock lobster size-structure for trophic interactions: choice of soft-sediment bivalve prey. *Marine Biology 149*: 447–454.	Yes	Yes	CROP, Tawharanui, Hahei

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PUBLICATION	NO-TAKE NEEDED?	RESERVE FOCUSED?	RESERVES USED IN STUDY
Langlois, T.J.; Ballantine, W.J. 2005: Marine ecological research in New Zealand: developing predictive models through the study of no-take marine reserves. *Conservation Biology 19*: 1763–1770.	Yes	Yes	REVIEW
Le Port, A.; Sippel, T.; Montgomery, J.C. 2008: Observations of mesoscale movements in the short-tailed stingray, *Dasyatis brevicaudata* from New Zealand using a novel PSAT tag attachment method. *Journal of Experimental Marine Biology and Ecology 359*: 110–117.	No	Yes	PKI
Leum, L.L.; Choat, J.H. 1980: Density and distribution patterns of the temperate marine fish *Cheilodactylus spectabilis* (Cheilodactylidae) in a reef environment. *Marine Biology 57*: 327–337.	No	No	CROP
MacDiarmid, A.B. 1985: Sunrise release of larvae from the palinurid rock lobster *Jasus edwardsii*. *Marine Ecology Progress Series 21*: 313–315.	No	Yes	CROP
MacDiarmid, A.B. 1988: Experimental confirmation of external fertilization in the southern temperate rock lobster *Jasus edwardsii* (Hutton) (Decapoda, Palinuridae). *Journal of Experimental Marine Biology and Ecology 120*: 277–285.	No	Yes	CROP
MacDiarmid, A.B. 1989: Molting and reproduction of the spiny lobster *Jasus edwardsii* (Decapoda, Palinuridae) in northern New-Zealand. *Marine Biology 103*: 303–310.	No	Yes	CROP
MacDiarmid, A.B. 1991: Seasonal changes in depth distribution, sex-ratio and size frequency of spiny lobster *Jasus edwardsii* on a coastal reef in northern New Zealand. *Marine Ecology Progress Series 70*: 129–141.	No	Yes	CROP
MacDiarmid, A.B. 1994: Cohabitation in the spiny lobster *Jasus edwardsii* (Hutton, 1875). *Crustaceana 66*: 341–355.	No	Yes	CROP
MacDiarmid, A.B.; Breen, P.A. 1993: Spiny lobster population change in a marine reserve. Pp. 47–56 in Battershill, C.N.; Schiel, D.R.; Jones, G.P.; Creese, R.G.; MacDiarmid, A.B. (Eds): Proceedings of the Second International Temperate Reef Symposium, 7–10 January 1992, Auckland. NIWA Marine, Auckland.	Yes	Yes	CROP, PKI
MacDiarmid, A.B.; Hickey, B.; Maller, R.A. 1991: Daily movement patterns of the spiny lobster *Jasus edwardsii* (Hutton) on a shallow reef in northern New Zealand. *Journal of Experimental Marine Biology and Ecology 147*: 185–205.	No	Yes	CROP
McCormick, M.I. 1989: Reproductive ecology of the temperate reef fish *Cheilodactylus spectabilis* (Pisces, Cheilodactylidae). *Marine Ecology Progress Series 55*: 113–120.	No	No	CROP
McCormick, M.I. 1989: Spatio-temporal patterns in the abundance and population structure of a large temperate reef fish. *Marine Ecology Progress Series 53*: 215–225.	No	No	CROP
McCormick, M.I. 1998: Ontogeny of diet shifts by a microcarnivorous fish, *Cheilodactylus spectabilis*: relationship between feeding mechanics, microhabitat selection and growth. *Marine Biology132*: 9–20.	No	No	CROP
McCormick, M.I.; Choat, J.H. 1987: Estimating total abundance of a large temperate reef fish using visual strip transects. *Marine Biology 96*: 469–478.	Yes	Yes	CROP
Millar, R.B.; Willis, T.J. 1999: Estimating the relative density of snapper in and around a marine reserve using a log-linear mixed-effects model. *Australian and New Zealand Journal of Statistics 41*: 383–394.	Yes	Yes	CROP
Miller, K.J.; Mundy, C.N.; Chadderton, W.L. 2004: Ecological and genetic evidence of the vulnerability of shallow-water populations of the stylasterid hydrocoral Errina novaezelandiae in New Zealand's fiords. *Aquatic Conservation: Marine and Freshwater Ecosystems 14*: 75–94.	Yes	Yes	The Gut

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PUBLICATION	NO-TAKE NEEDED?	RESERVE FOCUSED?	RESERVES USED IN STUDY
Mislan, K.A.S.; Babcock, R.C. 2008: Survival and behaviour of juvenile red rock lobster, *Jasus edwardsii*, on rocky reefs with varying predation pressure and habitat complexity. *Marine and Freshwater Research 59*: 246–253.	Yes	Yes	CROP
Newcombe, E.M.; Taylor, R.B. 2010: Trophic cascade in a seaweed-epifauna-fish food chain. *Marine Ecology Progress Series 408*: 161–167.	No	No	CROP
Pande, A.; Gardner, J.P.A. 2009: A baseline biological survey of the proposed Taputeranga Marine Reserve (Wellington, New Zealand): spatial and temporal variability along a natural environmental gradient. *Aquatic Conservation: Marine and Freshwater Ecosystems 19*: 237–248.	Yes	No	Taputeranga
Pande, A.; MacDiarmid, A.B.; Smith, P.J.; Davidson, R.J.; Cole, R.G.; Freeman, D.; Kelly, S.; Gardner, J.P.A. 2008: Marine reserves increase the abundance and size of blue cod and rock lobster. *Marine Ecology Progress Series 366*: 147–158.	Yes	Yes	various
Parsons, D.; Egli, D. 2005: Fish movement in a temperate marine reserve: new insights through application of acoustic tracking. *Marine Technology Society Journal 39*: 56–63.	Yes	Yes	CROP
Parsons, D.M.; Babcock, R.C.; Hankin, R.K.S.; Willis, T.J.; Aitken, J.P.; O'Dor, R.K.; Jackson, G.D. 2003: Snapper *Pagrus auratus* (Sparidae) home range dynamics: acoustic tagging studies in a marine reserve. *Marine Ecology Progress Series 262*: 253–265.	Yes	Yes	CROP
Parsons, D.M.; Morrison, M.A.; Slater, M.J. 2010: Responses to marine reserves: decreased dispersion of the sparid *Pagrus auratus* (snapper). *Biological Conservation 143*: 2039–2048.	Yes	Yes	CROP
Parsons, D.M.; Shears, N.T.; Babcock, R.C.; Haggitt, T.R. 2004: Fine-scale habitat change in a marine reserve, mapped using radio-acoustically positioned video transects. *Marine and Freshwater Research 55*: 257–265.	Yes	Yes	CROP
Pinkerton, M.H.; Lundquist, C.J.; Duffy, C.A.J.; Freeman, D.J. 2008: Trophic modelling of a New Zealand rocky reef ecosystem using simultaneous adjustment of diet, biomass and energetic parameters. *Journal of Experimental Marine Biology and Ecology 367*: 189–203.	Yes	Yes	Te Tapuwae o Rongokako
Radford, C.; Jeffs, A.; Tindle, C.; Montgomery, J.C. 2008: Resonating sea urchin skeletons create coastal choruses. *Marine Ecology Progress Series 362*: 37–43.	No	No	CROP
Radford, C.A.; Jeffs, A.G.; Tindle, C.T.; Montgomery, J.C. 2008: Temporal patterns in ambient noise of biological origin from a shallow water temperate reef. *Oecologia 156*: 921–929.	No	No	CROP
Radford, C.A.; Stanley, J.A.; Tindle, C.T.; Montgomery, J.C.; Jeffs, A.G. 2010: Localised coastal habitats have distinct underwater sound signatures. *Marine Ecology Progress Series 401*: 21–29.	No	No	CROP
Ross, P.M.; Thrush, S.F.; Montgomery, J.C.; Walker, J.W.; Parsons, D.M. 2007: Habitat complexity and predation risk determine juvenile snapper (*Pagrus auratus*) and goatfish (*Upeneichthys lineatus*) behaviour and distribution. *Marine and Freshwater Research 58*: 1144–1151.	No	No	CROP
Russell, B.C. 1977: Population and standing crop estimates for rocky reef fishes of northeastern New Zealand. *New Zealand Journal of Marine and Freshwater Research 11*: 23–36.	No	No	CROP
Russell, B.C. 1983: The food and feeding habits of rocky reef fish of north-eastern New Zealand. *New Zealand Journal of Marine and Freshwater Research 17*: 121–145.	No	No	CROP

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PUBLICATION	NO-TAKE NEEDED?	RESERVE FOCUSED?	RESERVES USED IN STUDY
Salomon, A.K.; Gaichas, S.K.; Shears, N.T.; Smith, J.E.; Madin, E.M.P.; Gaines, S.D. 2010: Key features and context-dependence of fishery-induced trophic cascades. *Conservation Biology 24*: 382–394.	Yes	Yes	CROP
Salomon, A.K.; Shears, N.T.; Langlois, T.J.; Babcock, R.C. 2008: Cascading effects of fishing can alter carbon flow through a temperate coastal ecosystem. *Ecological Applications 18*: 1874–1887.	Yes	Yes	CROP, Tawharanui, Long Bay, PKI
Schiel, D.R. 1982: Selective feeding by the echinoid, *Evechinus chloroticus*, and the removal of plants from subtidal algal stands in northern New Zealand. *Oecologia 54*: 379–388.	No	No	CROP
Schiel, D.R. 1984: Poor Knights Islands Marine Reserve survey. *Leigh Marine Laboratory Bulletin 15*. University of Auckland, Auckland. 93 p.	Yes	No	PKI
Schiel, D.R. 1988: Algal interactions on shallow subtidal reefs in northern New Zealand—a review. *New Zealand Journal of Marine and Freshwater Research 22*: 481–489.	No	No	CROP
Schiel, D.R.; Choat, J.H. 1980: Effects of density on monospecific stands of marine algae. *Nature 285*: 324–326.	No	No	CROP
Schiel, D.R.; Kingsford, M.J.; Choat, J.H. 1986: Depth distribution and abundance of benthic organisms and fishes at the subtropical Kermadec Islands. *New Zealand Journal of Marine and Freshwater Research 20*: 521–535.	No	No	Kermadecs
Shears, N.T.; Babcock, R.C. 2002: Marine reserves demonstrate top-down control of community structure on temperate reefs. *Oecologia 132*: 131–142.	Yes	Yes	CROP, Tawharanui
Shears, N.T.; Babcock, R.C. 2003: Continuing trophic cascade effects after 25 years of no-take marine reserve protection. *Marine Ecology Progress Series 246*: 1–16.	Yes	Yes	CROP
Shears, N.T.; Babcock, R.C.; Duffy, C.A.J.; Walker, J.W. 2004: Validation of qualitative habitat descriptors commonly used to classify subtidal reef assemblages in north-eastern New Zealand. *New Zealand Journal of Marine and Freshwater Research 38*: 743–752.	No	No	CROP
Shears, N.T.; Babcock, R.C.; Salomon, A.K. 2008: Context dependent effects of fishing: variation in trophic cascades across environmental gradients. *Ecological Applications 18*: 1860–1873.	Yes	Yes	CROP, Tawharanui, Long Bay, Hahei, PKI, Tuhua
Shears, N.T.; Grace, R.V.; Usmar, N.R.; Kerr, V.; Babcock, R.C. 2006: Long-term trends in lobster populations in a partially protected vs. no-take marine park. *Biological Conservation 132*: 222–231.	Yes	Yes	Tawharanui
Shears, N.T.; Ross, P.M. 2009: Blooms of benthic dinoflagellates of the genus *Ostreopsis*; an increasing and ecologically important phenomenon on temperate reefs in New Zealand and worldwide. *Harmful Algae 8*: 916–925.	No	No	CROP
Shears, N.T.; Ross, P.M. 2010: Toxic cascades: multiple anthropogenic stressors have complex and unanticipated interactive effects on temperate reefs. *Ecology Letters 13*: 1149–1159.	No	Yes	CROP
Shears, N.T.; Smith, F.; Babcock, R.C.; Duffy, C.A.J.; Villouta, E. 2008: Evaluation of biogeographic classification schemes for conservation planning: application to New Zealand's coastal marine environment. *Conservation Biology 22*: 467–481.			
Stocker, L.J. 1986: Artificial effects of caging on the recruitment and survivorship of a subtidal colonial invertebrate. *Marine Ecology Progress Series 34*: 305–307.	No	Yes	CROP

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PUBLICATION	NO-TAKE NEEDED?	RESERVE FOCUSED?	RESERVES USED IN STUDY
Syms, C. 1995: Multiscale analysis of habitat association in a guild of blennioid fishes. *Marine Ecology Progress Series 125*: 31–43.	No	No	CROP
Syms, C.; Jones, G.P. 1999: Scale of disturbance and the structure of a temperate fish guild. *Ecology 80*: 921–940.	No	No	CROP
Taylor, R.B. 1998: Density, biomass and productivity of animals in four subtidal rocky reef habitats: the importance of small mobile invertebrates. *Marine Ecology Progress Series 172*: 37–51.	No	No	CROP
Taylor, R.B. 1998: Seasonal variation in assemblages of mobile epifauna inhabiting three subtidal brown seaweeds in northeastern New Zealand. *Hydrobiologia 361*: 25–35.	No	No	CROP
Taylor, R.B. 1998: Short-term dynamics of a seaweed epifaunal assemblage. *Journal of Experimental Marine Biology and Ecology 227*: 67–82.	No	No	CROP
Taylor, R.B.; Brown, P.J. 2006: Herbivory in the gammarid amphipod *Aora typica*: relationships between consumption rates, performance and abundance across ten seaweed species. *Marine Biology 149*: 455–463.	No	No	CROP
Taylor, R.B.; Cole, R.G. 1994: Mobile epifauna on subtidal brown seaweeds in northeastern New Zealand. *Marine Ecology Progress Series 115*: 271–282.	No	No	CROP
Thompson, S.M. 1983: Homing in a territorial reef fish. *Copeia 1983*: 832–834.	No	No	CROP
Thompson, S.M.; Jones, G.P. 1983: Interspecific territoriality and competition for food between the reef fishes *Forsterygion varium* and *Pseudolabrus celidotus*. *Marine Biology 76*: 95–104.	No	No	CROP
Trowbridge, C.D. 1996: Introduced versus native subspecies of *Codium fragile*: how distinctive is the invasive subspecies tomentosoides? *Marine Biology 126*: 193–204.	No	No	CROP
Uunila, L. 2001: Community involvement in New Zealand marine reserve management: examining practice. *Science and Stewardship to Protect and Sustain Wilderness Values 27*: 142–147.			
Wellenreuther, M.; Barrett, P.T.; Clements, K.D. 2007: Ecological diversification in habitat use by subtidal triplefin fishes (Tripterygiidae). *Marine Ecology Progress Series 330*: 235–246.	No	No	CROP
Wellenreuther, M.; Clements, K.D. 2007: Reproductive isolation in temperate reef fishes. *Marine Biology 152*: 619–630.	No	No	CROP
Wicks, L.C.; Gardner, J.P.A.; Davy, S.K. 2010: Spatial patterns and regional affinities of coral communities at the Kermadec Islands Marine Reserve, New Zealand—a marginal high-latitude site. *Marine Ecology Progress Series 400*: 101–113.	No	No	Kermadecs
Williams, G.J.; Cameron, M.J.; Turner, J.R.; Ford, R.B. 2008: Quantitative characterisation of reef fish diversity among nearshore habitats in a northeastern New Zealand marine reserve. *New Zealand Journal of Marine and Freshwater Research 42*: 33–46.	Yes	Yes	CROP
Williamson, J.E.; Creese, R.G. 1996: Colonisation and persistence of patches of the crustose brown alga *Pseudolithoderma* sp. *Journal of Experimental Marine Biology and Ecology 203*: 191–208.	No	No	CROP
Williamson, J.E.; Creese, R.G. 1996: Small invertebrates inhabiting the crustose alga *Pseudolithoderma* sp. (Ralfsiaceae) in northern New Zealand. *New Zealand Journal of Marine and Freshwater Research 30*: 221–232.	No	No	CROP

Continued on following page

Appendix 1 continued

PUBLICATION	NO-TAKE NEEDED?	RESERVE FOCUSED?	RESERVES USED IN STUDY
Williamson, J.E.; Rees, T.A.V. 1994: Nutritional interaction in an alga barnacle association. *Oecologia 99*: 16–20.	No	Yes	CROP
Willis, T.J.; Anderson, M.J. 2003: Structure of cryptic reef fish assemblages: relationships with habitat characteristics and predator density. *Marine Ecology Progress Series 257*: 209–221.	Yes	Yes	CROP
Willis, T.J.; Babcock, R.C. 1998: Retention and in situ detectability of visible implant fluorescent elastomer (VIFE) tags in *Pagrus auratus* (Sparidae). *New Zealand Journal of Marine and Freshwater Research 32*: 247–254.	No	No	CROP
Willis, T.J.; Babcock, R.C. 2000: A baited underwater video system for the determination of relative density of carnivorous reef fish. *Marine and Freshwater Research 51*: 755–763.	Yes	Yes	Hahei
Willis, T.J.; Badalamenti, F.; Milazzo, M. 2006: Diel variability in counts of reef fishes and its implications for monitoring. *Journal of Experimental Marine Biology and Ecology 331*: 108–120.	No	No	PKI
Willis, T.J.; Millar, R.B. 2005: Using marine reserves to estimate fishing mortality. *Ecology Letters 8*: 47–52.	Yes	Yes	CROP, Tawaharanui, Hahei
Willis, T.J.; Millar, R.B.; Babcock, R.C. 2000: Detection of spatial variability in relative density of fishes: comparison of visual census, angling, and baited underwater video. *Marine Ecology Progress Series 198*: 249–260.	Yes	Yes	CROP
Willis, T.J.; Millar, R.B.; Babcock, R.C. 2003: Protection of exploited fish in temperate regions: high density and biomass of snapper *Pagrus auratus* (Sparidae) in northern New Zealand marine reserves. *Journal of Applied Ecology 40*: 214–227.	Yes	Yes	CROP, Tawharanui, Hahei
Willis, T.J.; Millar, R.B.; Babcock, R.C.; Tolimieri, N. 2003: Burdens of evidence and the benefits of marine reserves: putting Descartes before des horse? *Environmental Conservation 30*: 97–103.	Yes	Yes	REVIEW
Willis, T.J.; Parsons, D.M.; Babcock, R.C. 2001: Evidence for long-term site fidelity of snapper (*Pagrus auratus*) within a marine reserve. *New Zealand Journal of Marine and Freshwater Research 35*: 581–590.	No	Yes	CROP
Willis, T.J.; Saunders, J.E.H.; Blackwood, D.L.; Archer, J.E. 1999: First New Zealand record of the Australian bridled goby, *Arenigobius bifrenatus* (Pisces: Gobiidae). *New Zealand Journal of Marine and Freshwater Research 33*: 189–192.	No	No	Pollen Island
Wing, S.R. 2009: Decadal-scale dynamics of sea urchin population networks in Fiordland, New Zealand are driven by juxtaposition of larval transport against benthic productivity gradients. *Marine Ecology Progress Series 378*: 125–134.	No	No	various Fiordland
Wolfenden, J.; Cram, F.; Kirkwood, B. 1994: Marine reserves in New Zealand—a survey of community reactions. *Ocean and Coastal Management 25*: 31–51.	Yes	Yes	CROP
Wood, A.R.; Gardner, J.P.A. 2007: Small spatial scale population genetic structure in two limpet species endemic to the Kermadec Islands, New Zealand. *Marine Ecology Progress Series 349*: 159–170.	No	No	Kermadecs

Appendix 2

University theses based on research conducted in New Zealand marine reserves to 2009, listed chronologically

N = no, Y = yes, H = helpful. All theses from University of Auckland, unless marked with * (Victoria University) or # (University of Otago).

AUTHOR	DATE	DEGREE	TITLE	RESERVE USED	RESERVE REQUIRED? NO/YES/HELPFUL
Russell, B.C.	1971	MSc	Ecological relationships of rocky reef fishes of north-eastern New Zealand	Cape Rodney–Okakari Point	N
Don, G.L.	1975	MSc	Effects of grazing by *Evechinus chloroticus* (Val.) on populations of *Ecklonia radiata* (Ag.)	Cape Rodney–Okakari Point	N
Levis, L.A.	1975	MSc	Marine littoral diatoms in the Leigh area	Cape Rodney–Okakari Point	N
Schiel, D.R.T.	1975	MSc	The colonisation of hard substrata by sessile organisms in an enclosed marine basin	Cape Rodney–Okakari Point	N
Doherty, P.J.	1976	MSc	Aspects of the feeding ecology of the subtidal brachiopod, *Terebratella inconspicua* (Sowerby, 1846)	Cape Rodney–Okakari Point	N
Watts, R.N.	1977	MSc	Pattern on a rocky intertidal shore a methodological study	Cape Rodney–Okakari Point	N
Johnson, K.A.	1978	PhD	Studies on some crustose coralline algae of New Zealand, and aspects of the systematics of the family Corallinaceae	Cape Rodney–Okakari Point	N
Ayling, A.L.	1979	PhD	Population biology and competitive interactions in subtidal sponge dominated communities of temperate waters	Cape Rodney–Okakari Point	N
Venus, G.C.	1979	MSc	Settlement patterns among encrusting organisms found under sub-tidal boulders at Leigh, New Zealand	Cape Rodney–Okakari Point	N
Willan, R.C.	1979	PhD	The ecology of two New Zealand opisthobranch molluscs	Cape Rodney–Okakari Point	N
Hartley, G.W.	1980	MSc	The population biology of four co-occurring herbivorous subtidal gastropods	Cape Rodney–Okakari Point	N
Kingsford, M.J.	1980	MSc	Interrelationships between spawning and recruitment of *Chromis dispilus* (Pisces: Pomacentridae)	Cape Rodney–Okakari Point	H
Poynter, M.R.	1980	MSc	Distribution and abundance of a temperate reef fish *Parika scaber* (Monacanthidae) with emphasis on recruitment, plus aspects of feeding ecology and growth	Cape Rodney–Okakari Point	H
Schiel, D.R.T.	1980	PhD	A demographic and experimental evaluation of plant and herbivore interactions in subtidal algal stands	Cape Rodney–Okakari Point	H
Thompson, S.M.	1980	MSc	Ecological and behavioural factors influencing the distribution and abundance patterns of tripterygiid fishes with particular reference to *Tripterygion varium*	Cape Rodney–Okakari Point	H
Wong, P.S.P.	1980	PhD	The form and function of the digestive and respiratory systems of the marine pulmonate *Siphonaria zelandica*	Cape Rodney–Okakari Point	N

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AUTHOR	DATE	DEGREE	TITLE	RESERVE USED	RESERVE REQUIRED? NO/YES/HELPFUL
Bonin, D.R.	1981	MSc	Systematics and life histories of New Zealand Bonnemaisoniaceae (Rhodophyta)	Cape Rodney–Okakari Point	N
Jones, G.P.	1981	PhD	Interrelationships between ecology, behaviour and life history in the protogynous hermaphrodite *Pseudolabrus celidotus* (Pisces: Labridae)	Cape Rodney–Okakari Point	H
Kingett, P.D.	1981	MSc	Factors influencing the distribution and abundance of *Chrysophrys auratus* in a temperate reef system	Cape Rodney–Okakari Point	Y
MacDiarmid, A.B.	1981	MSc	Factors influencing the distribution and abundance of two temperate planktivorous reef fish, *Pempheris adspersa* and *Scorpis violacenus*	Poor Knights Islands	H
Novaczek, I.	1981	PhD	The development and phenology of *Ecklonia radiata* (C.Ag.) J.Ag.	Cape Rodney–Okakari Point	N
Andrew, N.L.	1982	MSc	Experimental study of the distribution and abundance of *Evechinus chloroticus* (Echinoidea: Echinometridae)	Cape Rodney–Okakari Point	Y
Burgett, J.M.	1982	MSc	The feeding ecology of *Patiriella regularis* (Verrill) in the rocky intertidal	Cape Rodney–Okakari Point	N
Davis, A.R.	1982	MSc	The ecology of a predatory gastropod *Lepsiella scobina* (Quoy and Gaimard)	Cape Rodney–Okakari Point	N
Edwards, M.G.	1982	MSc	Gastropod-algal interactions in the intertidal region	Cape Rodney–Okakari Point	N
Walls, K.S.	1982	MSc	Small scale current patterns and zooplankton distribution around Goat Island, Leigh Marine Reserve	Cape Rodney–Okakari Point	N
Lowe, M.L.	1983	MSc	Distribution of zooplankton around Goat Island, Leigh Marine Reserve	Cape Rodney–Okakari Point	N
Mutch, P.G.	1983	MSc	Factors influencing the density and distribution of the blue cod (*Parapercis colias*) Pisces: Mugiloididae)	Cape Rodney–Okakari Point	Y
Slooten, E.	1983	MSc	The reproductive behaviour of *Opifex fuscus* Hutton an evolutionary approach	Cape Rodney–Okakari Point	N
Taylor, N.J.	1983	MSc	Silica and marine phytoplankton: a quantitative survey of the hydrology, nutrients and phytoplankton in Goat Island Bay, together with an analysis of the role of silica and other factors on the growth and morphology of *Coscinodiscus granii* Gough (Diatomophyceae)	Cape Rodney–Okakari Point	N
Thompson, B.A.	1983	MSc	The distribution and abundance of icthyoplankton in the Leigh Marine Reserve, New Zealand	Cape Rodney–Okakari Point	N
Watson, G.B.	1983	MSc	Respiratory properties of parore blood: a molecular study	Cape Rodney–Okakari Point	N
Ling, N.	1984	MSc	Haematological responses to capture stress in parore	Cape Rodney–Okakari Point	N
Stocker, L.J.	1984	MSc	Recruitment, growth and mortality in the subtidal ascidian *Pseudodistoma novaezelandiae* (Ascidiacea: Polyclinidae)	Cape Rodney–Okakari Point	N
Clements, K.D.	1985	MSc	Feeding in two New Zealand herbivorous fish, the butterfish *Odax pullus* and the marblefish *Aplodactylus arcidens*	Cape Rodney–Okakari Point	H
Mortimer, G.N.	1985	MSc	The distribution and abundance of underboulder chitons	Cape Rodney–Okakari Point	N
Kingsford, M.J.	1986	PhD	Distribution patterns of fish during the planktonic period of their life history	Cape Rodney–Okakari Point	N

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AUTHOR	DATE	DEGREE	TITLE	RESERVE USED	RESERVE REQUIRED? NO/YES/HELPFUL
McCormick, M.I.	1986	MSc	Spatial and temporal patterns of abundance of *Cheilodactylus spectabilis* (Pisces: Cheilodactylidae)	Cape Rodney–Okakari Point	Y
Meekan, M.G.	1986	MSc	Distribution and abundance of the herbivorous fish *Odax pullus* and its influence on its food plant *Ecklonia radiata* within a temperate reef environment	Cape Rodney–Okakari Point	Y
Milicich, M.J.	1986	MSc	Aspects of the early life history of *Parika scaber* (Pisces: Monacanthidae)	Cape Rodney–Okakari Point	H
Sylvester, T.	1986	MSc	Food limitation: a preliminary study on two groups of benthic feeding carnivorous fish in a temperate reef system	Cape Rodney–Okakari Point	Y
Atkinson, M.H.	1987	MSc	Ontogenetic patterns in presettlement *Chrysophrys auratus* (Sparidae)	Cape Rodney–Okakari Point	H
Battershill, C.N.	1987	PhD	Factors affecting the structure and dynamics of subtidal communities characterised by sponges	Cape Rodney–Okakari Point	H
Dickson, P.	1987	MSc	Initiation and growth of under-boulder communities in Goat Island Bay (Whakatuwhenua), Leigh	Cape Rodney–Okakari Point	H
Grant-Mackie, E.	1987	MSc	Aspects of the biology of the horse mussel, *Atrina zelandica*	Cape Rodney–Okakari Point	N
Keestra, B.H.	1987	MSc	The ecology of *Cookia sulcata* (Gmelin), with special reference to the coralline flats habitat, and associated guild of subtidal invertebrate grazers	Cape Rodney–Okakari Point	N
Kerrigan, B.A.	1987	MSc	Abundance patterns of intertidal and subtidal populations of *Evechinus chloroticus*	Cape Rodney–Okakari Point	Y
MacDiarmid, A.B.	1987	PhD	The ecology of *Jasus edwardsii* (Hutton) (Crustacea: Palinuridae)	Cape Rodney–Okakari Point	Y
Manson, B.A.	1987	MSc	The reproductive biology and ecology of *Amaurochiton glaucus* (Gray, 1828) (Mollusca: Polyplacophora) on a rocky shore	Cape Rodney–Okakari Point	N
Ackley, J.C.	1988	MSc	The ecology of juvenile leatherjackets, *Parika scaber*	Cape Rodney–Okakari Point	H
Handford, C.	1988	MSc	The habitat, population dynamics and social organisation of two tripterygiid fishes	Cape Rodney–Okakari Point	H
Hooker, S.H	1988	MSc	The demography of paua (*Haliotis iris*), with special reference to juveniles	Cape Rodney–Okakari Point	Y
Tricklebank, K.A.	1988	MSc	Distribution and abundance of neustonic ichthyoplankton off northeastern New Zealand	Cape Rodney–Okakari Point	N
Cook, S.d C.	1989	MSc	Distribution, abundance and feeding biology of the asteroid *Coscinasterias calamaria*	Cape Rodney – Okakari Point	N
Hartill, B.W.	1989	MSc	Influence of behaviour on the distribution and abundance of *Myliobatus tenuicaudatus*	Cape Rodney–Okakari Point	H
Moltschaniwskyj, N.A.	1989	MSc	Settlement and recruitment of *Upeneichthys lineatus* (Pisces: Mullidae)	Cape Rodney–Okakari Point	H
White, S.E.	1989	MSc	Ecology and behaviour of mobile epifauna on rocky reef macroalgae	Cape Rodney–Okakari Point	N
Bollard, B.A.	1990	MSc	The effects of varying cortisol levels on metabolic and hematological parameters in snapper, *Chrysophrys auratus*	Cape Rodney–Okakari Point	Y
Connell, S.D.	1990	MSc	Population ecology of *Forsterygion varium*: the roles of recruitment and postrecruitment processes	Cape Rodney–Okakari Point	Y

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AUTHOR	DATE	DEGREE	TITLE	RESERVE USED	RESERVE REQUIRED? NO/YES/HELPFUL
Gabites, B.P.	1990	MSc	Shelter related distribution of the lobster *Jasus edwardsii*	Cape Rodney–Okakari Point	Y
Jones, A.D.	1990	MSc	The macroparasitic fauna of *Chrysophrys auratus*	Cape Rodney–Okakari Point	H
Morrison, M.A.	1990	MSc	Ontogenetic shifts in the ecology of the parore, *Girella tricuspidata*	Cape Rodney–Okakari Point	H
Robbins, B.D.	1990	MSc	Population dynamics of the kelp-dwelling isopod, *Amphoroidea longipes*	Cape Rodney–Okakari Point	N
Sharples, D.F.	1990	MSc	Effects of stress on the cortisol response in a wild fish	Cape Rodney–Okakari Point	Y
Warren, E.J.	1990	MSc	Spawning patterns within the breeding seasons of *Favonigobius lateralis* (Family: Gobiidae) and *Forsterygion lapillum* (Family: Tripterygiidae)	Cape Rodney–Okakari Point	H
Beresford, D.L.	1991	MSc	The macroparasitic fauna and pathology of the leatherjacket, *Parika scaber*	Cape Rodney–Okakari Point	H
De Beer, M.C.	1991	MSc	Corneal iridescence and visual axes in two benthic shallow water marine teleosts	Cape Rodney–Okakari Point	N
Pankhurst, P.M.	1991	PhD	Growth, development and visual ontogeny of two temperate reef teleosts *Pagrus auratus* (Sparidae) and *Forsterygion varium* (Tripterygiidae)	Cape Rodney–Okakari Point	H
Taylor, R.B.	1991	MSc	Effects of *Notolabrus celidotus* (Labridae) predation on motile macroalgal epifauna	Cape Rodney–Okakari Point	H
West, S.A.	1991	MSc	Population biology and ecology of three species of *Maurea* (Trochidae: Gastropoda)	Cape Rodney–Okakari Point	N
Syms, C.	1992	MSc	Spatial scale and the structure and dynamics of a blennioid fish guild	Cape Rodney–Okakari Point	H
Williamson, J.E.	1992	MSc	Distribution patterns and life-history features of the intertidal encrusting alga *Pseudolithoderma* sp.	Cape Rodney–Okakari Point	N
Barnett, C.W.	1993	MSc	Spawning dynamics and behaviour of the demoiselle *Chromis dispilus*	Cape Rodney–Okakari Point	H
Cole, R.G.	1993	PhD	Distributional relationships among subtidal algae, sea urchins and reef fish in northeastern New Zealand	Cape Rodney–Okakari Point	Y
Coupe, N.M.	1993	MSc	The variability of zooplankton at the Leigh Marine Reserve	Cape Rodney–Okakari Point	N
Gorter, R.	1993	MSc	Survey methodology for marine conservation	Cape Rodney–Okakari Point	Y
Anderson, T.J.	1994	MSc	Taxonomy and ecology of shallow-benthic octopus in north-eastern New Zealand	Cape Rodney – Okakari Point	H
Duckworth, A.R.	1994	MSc	The aquaculture and ecology of three species of Porifera	Cape Rodney–Okakari Point	H
Hobby, A.C.	1994	MSc	Role of gonadal steroids in the regulation of post-ovulatory egg viability in teleosts	Cape Rodney–Okakari Point	N
Lowe, T.E.	1995	PhD	The effects of stress on hematology and energy metabolism in marine fishes	Cape Rodney–Okakari Point	Y
Skipworth, E.	1995	MSc	The ventral lateral line canals of batoid elasmobranchs	Cape Rodney – Okakari Point	N
Archer, J.E.	1996	MSc	Aspects of the reproductive and larval biology and ecology, of the temperate holothurian *Stichopus mollis* (Hutton)	Cape Rodney–Okakari Point	N
Aspden, C.J.	1996	MSc	Habitat utilisation and demography of *Haliotis virginea*, the white-footed paua, in northeastern New Zealand	Cape Rodney–Okakari Point	H
Brown, P.J.	1996	MSc	Effects of humans on rocky intertidal organisms	Cape Rodney–Okakari Point	Y

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Appendix 2 continued

AUTHOR	DATE	DEGREE	TITLE	RESERVE USED	RESERVE REQUIRED? NO/YES/HELPFUL
Travers, V.	1996	MSc	Morphological variation in *Carpophyllum flexuosum*	Cape Rodney–Okakari Point	H
Bewick, M.D.	1997	MSc	Effect of dietary manipulation on energetic status and amino acid composition in the New Zealand abalone *Haliotis iris*	Cape Rodney–Okakari Point	H
Keuskamp, D.	1997	MSc	Recruitment and population dynamics of *Evechinus chloroticus*	Cape Rodney–Okakari Point	Y
Mehta, T.S.	1997	MSc	The role of biological rhythms in the zonation of the intertidal isopod Cirolana cookii	Cape Rodney–Okakari Point	N
Neill, M.A.	1997	MSc	Demography of *Haliotis iris* and *H. australis* from north-eastern New Zealand	Cape Rodney–Okakari Point	Y
Taylor, R.B.	1997	PhD	The role of small mobile epifauna in subtidal rocky reef ecosystems	Cape Rodney–Okakari Point	H
Vial, T.H.	1997	MSc	Comparative feeding biology of two temperate water herbivorous fish, silver drummer, *Kyphosus sydneyanus*, and parore, *Girella tricuspidata*	Cape Rodney–Okakari Point	H
Bell, A.H.	1998	MSc	The feeding dynamics of the sponge *Polymastia croceus* (Porifera: Demospongiae: Hadromerida) and implications for its ecology and aquaculture	Cape Rodney–Okakari Point	N
Fisher, C.J.	1998	MSc	Population ecology of three species of triplefins (family Tripterygiidae)	Cape Rodney–Okakari Point / Tawharanui Marine Park	N
Freeman, D.	1998	MSc	Ecological interactions between three herbivorous gastropods and *Ecklonia radiata* (Laminariales) in northeastern New Zealand kelp forests	Cape Rodney–Okakari Point	N
Heltzel, P.S.	1998	MSc	Population biology of *Monomyces rubrum* (Scleractinia: Anthozoa)	Cape Rodney–Okakari Point	N
Muller, C.G.	1998	MSc	Can snapper (*Pagrus auratus*) [Pisces: Sparidae] feed visually at night?	Cape Rodney–Okakari Point	Y
Samuela, A.T.	1998	MSc	Ammonium metabolism in the symbiotic sea anemone *Anthopleura aureoradiata*	Cape Rodney–Okakari Point	N
Spencer, S.	1998	MSc	Patch dynamics of the intertidal barnacle *Chamaesipho columna*	Cape Rodney – Okakari Point	H
Wilkie, M.	1998	MSc	The grazing impact of *Chiton pelliserpentis*, with emphasis on bioerosion	Cape Rodney–Okakari Point	H
Henderson, S.D.	1999	MSc	Aspects of the ecology of Jason mirabilis and its prey	Cape Rodney–Okakari Point	N
Hunter, R.M.	1999	MSc	Ammonium metabolism and reproduction in *Enteromorpha* sp. exposed to high salinity	Cape Rodney–Okakari Point	N
Johnston, R.L.	1999	MSc	Ecology of *Ophiopsammus maculata* in northeastern New Zealand	Cape Rodney–Okakari Point	N
Kelly, S.	1999	PhD	Marine reserves and the spiny lobster, *Jasus edwardsii*	Cape Rodney–Okakari Point / Te Whanganui a Hei (Hahei) / Tawharanui Marine Park	Y
Osumi, K.	1999	MSc	Stock enhancement and habitat association of juvenile paua (*Haliotis iris*) in northeastern New Zealand	Cape Rodney–Okakari Point	Y
Saunders, J.E.H.	1999	MSc	Patterns in the abundance and distribution of juvenile fishes and invertebrate benthos in intertidal estuarine habitats	Motu Manawa-Pollen Island	N
Walker, J.W.	1999	MSc	Subtidal reefs of the Hauraki Gulf	Cape Rodney–Okakari Point	H
Haggitt, T.E.	2000	MSc	Ecological and physiological aspects of *Ecklonia radiata* (Laminariales) in relation to dieback	Cape Rodney–Okakari Point	Y

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Appendix 2 continued

AUTHOR	DATE	DEGREE	TITLE	RESERVE USED	RESERVE REQUIRED? NO/YES/HELPFUL
Clarke, C.B.	2001	PhD	Growth and survival of *Haliotis iris* in northern New Zealand, with special reference to aquaculture	Cape Rodney–Okakari Point	Y
Feary, D.A.	2001	MSc	Trophic morphology, diet and habitat use of the New Zealand triplefins (family: Tripterygiidae)	Cape Rodney–Okakari Point	N
Mauger, J.W.	2001	MSc	Sperm depletion and regeneration in the spiny lobster *Jasus edwardsii*	Cape Rodney–Okakari Point	Y
Pande, A.	2001	PhD*	Evaluating biological change in New Zealand marine reserves	Taputeranga (Island Bay)	Y
Stewart, C.L.	2001	MSc	Aspects of the physical oceanography of the Poor Knights region, north-east New Zealand	Poor Knights Islands	N
van Dijken, G.V.	2001	MSc	Aspects of the ecology of the New Zealand seahorse, *Hippocampus abdominalis*	Cape Rodney–Okakari Point	H
Willis, T.J.	2001	PhD	Marine reserve effects on snapper (*Pagrus auratus*: Sparidae) in northern New Zealand	Cape Rodney–Okakari Point / Te Whanganui a Hei (Hahei) / Tawharanui Marine Park	Y
Boyle, P.R.	2002	PhD	Physiological and behavioral studies on the ecology of some New Zealand chitons	Cape Rodney–Okakari Point	N
Curson, D.J.	2002	MSc	The effect of disturbance on sessile marine communities of vertical walls	Cape Rodney–Okakari Point	H
Parsons, D.	2002	MSc	Habits and habitats of snapper (*Pagrus auratus*: Sparidea) in a marine reserve	Cape Rodney–Okakari Point	Y
Shears, N.T.	2002	PhD	Ecological response of shallow subtidal reef communities to marine reserve protection in northeastern New Zealand	Cape Rodney–Okakari Point / Te Whanganui a Hei (Hahei)	Y
Smith, T. L.	2002	MSc	Aspects of the life history of Culicia rubeola (Scleractinia: Anthozoa)	Cape Rodney–Okakari Point	H
Denny, C.M.	2003	MSc	Ecology of reef fishes in northeastern New Zealand and the relative importance of natural and human influences	Poor Knights Islands	Y
Ross, P.M.	2003	MSc	Habitat associations of juvenile snapper	Cape Rodney–Okakari Point	Y
Haggitt, T.R.	2004	PhD	Demography and biochemistry of *Ecklonia radiata* (Laminariales) in north-eastern New Zealand	Cape Rodney–Okakari Point	H
Struthers, C.D.	2004	MSc*	Monitoring of blue cod (*Parapercis colias*) at Kapiti Island Marine Reserve, New Zealand: a comparison of survey methodologies	Kapiti Island	Y
Franke, E.S.	2005	PhD	Aspects of fertilization ecology in *Evechinus chloroticus* and *Coscinasterias muricata*	Cape Rodney–Okakari Point	H
Langlois, T.J.	2005	PhD	Influence of reef-associated predators on adjacent soft-sediment communities	Cape Rodney–Okakari Point / Tawharanui Marine Park	Y
Walker, J.R.	2005	PhD	The ecology of wave-sheltered subtidal rocky reefs in northeastern New Zealand	Cape Rodney–Okakari Point	H
Jockheck, J. H.	2006	MSc	Effects of gastropod grazing on the kelp *Ecklonia radiata* in northeastern New Zealand	Cape Rodney–Okakari Point	N
Spong, K.T.	2006	MSc	Intraspecific variation in resistance to herbivores in the subtidal brown seaweed *Carpophyllum flexuosum*	Cape Rodney – Okakari Point	N
Radford, C.A.	2007	PhD	Ambient underwater sound: understanding its origins, variations and biological role	Cape Rodney–Okakari Point	N

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AUTHOR	DATE	DEGREE	TITLE	RESERVE USED	RESERVE REQUIRED? NO/YES/HELPFUL
Veale, A.J.	2007	MSc	Phylogeography of two intertidal benthic marine invertebrates around New Zealand: the waratah anemone (*Actinia tenebrosa*) and the snakeskin chiton (*Sypharochiton pelliserpentis*)	Cape Rodney–Okakari Point	N
Wellenreuther, M.	2007	PhD	Ecological factors associated with speciation in New Zealand triplefin fishes (Family Tripterygiidae)	Cape Rodney–Okakari Point	N
Egli, D.P.	2008	PhD	Population dynamics and individual movement of snapper, Pagrus auratus, in a temperate marine reserve	Cape Rodney–Okakari Point	Y
Freeman, D.	2008	PhD	The ecology of spiny lobsters (*Jasus edwardsii*) on fished and unfished reefs	Te Tapuwae o Rongokako	Y
Jack, L.	2009	PhD#	The ecological role of rock lobsters in Fiordland	Fiordland[†]	Y
Le Port, A.	2009	PhD	Phylogenetics, phylogeography and behavioural ecology of short-tailed (*Dasyatis brevicaudata*) and longtail (*D. thetidis*) stingrays	Poor Knights Islands	H
Subedar, K.	2009	MSc	Homing in two New Zealand triplefins: *Forsterygion varium* and *Forsterygion lapillum*	Cape Rodney–Okakari Point	N

[†] The Gut (Doubtful Sound), Piopiotahi (Milford Sound), Kutu Parera (Gaer Arm), Moana Uta (Wet Jacket Arm), Taumoana (Five Fingers), Te Tapuwae o Hua (Long Sound).

Appendix 3

Other published and unpublished reports on New Zealand marine reserves

Reports listed by location of marine reserve reported on, then by time. 'No-take needed?' indicates whether the main aims of the study were achievable without a no-take area, 'Reserve focused?' indicates whether the study was directed at specifically determining marine reserve effects. MRA = Marine Reserve Application. Review = previously published data from one or more reserves were used. Clio = Hawea (Clio Rocks), CROP = Cape Rodney–Okakari Point (Leigh) Marine Reserve, Elizabeth Island = Taipari Roa (Elizabeth Island), Five Finger = Taumoana (Five Finger Peninsula), Gaer Arm = Kutu Parera (Gaer Arm), Gold Arm = Kahukura (Gold Arm), Long Bay = Long Bay – Okura, Long Island = Long Island – Kokomohua, Long Sound = Te Tapuwae o Hua (Long Sound), PKI = Poor Knights Islands Marine Reserve, Milford = Piopiotahi (Milford Sound), Pollen Island = Motu Manawa – Pollen Island, Hahei = Te Whanganui A Hei Marine Reserve, The Gut = Te Awaru Channel (The Gut), Tuhua = Tuhua (Mayor Island), Wet Jacket = Moana Uta (Wet Jacket Arm),

YEAR	REFERENCE	TYPE	LOCATION
1978	Ayling, A.M. 1978: Cape Rodney to Okakari Point Marine Reserve: a biological survey. *Leigh Laboratory Bulletin 1*. University of Auckland, Auckland. 98 p.		CROP
1986	Jeffs, A. 1986: Paua report: a preliminary investigation of *Haliotis iris* in Leigh Marine Reserve. Ministry of Agriculture and Fisheries (MAF), Wellington.	MAF internal report	CROP
1988	Cole, R.G. 1988: Summer monitoring programme final report. Report held at University of Auckland Leigh Marine Laboratory, Leigh.	AU report	CROP
1993	Babcock, R.C.; Cole, R.G. 1993: The extent of die-back of the kelp Ecklonia radiata in the Cape Rodney to Okakari Point Marine Reserve. *Conservation Science Advisory Notes 44*. Department of Conservation, Wellington. 27 p.		CROP
1993	Jeffs, A. 1993: The impacts of a glass-bottom boat operation in Goat Island Bay: an independent impact assessment. Report to the Department of Conservation on behalf of the Habitat Exploration Partnership. Auckland. 49 p.	Report to DOC	CROP
1997	Willis, T.J.; Babcock, R.C. 1997: Investigation of methods for assessing reef fish populations and the effects of marine reserves. Report to the Department of Conservation, Wellington. 67 p.	Report to DOC	CROP
1997	Department of Conservation 1997: Leigh reserve complex: draft conservation management plan. Department of Conservation, Auckland Conservancy, Auckland.		CROP
1997	Shears, N.T.; Babcock, R.C. 1997: 1996–97 Resurvey of Cape Rodney to Okakari Point Marine Reserve. Leigh Marine Laboratory unpublished bulletin. 62 p.	AU report	CROP
2000	Kelly, S. 2000: Cape Rodney to Okakari Point Marine Reserve lobster monitoring programme: May 2000 survey. Report to the Department of Conservation prepared by Coastal & Aquatic Systems Limited, Auckland. June 2000. Investigation NRO/06. 18 p.	Report to DOC	CROP
2000	Parsons, D.M.; Babcock, R.C.; Willis, T.J. 2000: Monitoring of *P. auratus* (snapper) in the Cape Rodney to Okakari Point Marine Reserve, by use of a radio acoustic positioning and telemetry system. Report to the Department of Conservation, Auckland. June 2000. 20 p.	Report to DOC	CROP

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YEAR	REFERENCE	TYPE	LOCATION
2000	Shears, N.T.; Babcock, R.C. 2000: Cape Rodney to Okakari Point Marine Reserve benthic monitoring programme—1999/2000. Report to the Department of Conservation, Northern Regional Office, Hamilton, prepared by Leigh Marine Laboratory, University of Auckland, August 2000.Investigation NRO/02/01. 41 p.	Report to DOC	CROP
2000	Willis, T.J.; Babcock, R.C. 2000: Cape Rodney to Okakari Point Marine Reserve fish monitoring programme 2000. Report to the Department of Conservation, Hamilton,Leigh Marine Laboratory, University of Auckland, November 2000. Investigation NRO/02/02. 27 p.	Report to DOC	CROP
2001	Kelly, S. 2001: Cape Rodney to Okakari Point Marine Reserve lobster monitoring programme: May 2001 survey. Report to the Department of Conservation, Auckland, prepared by Coastal & Aquatic Systems Limited, Auckland. June 2001. 25 p.	Report to DOC	CROP
2002	Babcock, R.C.; Attwood, C.G.; Egli, D.P.; Parsons, D.; Willis, T.J. 2002: Optimising marine reserve design in New Zealand—Part 2: individual based models. Report to the Department of Conservation, Northern Regional Office, Investigation NRO/07. December 2002.	Report to DOC	CROP
2002	Egli, D.P.; Babcock, R.C. 2002: Optimising marine reserve design in New Zealand—Part I: behavioural data for individual based models. Report to the Department of Conservation, Northern Regional Office, Investigation NRO/07. June 2002.	Report to DOC	CROP
2003	Taylor, R.B.; Anderson, M.J.; Egli, D.; Willis, T.J. 2003: Cape Rodney to Okakari Point Marine Reserve Monitoring 2003: final report. Report to the Department of Conservation, Auckland. 38 p.	Report to DOC	CROP
2003	Willis, T.J., Babcock, R.C., Anderson, M.J. 2003: Cape Rodney to Okakari Point Marine Reserve fish monitoring programme 2000–2002. Report to the Department of Conservation, Auckland. prepared by Leigh Marine Laboratory, University of Auckland, January 2003. 42 p.	Report to DOC	CROP
2004	Haggitt, T.; Kelly, S. 2004: Cape Rodney to Okakari Point Marine Reserve Lobster Monitoring Programme: 2004 Survey. Report to the Department of Conservation, Auckland. June 2004. 18 p.	Report to DOC	CROP
2005	Taylor, R.B.; Anderson, M.J.; Egli, D.; Usmar, N.; Willis, T.J. 2005: Cape Rodney to Okakari Point Marine Reserve Monitoring 2005: final report. Report to the Department of Conservation, Auckland. 38 p.	Report to DOC	CROP
2009	Haggitt, T.; Mead, S. 2009: Cape Rodney–Okakari Point Marine Reserve and Tawharanui Marine Park Lobster Monitoring Programme: May 2009 Survey. Report to the Department of Conservation, Auckland. 41 p.	Report to DOC	CROP, Tawharanui Marine Park
2004	Shears, N.T.; Babcock, R.C. 2004: Indirect effects of marine reserves on New Zealand's rocky coastal communities. *DOC Science Internal Series 192*. Department of Conservation, Wellington. 49 p		CROP; Tawharanui Marine Park; Hahei; Tuhua; Long Bay-Okura; Poor Knights Islands
2003	Asprey, D.; Wright, G.; Prins, E.; Coventry, T.; Conway, R.; Heenan, A. 2003: Final report of Project Fiordland 2002–2003.	Report	Elizabeth Island, The Gut, Gaer Arm
2003	Wing, S.R.; Bowman, M.H.; Smith, F.; Rutger, S.M. 2003: Analysis of biodiversity patterns and management decision making processes to support stewardship of marine resources and biodiversity in Fiordland—a case study. Report 1 of 3 to the Ministry for the Environment (MfE), New Zealand, prepared by Department of Marine Science, University of Otago. 166 p.	Report to MfE	Fiordland

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YEAR	REFERENCE	TYPE	LOCATION
2004	Wing, S.R.; Bowman, M.H.; Smith, F.; Rutger, S.M. 2004: Analysis of biodiversity patterns and management decision making processes to support stewardship of marine resources and biodiversity in Fiordland a case study. Report 2 of 3 to the Ministry for the Environment (MfE), New Zealand, prepared by Department of Marine Science, University of Otago. 62 p.	Report to MfE	Fiordland
2005	Wing, S.R.; Bowman, M.H.; Smith, F.; Rutger, S.M. 2005: Analysis of biodiversity patterns and management decision making processes to support stewardship of marine resources and biodiversity in Fiordland—a case study. Report 3 of 3 to the Ministry for the Environment (MfE), New Zealand, prepared by Department of Marine Science, University of Otago. 170 p.	Report to MfE	Fiordland
2002	Anderson, M.J. 2002: Structures for establishing a database for marine monitoring. *DOC Science Internal Series 58*. Department of Conservation, Wellington. 21 p.		General
2003	Cole, R.G. 2003: How long should marine reserves be monitored for—and why? *DOC Science Internal Series 130*. Department of Conservation, Wellington. 20 p.		General
2003	Cole, R.G. 2003: What are the ecological impacts of marine reserves in New Zealand? Report to the Department of Conservation, Hamilton prepared by NIWA, Nelson. NIWA Client Report NEL2003- 010, NIWA Project DOC03401. 33 p.	Report to DOC	General
1995	McLean, M.; Grange K. 1995: A marine habitat survey of marine reserve options, northeast of Nelson. Report to the Royal Forest and Bird Protection Society prepared by NIWA, Nelson. NIWA Research Ltd. Publication 1995/ NEL60402/12.	Report to Forest & Bird	Horoirangi
1996	Grange, K.R.; Cole, R. 1996: A further survey of potential marine reserve sites off the Boulder Bank. Report to the Royal Forest and Bird Protection Society prepared by NIWA, Nelson. NIWA Research Ltd. Publication 1996/ NEL60412/1.	Report to Forest & Bird	Horoirangi
2003	Shears, N.T. 2003: Shallow subtidal reef communities of the Nelson Boulder Bank and northern coast. Report to the Department of Conservation, Nelson Conservancy, Nelson. 21 p	Report to DOC	Horoirangi
2006	Davidson, R.J. 2006: Horoirangi Marine Reserve, North Nelson, rocky shore baseline biological report. Report to the Department of Conservation, Nelson-Marlborough Conservancy, Nelson, prepared by Davidson Environmental Limited. Survey and Monitoring Report No. 513. 81 p.	Report to DOC	Horoirangi
2006	Grange, K.; Cairney, D.; Cole, R. 2006: Marine habitats of Horoirangi Marine Reserve, Nelson. Report to the Department of Conservation Nelson-Marlborough Conservancy, Nelson, prepared by NIWA. NIWA Client Report NEL2006-01, June 2006. 28 p.	Report to DOC	Horoirangi
1987	Baxter, A.S. 1987a: Kapiti Island: subtidal ecological survey. Central Fishery Management Area Internal Report 87/2. Ministry of Agriculture and Fisheries, Napier.	MAFF internal report	Kapiti Island
1987	Baxter, A.S. 1987b: Kapiti Island: marine recreational survey. Central Fishery Management Area Internal Report 87/3. Ministry of Agriculture and Fisheries, Napier. 17 p.	MAFF internal report	Kapiti Island
1993	Battershill, C.N.; Murdoch, R.C.; Grange, K.R.; Singleton, R.J.; Arron, E.S.; Page, M.J.; Oliver, M.D. 1993: A survey of the marine habitats and communities of Kapiti Island. Report to the Department of Conservation, Wellington, prepared by NIWA. NIWA Client Report 1993/41. 138 p.	Report to DOC	Kapiti Island
1996	Cole, R.G.; Singleton, R.J. 1996: Monitoring of reef fish populations at Kapiti Island during aerial poisoning for rats. Report to the Department of Conservation, Wellington, prepared by NIWA, Nelson. 13 p.	Report to DOC	Kapiti Island

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YEAR	REFERENCE	TYPE	LOCATION
1996	Miskelly, C. 1996: Susceptibility of marine fish to brodifacoum poisoning. Internal report to the Kapiti Marine Reserve Committee for their meeting 26/6/1996. Department of Conservation, Wellington Conservancy, Wellington.	Report to DOC	Kapiti Island
2003	Stewart, R.A.; MacDiarmid, A.B. 2003: A survey of kaimoana at Kapiti Island, 1999 and 2000. Report to the Department of Conservation, Wellington, prepared by NIWA. NIWA Client Report NEL 2003-015. NIWA, Wellington. 42 p.	Report to DOC	Kapiti Island
1985	Francis, M.P. 1985: The Kermadec Islands. A marine reserve proposal. *Fisheries Research Division Internal Report 29*. Ministry of Agriculture and Fisheries, Wellington. 33 p. [contains bibliography].	MAFF internal report	Kermadec Islands
1990	Grace, R.V. 1990a: Long Bay Regional Park brief marine survey. Report to Auckland Regional Council, Parks Department. 16 p.	Report to ARC	Long Bay-Okura
1990	Grace, R.V. 1990b: Long Bay Regional Park marine survey. *ARC Parks Technical Publication Series 10*. Auckland Regional Council Parks Service, Auckland.	Report to ARC	Long Bay-Okura
1990	Grace, R.V. 1990c: Long Bay Regional Park benthos dredge survey. *ARC Parks Technical Publication Series 11*. Auckland Regional Council Parks Service, Auckland. 15 p.	Report to ARC	Long Bay-Okura
1990	Green, B. 1990: Long Bay Regional Park. Baseline marine survey. Technical report to Auckland Regional Council, Parks Department, Auckland.	Report to ARC	Long Bay-Okura
1992	Green, B.S. 1992: Long Bay Regional Park intertidal monitoring. Interim report. *ARC Parks Technical Publication 13*. Auckland Regional Council Parks Service, Auckland. 11 p.	Report to ARC	Long Bay-Okura
1993	Green, B. 1993: A review of marine surveys and monitoring within Auckland Regional Parks. Report to Auckland Regional Parks Service, Auckland.	Report to ARC	Long Bay-Okura
1994	Green, B.S. 1994: Long Bay Regional Park intertidal monitoring 1994. *ARC Parks Technical Publication 15*. Auckland Regional Council Parks Service, Auckland.	Report to ARC	Long Bay-Okura
1995	Browne, G.; Pawley, M. 1995: Trends in intertidal shellfish surveys: 1993–1995. MAF report. MAF, Auckland.	MAF internal report	Long Bay-Okura
1996	Green, B.S. 1996: Long Bay Regional Park intertidal monitoring 1996. *ARC Parks Technical Publication 16*. Auckland Regional Council Parks Service, Auckland. 13 p.	Report to ARC	Long Bay-Okura
1997	Turner et al 1997: Report on Long Bay pilot study. Report for Auckland Regional Council prepared by NIWA. NIWA Client report ARC70221, August 1997. 21 p.	Report to ARC	Long Bay-Okura
1999	Babcock, R.C.; Creese, R.G.; Shears, N.T. 1999a: Long Bay monitoring programme, 1998 sampling. Report prepared for Auckland Regional Council. (June 1999.) 57 p.	Report to ARC	Long Bay-Okura
1999	Babcock, R.C.; Creese, R.G.; Walker, J. 1999b: Long Bay monitoring programme, 1999 sampling. Report prepared for Auckland Regional Council. (November 1999) 69 p.	Report to ARC	Long Bay-Okura
1999	Morrison, M.; Shankar, U.; Drury, J. 1999: An acoustic and video assessment of the soft sediment habitats of the Okura/Long Bay area. Report to Auckland Regional Council prepared by NIWA. Project ARC09120. 19 p.	Report to ARC	Long Bay-Okura
2000	Saunders, J.; Creese, R.G. 2000: Baseline monitoring of the Long Bay-Okura Marine Reserve: 2000 summary report. Report to the Department of Conservation, Wellington, October 2000. 64 p.	Report to DOC	Long Bay-Okura
2002	Anderson, M.J.; Ford, R.B.; Honeywill, C.; Feary. D.A. 2002: Ecological monitoring of the Okura Estuary Report 3: final report for the year 2001–2002. ARC Technical Publication 215. Auckland Regional Council Parks Service, Auckland. 97 p.	Report to ARC	Long Bay-Okura

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YEAR	REFERENCE	TYPE	LOCATION
2002	Ward, N. 2002: Survey of the relative abundance of snapper (*Pagrus auratus*) in the Long Bay-Okura Marine Reserve by baited underwater video. Leigh Marine Laboratory report. 13 p.		Long Bay-Okura
2003	Ford, R.; Honeywill, C.; Brown, P.; Peacock, L. 2003: The Long Bay Monitoring Program Report 2002—2003. *ARC Technical Publication 206*. Auckland Regional Council Parks Service, Auckland. 69 p.	Report to ARC	Long Bay-Okura
1993	Grange, K.R.; Singleton, R.J. 1993: An analysis of marine benthic data from Long Island-Kokomohua Marine Reserve and control areas. Report to the Department of Conservation, Nelson. Prepared by NIWA, Wellington. NIWA, NZOI, 1993/43, Wellington. 15 p.	Report to DOC	Long Island
1995	Davidson, R.J. 1995: Long Island-Kokomohua Marine Reserve: subtidal biological baseline report. *Nelson/ Marlborough Conservancy Occasional Publication No. 17*. Department of Conservation, New Zealand. 37 p.	Report to DOC	Long Island
1997	Davidson, R.J. 1997: Biological monitoring of Long Island-Kokomohua Marine Reserve, Queen Charlotte Sound, Marlborough Sounds: update September 1993 to April 1997. Report to the Department of Conservation. Nelson/Marlborough Conservancy, prepared by Nelson by Davidson Environmental Consultants Ltd. Research, Survey and Monitoring Report No. 150. 40 p.	Report to DOC	Long Island
2000	Davidson, R.J. 2000: Biological monitoring of Long Island-Kokomohua Marine Reserve, Queen Charlotte Sound, New Zealand. Report to the Department of Conservation. Nelson/Marlborough Conservancy, Nelson, prepared by Davidson Environmental Consultants.	Report to DOC	Long Island
2004	Davidson, R.J. 2004: Long Island-Kokomohua Marine Reserve, Queen Charlotte Sound 1992–2003. Report to the Department of Conservation. Nelson/ Marlborough Conservancy, Nelson, prepared by Davidson Environmental Consultants (Report No. 343). 122 p.	Report to DOC	Long Island
2009	Davidson, R.J.; Abel, W.; Richards, L.A. 2009: Biological monitoring update for Long Island-Kokomohua Marine Reserve, Queen Charlotte Sound 1992–2009. Report to the Department of Conservation. Nelson/ Marlborough Conservancy, Nelson, prepared by Davidson Environmental Limited. Survey and Monitoring Report No. 573. 72 p.	Report to DOC	Long Island
2005	Davidson, R.J.; Richards, L. 2005a: Comparison of fish at reserve and control sites from Long Island and Tonga Island Marine Reserves using baited underwater video (BUV), catch, measure, release (CMR) and underwater visual counts (UVC). Report to the Department of Conservation, Nelson/Marlborough Conservancy prepared by Davidson Environmental Limited. Research, Survey and Monitoring Report Number 466. 35 p.	Report to DOC	Long Island; Tonga Island
2005	Davidson, R.J.; Richards, L.R. 2005b. Tonga Island Marine Reserve, Abel Tasman National Park update of biological monitoring, 1993–2005. Report to the Department of Conservation, Nelson prepared by Davidson Environmental Limited. Survey and Monitoring Report No. 484. 103 p.	Report to DOC	Long Island; Tonga Island
2009	Willis, T.J.; Handley, S.J.; Page, M.J.; Cairney, D.G.; D'Archino, R. 2009: Fiordland (Te Moana o Atawhenua) Marine Area monitoring survey 2008/2009. Report to the Department of Conservation, Te Anau prepared by NIWA, Nelson. NIWA Client report NEL2009-035. 48 p.	Report to DOC	Long Sound, Five Fingers, Wet Jacket, Gaer Arm, Gold Arm, Clio
2007	Wing, S.; Jack, L. 2007: Biological monitoring of the Fiordland (Te Moana o Atawhenua) Marine Area and Fiordland's marine reserves—2007. Final report (unreviewed) to the Department of Conservation, Te Anau. 90 p.	Report to DOC	Long Sound, Five Fingers, Wet Jacket, Gaer Arm, Gold Arm, Clio Rocks, Elizabeth Island, Milford

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YEAR	REFERENCE	TYPE	LOCATION
1973	Ballantine, W.J.; Grace, R.V.; Doak, W. 1973: Mimiwhangata 1973 report. Report to Turbott and Halstead, Auckland. Held at Auckland University, Leigh Marine Laboratory.	Report	Mimiwhangata MRA
2002	Denny, C.M.; Babcock, R.C. 2002: Fish survey of the Mimiwhangata Marine Park, Northland. Report to the Department of Conservation, Northland Conservancy. 28 p.	Report to DOC	Mimiwhangata MRA
2002	Grace, R.V.; Kerr, V. 2002: Mimiwhangata Marine Park draft report 2002—historic marine monitoring update. Report to the Department of Conservation, Northland Conservancy, Whangarei. 21 p.	Report to DOC	Mimiwhangata MRA
2004	Usmar, N.R. Denny, C.M.Shears, N.T.; Babcock, R.C. 2004: Mimiwhangata Marine Park Monitoring Report 2003. Report to the Department of Conservation, Whangarei. 32 p.	Report to DOC	Mimiwhangata MRA
2005	Kerr, V.; Grace, R.V. 2005: Intertidal and subtidal habitats of Mimiwhangata Marine Park and adjacent shelf. *DOC Research & Development Series 201*. Department of Conservation, Wellington. 54 p.		Mimiwhangata MRA
1992	Forlong, R. 1992: Potential areas for marine protection. Otago Conservancy internal report, Department of Conservation, Dunedin. 25 p.	Internal DOC report	Nugget Point MRA
1992	Fyfe, J. 1992: Four Otago marine reserve options—an overview of biological values. Otago Conservancy internal report, Department of Conservation, Dunedin. 64 p.	Internal DOC report	Nugget Point MRA
1992	Gorter, R. 1992: Nugget Point marine environs. *Otago Conservancy Miscellaneous Series No. 12*. Department of Conservation, Dunedin. 76 p.		Nugget Point MRA
1996	Baird, K. 1996: Habitat mapping and distribution using side-scan sonar, Nugget Point. Draft. Otago Conservancy internal report, Department of Conservation, Dunedin.	Internal DOC report	Nugget Point MRA
1991	Coffey, B.T.; Williams, B. 1991: A contribution to a description of biological resources in estuarine, intertidal and shallow subtidal habitats: south of the Mokau River to Tongarporutu, Feb–March 1991. Report to the Department of Conservation, Wanganui prepared by Brian T. Coffey and Associates Ltd, Whangamata.	Report to DOC	Paraninihi
1992	Coffey, B.T.; Williams, B. 1992a: A contribution to a description of marine biological resources, Mokau to Pariokariwa Point, North Taranaki coast, 1991–1992. Report to the Department of Conservation, Wanganui prepared by Brian T. Coffey and Associates Ltd, Whangamata.	Report to DOC	Paraninihi
1992	Coffey, B.T., Williams, B. 1992b: Coastal and marine habitats of North Taranaki. Report to the Department of Conservation, Wanganui prepared by Brian T. Coffey and Associates Ltd, Whangamata.	Report to DOC	Paraninihi
1996	Battershill, C.N.; Page, M.J. 1996: Preliminary survey of Pariokariwa Reef North Taranaki. Report to the Department of Conservation, Wanganui prepared by NIWA, Wellington. NIWA Client report 1996/10-WN. 15 p.	Report to DOC	Paraninihi
1997	Foster, G.A.; MacDiarmid, A. 1997: Seabed conditions of the proposed Paraninihi Marine Reserve, North Taranaki. Report to the Department of Conservation, Wellington prepared by NIWA, Wellington. NIWA Client report WLG1997/30. 9 p.	Report to DOC	Paraninihi
1999	Wanganui file ref COA-0201—C. Duffy observational data from dives in proposed area. File note sent to NRO March 1999.	Internal DOC report	Paraninihi
1987	Grange, K.; McKnight, D.G. 1987: A summary of existing marine ecological information on Stewart Island of relevance to marine protected area proposals. Report to the Department of Conservation, Wellington prepared by New Zealand Oceanographic Institute, DSIR, Wellington. 48 p.	Report to DOC	Paterson Inlet

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YEAR	REFERENCE	TYPE	LOCATION
1989	Walls, K. 1989: Paterson Inlet, Stewart Island—a case for a marine protected area. Pp 49–53 in Norton, D.A. (Ed): Management of New Zealand's natural estate: proceedings of a symposium of the New Zealand Ecological Society held at the University of Otago, Dunedin, 22–25 August 1988. *New Zealand Ecological Society Occasional Publication No. 1.* Christchurch. 119 p.	Internal DOC report	Paterson Inlet
1992	Hare, J. 1992: Paterson Inlet marine benthic assemblages. Report of coastal investigations. *Southland Conservancy Technical Series 5*. Department of Conservation, Invercargill. 88 p.		Paterson Inlet
1998	Chadderton, W.L. 1998: Side-scan sonar and spot dive survey of Sydney Cove patch reef. Report held in Department of Conservation, Southland Conservancy files. 3 p.	Internal DOC report	Paterson Inlet
2003	Chadderton, W.L.; Davidson, R.J. 2003: Baseline report on fish from the proposed Paterson Inlet (Waka a Te Wera) Marine Reserve, Stewart Island (Rakiura; 1994–1999). Report to the Department of Conservation, Southland Conservancy, prepared by Davidson Environmental Limited. *Survey and Monitoring Report No. 168*. 47 p.	Report to DOC	Paterson Inlet
2006	Wing, S. 2006: Baseline ecological monitoring of the Ulva Island/Te Wharawhara Marine Reserve. Report to the Department of Conservation, Southland Conservancy. 64 p.	Report to DOC	Paterson Inlet
1993	Chadderton, W.L. 1993: Harrison Cove. Moorings in Piopiotahi Marine Reserve: an environmental impact assessment. Internal report. Southland Conservancy, Department of Conservation, Invercargill.	Internal DOC report	Piopiotahi (Milford Sound)
1993	Turnbull, J. 1993: Draft Piopiotahi Marine Reserve biological monitoring report of October 1993 trip. Internal report, Southland Conservancy, Department of Conservation, Invercargill.	Internal DOC report	Piopiotahi (Milford Sound)
1996	Grange, K. 1996: The Milford Sound Underwater Observatory. Report of an inspection visit 31 April–1 May 1996. Report to the Department of Conservation, Te Anau prepared by NIWA, Nelson. 27 p.	Report to DOC	Piopiotahi (Milford Sound)
2000	Munn, A.. 2000: Rock lobster monitoring in Piopiotahi Marine Reserve. Internal report, Southland Conservancy, Department of Conservation, Invercargill. 17 p.	Internal DOC report	Piopiotahi (Milford Sound)
2002	Smith, E. 2002: Lobster survey of Piopiotahi Marine Reserve, Milford Sound. Internal report, Southland Conservancy, Department of Conservation, Invercargill. 13 p.	Internal DOC report	Piopiotahi (Milford Sound)
1996	Rutledge, M. 1996: A preliminary intertidal and subtidal survey of Flea Bay. Internal report, Canterbury Conservancy, Department of Conservation, Christchurch. 9 p.	Internal DOC report	Pohatu
2001	Davidson, R.J.; Barrier, R.; Pande, A. 2001: Baseline biological report on Pohatu Marine Reserve, Akaroa, Banks Peninsula. Report to the Department of Conservation, [Christchurch], prepared by Davidson Environmental Ltd. 22 p.	Report to DOC	Pohatu
2003	Davidson, R.J.; Abel, W. 2003: Second sampling of Pohatu Marine Reserve, Flea Bay, Banks Peninsula (September 2002). Report to the Department of Conservation, DeVauchelle, Canterbury, prepared by Davidson Environmental Ltd. Survey and Monitoring Report No. 443.	Report to DOC	Pohatu
2002	Sivaguru, K.; Grace, R.V. 2002: Benthos and sediments of Motu Manawa (Pollen Island) Marine Reserve. Internal report, Auckland Conservancy, Department of Conservation.	Internal DOC report	Pollen Island
1979	Ritchie et al 1979: Environmental impact report: Poor Knights Islands Marine Reserve. Ministry of Agriculture and Fisheries (MAF), Wellington. 66 p.	MAF internal report	Poor Knights Islands
1984	Schiel, D.R. 1984: Poor Knights Islands Marine Reserve survey of subtidal reefs. *Leigh Laboratory Bulletin No. 15*. University of Auckland, Auckland. 93 p.	AU report	Poor Knights Islands

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YEAR	REFERENCE	TYPE	LOCATION
1986	Battershill, C. 1986: The marine benthos of caves, archways and open reef walls of the Poor Knights Islands. Report to the New Zealand Ministry of Agriculture and Fisheries (MAF), Wellington.	MAF internal report	Poor Knights Islands
2000	Willis, T.J. Denny, C.M. 2000: Effects of Poor Knights Islands Marine Reserve on demersal fish populations. Report to the Department of Conservation, [Auckland], prepared by University of Auckland. Report no. 2519. 34 p.	Report to DOC	Poor Knights Islands
2001	Brook, F.J.; Grenfell, H.R.; Hayward, B.W. 2001: Preliminary report on the biota of shallow (20–65 m) sediment substrata in the Poor Knights Islands Marine Reserve, northeastern Northland. Report to the Department of Conservation.	Report to DOC	Poor Knights Islands
2003	Denny, C.M.; Willis, T.J.; Babcock, R.C. 2003: Effects of Poor Knights Islands marine reserve on demersal fish populations. *DOC Science Internal Series 142*. Department of Conservation, Wellington. 34 p.		Poor Knights Islands
2004	Denny, C.M.; Shears, N.T. 2004: Effects of five years of no-take marine reserve protection on reef fish populations at the Poor Knights Islands. Report to the Department of Conservation, Northland Conservancy. 42 p.	Report to DOC	Poor Knights Islands
2007	Shears, N.T. 2007: Shallow subtidal reef communities at the Poor Knights Islands Marine Reserve after eight years of no-take protection. Report to the Department of Conservation, Northland Conservancy, Contract: Marine 2006/003. 48 p.	Report to DOC	Poor Knights Islands
1989	Cole, R.G.; Jackson, B. 1989: Marine survey of Wellington's south coast. Report to the Department of Conservation. Wellington.	Report to DOC	Taputeranga
2008	Eddy, T.; Gardner, J.; Bell, J. 2008: A status report on the biological and physical information for Wellington's south coast with monitoring recommendations for the Taputeranga Marine Reserve. Report to the Department of Conservation, Wellington Conservancy. 57 p.	Report to DOC	Taputeranga
1990	Creswell, P.D.; Warren, E.J. 1990: The flora and fauna of the Southern Hawke's Bay coast. Report held at the East Coast Hawke's Bay Conservancy, Department of Conservation. 135 p.	Internal DOC report	Te Angiangi
1992	Duffy, C.A.J. 1992: Shallow rocky reef habitats in Hawke's Bay Report held at Department of Conservation, Wellington.	Internal DOC report	Te Angiangi
1993	Haddon, M.; Anderlini, V. 1993: Evaluation of Southern Hawke's Bay coast intertidal data. The use of presence/absence data. Report to the Department of Conservation, Napier] prepared by School of Biological Sciences, Victoria University of Wellington. *Coastal Marine Research Unit Report No. 23*. 38 p.	Report to DOC	Te Angiangi
1993	Haddon, M. 1993: Evaluation of Southern Hawke's Bay coast intertidal data II. The use of presence/absence data. Report to the Department of Conservation, Napier prepared by School of Biological Sciences, Victoria University of Wellington. *Coastal Marine Research Unit Report No. 24*. 59 p.	Report to DOC	Te Angiangi
1994	DOC (Department of Conservation) 1994: Te Angiangi (Aramoana–Blackhead, Central Hawke's Bay) marine reserve application. *Hawke's Bay Conservancy Series No. 7*. Department of Conservation, Napier. 86 p.		Te Angiangi
2001	DOC (Department of Conservation) 2001a: Te Angiangi marine reserve: intertidal paua and kina monitoring 1999–2001. Technical Support (Marine & Freshwater), East Coast Hawke's Bay Conservancy, Gisborne, 22 p.	Internal DOC report	Te Angiangi
2001	DOC (Department of Conservation) 2001b: Te Angiangi Marine Reserve biological Monitoring Plan. *East Coast Hawke's Bay Conservancy Technical Support Series 6*. Department of Conservation, Gisborne. 25 p.		Te Angiangi

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YEAR	REFERENCE	TYPE	LOCATION
2003	Freeman, D.J.; Duffy, C.A.J. 2003: Te Angiangi Marine Reserve: reef fish monitoring 1995–2003. *East Coast Hawke's Bay Conservancy, Technical Support Series 14*. Department of Conservation, Gisborne. 45 p.		Te Angiangi
2005	Funnell, G.A.; Hancock, N.; Willitson, T.; Drury, J. 2005: Tuingara to Blackhead Point Habitat Mapping. Report to the Department of Conservation, Gisborne prepared by NIWA, Hamilton. NIWA Client Report: HAM2004-094. 29 p.	Report to DOC	Te Angiangi
2006	Freeman, D. 2006: Te Angiangi and Te Tapuwae o Rongokako Marine Reserves: intertidal paua and kina monitoring. *East Coast Hawke's Bay Conservancy Technical Support Series 26*. Department of Conservation, Gisborne. 23 p.		
1990	Grange, K.R. 1990: Unique marine habitats in the New Zealand fiords: a case for preservation. Report to the Department of Conservation, Wellington, prepared by New Zealand Oceanographic Institute, Wellington. 70 p.	Report to DOC	Te Awaatu
1995	Miller, K. 1995: Size-frequency distribution of red corals at Te Awaatu Marine Reserve, Doubtful Sound, Fiordland. Report to the Department of Conservation, Invercargill prepared by NIWA, Wellington. Contract Report 1995/14-WN. 7 p.	Report to DOC	Te Awaatu
1997	Miller, K.J. 1997: Studies of the growth rates of red coral in Fiordland. Interim report. Report to the Department of Conservation, Invercargill prepared by NIWA, Wellington.	Report to DOC	Te Awaatu
1998	Miller, K.J. 1998: Population structure and growth rates of red coral in Doubtful Sound, Fiordland. Report to the Department of Conservation, Invercargill prepared by NIWA, Wellington. Contract report WLG98/14. 13 p.	Report to DOC	Te Awaatu
1999	Kelly, S. 1999: 1999 lobster survey of Te Awaatu (The Gut) Marine Reserve, Doubtful Sound. Report to the Department of Conservation, Invercargill prepared by Coastal and Aquatic Systems Ltd, Clevedon. 12 p.	Report to DOC	Te Awaatu
1999	Miller, K.J.; Mundy, C. 1999: Population structure, damage frequency and growth rates of red coral in Doubtful Sound. Report to the Department of Conservation, Invercargill prepared by NIWA, Wellington. 21 p.	Report to DOC	Te Awaatu
2000	Miller, K.J.; Mundy, C. 2000: Monitoring red corals in the Te Awaatu Marine Reserve: 1995–2000. Report to the Department of Conservation, Invercargill 21 p.	Report to DOC	Te Awaatu
2001	Smith, E.D. 2001: Lobster survey of Te Awaatu (The Gut) Marine Reserve, Doubtful Sound. Department of Conservation, Southland Conservancy, Invercargill. July 2001.	Internal DOC report	Te Awaatu
2003	Wilans, [initials]. 2003: Lobster survey of Te Awaatu (The Gut) marine reserve, Doubtful Sound. Department of Conservation, Southland Conservancy, Invercargill. December 2003.	Internal DOC report	Te Awaatu
1991	Hogan, K.; Seymour, T.; Gordon, P. 1991: Kaiora Marine Reserve proposal, a preliminary intertidal and subtidal site survey. East Coast Conservancy, Department of Conservation, Gisborne. 56 p.	Internal DOC report	Te Tapuwae o Rongokako
2001	DOC (Department of Conservation) 2001c: Te Tapuwae O Rongokako marine reserve: report on baseline survey. Technical Support Officer (Marine & Freshwater), East Coast Hawke's Bay Conservancy, Department of Conservation, New Zealand.	Internal DOC report	Te Tapuwae o Rongokako
2001	DOC (Department of Conservation) 2001d: Te Tapuwae O Rongokako marine reserve: intertidal Paua and kina survey. Technical Support Officer (Marine & Freshwater), East Coast Hawke's Bay Conservancy, Department of Conservation, New Zealand.	Internal DOC report	Te Tapuwae o Rongokako

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YEAR	REFERENCE	TYPE	LOCATION
2001	DOC (Department of Conservation) 2001e: Te Tapuwae O Rongokako marine reserve: biological monitoring plan. Technical Support Officer (Marine & Freshwater), East Coast Hawke's Bay Conservancy, Department of Conservation, New Zealand.	Internal DOC report	Te Tapuwae o Rongokako
2003	Booth, J.D. 2003: Research sampling design for rock lobsters in Te Tapuwae o Rongokako Marine Reserve. *DOC Science Internal Series 128*. Department of Conservation, Wellington. 25 p.		Te Tapuwae o Rongokako
2004	Stephens, S.; Haskew, R.; Lohrer, D.; Oldman, J. 2004: Larval dispersal from the Te Tapuwae O Rongokako Marine Reserve: numerical model simulations. Report to the Department of Conservation, Gisborne prepared by National Institute of Water & Atmospheric Research Ltd. Hamilton. 54 p.	Report to DOC	Te Tapuwae o Rongokako
1990	Coffey, B.T.; Grace, R.V. 1990: Proposed marine reserve, Hahei: a preliminary assessment and habitat inventory. Report to the Department of Conservation, Hamilton prepared by Brian T. Coffey and Associates Ltd, Whangamata. 54 p.	Report to DOC	Te Whanganui A Hei
1996	Kelly, S. 1996: 1996 lobster survey of Te Whanganui A Hei Marine Reserve. Report to the Department of Conservation, Hamilton prepared by Coastal & Aquatic Systems Ltd, Clevedon.	Report to DOC	Te Whanganui A Hei
1997	Kelly, S. 1997: 1997 Lobster survey of Te Whanganui A Hei Marine Reserve. Report to the Department of Conservation, Hamilton, prepared by Coastal & Aquatic Systems Ltd, Clevedon.	Report to DOC	Te Whanganui A Hei
1997	Willis, T.J. 1997: Survey of fishes at Te Whanganui A Hei Marine Reserve winter 1997. Report to Waikato Conservancy, Department of Conservation, Hamilton.	Report to DOC	Te Whanganui A Hei
1999	Kelly, S. 1999c: 1999 Lobster survey of the Cathedral Cove (Te Whanganui A Hei) Marine Reserve. Report to the Department of Conservation, Hamilton, prepared by Coastal & Aquatic Systems Ltd, Clevedon.	Report to DOC	Te Whanganui A Hei
2000	Kelly, S. 2000b: Lobster survey of the Cathedral Cove (Te Whanganui A Hei) Marine Reserve. Report to the Department of Conservation, Hamilton prepared by Coastal & Aquatic Systems Ltd, Clevedon. June 2000.	Report to DOC	Te Whanganui A Hei
2000	Shears, N.; Walker, J.; Babcock, R. 2000: Te Whanganui A Hei Marine Reserve benthic community monitoring program—1999/2000. Report to the Department of Conservation, Hamilton, August 2000. Investigation No. NRO/02/03. 39 p.	Report to DOC	Te Whanganui A Hei
2000	Willis, T.J. 2000: Te Whanganui A Hei Marine Reserve fish monitoring programme Investigation NRO/02/04. Reports 1. Diver surveys, 2. Changes in snapper and blue cod density. Report to the Department of Conservation, Hamilton. June 2000.	Report to DOC	Te Whanganui A Hei
2001	Kelly, S. 2001c: Lobster survey of the Cathedral Cove (Te Whanganui A Hei) Marine Reserve. Report to the Department of Conservation, Hamilton prepared by Coastal & Aquatic Systems Ltd, Clevedon. June 2001.	Report to DOC	Te Whanganui A Hei
2002	Kelly, S. 2002: Lobster tagging in the Cathedral Cove Marine Reserve: 2001 trial and recommendations. Report to the Department of Conservation, Hamilton prepared by Coastal & Aquatic Systems Ltd, Clevedon.	Report to DOC	Te Whanganui A Hei
2003	Kelly, S.; Haggitt, T. 2003: 2003 lobster survey of the Cathedral Cove (Te Whanganui A Hei) Marine Reserve. Report to the Department of Conservation, Hamilton prepared by Coastal & Aquatic Systems Ltd, Maraetai, June 2003.	Report to DOC	Te Whanganui A Hei

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YEAR	REFERENCE	TYPE	LOCATION
2003	Taylor, R.B.; Anderson, M.J.; Usmar, N.R.; Willis, T.J. 2003b: Te Whanganui A Hei Marine Reserve fish monitoring 2003: final report. Report to the Department of Conservation, Hamilton, August 2003.	Report to DOC	Te Whanganui A Hei
2003	Willis, T.J.; Anderson, M.J.; Babcock, R.C. 2003c: Te Whanganui A Hei Marine Reserve fish monitoring 2003: final report. Report to the Department of Conservation, Hamilton, January 2003.	Report to DOC	Te Whanganui A Hei
2004	Haggitt, T.; Kelly, S. 2004b: 2004 lobster survey of the Cathedral Cove (Te Whanganui A Hei) Marine Reserve. Report to the Department of Conservation, Hamilton, June 2004.	Report to DOC	Te Whanganui A Hei
2004	Haggitt, T.; Kelly, S. 2004c: Te Whanganui a Hei Marine Reserve Marine Reserve biological monitoring plan. Report to the Department of Conservation, Hamilton. April 2004.	Report to DOC	Te Whanganui A Hei
2004	Hewitt, J.E.; Chiaroni, L.D.; Funnell, G.A.; Hancock, N. 2004: Te Whanganui A Hei Marine Reserve habitat mapping. Report to the Department of Conservation, Hamilton, prepared by NIWA Hamilton. NIWA Client Report. 32 p.	Report to DOC	Te Whanganui A Hei
2004	Taylor, R.B.; Anderson, M.J.; Usmar, N.R.; Willis, T.J. 2004: Te Whanganui A Hei Marine Reserve fish monitoring 2004: final report. Report to the Department of Conservation, Hamilton. July 2004. 39 p.	Report to DOC	Te Whanganui A Hei
2006	Haggitt, T.; Mead, S. 2006. Te Whanganui-a-Hei Marine Reserve biological monitoring programme: May–June 2006 survey. Report to the Department of Conservation, Waikato Conservancy. August 2006.	Report to DOC	Te Whanganui A Hei
2006	Taylor, R.B.; Anderson, M.J.; Usmar, N.R.; Willis, T.J. 2006: Te Whanganui A Hei Marine Reserve fish monitoring 2004: final report. Report to the Department of Conservation, Hamilton. July 2006. 50 p.	Report to DOC	Te Whanganui A Hei
2009	Haggitt, T.; Mead, S. 2009a. Te Whanganui-a-Hei Marine Reserve benthic and lobster monitoring programme: May–June 2009 survey. Report to the Department of Conservation, Waikato Conservancy, June 2009. 83 p.	Report to DOC	Te Whanganui A Hei
1994	Garrick, A. 1994a: Update on biological monitoring, Tuhua and Te Whanganui a Hei Marine Reserves. Bay of Plenty Conservancy, Department of Conservation, Hamilton.	Internal DOC report	Te Whanganui A Hei; Tuhua
1991	Davidson, R.J. 1991: A report on the intertidal and shallow subtidal ecology of Abel Tasman National Park, Nelson. Nelson/Marlborough Conservancy Occasional Publication No. 4. Department of Conservation, Nelson. 121 p.		Tonga Island
1999	Davidson, R.J. 1999: Tonga Marine Reserve, Abel Tasman, Nelson: subtidal biological baseline report. Report to the Department of Conservation, Nelson/Marlborough Conservancy, Nelson, prepared by Davidson Environmental Consultants. Research, Survey and Monitoring Report No. 175. 22 p.	Report to DOC	Tonga Island
2001	Davidson, R.J. 2001a: Tonga Island Marine Reserve: proposed protocol for ongoing subtidal biological monitoring. Report to the Department of Conservation. Nelson/Marlborough Conservancy, Nelson prepared by Davidson Environmental Consultants. Research, Survey and Monitoring Report No. 316. 19 p.	Report to DOC	Tonga Island
2007	Davidson, R.J.; Richards, L.R.; Baxter, A. 2007. Tonga Island Marine Reserve, Abel Tasman National Park update of biological monitoring, 1993–2007. Report to the Department of Conservation, Nelson/Marlborough Conservancy, Nelson prepared by Davidson Environmental Consultants. Survey and Monitoring Report No. 484. 103 p.	Report to DOC	Tonga Island

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YEAR	REFERENCE	TYPE	LOCATION
2008	Willis, T.J.; Triossi, F.; Meynier, L. 2008: Diet of fur seals Arctocephalus forsteri at Tonga Island, Abel Tasman National Park. Report to the Department of Conservation, Nelson/Marlborough Conservancy, Nelson prepared by NIWA, Nelson. NIWA Client report NEL2008-011. 12 p.	Report to DOC	Tonga Island
1991	Jones, A.J.; Garrick, A.S. 1991: Tuhua (Mayor Island) marine habitats: a preliminary intertidal and subtidal survey. *Bay of Plenty Conservancy Technical Report Series 4*. Department of Conservation, Rotorua. 128 p.		Tuhua
1993	Grange, K.R. 1993: An analysis of fish abundance and distribution data, Mayor Island (Tuhua) Marine Reserve baseline survey. *Conservation Advisory Science Notes 40*. Department of Conservation, Wellington. 34 p.		Tuhua
1994	Garrick, A. 1994b: Tuhua Marine Reserve. Bay of Plenty Conservancy, Department of Conservation, Rotorua.	Internal DOC report	Tuhua
1994	McDiarmid, A. 1994: Kina sampling and marine reserve monitoring. *Conservation Advisory Science Notes 7*5, Department of Conservation, Wellington. 7 p.		Tuhua
2000	Pawley, M. 2000: Statistical analysis of key species on Major Island (Tuhua) Marine Reserve. Draft. Report to the Department of Conservation, Northern Regional Office, Hamilton.	Report to DOC	Tuhua
2004	Shears, N.T.; Usmar, N.R. 2004b: Response of reef fish to partial and no-take protection at Tuhua (Mayor) Island, Report to the Department of Conservation, Wellington. June 2004. 30 p.	Report to DOC	Tuhua
2006	Smith, F. 2006: Regional patterns of diversity for subtidal epifaunal invertebrates in the Bay of Plenty. Report for the Department of Conservation, Rotorua. June 2006.	Report to DOC	Tuhua
2006	Shears, N.T.; Usmar, N.R. 2006a: Response of reef fish to partial and no-take protection at Mayor Island (Tuhua). *DOC Research and Development Series 243*. Department of Conservation, Wellington. 31 p		Tuhua
2006	Young, K.; Ferreira, S.; Jones, A.; Gregor, K. 2006: Recovery of targeted reef fish at Tuhua Marine Reserve—monitoring and constraints. *DOC Research and Development Series 251*. Department of Conservation, Wellington. 23 p.		Tuhua
2003	Cole, R.G.; Alcock, N.; Carbines, G.; Stewart, R. 2003: Volkner Islets Marine Reserve proposal—supplementary information. Report to the Department of Conservation, Rotorua prepared by NIWA, Nelson. NIWA Client Report: NEL2002:006. March 2003.	Report to DOC	Te Paepae o Aotea (Volkner Rocks)
1990	Davidson, R.J. 1990: A report on the ecology of Whanganui Inlet, north-west Nelson. *Nelson/Marlborough Conservancy Occasional Publication No. 2*, Department of Conservation, Nelson. 127 p.		Westhaven (Te Tai Tapu)