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Tonga Island Marine Reserve: proposed protocol for ongoing subtidal biological monitoring

Research, Survey and Monitoring Report Number 316

A report prepared for:

Department of Conservation

Private Bag 5

Nelson

By:

Robert J. Davidson

Tonga Island Marine Reserve:

Proposed Protocol for

Ongoing Subtidal Biological Monitoring

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Summary

This document presents a proposed protocol for ongoing monitoring of the Tonga Island Marine Reserve, Abel Tasman National Park, Tasman Bay. The present report also presents new biological data collected during 1999.

The data collected during the present study were repeated measures of particular baseline information collected during 1993 and 1994 and published in Davidson (1999). The aim of repeating these particular 1993-1994 measures was to assess their suitability for ongoing monitoring of the reserve.

These data and existing data collected by Davidson (1992), Davidson and Chadderton (1994), Davidson 1999, Davidson *et al.* (in press), Shears *et al.* (in prep.) and those data collected as part of the present study were used to design a monitoring protocol for Tonga Island Marine Reserve. Aspects considered appropriate to include in a monitoring programme included:

- Underwater visual reef fish transects (density);
- Kina and particular gastropod size and abundance;
- Shallow rocky benthic organism abundance;
- Scallop density;
- Horse mussel density and size; and
- Shore profiles.

Monitoring details, timing and frequency have been summarised below.

Reef fish
Activity = calculation of density, length frequency and mean size of selected species
Habitats = 12 shallow rocky reef barrens, 1 shallow rocky reef with a macroalgae cover
Sites = 13 (6 control, 7 reserve)
Sample method = diver visual strip transect
Sampling unit size = 30 m long x 2 m wide (60 m^2)
Stratification = two depth strata (5 – 6 m and 9 - 10 m)
Replication = 12 transects per site (i.e. 6 in each depth stratum)
Timing = December or April (pending results from December 2000 and April 2001 sampling)
Recommended frequency = minimum every second year
Next samples recommended = December 2000 and April 2002

Snapper and/or blue cod
Activity = calculation of abundance, length frequency and mean size of snapper and blue cod
Habitats = soft bottom habitat immediately adjacent to rocky reefs
Sites = 13 (6 control, 7 reserve)

Sample method = underwater baited video station and/or hand-lining
Depth = variable depending on site
Replication = 1 sample per site
Timing = March/April
Recommended frequency = every second year after the initiation of this sampling
Next samples recommended = when the abundance of these species increases allowing statistical analyses

Benthic quadrats
Activity = species presence/absence and calculation of density or percentage cover
Habitat sampled = eight sites on rocky reef barrens and one reserve site on algal forest. Rock tops and sloping sides (not vertical walls, overhangs or caves)
Depth = 5 m to 10 m
Sample method = quadrat counts
Sampling unit size = 1 m^2 quadrat
Sites = 9 (4 control, 5 reserve)
Quadrat deployment = haphazard
Replication = 8 quadrats per site
Timing = December to April
Recommended frequency = minimum once every five years
Next sample recommended = April 2001

Kina and gastropods
Activity = calculation of density for all species and size frequency and mean size for kina
Habitat sampled = rocky reef urchin barrens and macroalgae habitat from 5 m to 10 m depth
Sites = 7 (3 control rocky barren, 3 reserve rocky barren and 1 reserve algae habitat)
Sampling unit size = 1 m^2 quadrats
Replication = 30 quadrats per site
Measure sample size = 80 measurements of kina test diameter
Deployment = haphazard
Timing = December to April
Recommended frequency = minimum once every five years
Next sample recommended = April 2002

Spiny lobster
Activity = calculation of density, length frequency, mean size and sex structure
Habitat = rocky reef from 5 m to 11 m depth
Sites = 8 (4 control, 4 reserve)
Sample method = diver belt transects
Sampling unit size = 25 m x 4 m (100 m^2)
Stratification = two depth strata (shallow 5-6 m, deep 10-11 m)
Transect deployment = haphazard
Replication = 10 transects per site (5 shallow and 5 deep)

Timing = December to April (pending results from December 2000 resample)
Recommended frequency = minimum once every two years
Next sample recommended = December 2000, 2002

Scallops and horse mussels

Activity = Calculation of horse mussel and scallop density. Calculation of horse mussel size
Habitat = sand, fine sand or mud located from 4 m to 13 m depth
Sites = 4 (2 control, 2 reserve)
Sample method = diver belt transects
Sampling unit size = 50 m x 1 m (50 m^2)
Transect deployment = haphazard
Replication = 10 transects per site (depth range site specific)
Timing = December to April
Recommended frequency = minimum once every third year
Next sample recommended = Summer 2002/2003

Subtidal profiles

Activity = description of near-shore habitat distributions
Habitat = reef and sedimentary substrata from mean low water to 100 – 150 m offshore
Sites = 10 (5 control, 5 reserve)
Sample method = diver strip transect
Deployment = at sites of original 1991 transects
Replication = 1 transect per site
Timing = December to April
Recommended frequency = minimum once every five years
Next sample recommended = April 2001

Referees

The report also addresses comments by Dr. Ken Grange and Dr. Russell Cole (NIWA, Nelson) on a draft proposal for monitoring of the marine reserve produced by Davidson Environmental Ltd in 1999.

1. Introduction

This document presents: (A) a proposed protocol for ongoing monitoring of the Tonga Island Marine Reserve; and (B) updated data collected during September 1999.

The aim of the proposed monitoring protocol outlined in the present report is to detect any biological change as a result of the establishment of the Tonga Island Marine reserve.

The proposed monitoring protocol and the associated methodology has been based on:

- existing baseline data for the Tonga Island Marine Reserve (Davidson 1999);
- existing information on the general ecology and biological features of the Abel Tasman coastline (Davidson 1992, Davidson and Chadderton 1994);
- data collected as part of a Department of Conservation "blue package" project titled "Effects of marine reserve protection on spiny lobster abundance and size at Tonga Island Marine Reserve, New Zealand. Submitted to *Aquatic Conservation: Marine and Freshwater Ecosystems* (Davidson *et. al.*, in press.);
- experience gained through six years of monitoring of the Long Island-Kokomohua Marine Reserve (Davidson 1995, 1997, Davidson 2000, Cole *et al.*,. 2000, Davidson in press, Villouta *et al.*, in prep.);
- data collected during September 1999 from Tonga Island Marine Reserve; and
- a range of standard scientific protocols used in monitoring marine reserves in New Zealand.

The additional data collected in September 1999 and presented in the present report included:

- Underwater visual fish transects collected from 13 sites (7 reserve and 6 control);
- Scallop density and size frequency collected from 2 reserve and 2 control sites; and
- Horse mussel density collected from 2 reserve and 2 control sites.

2. Study Area and Marine Reserve

The Abel Tasman coastline and the Tonga Island Marine Reserve are located centrally within Tasman and Golden Bays, Nelson. The coastline within the marine reserve and the adjacent coast is adjacent to the Abel Tasman National Park (see Dennis 1985 for review). This coastline is sheltered from large ocean swells and is predominantly influenced by wind generated waves which quickly subside with a drop or change in wind direction. High sediment input from the hill catchments both within and adjacent to this coast, combined with regular sea-breezes and large tides (4.7 m extreme high tide) maintain water clarity at consistently low levels (approximately 2-8 m horizontal distance). Water temperatures range from 10^{o} C to 22 ^{o}C (Dix 1970).

Rocky reefs may extend to a depth of 14 m and are bordered by gently sloping soft sediment shores. Soft shores are primarily characterised by broken shell and coarse sands with a silt component. Granite boulder and bedrock substrata dominate the Abel Tasman coast. Less than 1% of rocky shores along the National Park coast are composed of limestone (Davidson 1992).

The distribution of habitats and associated communities along the Abel Tasman coast are relatively homogeneous (Davidson 1992), except for communities associated with limestone substrata. Davidson and Chadderton (1994) reported that subtidal communities found on limestone were dramatically different to communities inhabiting granite shores. Sample sites within the present study were confined to granite rock and the adjacent soft shores located in comparable shore aspects and depths.

Tonga Island Marine Reserve was established in November 1993. The reserve is 1835 hectares in size and extends one nautical mile or 1.852 km offshore from mean high water (Figure 1). The marine reserve boundaries are from the headland immediately north of Bark Bay to Awaroa Head and include the shoreline of all islands and stacks within its boundaries.

3. Materials and Methods

3.1 SCALLOP AND HORSE MUSSEL

Scallop and horse mussel density and size frequency of scallops were collected from either nine or ten 50 m x 1 m quadrats during September 1999. Quadrats were sampled from two control sites located in Bark Bay and two reserve sites located in Tonga Roadstead (Figure 2, Table 1). Quadrats were deployed haphazardly by divers instructed to swim at least 10 m distance from the previous quadrat. Within each quadrat, divers counted all scallops and horse mussels and measured the maximum width of all scallops.

In December 1993, horse mussel and scallop data were collected from six 150 m by 1 m wide quadrats at three reserve and three control sites. During the present study quadrat sizewas reduced thereby allowing the number of replicates collected by divers to be increased with no additional time in the water.

3.2 UNDERWATER VISUAL FISH TRANSECTS

Fish density was investigated in September 1999 using underwater visual census methods (Bell 1983, McCormick & Choat 1987; Buxton & Smale 1989, Cole *et al.* 1990, Cole 1994). Fish counts were collected using a 30 m long by 2 m wide transect deployed at (7 reserve and 6 control sites, Table 1, Figure 1). All fish transects were collected between 4 m -10 m depth depending on habitat

and location. All transects were collected in association with rocky reef habitat. At one reserve site, transects were collected from macroalgae habitat (i.e. dense *Carpophyllum flexuosum* forest) growing on bedrock and medium and large boulder substrata (Foul Point, B14). No comparable control habitat has been recorded from the Abel Tasman coastline (Davidson 1992, Davidson and Chadderton 1994).

At replicate, a lead weight attached to the transect line was placed onto the benthos. As the diver swam away from the weight, the line automatically reeled from the spool. At a distance of 8 m from the weight, a tag on the line indicated the start of the first fish transect. The end of each 30 m long transect a further 8 m of line was then released by the diver before the next transect was commenced. All fish were only counted during the outgoing journey. Three transects separated by a buffer zone were conducted on each outgoing journey. All transects were parallel to the shore within a particular depth range. A total of 12 replicates were collected from each site. Fish transects collected from the "macroalgae" habitat were conducted immediately above the seaweed canopy (i.e. up to 1.5 m above the substratum).

Blue cod (*Parapercis colias*) were recorded in three size categories (<10cm, 10 – 30 cm and >30 cm). Transects were collected at a swimming speed that ensured spotty (*Notolabrus chelidotus*) and blue cod did not catch and overtake divers. The automatic line-spool method enabled sampling of a pre-determined habitat consistently over the entire transect length and avoided problems such as diver mobbing by spotty and blue cod when laying a line out and then recording a disproportionate number of these species on the return journey (Grange *et al.,* 1995). This method also allowed each diver to alter course to stay within the appropriate habitat and depth zone.

4. Results (baseline versus new data)

4.1 SAMPLE SITES

Davidson (1999) collected scallop and horse mussel data were during December 1994 and fish data during December 1993 and December 1994. Scallop, horse mussel and fish were resampled as part of the present study during September 1999. Sample sites, depths and dates have been summarised in Table 1. Fish sample sites have been displayed in Figure 1, while scallop and horse mussel sample sites have been displayed Figure 2.

4.2 *PECTEN NOVAEZELANDIAE* (SCALLOP)

Scallop density data have been presented in Appendix 1 and 2. Scallop abundance was relatively low at all sites on both sample occasions (Table 2). Scallops were most common at the Tonga (south) site and were either absent or uncommon from the central and northern reserve sites. At the control location, scallops were most abundant in both sample years at the northern site (Table

2). Relatively little change in scallop density occurred sample events at the same sites. Scallop abundance pooled from sites in Bark Bay (i.e. 1993 and 1999) was higher than the pooled density from reserve sites located in Tonga Roadstead (Bark Bay (control site) mean = 0.063 per m^{-2}, SE = 0.016; Marine Reserve mean = 0.043 per m^{-2}, SE = 0.023)(Table 2).

Scallop size data are presented in Appendix 3 and 4. At the pooled control sites, scallop size did not change from December 1993 to September 1999 (T = -0.008, P = 0.99)(Figure 3). At pooled reserve sites scallop size declined significantly from 1993 to 1999 (T = 5.31, P =< 0.0001). No significant difference between pooled reserve and control sites was recorded in December 1993 (T = -1.55, P = 0.12), however, scallops were significantly larger outside the reserve in September 1999 (T = -3.90, P = 0.0001)(Figure 3).

4.3 ATRINA ZEALANDICA (HORSE MUSSEL)

Very few horse mussels were recorded from control (Bark Bay) and reserve (Tonga Roadstead) sites in December 1993 (Table 2, Appendices 1 and 2). In September 1999, horse mussel density at one reserve site and both control sites had increased compared with 1993 (Table 2). Horse mussel density pooled from all stations in Bark Bay (i.e. 1993 and 1999) was higher than the density pooled from all stations in the reserve (Bark Bay (control site) mean = 0.17 per m^{-2}, SE = 0.11; Tonga mean = 0.085 per m^{-2}, SE 0.065). Horse mussel density data have been presented in Appendix 1 and 2.

4.4 FISH

4.4.1 Presence/absence

Visual underwater transects were sampled in December 1993, December 1994 (In Appendix 6 and 7 In: Davidson 1999) and were sampled again in September 1999 (Appendix 5 In: present report). Data collected from 1993 and 1994 were pooled by Davidson (1999) and treated as baseline data representative of the sites prior to reservation.

A total of 65 species of fish have been recorded from the Abel Tasman (Davidson 1992, National Museum Database). No study, however, has specifically and thoroughly sampled fish. It is therefore probable that present records do not describe all species present in reserve and control areas.

In 1993 and 1994, divers recorded 15 fish species during visual fish transects (Table 7 In: Davidson 1999). In September 1999, divers recorded 14 species of fish (Table 3). The difference between fish recorded from transects and those known from the coast was accentuated as cryptic and crevice dwelling species and all species of triplefin were deliberately ignored by divers during visual transect counts (Davidson 1999).

Spotty was recorded from all sample sites in 1999 (Table 3). Spotty was also the most frequently encountered fish species in 1993 and 1994. Tarakihi were recorded from 80% of sites in 1993/1994, but were only encountered at 38% of sites in 1999. Blue moki and butterfly perch were encountered at approximately half of all sites in both studies. Goatfish were uncommon during 1999 compared to 1993/1994 (Table 3). No blue cod less than <10 cm length were recorded on both sample occasions. Blue cod, banded wrasse and scarlet wrasse were encountered at a greater proportion of sites both within the reserve and at control sites during 1999 compared with 1993/94. All other species were recorded from 36% or less of sample sites, with magpie moki recorded from one site (i.e. Totaranui north site in 1993/94 and Separation Point south site in 1999).

Reef fish such as trumpeter, girdled wrasse, butterfish and copper moki regularly recorded from the outer Marlborough Sounds (R. Davidson pers. obs.), were not recorded from transects by Davidson (1999) or during the present study. Butterfish were observed from one site at Snapper Rocks in 1993/94 and from one transect at Foul Point during the present study.

Raw transect data, sample dates, habitats, and depths are presented here in Appendix 5 and in Appendices 6 and 7 in Davidson (1999).

4.4.2 Habitat

Mean density of fish recorded from shallow boulder habitats from pooled reserve and control treatments collected during December 1993/94 and September 1999 are presented in Table 4.

Spotty was the most abundant fish species recorded during counts collected during both sample events (Table 4). Blue cod >30 cm. length was only recorded from one reserve site during September 1999. Blue cod 10 cm to 30 cm length were recorded from both sample events but were relatively uncommon (i.e. <0.15 individuals per 60 m^{-2}) (Table 4). Tarakihi was one of the two most abundant fish species sampled during 1993/94, but were relatively uncommon during 1999. Banded wrasse, butterfly perch, blue moki, red moki, magpie moki, marblefish, sweep and leatherjacket were all recorded in relatively low densities during both sample events (Table 4).

4.4.3 Reserve versus control sites

Mean densities of fish species recorded from the shallow boulder habitat for each treatment (pooled reserve and pooled control) for both sample events have been presented in Table 4 and Figures 4 and 5. Comparable densities of each species of fish were recorded between reserve and control treatments in both 1993/94 and 1999. For most species in 1993/94 and 1999 densities of fish were highest from the control treatment (Table 4).

Table 4 Mean density (per 60 m^{-2})(1 SE) of fish from shallow boulder habitat from pooled reserve and control sites along the Abel Tasman coast.

	Davidson (1999)(Dec 1993/94)		Present study (Sept. 1999)	
Species	Reserve Shallow boulder	Control Shallow boulder	Reserve Shallow boulder	Control Shallow boulder
Number of sites	9	4	7	6
Number replicates	119	45	85	72
Spotty	1.29 (0.32)	0.89 (0.4)	1.48 (0.35)	1.76 (0.53)
Tarakihi	0.82 (1.02)	1.33 (0.12)	0.12 (0.12)	0.13 (0.17)
Blue moki	0.25 (0.18)	0.13 (0.12)	0.11 (0.09)	0.03 (0.04)
Goatfish	0.19 (0.1)	0.09 (0.08)	0	0.01 (0.03)
Butterfly perch	0.21 (0.12)	0.49 (0.44)	0.16 (0.11)	0.32 (0.21)
Blue cod 10-30cm	0.04 (0.04)	0.02 (0.04)	0.11 (0.08)	0.15 (0.11)
Blue cod >30cm	0	0	0.05 (0.06)	0
Scarlet wrasse	0.05 (0.04)	0.36 (0.30)	0.13 (0.09)	0.29 (0.16)
Marblefish	0.06 (0.06)	0.16 (0.12)	0	0.03 (0.04)
Banded wrasse	0.08 (0.06)	0.04 (0.06)	0.07 (0.06)	0.1 (0.1)
Seahorse	0.02 (0.04)	0.02 (0.04)	0	0
Opal fish	0	0	0	0
Red moki	0.008 (.016)	0.04 (0.06)	0.02 (0.03)	0
Sweep	0.03 (0.02)	0	0.02 (0.03)	0.01 (0.03)
Leatherjacket	0	0.02 (0.04)	0.02 (0.02)	0.01 (0.03)
Magpie moki	0	0	0	0.01 (0.03)
Butterfish	0	0	0.01 (0.02)	0

5.0 MONITORING

5.1 Existing data

Detection of change in the marine environment is often difficult due to "normal" environmental variability (Underwood 1991, 1993, 1993, 1994). In most cases, human and financial resources influence the success of a monitoring programme (i.e. temporal and spatial scales). Type I and II errors (type I error = detecting a difference when no difference exists, type II error = not detecting a difference when a difference exists) should be an important consideration at all times in the construction of a monitoring programme (Fairweather 1991, Underwood 1991, 1993, 1994a, 1994b). An inadequate baseline study (i.e. without sufficient temporal, spatial or subject matter) will ultimately restrict subsequent data collection and/or interpretation.

The baseline study of Tonga Island Marine Reserve (Davidson 1999) provides the opportunity

to initiate ongoing monitoring. Although lacking temporal scale, the baseline provides the opportunity to re-collect information established in the early months of marine reservation. In New Zealand, this opportunity is relatively rare.

It is suggested as a guideline, that ongoing monitoring of the Tonga Island Marine Reserve include a minimum programme of:

- collection of underwater fish counts;
- collection of quantitative benthic community data;
- collection of key species data; and
- collection of shore profiles.

5.2 Reef fish abundance and size

Fish density and size class would be investigated during underwater visual strip transect methods (Bell 1983, McCormick & Choat 1987; Buxton & Smale 1989, Cole *et al.* 1990, Cole 1994, Cole *et al.,* 2000). In future years if visual methods show an increase in snapper and/or blue cod abundance, it is recommended that either underwater baited video methods (Willis *et al.*, 2000).or catch measure and release methods (Davidson 2000) be considered for snapper and blue cod

Visual strip transect methods

It is recommended that the shallow rocky habitat type be adopted for ongoing monitoring as it presents the best opportunity for adequate water visibility required for fish counting methodology (i.e. > 4.5 m horizontal distance). For all replicate counts, it is recommended that methodology used by Davidson 1999 should be adopted. The line on a spool method enables divers to sample a pre-determined habitat consistently over the entire transect length thereby avoiding problems such as diver mobbing by spotty and blue cod when laying a line out and then recording a disproportionate number of these species on the return journey. This method also ensures divers can alter course while swimming in order to keep within the appropriate habitat and depth zone and also allowed measurement of up to 3 contiguous replicates separated by an appropriate buffer in a relatively short time.

The seven reserve and six control sites proposed for monitoring have been summarised in Table 5. The seventh reserve site (i.e. Foul Point) represents algae habitat growing on shallow rocky substrata. This is the only site of its kind along the Abel Tasman Coast (Davidson 1992, Davidson and Chadderton 1994).

Transects at each site should be conducted at random depths within the predetermined depth range. Davidson (2000) has successfully detected change in blue cod abundance in the Long Island-Kokomohua Marine Reserve sampling 12 replicates per site. It is suggested that 12

replicates be collected at each site for the Abel Tasman Coast. Transects should be investigated at a swimming speed that ensures spotty (*Notolabrus chelidotus*) and other reef fish such as blue cod (*Parapercis colias*) do not catch and overtake divers.

Table 5 Proposed underwater diver fish sample sites located along the Abel Tasman.

Site no	Site name	Treatment	Habitat (depth)
B1	Separation Point (South)	Control	Boulder 5-10 m
B2	Totaranui (north)	Control	Boulder 5-10 m
B3	Totaranui Reef	Control	Boulder 5-10 m
B4	Awaroa Head	Control	Boulder 5-10 m
B16	Bark Bay Reef	Control	Boulder 5-10 m
B17	Totatara Rock	Control	Boulder 5-10 m
B5	Canoe Bay	Reserve	Boulder 5-10 m
B6	Abel Head	Reserve	Boulder 5 –10 m
B8	Cottage Loaf (south)	Reserve	Boulder 5-10 m
B10	Reef Point, Tonga	Reserve	Boulder 5-10 m
B12	Tonga Island (east)	Reserve	Boulder 5-10 m
B14	Foul Point	Reserve	Algae 5-10 m
B15	Whale Rock	Reserve	Boulder 5-10 m

Divers should be trained to estimate the size of particular fish species. Fish species to be estimated to the nearest centimeter include blue cod, blue moki, red moki and butterfish.

5.3 Quantitative benthic community data

Babcock *et al.* (1999) documented a decline in the extent of the urchin barrens in Cape Rodney to Okakari Point Marine Reserve. Shortly after establishment of the reserve barrens occupied 33% of the rocky reef compared to approximately 3% 20 years later. The authors stated that urchin barrens have been replaced by kelp forest with a consequent doubling of estimated primary productivity within the reserve. These changes have been attributed to changes in grazer abundance (thought to be primarily urchins) following the gradual increase in the density of large predators (i.e. spiny lobster and large carnivorous reef fish) in the reserve. The nature and timing of these changes, however, was not known as there was no systematic monitoring programme in place over this period. Detection of any comparable change from rock barrens to a macroalgae dominated state may potentially occur along the Abel Tasman coast. Grazer – algae interactions along the Abel Tasman coast have been discussed in detail by Davidson and Chadderton (1994), while historic evidence of more extensive coverage of macroalgae cover was displayed in Davidson (1992).

Three methods of monitoring may assist with the detection of any change in habitat

composition. These include collection of (1) benthic community data, (2) abundance and size of grazers and (3) description of habitat along shore profiles.

Both hard shore and soft shore benthic community data have been sampled from reserve and control stations along the Abel Tasman coast (Davidson 1999). It is recommended that only hard shore sites be monitored as these areas present the greatest probability of change due to reservation.

It is recommended that hard shores be sampled from a total of 9 sites (5 reserve and 4 control) (Table 6). Eight of the sites will be located on bedrock and boulder urchin barren habitat, while one reserve site will be located within macroalgal habitat (Table 6).

Davidson (1999) adopted a total of 39 conspicuous species that were sampled from a variety of depths on boulder, bedrock or algae covered rock. It is recommended that the same set of species be used for ongoing monitoring of the reserve.

Table 6 Recommended hard shore quantitative sample sites along the Abel Tasman.

Site no.	Site name	Treatment	Habitat (depth)
B1	Separation Point (South)	Control	Boulder 5-10 m
B4	Awaroa Head	Control	Boulder 5-10 m
B16	Bark Bay Reef	Control	Boulder 5-10 m
B17	Totara Rock	Control	Boulder 5-8 m
B5	Canoe Bay	Reserve	Boulder 5-10 m
B8	Cottage Loaf (south)	Reserve	Boulder 5-10 m
B12	Tonga Island (east)	Reserve	Boulder 5-10 m
B14	Foul Point	Reserve	Macroalgae 5-10 m
B15	Whale Rock	Reserve	Boulder 5-10 m

Methods

At each station, eight random one square metre quadrats should be sampled within the predetermined depth range. The habitat selected for sampling should be bedrock and boulder tops and sloping sides. Vertical walls, overhangs and caves should be avoided as these areas support a different community type to rock tops and sloping sides (Davidson 1992). Physical features (substratum and depth), percentage cover of turfing algae (e.g. *Caulerpa* spp., *Corallina officinalis* and other small red algae), number of stipes of large brown algae (e.g. *Carpophyllum flexuosum*), percentage cover of encrusting invertebrates (e.g. sponges, bryozoans and ascidians) and the number of particular conspicuous invertebrates should be recorded from each quadrat preferably by the same divers. Diver percentage cover estimates should be regularly monitored to ensure consistency between sample events.

5.4 Key species

It is recommended that particular benthic species be monitored. Davidson (1999) collected density and size data for selected particular species because they were either recreationally and/or commercially targeted, could potentially modify habitat structure (i.e. dominant grazer or predator), or were important food for other species (e.g. gastropods representing food for spiny lobster). Davidson (1999) reported that most stations sampled within and outside the marine reserve supported relatively high numbers of these species. Davidson (1999) sampled kina and Cook's turban at 22 sites and cats eye snails at 14 sites. Davidson and Chadderton (1994) sampled kina and gastropods from extreme low water to 6 m depth from six sites all located outside the marine reserve. Shears *et al.* (in prep) has also collected density data for a variety of invertebrates including the target organisms. The author sampled invertebrates and algae densities at particular depths from 12 sites inside and 12 outside the reserve during 1999.

Species sampled by Davidson (1999) and suggested for ongoing monitoring included:

- kina (*Evechinus chloroticus*;
- Cook's turban (*Cookia sulcata)*;
- cats-eye (*Turbo smaragdus);*
- spiny lobster (*Jasus edwardsii);*
- scallop (*Pecten novaezelandiae*);
- horse mussel (*Atrina zelandica*); and
- Green topshell (*Trochus viridus*) and limpets (*Cellana* spp.).

Methods

Kina and gastropods size and density

It is recommended that kina (*Evechinus chloroticus*) size and density be sampled, Cook's turban (*Cookia sulcata*), cats-eye (*Turbo smaragdus),* green topshell (*Trocus viridus*) and limpets (*Cellana* spp.) density be monitored from three reserve and three control sites along the Abel Tasman coast. Density of these species should be determined using 1 m^2 quadrats deployed haphazardly within the predetermined depth ranges (Table 7). A minimum of 30 quadrats should be sampled at each site on each sample occasion. Kina maximum test diameter from within quadrats should be measured *in situ* using callipers to the nearest millimeter. It is recommended that, where possible, a minimum of 80 individuals be measured per site.

A total of seven sites, three control sites on rocky barrren habitat, three reserve sites on rocky barren habitat and one reserve site in macroalgae forest are outline in Table 7.

Spiny lobster size, sex and density

Spiny lobster (*Jasus edwardsii*) density, sex and size should be investigated from haphazardly deployed quadrats (25 m x 4 m) installed at two depths at 4 control and 4 reserve stations according to methodology adopted by Davidson *et al.* (in prep.) (Table 8). Ten replicate transects should be collected from each depth strata at each site. Using a torch, divers should thoroughly search all caves, crevices within a 2 m wide strip on one side of the transect line on the outgoing journey and the same size strip on the opposite side of the transect line during the return journey. Searches should be restricted to particular depths and habitat types according to those sampled by Davidson (1999) and Davidson *et al.* (in prep.). Spiny lobster carapace length should be estimated *in situ* by divers experienced in visual size estimates. Spiny lobster sex should be recorded wherever possible.

Table 7 Recommended sample sites for particular key species located along the Abel Tasman coastline.

Site no.	Site name	Type	Kina	Cook's turban	Cats-eye
B1	Separation (South)	Control	Boulder 5-10 m	Boulder 5-10 m	Boulder 5-10 m
B4	Awaroa Head	Control	Boulder 5-10 m	Boulder 5–10m	Boulder 5-10 m
B17	Totara Rock	Control	Boulder 5-8 m	Boulder 5 – 8 m	Boulder 5-8 m
B5	Canoe Bay	Reserve	Boulder 4-10 m	Boulder 5 –10m	Boulder 5-10 m
B13	Arch Point	Reserve	Boulder 5 – 10 m	Boulder 5 – 10m	Boulder 5 –10m
B14	Foul Point	Reserve	Algae 5-10 m	Algae 5-10 m	Algae 5-10 m
B15	Whale Rock	Reserve	Boulder 5-10 m	Boulder 5-10 m	Boulder 5-10 m

Scallops and horse mussel density

Davidson (1999) sampled scallops and horse mussel abundance from three sites in Tonga Roadstead (reserve) and three sites in Bark Bay (control). Preliminary result suggest that horse mussel density had increased at both control and reserve sites. It is therefore recommended that scallop and horse mussel density be monitored from two reserve and two control sites (Table 9). At each site, scallops and horse mussels should be counted from a minimum of ten 50 m long x 1 m wide quadrats deployed randomly at each site used by Davidson (1999).

Table 8 Recommended spiny lobster sample sites located along the Abel Tasman. Recommended quadrat size = 25 m x 4 m, number of replicates per depth = 5.

Site no.	Name	Treatment	Habitat and depths
B1	Separation Pt (south)	Control	Boulder 5-6 m, 10-11 m
B4	Awaroa Head	Control	Boulder 5-6 m, 10-11 m
B16	Bark Bay Reef	Control	Boulder 5-6 m, 10-11 m
B18	Pitt Head	Control	Boulder 5-6 m, 10-11 m
B8	Cottage Loaf	Reserve	Boulder 5-6 m, 10-11 m
B12	Tonga Island(east)	Reserve	Boulder 5-6 m, 10-11 m
B14	Foul Point	Reserve	Algae 5-6 m, 10-11 m
B16	Whale Rock	Reserve	Boulder 5-6 m, 10-11 m

Table 9 Recommended scallop and horse mussel sample sites along the Abel Tasman.

Site no.	Site name	Treatment	Depth (m)
S1	Tonga (north)	Reserve	Soft 9-13 m
S3	Tonga (south)	Reserve	Soft 5-10 m
S4	Bark Bay (north)	Control	Soft 4-7 m
S5	Bark Bay (centre)	Control	Soft 6-12 m

5.5 Subtidal profiles

Davidson (1992) collected 20 subtidal profiles, (seven reserve, 13 non-reserve) during the summer of 1991. The author recorded distance from mean low water, depth, substratum and algal cover if present. No percentage cover estimates were presented in the 1992 report. Subtidal profile data collected form two non-reserve and three reserve sites were presented in Appendix 8 of Davidson (1999). These profiles were collected in December 1993 and describe distance from low water, depth, percentage cover of each major substratum type and for most areas, percentage cover of large brown macroalgal species.

Methods

A lead core rope marked at 5 m intervals should be deployed perpendicular to the shore from mean low water. Care should be taken to ensure that the transect has been deployed in a direct line offshore with no kinks or loops in the rope. Divers should record distance, depth, where major substratum types start and finish, percentage cover of the major substratum types and estimate percentage cover of each macroalgal species. The start and end of any areas of macroalgal species along the transect should also be recorded. Macroalgal species include *C maschallocarpum, C flexuosum, Ecklonia radiata*, turfing algae and coralline paint.

Table 10 Recommended shore profile sites from along the Abel Tasman coast. Profiles should be collected from mean low water.

Site no.	Site name	Treatment
B0	Separation point (north)	Control
B1	Separation Point (south)	Control
B3	Totaranui Reef	Control
B4	Awaroa Head	Control
B7	Brereton Bay	Reserve
B11	Tonga Island (north)	Reserve
B13	Arch Point	Reserve
B14	Foul Point	Reserve
B15	Whale Rock	Reserve
B16	Bark Bay Reef	Control

5.6 Sample frequency and time of year

Reef fish

Comparison of data collected from December 1993/1994 with data collected during September 1999 suggests there has been little change due to the removal of fishing from the reserve. However, several common reef fish species have become more abundant and larger within marine reserves in New Zealand and overseas (Cole *et al* 1990; Bennett and Attwood 1991, 1993; Davidson 2000; Willis *et al.* 2000). It is therefore recommended that underwater visual fish transects be conducted at the 13 sites every second year. The time of the year when sampling occurs should be based on a comparison between spring and summer data collected during the 2000 to 2001 year.

In the 2000 to 2001 financial year fish should be visually counted from the 13 sites in December 2000 and again in April 2000 to identify the presence of any seasonal patterns between spring and late summer to early autumn. If no pattern is apparent fish sampling could be conducted within a wider time scale allowing selection of optimum water visibility conditions.

Snapper and blue cod

Willis *et al.* (2000) reported a significant difference ion snapper size and abundance between reserve and non-reserve areas. The author reported that the use of underwater baited video station were a successful method for sampling these species. Davidson (2000) successfully used catch, measure and release methodology to sample the size of blue cod within Long Island-Kokomohua Marine Reserve.

In future years if visual methods show an increase in snapper and/or blue cod abundance, it is

recommended that underwater baited video or catch measure and release methods be considered (see Willis *et al*., 2000 and Davidson 2000 for methodology).

Benthic quadrats

The benthic quadrat data is time consuming and may notshow a rapid change due to removal of fishing. It is therefore recommended that benthic quadrat data be collected once every five years. These data should preferably be re-analyzed using a multivariate cluster analysis and species association test. It is unlikely that the abundance of the majority of these subtidal animals would vary seasonally, however as a precautionary measure it is recommended that data be collected between December and March (i.e. summer months).

Kina and gastropods

Similarly kina size and kina and gastropod abundance may not change rapidly due to reservation and may change as a result of the increase in numbers of predators such as snapper and spiny lobster. It is therefore recommended that kina size and kina and gastropod abundance be sampled a minimum of once every five years. It is unlikely that the abundance of these subtidal animals would vary seasonally, however as a precautionary measure it is recommended that data be collected between December and March (i.e. summer months).

Spiny lobster

Davidson *et al.* (in prep.) reported that spiny lobsters were larger and more abundant inside the reserve six years after it was established. This species appears to be responding well to the removal of fishing and should therefore be one of the main focal points of monitoring Tonga Island Marine Reserve. It is therefore recommended that spiny lobster size, sex and abundance be sampled at a minimum of second year.

Results from seasonal data collected from December 1998 to March 2000 by Davidson *et al.* (in prep.), showed that spiny lobster abundance remained relatively consistent throughout the year apart from December when lowest densities were recorded. The baseline spiny lobster data collected by Davidson (1999) was during December 1994. In order to determine whether December represents a time of the year when spiny lobster are absent or hidden within refuges it is recommended that spiny lobster be resampled in December 2000. These data could then be compared with data collected by Davidson *et al* (in prep.). If no seasonal trend is apparent for December it would then be possible to sample spiny lobster density reliably from a greater time period throughout the year.

Scallops and horse mussels

Scallops are relatively short lived and exhibit major fluctuations in abundance in Tasman and Golden Bays. These animals can become very abundant in an area and can then suffer major

mortality. In contrast, horse mussels are relatively long-lived and have probably been adversely impacted by dredging from along the Abel Tasman coast. It is therefore recommended that horse mussel abundance be monitored. Scallop density can be collected during horse mussel counts and therefore should also be collected. It is recommended that horse mussel be measure instead of scallops. Sampling should occur at a minimum of every third year.

As horse mussels are relatively long lived it is unlikely that any seasonal trends would influence density and size measurements, however as a precautionary measure it is recommended that data be collected between December and March (i.e. summer months).

Subtidal profiles

Shore profiles potentially allow description of any change to habitat structure. Babcock *et al.* (1999) and Shears and Babcock (2000), documented changes to the distribution of rock barren and macroalgal habitats in the Cape Rodney to Okakari Point Marine Reserve. These changes are thought to represent a stable long-term alteration due to an increase in the abundance of large predators. It is therefore recommended that shore profile data be collected a minimum of once every five years concurrently with the benthic monitoring and more often if changes to habitat structure are observed.

5.7 Data storage and write-up

It is recommended that data should be entered into an appropriate data-base and a copy be supplied to the Department of Conservation for data security reasons. It is recommended that all data be written-up in report form once every four years. All raw data should be included in appendices format in that report.

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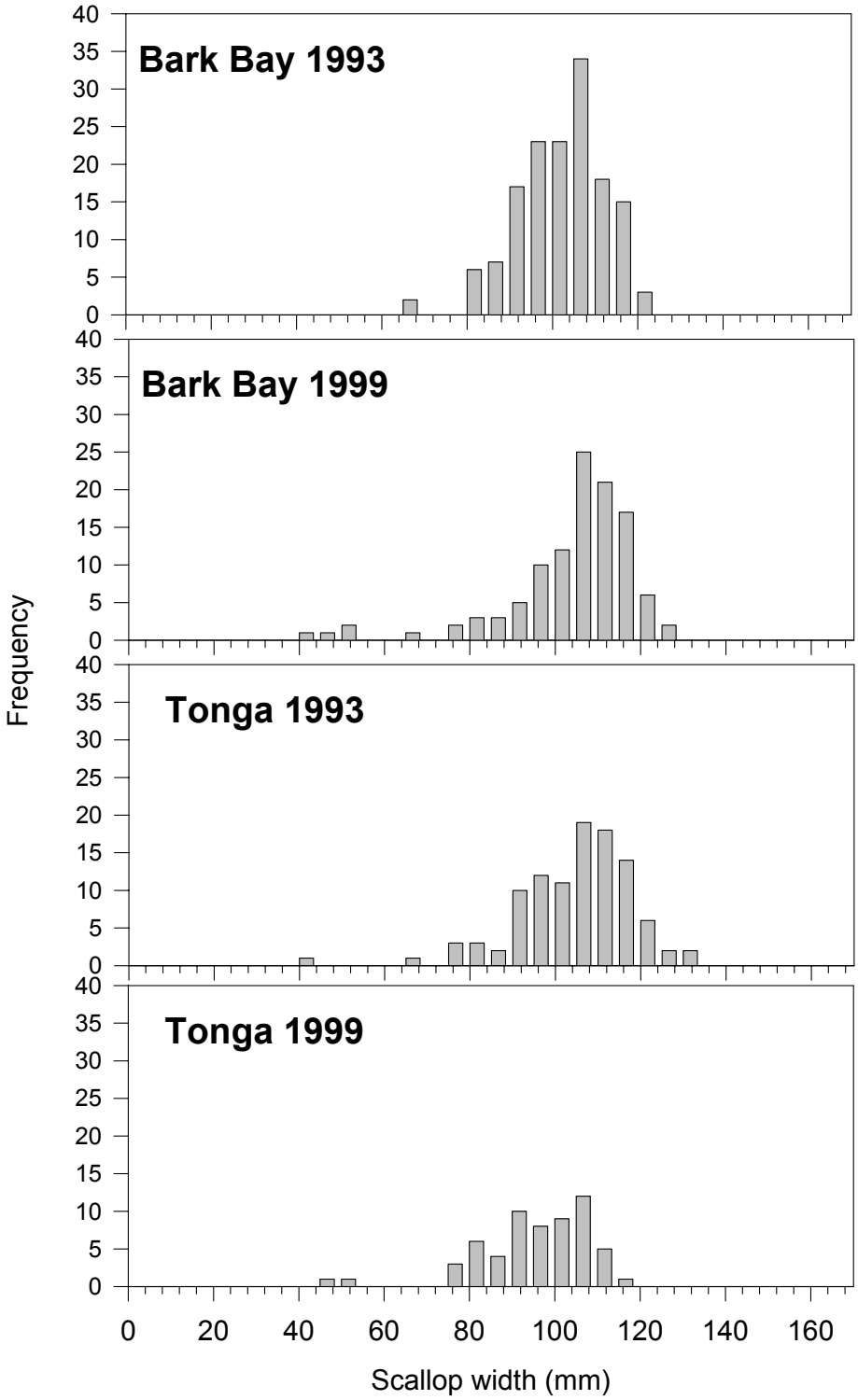

Figure 3 Size frequency of scallops in December 1993 and September 1999.

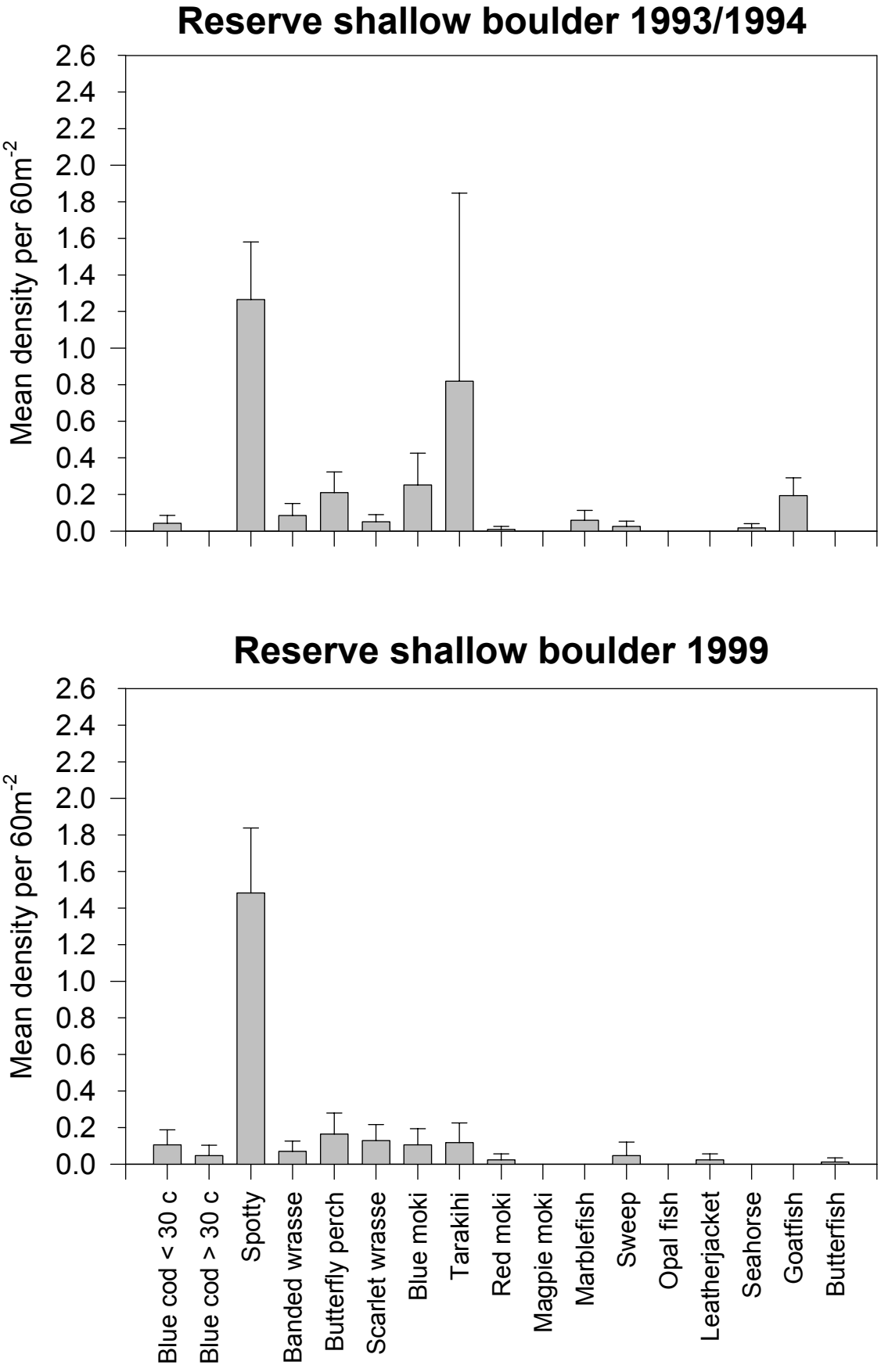

Figure 4 Pooled 1993 and 1994 reserve versus 1999 fish density data from shallow boulder habitat (4-10 m depth). Error bars represent 95% confidence.

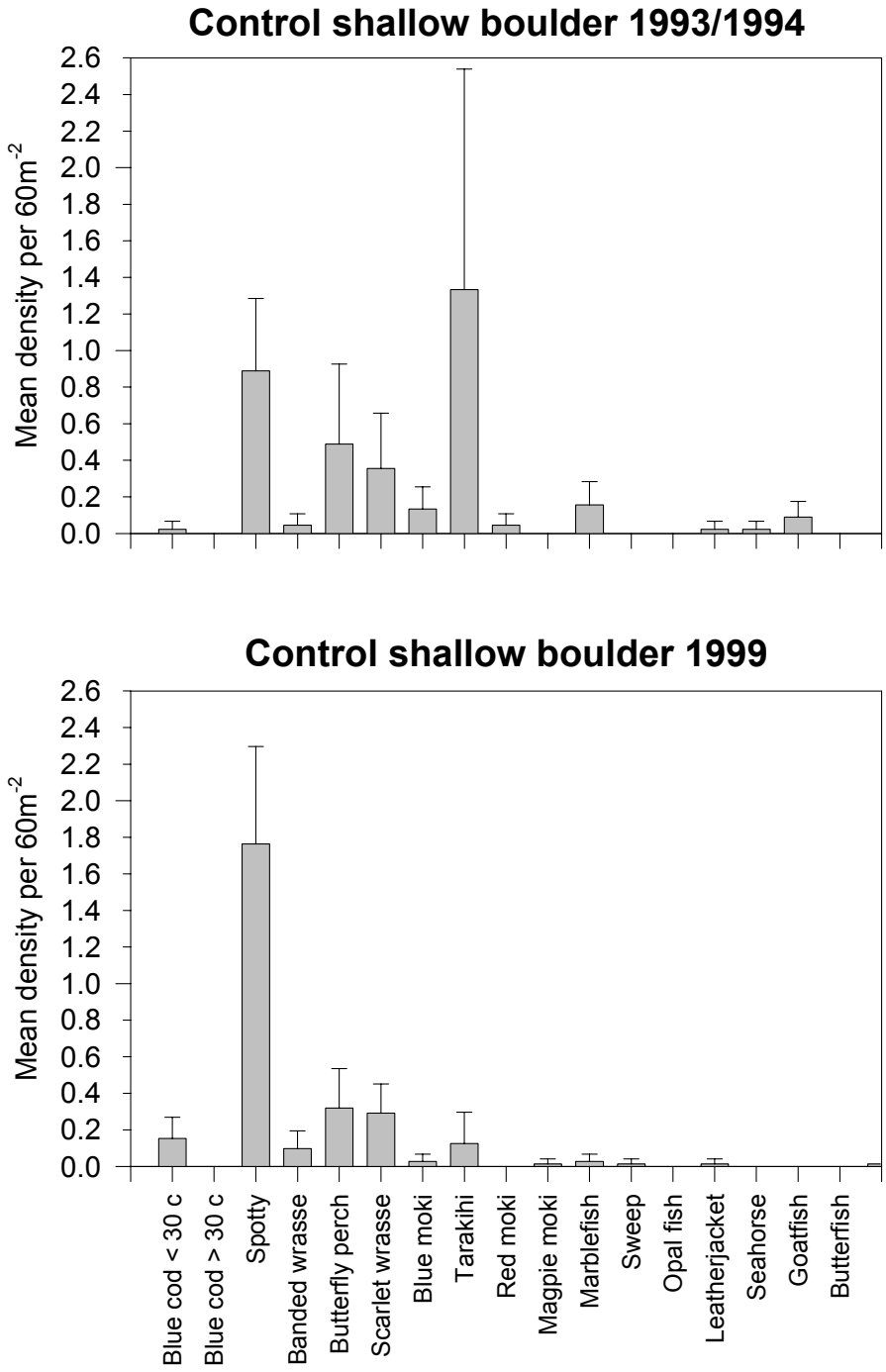

Figure 5 Pooled 1993 and 1994 control versus 1999 fish density data from shallow boulder habitat (4-10 m depth). Error bars represent 95% confidence.

Table 1 Location, habitat and depths where data were collected from along the Abel Tasman coastline during 1993, 1994 and September 1999

Site No.	Site name	Treatment	Scallop/Horse mussel 1993	Scallop/Horse mussel 1999	Fish 1993	Fish 1994	Fish 1999
B0	Separation Point (north)	Control				Boulder 7-9 m	
B1	Separation Point (South)	Control		**3.**	4.Boulder 5-10 m		Boulder 5-10 m
B2	Totaranui (north)	Control				5.Boulder 4-10 m	6.Boulder 4-10 m
B3	Totaranui Reef	Control					Bedrock 5-10 m
B4	Awaroa Head	Control			Boulder 5-10 m Boulder 10-15 m Soft 19-21 m		Boulder 5-10 m
B5	**Canoe Bay**	**Reserve**			**Boulder 4-10 m**		**Boulder 4-10 m**
B6	**Abel Head**	**Reserve**					
B7	**Brereton Bay**	**Reserve**			**Boulder 5-10 m**		**Boulder 5-10 m**
B8	**Cottage Loaf (north)**	**Reserve**				**Boulder 12-15 m**	
B9	**Cottage Loaf (south)**	**Reserve**			**Boulder 4-8 m** **Boulder 13-16 m** **Soft 15-16 m**		**Boulder 4-8 m**
B10	**Reef Point, Tonga**	**Reserve**			**Boulder 5-8 m** **Soft 10-15 m**		**Boulder 5-9 m**
B11	**Tonga Is. (north)**	**Reserve**			**Boulder 5-10 m** **Soft 6-18 m**		
B12	**Tonga Island (east)**	**Reserve**			**Boulder 4-8 m** **Soft 12-16 m**		**Boulder 4-8 m**
B13	**Arch Point, Tonga**	**Reserve**			**Boulder 4-6 m**		
B14	**Foul Point**	**Reserve**		**7.**	**8.Algae 5-8 m** **Soft 14-16 m**		**Algae 5-8 m**
B15	**Whale Rock**	**Reserve**				**Boulder 6-7 m**	**Boulder 6-10 m**
B16	Bark Bay Reef	Control				Boulder 10-15 m	Boulder 5-10
B17	Boundary Bay (south)	Control		**9.**	10.Boulder 4-6 m Soft 7-8 m		Boulder 4-6 m
B18	Snapper Rocks	Control					
S1	**Tonga (north)(S1)**	**Reserve**	**11.Soft 9-12 m**	**Soft 9-12 m**			
S2	**Tonga (centre)(S2)**	**Reserve**	**Soft 14-15 m**				
S3	**Tonga (south)(S3)**	**Reserve**	**Soft 6-13 m**	**Soft 6-13 m**			

S4	Bark Bay (north)(S4)	Control	12.Soft 3-6 m	Soft 3-6 m			
S5	Bark Bay (centre)(S5)	Control	13.Soft 6-9 m	Soft 6-9 m			
S6	Bark Bay (south)(S6)	Control	Soft 3-9 m				

Bold = reserve sites

Report table 2000

Table 3: Fish species recorded by Davidson 1999 compared with fish recorded during visual transects along the Abel Tasman National Park coast during the present study. Note: cryptic and cave dwelling species were not recorded.

	1993, 1994 (Davidson 1999)			Present study (Sept 1999 counts)		
Species	Reserve stations (%) (n = 17 sites)	Control stations (%) (n = 8 sites)	Total (%) (n = 25 sites)	Reserve stations (%) (n = 7 sites)	Control stations (%) (n = 6 sites)	Total (%) (n = 13 sites)
Spotty	15 (88)	7 (88)	22 (88)	7 (100)	6 (100)	13 (100)
Tarakihi	14 (82)	6 (75)	20 (80)	3 (43)	2 (33)	5 (38)
Blue moki	8 (47)	5 (63)	13 (52)	4 (57)	2 (33)	6 (46)
Goatfish	7 (41)	4 (50)	11 (44)	0 (0)	1 (17)	1 (8)
Butterfly perch	8 (47)	3 (38)	11 (44)	2 (29)	4 (67)	6 (46)
Blue cod	7 (41)	4 (50)	11 (44)	5 (71)	4 (67)	9 (69)
Scarlet wrasse	5 (29)	4 (50)	9 (36)	4 (57)	3 (50)	7 (54)

Marblefish	3 (18)	5 (63)	8 (32)	0 (0)	2 (33)	2 (15)
Banded wrasse	3 (18)	3 (38)	6 (24)	4 (57)	4 (67)	8 (62)
Seahorse	4 (24)	1 (13)	5 (20)	0 (0)	0 (0)	0 (0)
Opal fish	4 (24)	1 (13)	5 (20)	0 (0)	0 (0)	0 (0)
Red moki	3 (18)	1 (13)	4 (20)	2 (29)	0 (0)	2 (15)
Sweep	3 (18)	0 (0)	3 (12)	2 (29)	1 (17)	3 (23)
Leatherjacket	0 (0)	2 (25)	2 (8)	2 (29)	0 (17)	3 (23)
Magpie moki	0 (0)	1 (13)	1 (4)	0 (0)	1 (17)	1 (8)
Butterfish	0 (0)	0 (0)	0 (0)	1(14)	0 (0)	1 (8)

Report table 2000

Table 2 Mean density (per m^2) of scallops and horse mussels sampled from 150 m^2 quadrats in 1993 and 50 m quadrats in 1999 from two locations along the Abel Tasman during December 1993 and September 1999 (in brackets). Values = individuals per m^2.

Site No.	Site	Quadrats	Depth range (m)	Scallop		Horse mussel	
				Mean density	95 % confidence	Mean density	95 % confidence
S1	Tonga (north)	6 (9)	9 m-13 m	0 (0.013)	0 (0.0092)	0 (0.34)	0 (0.353)
S2	Tonga (centre)	9	14 m-15 m	0.004	0.003	0.02	0.01
S3	Tonga (south)	6 (10)	5 m- 10 m	0.1 (0.096)	0.061 (0.037)	0 (0.064)	0 (0.044)
S4	Bark Bay (north)	6 (9)	4 m-7 m	0.085 (0.11)	0.013 (0.053)	0 (0.35)	0 (0.098)
S5	Bark Bay (centre)	6 (10)	6 m-12 m	0.062 (0.04)	0.01 (0.019)	0 (0.5)	0 (0.21)
S6	Bark Bay (south)	6	3 m-9 m	0.018	0.013	0	0

Note: 1999 data presented in brackets

Report table 2000