CAPE RODNEY TO OKAKARI POINT MARINE RESERVE AND TAWHARANUI MARINE PARK FISH (BAITED UNDER WATER VIDEO SYSTEM) MONITORING 2007

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EXECUTIVE SUMMARY

- This report describes the results of Baited Underwater Surveys (BUV) of snapper and blue cod abundance in the Cape Rodney to Okakari Point (CROP) Marine Reserve and Tawharanui Marine Park, in north eastern New Zealand in 2007. The survey was undertaken in autumn and contributes to the time-series that started in 2000 in CROP by the Department of Conservation. For Tawharanui Marine Park the 2007, BUV survey was the second survey carried out since the incipient study of Willis et al's (2003a) which was done between 1997-1998.

- The current BUV survey in CROP indicated that legal-sized snapper were 30.2 times more abundant inside the reserve than outside. Densities were slightly lower than the level recorded in 2005. The average fork length of snapper inside the reserve was over 100 mm greater than that of snapper outside the reserve, which is consistent with previous surveys.

- The spatial distribution of legal snapper across reserve and non-reserve areas sampled during this survey was broadly consistent with earlier surveys, in that the highest densities occurred near the centre of the reserve and lowest densities were recorded at the western boundary.

- The average blue cod density and size inside the reserve remain slightly higher than outside the reserve although the average density dropped slightly from the level recorded in 2005. Blue cod abundance patterns appear negatively correlated with sea surface temperature.

- For Tawharanui Marine Park and non-protected areas surveyed, there was no apparent trend in the densities of fish sampled between the two areas in 2007. A further long time-series data collection is needed to understand the protection benefits in the park.

RECOMMENDATIONS

- The fish monitoring programme using BUV methodology should be continued at two year or more intervals with the current levels of sample replication in CROP Marine Reserve. The replication inside the Tawharanui Marine Park should be increased to six areas to increase the spatial replication inside the park.

- The sampling should be done in CROP Marine Reserve and Tawharanui Marine Park concurrently in the same season to understand the reserve effects in and adjacent to these protected areas (which are relatively close to each other) using identical sampling design and methodology. The sampling season and methodology should also be kept consistent with other Marine Reserve monitoring programs in the North Eastern Bio-region to enable a comparison at regional and national level.

- The timing and methodology of this monitoring program needs to be considered in other areas which have potential for future protection under the Marine Protected Area Policy and Implementation Plan to develop a network of representative marine protected areas.

INTRODUCTION

The Cape Rodney to Okakari Point (or Leigh) Marine Reserve (CROP) is the oldest no-take marine reserve of the 28 no-take marine reserves throughout New Zealand. As part of the management process the Department of Conservation (DOC) has ongoing monitoring programs in CROP Marine Reserve which mainly focus on heavily targeted species that are more likely to respond to protection such as snapper (*Pagrus auratus*), blue cod (*Parapercis colias*) and red rock lobster (*Jasus edwardsii*). As snapper is known to be one of the top predator reef fish species in CROP, the Auckland Conservancy of DOC began a regular monitoring of the abundance of reef fishes in CROP in 2000 (Willis & Babcock 2000a), although the relative abundance of exploited species (specifically snapper and blue cod) have been monitored since 1997 (Willis et al. 2003a, Taylor et al. 2003).

Monitoring of selected key species used specific methodologies such as baited underwater video (BUV). Willis & Babcock (2000b) used BUV for surveying carnivorous reef fish species like snapper and blue cod (that are attracted to bait), and underwater visual census (UVC) transects for surveying the remainder of the demersal reef fish species (Willis et al. 2003b). The fish surveys in CROP which began in 2000 were done using BUV and UVC methodologies concurrently. From 2000-2002, the surveys were done every six months, one survey around April-May and the other one around October-November to cover the seasonal variation in fish abundance. However, after 2002, the frequency of surveys was reduced to bi-annually, and took place around April-May. The surveys were carried out in 2003 and in 2005.

Tawharanui Marine Park (TMP), also a no-take marine park established in 1981 under Fisheries and Harbours Act legislation, is located ~ 8 km south of CROP. Snapper and blue cod abundances have been monitored within Tawharanui Marine Park using BUV between 1997 and 2000 (Willis et al, 2003a). The Auckland Regional Council has applied for the area to become a Marine Reserve, under the Marine Reserves Act.

In 2007, NIWA Auckland carried out a BUV-only snapper survey in CROP and in adjacent Tawharanui Marine Park (TMP) as part of their snapper tagging project for the Auckland Conservancy. Snapper and blue cod abundances have been monitored within Tawharanui Marine Park using BUV between 1997 and 2000 (Willies et al, 2003a). No fish monitoring has taken place in TMP after the study by Willies et al, 2003 until 2007. UVC surveys for the rest of the demersal fish in CROP Marine Reserve and Tawharanui Marine Park were completed in 2008 (Haggit & Mead, 2008).

This report presents the results of a BUV survey conducted in CROP Marine Reserve and Tawharanui Marine Park between May-June 2007 using identical methodology and design to previous BUV surveys (Willis & Babcock 2000a, Willis et al. 2003b, Taylor et al. 2003, Taylor et al, 2005).

METHODS

SURVEY DESIGN

The BUV sampling of CROP Marine Reserve and Tawharanui Marine Park was done between 28 May to 12 June, 2007 (Parsons, D., NIWA, Auckland). The survey design and methods were identical to those used by Willis et al. (2003b) in past BUV surveys. Survey sites were selected following a randomised block design. However, this survey was extended to include additional sites across Tawharanui Marine Park. A total of 20 areas were surveyed (Fig. 1) across the Leigh sites (6 reserve and 6 non-reserve) and Tawharanui coastline (3 sites inside and 5 sites outside). Four sites per area were selected for video deployments.

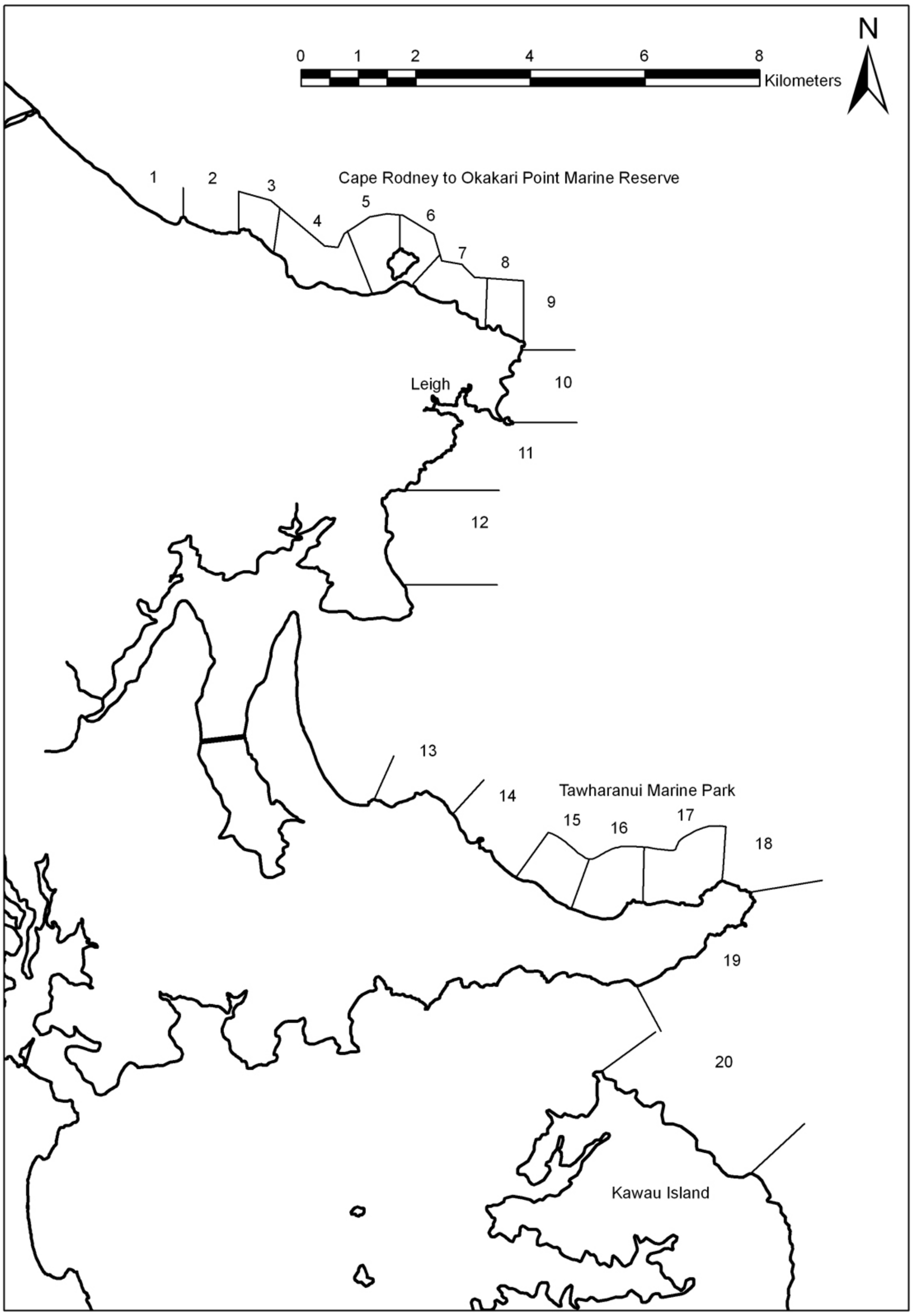

Figure 1. Map of sampling areas in and around the Cape Rodney to Okakari Point Marine Reserve and Tawharanu Marine Park. Blocks 3-8 inside CROP Marine Reserve & blocks 15-17 inside TMP

SURVEY METHOD

Baited underwater video

BUV sampling was done using two cameras deployed from the University of Auckland's R. V. Hawere. Each camera was mounted on a frame with the attached bait holder (Fig. 2). The bait holder contained four pilchards (*Sardinops neopilchardus*) that were broken up to maximise the odour plume, and a fifth whole pilchard was cable-tied to the lid. Fresh baits were used for each replicate. Prior to deployment, location data (including GPS coordinates), depth, and time were written down and filmed so that each video sequence was introduced by this information. The recorder for one of the two camera systems was situated on the anchored Hawere, and connected to the camera by a cable. In the second (new) system, a self-contained Sony digital camcorder in an underwater housing was used, so that it could be dropped and retrieved later via a surface float, with no anchoring of the vessel required. The field of view was the same as for the original BUV system to ensure that results were comparable. The use of a second camera enabled the researchers to reduce field time by running two BUV stations simultaneously. All video sequences were of 30 minutes duration (from the time the unit contacted the seabed) (Willis et al. 2003a).

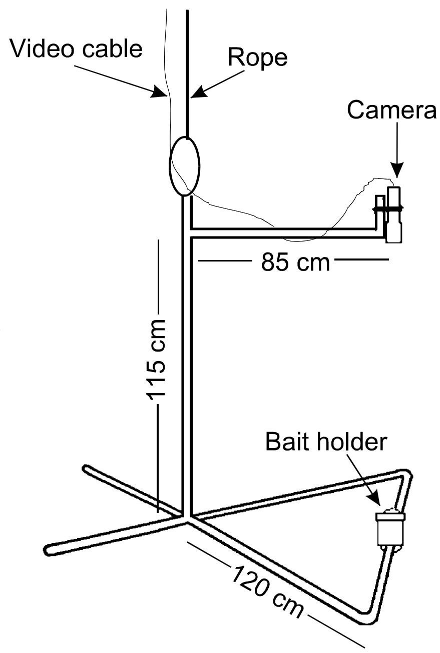

Figure 2. Baited underwater video assembly, with dimensions of the stand.

Analysis of Video Footage

Videotapes were played back on a VCR with a real-time counter, and the number of each species of fish present at the bait enumerated at 30 second intervals. The maximum number of snapper (MAXsna) and the maximum number of blue cod (MAXcod) present at the bait during each 30 min sequence were recorded, as well as the time from deployment at which each count was made (i. e., t_{MAXsna}, t_{MAXcod}). The MAX index has been previously shown to provide the best estimates of snapper and blue cod relative density (Willis & Babcock 2000b, Willis et al. 2000). Individual fish were measured (fork length for snapper, total length for blue cod) by digitising video images using the SigmaScan® image analysis system, and obtaining a three-point calibration (to compensate for wide-angle distortion) for each image using the marks visible on the base quadrat. Measurements were usually only made of those fish present within the quadrat when the count of the maximum number of fish of a given species in a sequence (e. g., MAXsna) was made. The only exception to this rule was where fish were seen elsewhere in the sequence that were obviously different fish, by virtue of size (i. e., differed from MAXsna measurements by > 100 mm). Small snapper that appeared early in the sequence were the most frequent additions to the dataset, but sometimes one or two large fish were measured in this way. While this meant that some fish moving in and out of the field of view might not have been measured, it also avoided repeated measurement of the same individuals.

The ability to measure fish length allowed the acquisition of three forms of snapper relative density data: the maximum number, and the number of fish > or < minimum legal size (e. g., LEGsna, JUVsna) (Willis et al. 2003a).

STATISTICAL ANALYSES

Data for previous years were obtained from Taylor et al, 2005. Three univariate variables of density of snapper i) of all sizes ii) of legal size (> 270 mm fork length) and iii) juveniles (< 270 mm fork length) were estimated as in previous reports. Ratios of densities of snapper between protected and not protected areas were also analysed using generalised linear models (generalised linear models (GLMs, McCullagh & Nelder 1989) as done in the previous reports.

RESULTS

Cape Rodney to Okakari Point Marine Reserve

Snapper *Pagrus auratus*

Total densities of snapper (MAXsna) within the reserve increased slowly from an average of ~12 individuals per BUV drop in four years from autumn 1998 to 14.6 in autumn 2002, the mean density (maximum) increased dramatically to 26.7 individuals per BUV drop in 2003. In autumn 2007, the mean density dropped to 16.8 ± 2.6 (SE) individuals per BUV drop from the last survey (19.0 ± 3.8 (SE)) (Fig. 3a, Table 1a). The mean density outside the reserve in 2005 was 5.3 ± 1.4 individuals per BUV drop which had dropped to 2.83 ± 0.7 in 2007 ((Fig. 3a, Table 1a)). However, legal sized (LEGsna snapper (>270 mm fork length) were 30.2 times more abundant inside the reserve (15.1 ± 2.4 (SE)) than outside (0.5 ± 0.2 (SE)) in 2007 which was a dramatic increase from the ratio of 12.8 observed in 2005 (Fig. 3b, Table 1a). The trend of legal snapper being rare outside the reserve in 2007 is consistent with previous surveys. Densities of undersize snapper (JUVsna) were 1.67 ± 041 (SE) individuals per BUV drop inside the reserve and 2.3 ± 0.6 (SE) individuals per BUV drop outside the reserve, which is also consistent with previous years (Fig.3c, Table 1a).

The spatial distribution of legal snapper across reserve and non-reserve areas sampled in 2007 was broadly consistent with earlier surveys, in that the highest densities occurred near the centre of the reserve, around Goat Island (Fig. 4), and lowest densities were recorded at the western boundary (Area 3). However, the eastern boundary (Area 8) continued to hold reasonable numbers of fish as recorded in previous surveys. Snapper densities are thought to be naturally low in Area 1 because of the limited seaward extent of reef. Areas 2 and 9, however have considerable reef area, but are intensively fished both from boats and the shore (T. J. Willis, pers. obs.). High fishing pressure from these areas is likely to affect reserve areas 3 and 8.

As in previous surveys, the average fork length of snapper inside the reserve in 2007 was over 100 mm greater than that of snapper outside the reserve (Fig. 5, Table 2). In 2005, the mean size of legal snapper were statistically different and higher inside the reserve compared to outside the reserve (Fig. 5, Table 2). A similar trend was apparent in 2007, although there has been an increase in the average size of snapper from both inside and outside the marine reserve since the 2005 survey.

Table 1a. Mean densities of snapper *Pagrus auratus* inside and outside the Cape Rodney to Okakari Point Marine Reserve, from 2000-2007 BUV surveys. Statistically significant (P < 0.05) ratios of reserve (R) to non-reserve (NR) densities are denoted by *. MAXsna = all fish, LEGsna = fish > 270 mm fork length, and JUVsna = fish < 270 mm fork length.

Survey	Density measure	Reserve mean	Non-reserve mean	R:NR ratio	Lower 95% CL for ratio	Upper 95% CL for ratio
Spring 2000	MAXsna	9.00	7.57	1.19	0.62	2.28
	LEGsna	4.23	0.05	88.77*	4.78	1646.98
	JUVsna	4.77	7.52	0.63	0.30	1.35
Autumn 2001	MAXsna	13.42	6.67	2.01*	1.12	3.62
	LEGsna	7.79	0.75	10.39*	3.84	28.07
	JUVsna	5.62	5.91	0.95	0.47	1.91
Spring 2001	MAXsna	7.08	4.09	1.73	0.87	3.45
	LEGsna	6.17	0.87	7.09*	2.51	20.06
	JUVsna	0.91	3.22	0.28*	0.11	0.76
Autumn 2002	MAXsna	14.58	5.62	2.59*	1.49	4.52
	LEGsna	10.33	0.79	13.05*	4.47	38.10
	JUVsna	4.24	4.83	0.88	0.46	1.17
Autumn 2003	MAXsna	26.67	4.08	6.53*	4.12	10.36
	LEGsna	21.92	0.79	27.69*	11.56	66.32
	JUVsna	4.75	3.29	1.44	0.82	2.54
Autumn 2005	MAXsna	19.04	5.29	3.60*	2.17	5.96
	LEGsna	16.54	1.29	12.81*	5.89	27.85
	JUVsna	2.50	4.00	0.63	0.28	1.38
Autumn 2007	MAXsna	16.75	2.83	5.59*	2..89	12.05
	LEGsna	15.08	0.50	30.16*	7.47	121.73
	JUVsna	1.67	2.33	0.71	0.35	1.45

Table 2. Mean sizes of snapper *Pagrus auratus* inside and outside the Cape Rodney to Okakari Point Marine Reserve, from 2000-2007 BUV surveys. Statistically significant ($P < 0.05$) differences are denoted by *. N = number of fish.

Survey	Reserve mean fork length (mm)	N: Reserve	Non-reserve mean fork length (mm)	N: Non-reserve	Difference between means (mm)	95% CI
<u>All snapper</u>						
Spring 2000	288.9	197	148.8	159	140.2*	24.9
Autumn 2001	307.7	322	203.5	160	104.1*	18.8
Spring 2001	389.2	165	217.9	94	171.3*	25.4
Autumn 2002	328.8	342	214.4	135	114.4*	19.1
Autumn 2003	351.6	640	242.1	98	109.5*	20.1
Autumn 2005	391.5	457	241.9	127	149.6*	22.7
Autumn 2007	404.1	399	197.8	68	206.3*	35.8
<u>Legal snapper</u>						
Spring 2000	410.6	96	278.0	1	132.6	269.1
Autumn 2001	374.2	187	333.5	18	40.7	47.8
Spring 2001	410.5	145	310.0	21	100.4*	45.9
Autumn 2002	371.3	242	300.3	19	71.1*	45.5
Autumn 2003	377.4	526	343.2	19	34.2	40.1
Autumn 2005	417.8	397	294.6	31	123.2*	41.2
Autumn 2007	422.8	306	312.3	12	110.48*	45.7

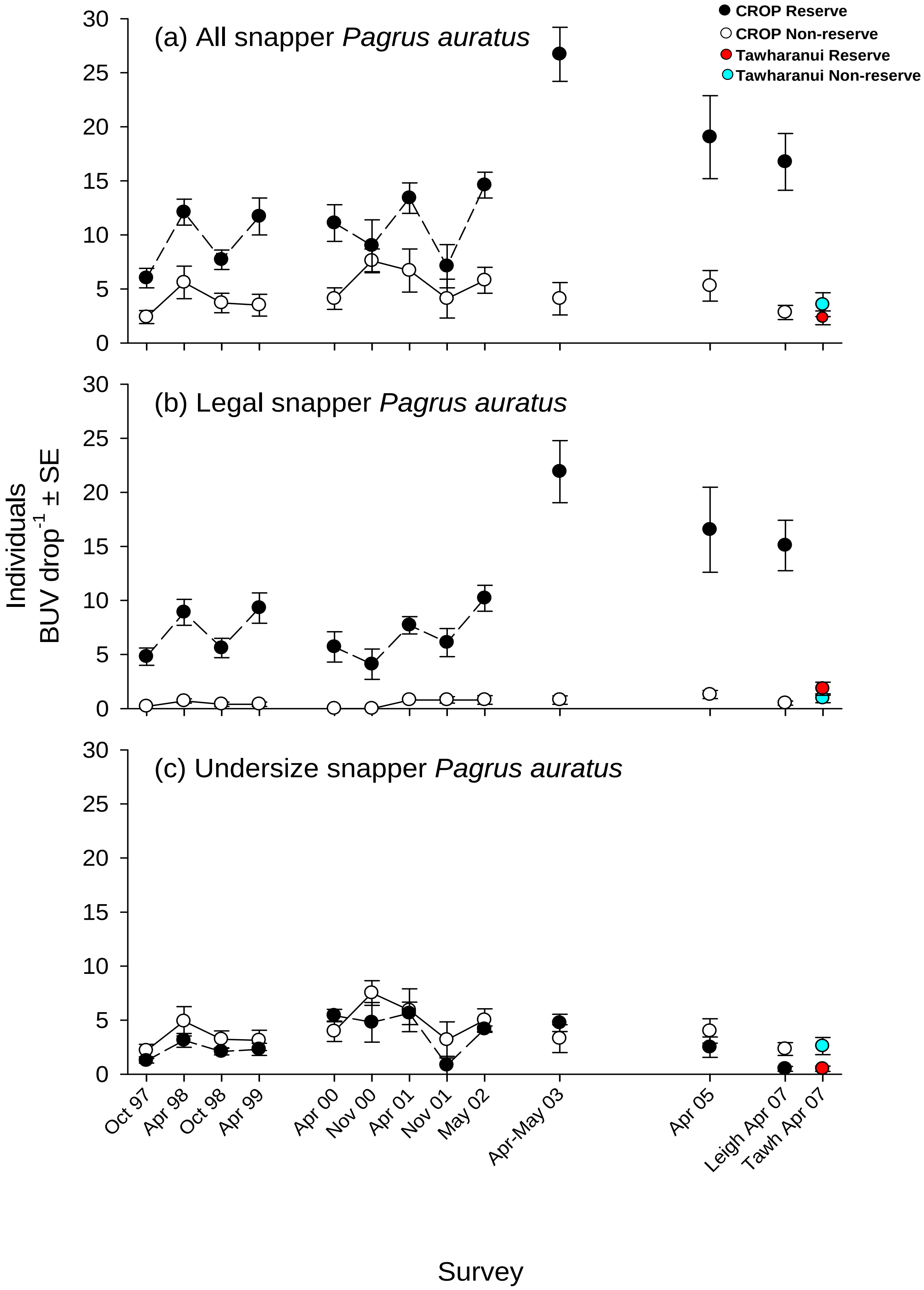

Figure 3. Long term trends in the relative density of snapper *Pagrus auratus* inside and outside the Cape Rodney to Okakari Point Marine Reserve and Tawharanui Marine Park, as measured using BUV. (a) All snapper (MAXsna), (b) Legal-size (> 270 mm fork length) snapper, (c) undersize snapper (< 270 mm fork length).

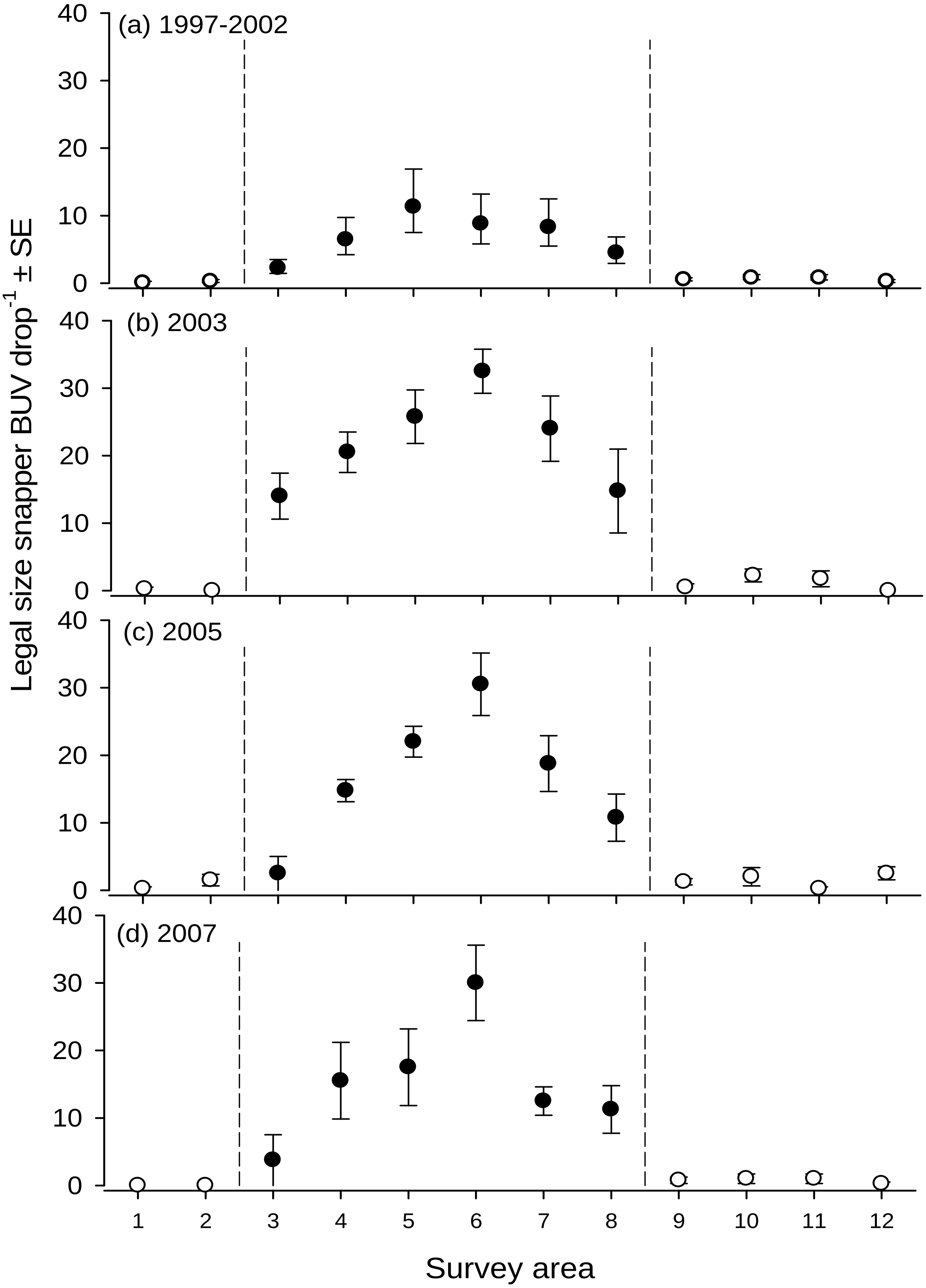

Figure 4. Relative density of legal-size snapper *Pagrus auratus* within the twelve survey areas, based on (a) modelled data from nine BUV surveys (October 1997–May 2002), and BUV data from 2003 (b),2005 (c) and 2007 (d). Closed symbols are within the reserve, open symbols are fished areas. Dashed vertical lines indicate reserve boundaries.

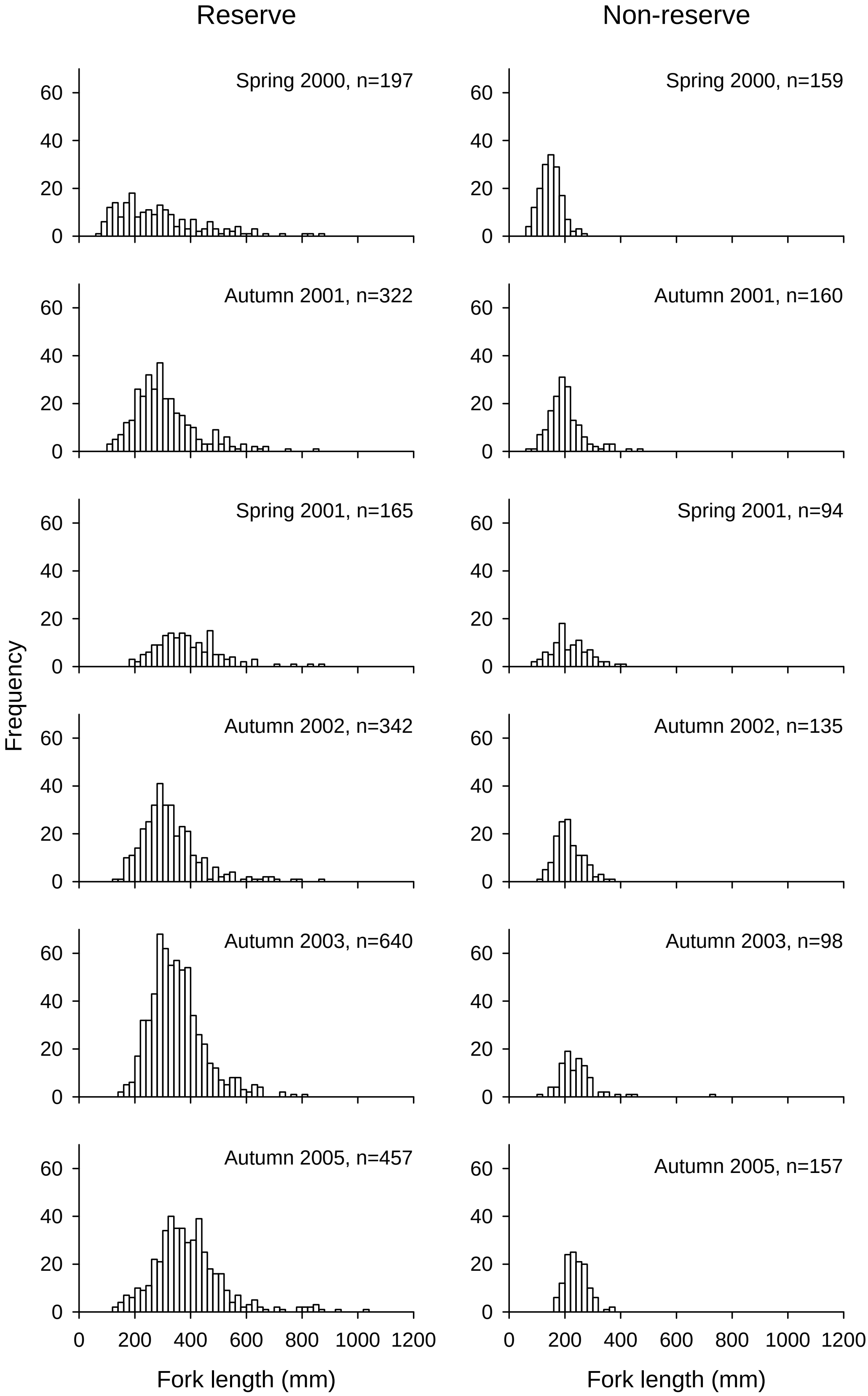

Figure 5a. Size frequency distributions of snapper *Pagrus auratus* inside and outside the Cape Rodney to Okakari Point Marine Reserve from 2000-2005, as measured using BUV

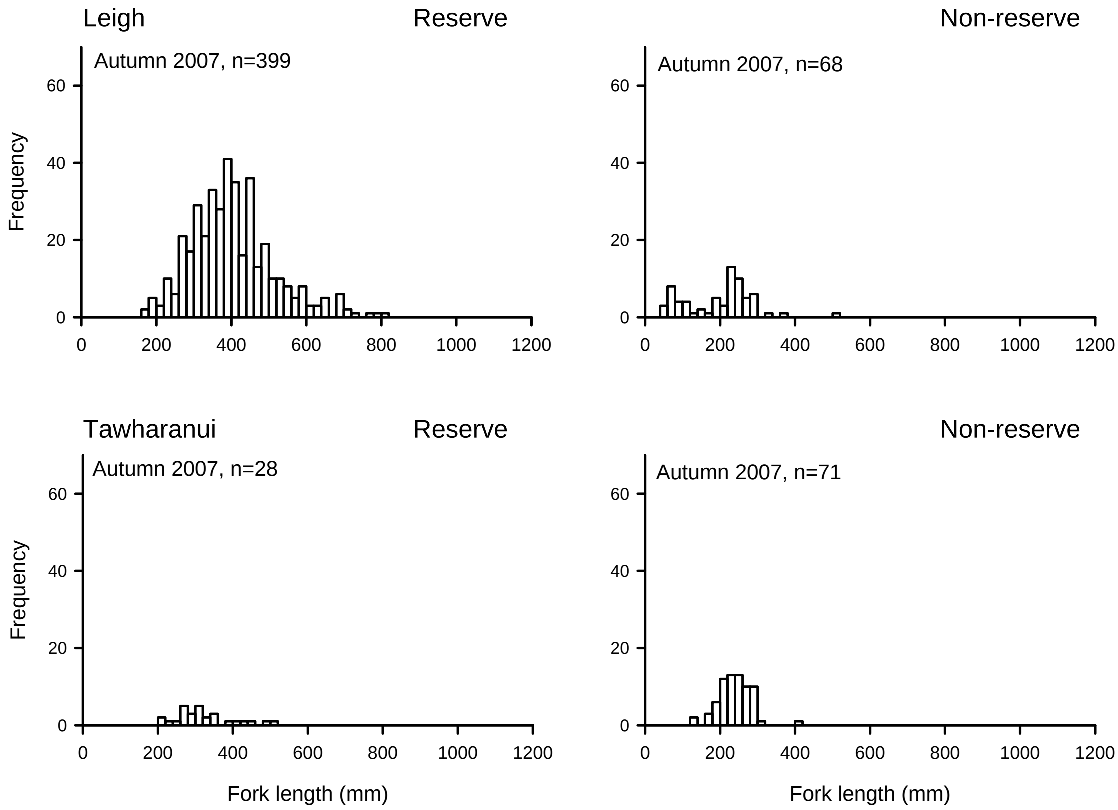

Figure 5b. Size frequency distributions of snapper *Pagrus auratus* inside and outside the Cape Rodney to Okakari Point Marine Reserve and inside and outside the Tawharanui Marine Park as measured using BUV.

Blue cod *Parapercis colias*

The average blue cod density inside the reserve dropped from 0.88 (2005) to 0.54 in 2007, but increased outside from 0.17 (2005) to 0.33 in 2007 (Table 3a). While the average blue cod density remained higher inside the reserve than outside the difference was not statistically significant (Fig.6a, Table 3a).

As in previous surveys, blue cod within the reserve were, on average, larger (321.6) than outside (234.8) the reserve, although the difference was not statistically significant (Table 4).

Table 3a. Mean densities of blue cod *Parapercis colias* inside and outside the Cape Rodney to Okakari Point Marine Reserve, from 2000-2007 BUV surveys. Statistically significant (P < 0.05) ratios of reserve (R) to non-reserve (NR) densities are denoted by *.

Survey	Reserve mean	Non-reserve mean	R:NR ratio	Lower 95% CL for ratio	Upper 95% CL for ratio
Spring 2000	0.64	0.14	4.45*	0.94	21.08
Autumn 2001	0.50	0.04	12.00*	2.02	71.36
Spring 2001	0.46	0.00	∞*		
Autumn 2002	0.42	0.13	3.33*	1.22	9.90
Autumn 2003	0.79	0.00	∞*		
Autumn 2005	0.88	0.17	5.25*	1.42	19.40
Autumn 2007	0.54	0.33	1.62	0.54	4.85

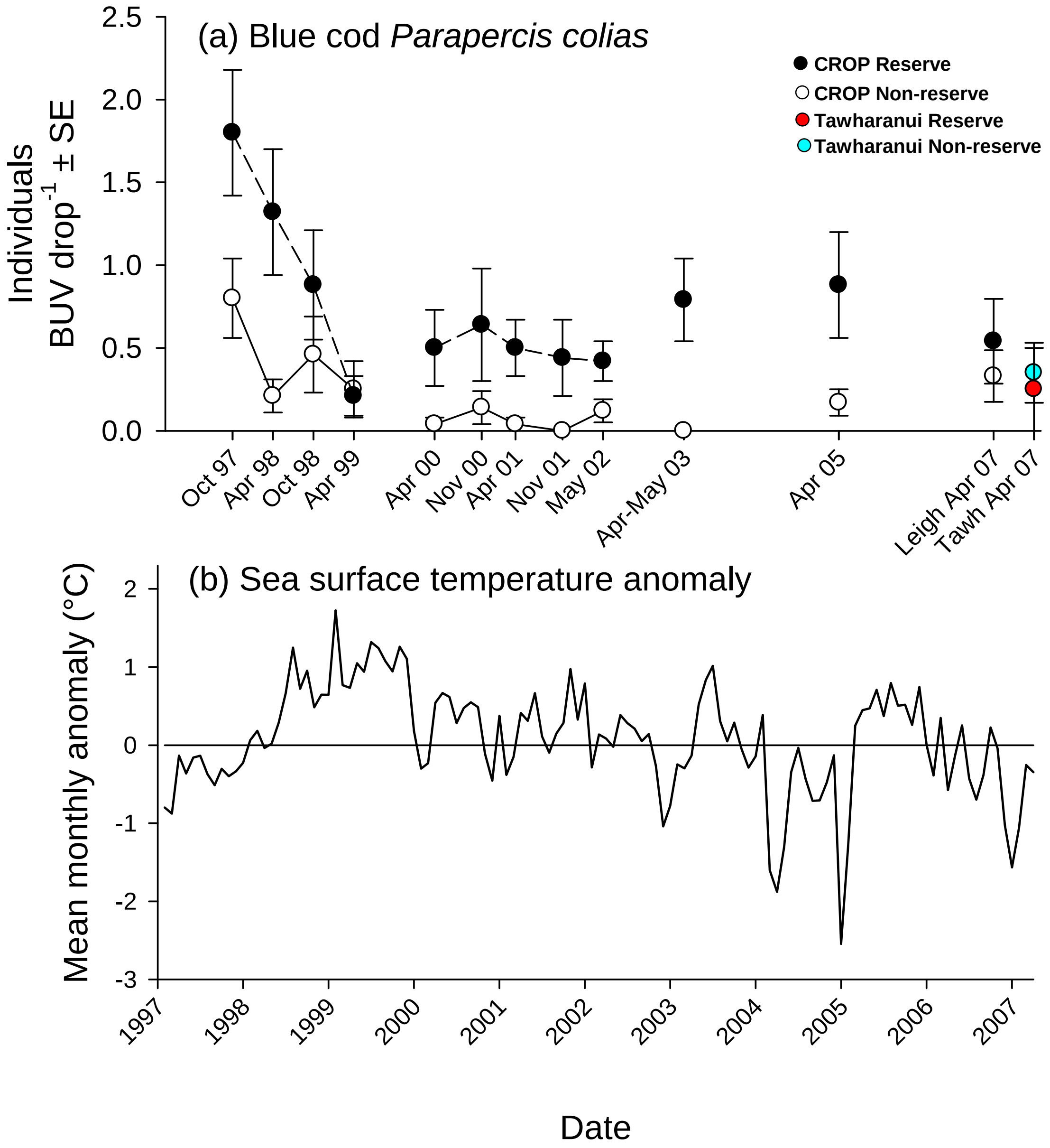

Figure 6. (a) Long term trends in the density of blue cod *Parapercis colias* inside and outside the Cape Rodney to Okakari Point Marine Reserve and inside and outside the Tawharanui Marine Park only in 2007, as measured using BUV. (b) Sea surface temperature anomalies (from long term average 1967-96).

Table 4a. Mean sizes of blue cod *Parapercis colias* inside and outside the Cape Rodney to Okakari Point Marine Reserve, from 2000-2007 BUV surveys. Statistically significant (P < 0.05) differences are denoted by *. N = number of fish.

Survey	Reserve mean fork length (mm)	N: Reserve	Non-reserve mean fork length (mm)	N: Non-reserve	Difference between means (mm)	95% CI
Spring 2000	314.0	14	242.7	4	71.2	75.8
Autumn 2001	257.2	12	117.0	1	140.2	-
Spring 2001	282.9	11	-	0	-	-
Autumn 2002	257.6	11	197.7	3	60.0	66.6
Autumn 2003	322.9	19	-	0	-	-
Autumn 2005	284.2	21	259.8	4	24.5	90.33
Autumn 2005	321.6	13	234.8	8	86.9	92.2
Autumn 2007	315.2	11	259.2	10	55.9	94.6

TAWHARANUI MARINE PARK

Snapper *Pagrus auratus*

There were no statistically significant differences in the mean densities of snapper inside and outside the Tawharanui Marine Park (Table1b). Except for legal-sized (LEGsna)snapper density, other mean densities were slightly higher outside the park than inside (Table 1b, Fig.3) and overall MAXsna in the park were approximately 4-fold lower than within CROP (Table 1b, Fig. 3).

Despite Area 14 having the highest density of legal-sized snapper of all areas surveyed (irrespective of status) the spatial distribution pattern of legal snapper abundance was not apparent inside the park, as is continually evident in CROP, i.e., higher legal-sized occur in the middle of the reserve with progressively lower densities towards the reserve boundary. Densities were consistently < 5 individuals per BUV drop across sites (Fig. 7).

Despite a higher abundance of snapper (MAXsna) in areas outside of the park , average fork length of snapper inside the park was relatively greater than that of snapper outside the park (Table 2b),

Table 1b. Mean densities of snapper *Pagrus auratus* inside and outside the Tawharanui Marne Park for the 2007 BUV survey. Statistically significant (P < 0.05) ratios of reserve (R) to non-reserve (NR) densities are denoted by *. MAXsna = all fish, LEGsna = fish > 270 mm fork length, and JUVsna = fish < 270 mm fork length.

Survey	Density measure	Reserve mean	Non-reserve mean	R:NR ratio	Lower 95% CL for ratio	Upper 95% CL for ratio
Autumn 2007	MAXsna	2.33	3.55	0.66	0.56	4.07
	LEGsna	1.83	0.95	1.92	0.70	5.29
	JUVsna	0.50	2.6	0.19	1.08	24.90

Table 2b. Mean sizes of snapper *Pagrus auratus* inside and outside the Tawharanui Marne Park for the 2007 BUV survey. Statistically significant (P < 0.05) differences are denoted by *. N = number of fish.

Survey	Reserve mean fork length (mm)	N: Reserve	Non-reserve mean fork length (mm)	N: Non-reserve	Difference between means (mm)	95% CI
<u>All snapper</u>						
Autumn 2007	323.2	28	239.6	71	83.6	26.7
<u>Legal snapper</u>						
Autumn 2007	346.8	22	312.3	19	53.6	39.2

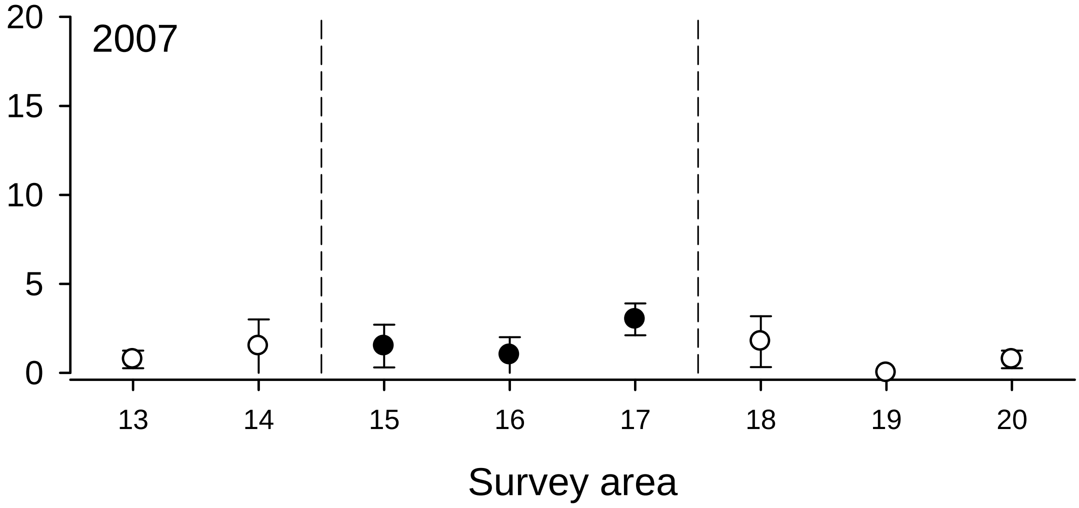

Figure 7. Relative density of legal-size snapper *Pagrus auratus* within the eight survey areas inside and outside Tawharanui marine park in 2007, based on modelled data. Closed symbols are within the reserve, open symbols are fished areas. Dashed vertical lines indicate park boundaries.

Blue cod *Parapercis colias*

There was no significant difference in the mean densities of blue cod inside and outside the Tawharanui marine park (Table 3b). The average fork length of blue code inside the park was about 100 mm greater than that of fish outside the park (Table 4b).

Table 3b. Mean densities of blue cod *Parapercis colias* inside and outside the Tawharanui Marien Park, for the 2007 BUV survey. Statistically significant ($P < 0.05$) ratios of reserve (R) to non-reserve (NR) densities are denoted by *.

Survey	Reserve mean	Non-reserve mean	R:NR ratio	Lower 95% CL for ratio	Upper 95% CL for ratio
Autumn 2007	0.25	0.35	0.71	0.12	1.67

Table 4b. Mean size of blue cod *Parapercis colias* inside and outside the outside the Tawharanui Marine Park, for the 2007 BUV survey. Statistically significant (*P* < 0.05) differences are denoted by *. N = number of fish.

Survey	Reserve mean fork length (mm)	N: Reserve	Non-reserve mean fork length (mm)	N: Non-reserve	Difference between means (mm)	95% CI
Autumn 2007	279.3	3	178.7	7	100.6	52.7

DISCUSSION

The findings from this survey were consistent with previous surveys and showed that there are differences in mean abundance and size of snapper and blue cod between Cape Rodney to Okakari Point Marine Reserve and non-reserve (control) areas. These differences also demonstrate clearly that snapper and blue cod show positive responses to protection. On the other hand, there was no difference in snapper and blue cod abundance inside and outside Tawharanui Marine Park, although the average fork length of snapper and blue cod was relatively greater inside the park than outside. Despite a lack of differences, further ongoing surveys in the Tawharanui Marine Park are warranted to understand spatial patterns within the reserve relative to non-reserve areas

Within CROP, the mean density of legal snapper dropped to 16.8 ± 2.6 (SE) individuals per BUV drop during this survey from the last 2005 survey (19.0 ± 3.8 (SE)) individuals per BUV. Despite the fluctuation in legal snapper density with the peak in 2003, the density inside the reserve remains above the level recorded in autumn 1998 (Willis et al. 2003b). However, the mean density of snapper recorded using BUV from 1997- 2007 indicates that snapper densities within the reserve have not yet stabilised and are likely to be dependent on the seasonal movement in and out of the reserve and the consequential influence of variation in the wider stock due to factors such as recruitment and fishing (Taylor et al, 2005).

The spatial distribution of legal snapper across reserve and non-reserve areas sampled in 2007 was broadly consistent with earlier surveys, in that the highest densities occurred near the centre of the reserve and lowest densities at the western boundary of the reserve. This might be a response to (i) differences in habitat quality, (ii) hand feeding of fish by the public, or (iii) higher levels of surveillance at the reserve centre as suggested by Cole (1994). Alternatively, lower snapper abundances near the boundaries of the reserve may be due to the increased probability that a snapper home range may overlap the reserve boundary as it is located further away from the reserve centre. This suggests that snapper residing within the reserve, but near the boundary, may leave the reserve at times. As a result these snapper will be exposed to some fishing pressure, hence reducing abundance near the boundaries relative to the centre of the reserve.

The average blue cod density during this survey dropped from the 2005 survey. As noted in previous surveys, there was no indication in the trend for a return to the high level measured in 1997. Willis et al. (2003b) suggested that the steep decline in average blue cod density from 1997 to 1999 might be attributable to increasing sea surface temperatures during that period, because blue cod are essentially a “southern” species presumably better suited to cooler waters. A much longer time-series is required to test the hypothesis that there is a negative correlation of blue cod densities with sea surface temperature, but the data thus far are broadly consistent with it, in that densities declined during the warming period of 1997-1999, were constant while temperature was constant from 2000-2002, and have increased slightly while the temperature dropped from 2003-2005.

There was no apparent trend in the mean densities of snapper and blue cod between the Tawharanui Marine Park and non-reserve areas in 2007, which mirror the findings of Willis et al (2003a), who carried out BUV surveys between 1997-1998. Legal-sized snapper densities were slightly higher inside the park (areas 15, 16 & 17) in the previous study compared to the current survey. However, there is no obvious explanation for this change in the densities inside the park. A further time-series data collection is needed to understand the changes occurring in areas within and adjacent to the TMP. The mean densities of snapper and blue cod in Tawharanui Marine Park were much lower compared to the densities recorded in CROP Marine Reserve in the current and previous surveys. In addition, a spatial trend of higher numbers in central areas of the reserve relative to boundary areas (as is consistently seen in CROP data) was not apparent at TMP. This may be due to insufficient spatial resolution in the survey design for TMP and a positive directive would be to increase the sampling areas inside the park to six areas for future surveys.

The UVC study of Haggitt & Mead (2008) within TMP recorded a slight increase in the mean snapper abundance inside the park than outside, but the difference was not statistically significant. However, this study also reported that larger (legal-sized snapper) displayed diver-negative responses during their survey and suggested that this behaviour could have contributed to a degree of underestimation of snapper numbers. There is a possibility that snapper might have shown a negative response to BUV methodology as the snapper population in the TMP may not be accustomed to this equipment.

The BUV surveys conducted to date, in the same season using the same methodology enabled us to compare the data among the surveys to understand the protection benefits for snapper and blue cod especially in CROP Marine Reserve. This ongoing monitoring programme clearly indicates a need for standardization of the timing of surveys and the methodology to help us determine reserve effects.

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