Commercial catch sampling for length and age of gemfish, alfonsino and rubyfish in QMA 2 in the 2006–07 and 2007–08 fishing years

P. L. Horn
C. P. Sutton

NIWA
Private Bag 14901
Wellington 6241

New Zealand Fisheries Assessment Report 2009/19
April 2009

Published by Ministry of Fisheries
Wellington
2009

ISSN 1175-1584

Horn, P.L.; Sutton, C.P. (2009).
Commercial catch sampling for length and age of gemfish, alfonsino and rubyfish in QMA 2 in the 2006–07 and 2007–08 fishing years.
New Zealand Fisheries Assessment Report 2009/19. 38 p.

This series continues the informal
New Zealand Fisheries Assessment Research Document series
which ceased at the end of 1999.

EXECUTIVE SUMMARY

Horn, P.L.; Sutton, C.P. (2009). Commercial catch sampling for length and age of gemfish, alfonsino and rubyfish in QMA 2 in the 2006–07 and 2007–08 fishing years.

***New Zealand Fisheries Assessment Report 2009/19*. 38 p.**

This report describes the sampling programme carried out on commercial landings of gemfish (*Rexea solandri*) in SKI 2, alfonsino (*Beryx splendens*) in BYX 2, and rubyfish (*Plagiogeneion rubiginosum*) in RBY 2, during the 2006–07 and 2007–08 fishing years, and the subsequent estimates of catch-at-age for these fisheries.

Most gemfish in SKI 2 were taken when target trawling for gemfish, tarakihi, or rubyfish. However, the reported level of targeting for gemfish was much higher in 2006–07 than in 2007–08. Most landings were taken between November and January; sampling in both years covered the landings peak. The target number of samples was achieved in 2007–08, but not in 2006–07. The mean weighted c.v. over all age classes was 38% in 2006–07 and 39% in 2007–08, both higher than the target of 30%. The commercial catch was dominated by fish aged between 2 and 8 years, which is generally consistent with previous years. However, in 2007–08, the proportions of 2 and 3 year old fish were higher than in almost all previous samples. The population now appears to comprise a wide range of year classes, each with approximately equal strength. This contrasts with pre-2005 distributions where a small number (1–4) of year classes were clearly dominant. The market sampling probably provides a good representation of the total catch.

Alfonsino from BYX 2 were taken predominantly as a target catch. In 2006–07, significant landings were spread throughout the year, which contrasts with the fisheries from 1998 to 2001 and in 2007–08, when most significant landings occurred at the start of the fishing year. The target number of samples was achieved in both years, and a high proportion of the landed catch was sampled. The mean weighted c.v. over all age classes was 18% in 2006–07 and 16% in 2007–08, lower than the target of 30%. In both sampled years, fish aged from 3 to 8 years were abundant in the catch, but with a strong mode at ages 4 and 5. There is a clear difference in the age distributions of the catch from the earlier (1998–2001) and later (2006–2008) sampling periods, but the reason for this is not clear. In the earlier samples, ages 5–9 dominated the catch. However, consistencies within both the earlier and later sampling periods suggest that the sampling may be producing a reasonable representation of the total catch. Instantaneous fishing mortality is estimated to have increased over time throughout the extended sampling period (i.e., 1998 to 2008).

Significant rubyfish landings from RBY 2 were taken sporadically throughout both sampled years, with few trawl tows reporting rubyfish as the target species. In 2007–08, three landings produced about 75% of the total catch, but none of these were sampled. The target number of samples was not achieved in either year. The mean weighted c.v. over all age classes was 101% in 2006–07 and 80% in 2007–08, much higher than the target of 30%. Neither distribution was considered to be sufficiently precise or representative of the total landings to allow any sound conclusions to be drawn on the catch composition.

1. INTRODUCTION

This document reports the results of Objectives 1 and 2 of Ministry of Fisheries Project INS2005-01. The project objectives were as follows.

1. To conduct sampling in fish processing sheds and determine the length and age composition of the commercial catch of alfonsino in BYX 2, gemfish in SKI 2, and rubyfish in RBY 2 during the 2006–07 fishing year. The target coefficient of variation (c.v.) for the catch at age is 30% (mean weighted c.v. across all age classes).
2. To conduct sampling in fish processing sheds and determine the length and age composition of the commercial catch of alfonsino in BYX 2, gemfish in SKI 2, and rubyfish in RBY 2 during the 2007–08 fishing year. The target coefficient of variation (c.v.) for the catch at age is 30% (mean weighted c.v. across all age classes).

This report fulfils the reporting requirements of Objective 2 of project INS2005-01. A preliminary report on Objective 1 was completed previously (Horn 2008), but the results from the 2006–07 fishing year are repeated here, with additional details and analyses.

Sampling of gemfish for length, sex, and age.
Gemfish are caught in coastal waters around mainland New Zealand in depths ranging from 50 to 550 m. SKI 2 (Figure 1) supported an important trawl fishery through the late 1980s to early 1990s, with annual landings peaking at over 1200 t. The TACC was 1300 t in the early 1990s, but this was reduced first in 1997–98, and again in 2000–01 to its current level of 240 t as the stock assessment indicated declining abundance. The SKI 2 fishery occurs primarily on non-spawning fish from October to April. Gemfish catches are minimal from May to September and it is assumed that adult fish migrate at this time to spawn in the northern waters of SKI 1 (Horn & Hurst 1999). Sampling of the commercial SKI 2 catch began in the 1995–96 fishing year, and was conducted annually up to 2004–05 (Horn et al. 2006). Sampling did not occur in 2005–06, but was conducted again in 2006–07 (Horn 2008). This report presents the length and age structure of gemfish caught in SKI 2 during the 2006–07 and 2007–08 fishing years, and compares these results with those from previous years.

Sampling of alfonsino for length, sex, and age.
Alfonsino are primarily associated with undersea structures such as the seamounts that occur off the lower east coast of the North Island (BYX 2) and on the Chatham Rise (BYX 3), in depths from 300–600 m (Figure 2). The TACC for BYX 2 has been about 1570 t since the 1993–94 fishing year. Annual landings have exceeded the TACC in all but two years since then, generally by 70–300 t. Landings have fluctuated between 1262 and 1868 t annually since 1985–86. Currently, most of the BYX 2 catch is taken by the target bottom and midwater trawling. The fishery tends to be most active at the start of the fishing year (i.e., October–January), but significant landings can occur in any month. Sampling of the commercial BYX 2 catch occurred previously in the three fishing years from 1998–99 to 2000–01 (Blackwell et al. 2002), and in 2006–07 (Horn 2008). This report presents the length and age structure of alfonsino caught in BYX 2 during the 2006–07 and 2007–08 fishing years, and compares these results with those from previous years.

Sampling of rubyfish for length, sex, and age.
Rubyfish catches were first reported in 1982–83. In 1990–91, 245 t was landed, mainly as bycatch in the trawl fisheries for alfonsino, gemfish, barracouta, hoki, and jack mackerel. Landings peaked at 735 t in 1995–96, and in subsequent years catches have fluctuated between 250 and 550 t. The level of direct targeting on rubyfish has increased over the history of the fishery. The main rubyfish grounds are the banks or 'hills' off the east coast of the North Island in QMA 2 (Figure 3), but rubyfish is also targeted in the Bay of Plenty. Since 2000–01 landings in RBY 2 have exhibited a declining trend, but have increased steadily in RBY 1 since 2003–04. In 2006–07 the RBY 1 landings exceeded the RBY 2 landings for the first time. Current TACCs are 433 t for RBY 2 and 300 t for RBY 1. Rubyfish data and otoliths from RBY 2 were collected in 1998–99, 1999–2000, and 2000–01 (Blackwell et al. 2002). Preliminary ageing was carried out using otoliths from the first two years, but further ageing was

postponed while work to validate the age of rubyfish was conducted. The validation project confirmed the preliminary rubyfish age estimates (Paul et al. 2004). Sampling was recommenced in 2006–07 (Horn 2008). This report presents the age structure of rubyfish caught in RBY 2 during the 2006–07 and 2007–08 fishing years, and compares these results with those from previous years.

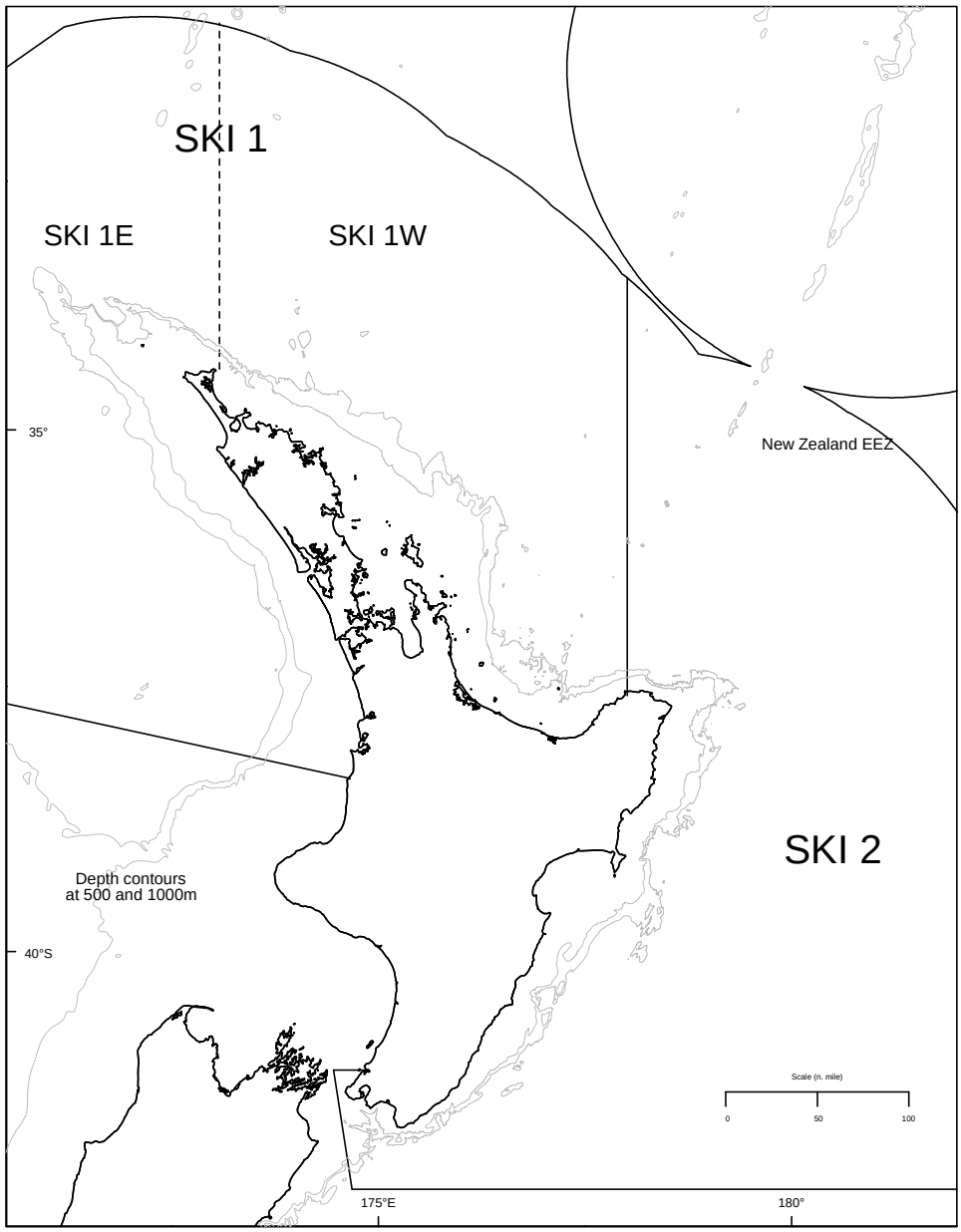

Figure 1: Definitions for the northern gemfish fisheries used in this report.

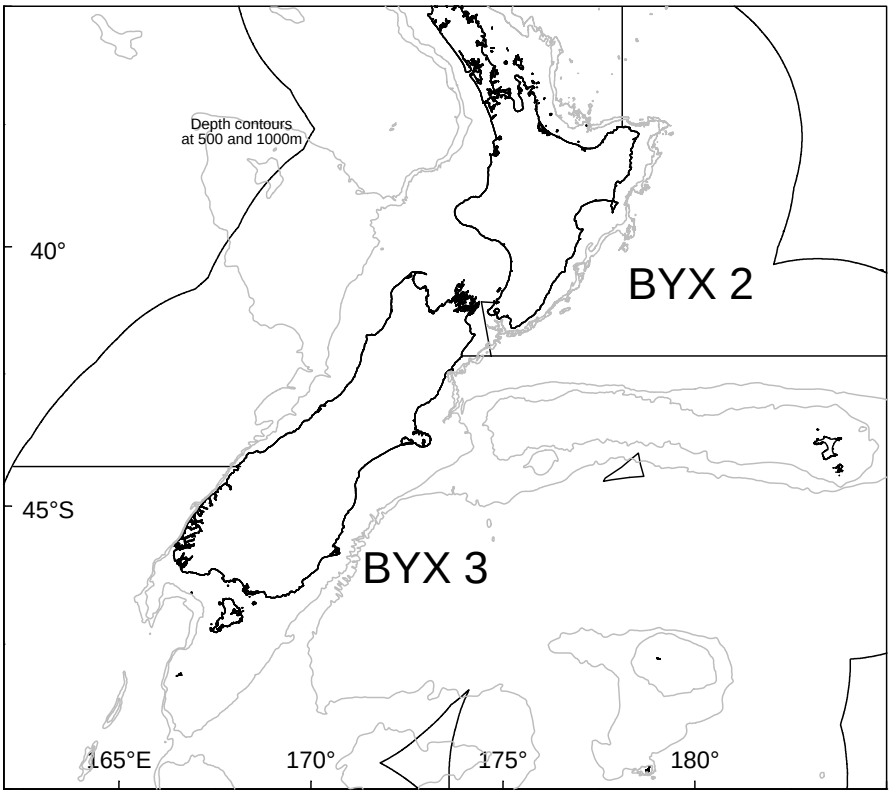

Figure 2: Definitions for the alfonsino fisheries used in this report.

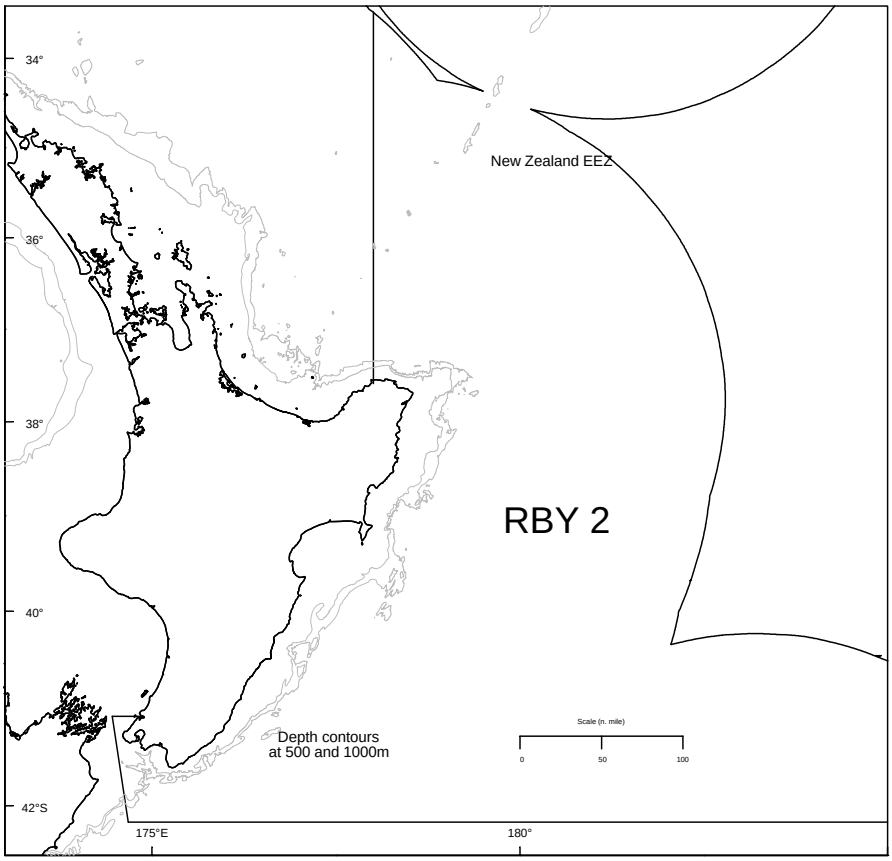

Figure 3: Definitions for the rubyfish fishery used in this report.

2. METHODS

2.1 Sampling of gemfish for length, sex, and age.

Data from 11 years of sampling SKI 2 were examined to estimate the required sampling effort to achieve a mean weighted target c.v. of 30% for the numbers at age. From the previous years, the mean (and range) of the number of samples collected, number of fish aged, and resulting c.v.s are: 14 (9–21) samples, 507 (371–698) ages, c.v. of 25% (13–38%). Consequently, in each fishing year, we planned to collect 15 samples, which would provide between 650 and 750 otolith pairs. Within each sample, up to 50 fish were randomly selected, measured to the nearest centimetre below fork length, sexed, and otoliths taken. A landing of gemfish qualified for sampling if we were informed that it was trawl-caught, taken entirely within SKI 2, and was of sufficient weight to probably comprise at least 50 fish.

In previous years, sampling strata had been based on vessels (Horn et al. 2006). A set of 10 key trawlers that had accounted for around two-thirds of the SKI 2 catch was identified and allocated as one stratum. All other vessels catching gemfish by any method were collectively grouped as another stratum. However, since 2004–05, some of these vessels had left the area or had stopped targeting gemfish. Also, we were warned by fishing representatives that most of the SKI 2 catch was likely to be taken as a trawl bycatch of other target species, and consequently, that most landings were likely to be relatively small. For 2006–07, two sampling strata were defined, based on time of year. The first stratum comprised October–December 2006, and contained a landings (and sampling) peak from mid October to mid November. The second stratum comprised January–September 2007, and contained a landings (and sampling) peak in January. For 2007–08, two sampling strata were defined, also based on time of year. The first stratum comprised October 2007–February 2008, and contained a landings peak in November–December. The second stratum comprised March–September 2008, and contained a landings peak in April–May. A third stratum, comprising line-caught gemfish, was also incorporated in the 2007–08 analysis (because, post sampling, one sampled landing was identified as being caught by this method).

All the otoliths collected from the market sampling, plus an additional 12 otoliths collected by observers from the SKI 2 fishery in 2006–07, were aged. Ageing was completed using the method of Horn & Hurst (1999). Before reading, otoliths were soaked in water for up to 1 hour to clarify the zonation pattern. Otoliths immersed in water against a dark background were illuminated by reflected light and examined under a binocular microscope at ×10 magnification. The number of translucent zones (which appear dark using this examination technique) was counted wherever the pattern was clearest on the posterior end of the distal otolith surface. The number of complete translucent zones (i.e., translucent zones with opaque material on both sides) was taken as the age of the fish.

Catch-at-age and catch-at-length estimates were produced using NIWA's 'catch-at-age' software (Bull & Dunn 2002). The software scaled the length frequency of fish from each landing up to the landed weight from that trip, and the sum of the distributions from each landing is then scaled up to the total landed weight for the fishing year. The landed catch from each year was determined from an extract provided by the Ministry of Fisheries in the December following fishing year completion. The age-length-sex data were used to generate an age-length-sex key, through which length data were passed to produce numbers-at-age by sex.

The precision of each length or age frequency was measured by the mean weighted c.v. This was calculated as the average of the c.v.s for the individual length or age classes weighted by the proportion of fish in each class. The c.v.s were calculated by bootstrapping: fish were resampled 300 times with replacement within each landing, and otoliths were randomly resampled from the entire set.

2.2 Sampling of alfonsino for length, sex, and age.

The catch sampling programme aimed to collect 15 samples per fishing year from the BYX 2 fishery. In each sample, 50 randomly chosen fish were measured to the nearest centimetre below fork length, sexed, and had their otoliths removed. For each year this would provide about 750 otoliths (assuming 15 samples) from which the age-length key for the BYX 2 fishery can be developed. This level of sampling intensity in three previous years had consistently produced catch-at-age distributions with mean weighted c.v.s lower than 30% (Blackwell et al. 2002). In previously sampled years, a small number of vessels had taken the bulk of the BYS 2 catch over a relatively short period near the start of the fishing year (Blackwell et al. 2002). Consequently, a single sampling stratum was defined for the 2006–07 and 2007–08 fishing years. A landing of alfonsino qualified for sampling if we were informed that it was trawl-caught, taken entirely within BYX 2, and was of sufficient weight to comprise at least 50 fish.

Massey & Horn (1990) noted that although alfonsino growth rates from different grounds were not statistically different, the age composition of samples from different grounds was different and therefore it is desirable to be able to identify catches from different grounds. Attempts to allocate samples to grounds were not successful in 1998–99, 1999–2000, and 2000–01, and this process appears to be impractical. Most vessels fish more than one ground during a trip and fish boxes may be mixed during stowing the catch, unloading onto trucks, and unloading and stowing in coolrooms at processing plants. Labelling individual boxes by vessel staff would be necessary to identify grounds and would be difficult to reliably organise and implement.

Fish ageing was carried out using the methods of Massey & Horn (1990). All collected otoliths were aged. Whole, untreated otoliths were immersed in water against a dark background, illuminated by reflected light, and examined under a binocular microscope at ×10 magnification. The number of translucent zones (which appear dark using this examination technique) was counted wherever the pattern was clearest. The number of complete translucent zones (i.e., translucent zones with opaque material on both sides) was taken as the age of the fish.

Catch-at-age and catch-at-length estimates were produced using NIWA's 'catch-at-age' software as described above for gemfish.

2.3 Sampling of rubyfish for length, sex, and age.

As in previous years, rubyfish samples were difficult to obtain because of the small number of landings and because of reluctance by processing sheds to allow fish to be sampled. This species is often sold whole, so cutting the fish lowers its value. The fish also spoil quite rapidly, so landings are quickly on-sold. Rubyfish are long-lived with the fishery dominated by 8–28 year old fish (Horn et al. 2004), so relatively intensive sampling is required to achieve the target c.v.

The sampling programme aimed to collect 20 samples per fishing year. Each sample was to comprise 50 fish, which were randomly selected, measured to the nearest centimetre below fork length, and sexed. Otoliths were collected from all fish in each sample. This would provide about 1000 otoliths (assuming 20 samples) from which the age-length key for the RBY 2 fishery can be developed. Previous sampling (1998–99 to 2000–01) had indicated that 20 sampled landings and about 850 aged otoliths provided sufficient data to nearly meet the target mean weighted c.v. of 30% (Blackwell et al. 2001, 2002). Any landing of rubyfish qualified for sampling.

Ageing of otolith thin sections was carried out using the methods of Paul et al. (2000). Readings were made using a stereomicroscope at ×100 magnification with illumination by transmitted light.

Catch-at-age and catch-at-length estimates were produced using NIWA's 'catch-at-age' software as described above for gemfish.

3. RESULTS

3.1 Sampling of gemfish in SKI 2

3.1.1 Gemfish in 2006–07

In 2006–07, an estimated 312 t of SKI 2 was landed, of which 96% was taken by trawlers. As in previous years the fishery was of short duration; 77% of landings were taken between October and January, and only 2% between June and September.

Fifteen samples were planned, but only 10 were collected between 4 October 2006 and 7 March 2007. However, the sampled landings (33 t) accounted for 11% of the total landings from the fishing year. The samples, all from trawl landings, were collected from the ports of Nelson, Gisborne, and Wellington. A total of 401 fish was measured and otolithed. A summary of samples is given in Table 1.

Table 1: Summary of catch sampling for gemfish from FMA 2 in the 2006–07 fishing year.

		Samples	Number of fish		Catch (t)	
Fishing method	Period	obtained	Measured	Aged	Sampled	Landed
Trawl	Oct–Dec	7	284	284	6.5	157
Trawl	Jan–Sep	3	117	117	26.4	141
Total		10	401	*413	32.9	298

* Includes 12 otoliths collected by observers from gemfish in FMA 2 during the 2006–07 fishing year

Sampling was relatively even by fishing method, with samples concentrated on bottom trawl landings, the method that produces most of the catch (Figure 4). The distribution of landings by fishing method and landing weight shows that most fishing trips produced less than 100 kg of gemfish (Figure 5). The sampled landings ranged between 58 kg and 14 t.

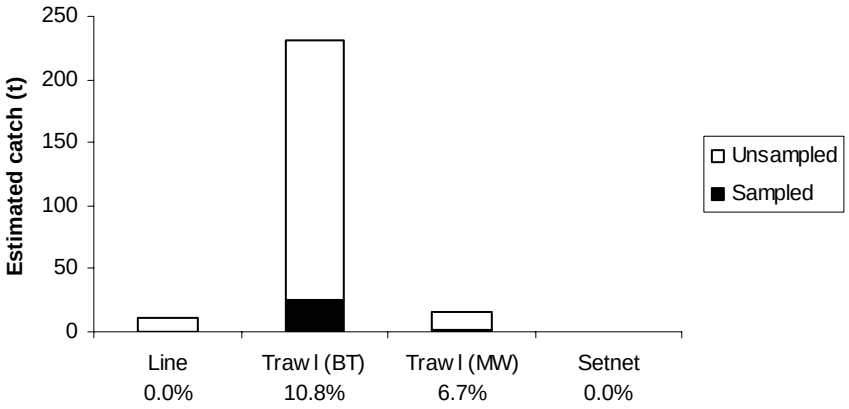

Figure 4: The composition, by fishing method, of the commercial catch and sampled catch of gemfish from FMA 2 in the 2006–07 fishing year. Percentages on the bottom axis show the amount of the catch sampled.

Most trawl-caught gemfish was stated to have been taken as the target species or as a bycatch of targeting tarakihi; most of the sampled landings were also from effort targeting these two species (Figure 6). Consequently, sampling by target species is reasonably representative of the fishery. Most of the samples were taken from Statistical Area 014, which also produced most of the landings (Figure 6). However, Areas 011, 012, and 013 produced about 35% of the landings but were under-sampled, while Area 015 was over-sampled. Landings by month exhibited major peaks in November and January (Figure 6). The proportions of landings sampled each month varied widely (0–29 %). While the sampling over time did cover much of the fishery, it appears that November and December were probably under-sampled.

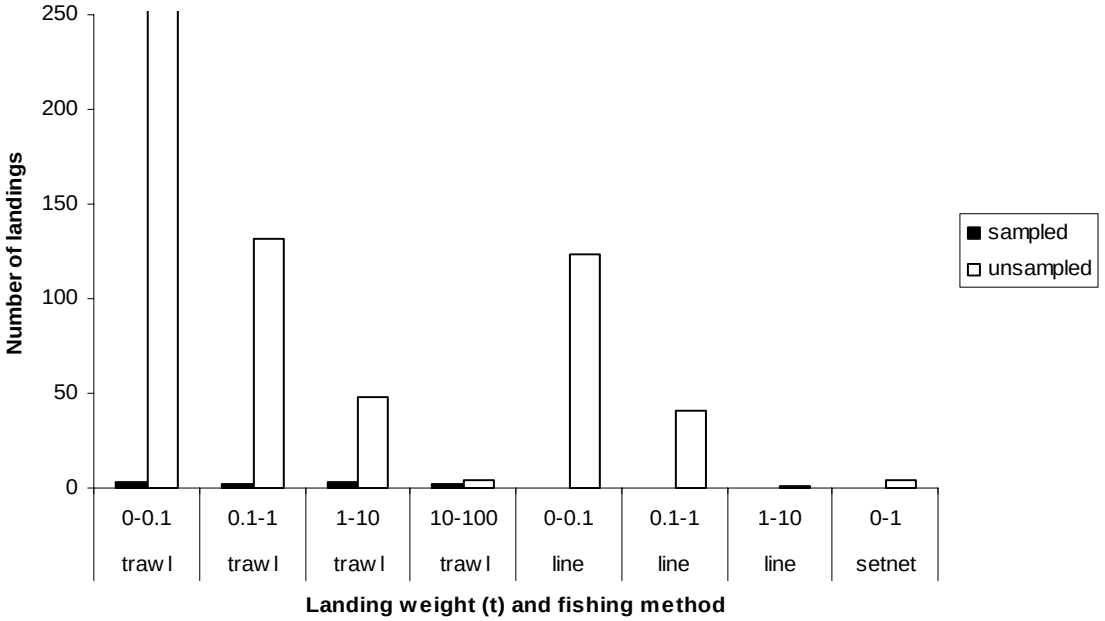

Figure 5: The distribution of sampled and unsampled gemfish landings, by fishing method and landing weight, in the 2006–07 fishing year.

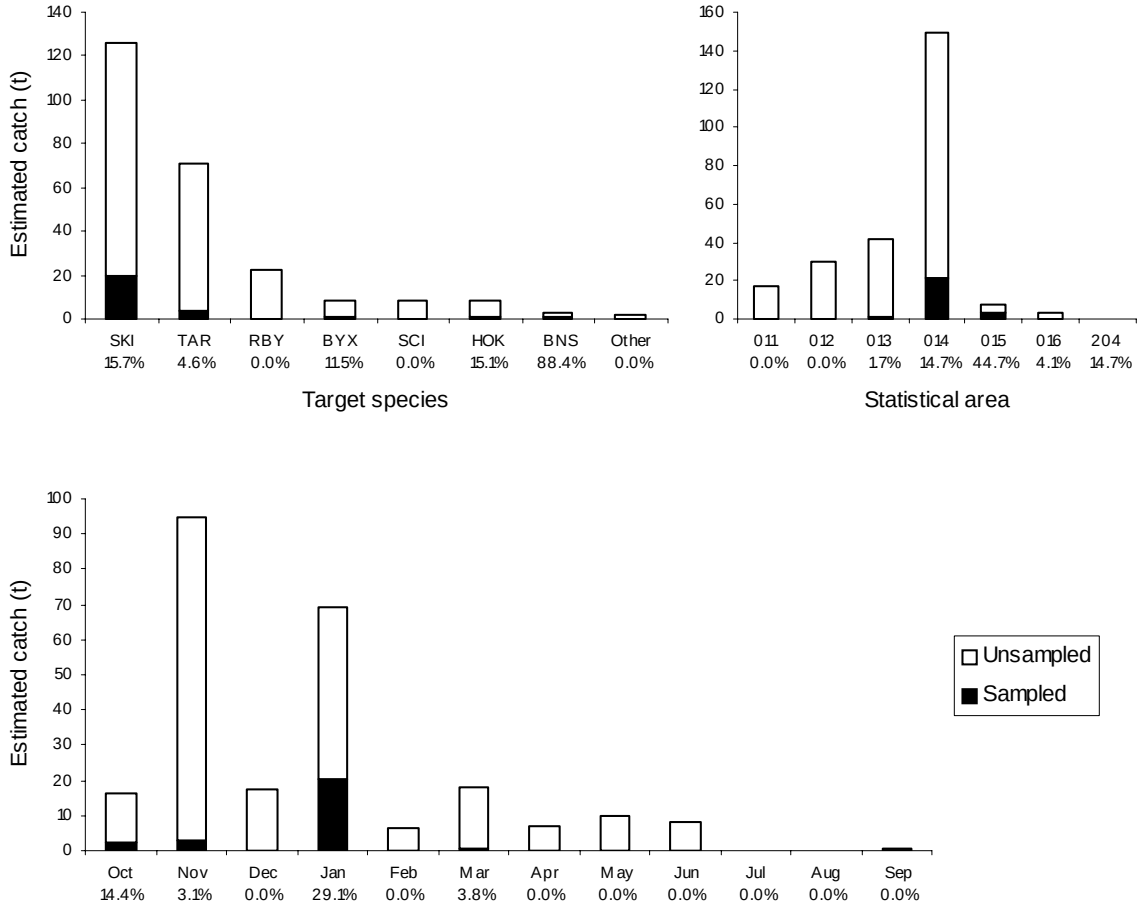

Figure 6: The composition (by target species, statistical area, and month) of the commercial trawl catch and sampled trawl catch of gemfish from FMA 2 in the 2006–07 fishing year. Percentages on the bottom axis show the amount of the catch sampled. Species codes: SKI, gemfish; TAR, tarakihi; RBY, rubyfish; SCI, scampi; HOK, hoki; BNS, bluenose.

Length frequencies from SKI 2 for 2006–07 are shown in Figure 7. The distribution ranges from 38 to 98 cm FL, with broad modes at around 63–69 cm for males and 74–81 cm females. Both distributions are only moderately spiky.

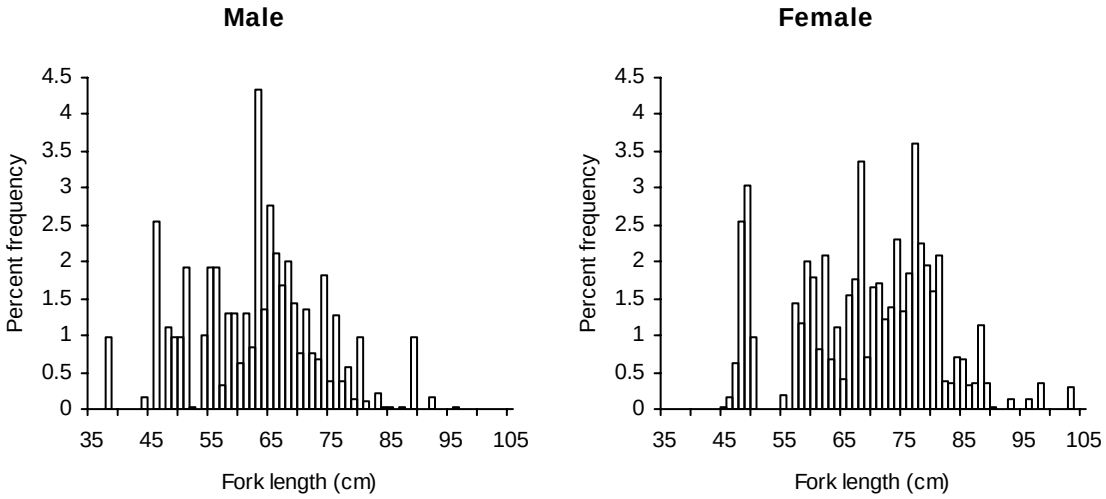

Figure 7: Scaled length-frequency distributions of male and female gemfish from SKI 2, in the 2006–07 fishing year.

The estimated catch-at-age, by sex, for 2006–07 is listed in Table 2. The mean weighted c.v. over all age classes was 38%, which was outside the target value of 30%. Plots of the age frequencies from the 1995–96 to 2004–05 and 2006–07 to 2007–08 fishing years are presented in Figures 12a and 12b. No exceptionally strong or weak year classes are apparent in the 2006–07 distribution. Most captured fish are less than 8 years old, which is expected given that the SKI 2 fishery targets non-spawning gemfish, including young, immature fish.

Table 2: Estimated catch-at-age (numbers and percentage) and calculated c.v.s from catch sampling in SKI 2 in 2006–07. The numbers of fish measured and aged, and the estimated mean weighted c.v.s, are also presented.

	Male			Female		
Age	Number	%	c.v.	Number	%	c.v.
2	1 166	0.99	1.694	0	0.00	–
3	9 197	7.81	0.622	8 683	7.38	0.602
4	12 908	10.96	0.460	10 958	9.31	0.427
5	12 893	10.95	0.358	8 421	7.15	0.339
6	7 413	6.30	0.362	9 551	8.11	0.227
7	4 053	3.44	0.420	9 553	8.11	0.266
8	2 790	2.37	0.483	6 906	5.87	0.294
9	1 518	1.29	1.054	4 434	3.77	0.384
10	96	0.08	2.112	2 047	1.74	0.531
11	1 166	0.99	1.579	1 266	1.08	0.715
12	0	0.00	–	1 253	1.06	0.713
13	0	0.00	–	459	0.39	1.848
14	0	0.00	–	249	0.21	1.304
15	184	0.16	2.156	428	0.36	1.654
20	0	0.00	–	115	0.10	1.939
21	20	0.02	3.285	0	0.00	–
Total measured			167			234
Total aged			172			241
Mean weighted c.v. (by sex)			53.4			40.4
Mean weighted c.v. (both sexes)						37.9

3.1.2 Gemfish in 2007–08

In 2007–08, an estimated 224 t of SKI 2 was landed, of which 92% was taken by trawlers. In contrast to previous years, the landings were spread throughout much of the year. Significant landings occurred each month from October to May, although a 'traditional' landings peak still occurred from November to January (accounting for about 53% of landings).

Fifteen samples were planned, and achieved. However, one of the samples was not able to be body cut, resulting only in unsexed lengths and otoliths; consequently, this sample was excluded from the analysis. A further sample in February was believed to have been taken by trawl, but was later established to have been line-caught. Consequently, it was included in the analysis representing the 8% of line-caught landings. A summary of samples is given in Table 3. The samples were collected from the ports of Nelson, Wellington, Napier, and Gisborne. About 5% of the total landed weight was sampled.

Table 3: Summary of catch sampling for gemfish from FMA 2 in the 2007–08 fishing year.

		Samples	Number of fish		Catch (t)	
Fishing method	Period	obtained	Measured	Aged	Sampled	Landed
Trawl	Oct–Feb	7	384	380	7.5	145
Trawl	Mar–Sep	6	284	284	2.9	61
Line	All year	1	43	43	0.3	17
Total		14	711	707	10.6	224

Sampling was relatively even by fishing method, with samples concentrated on bottom trawl landings, the method that produces most of the catch (Figure 8). The distribution of landings by fishing method and landing weight shows that most fishing trips produced less than 100 kg of gemfish (Figure 9). The sampled landings all ranged between 100 kg and 10 t.

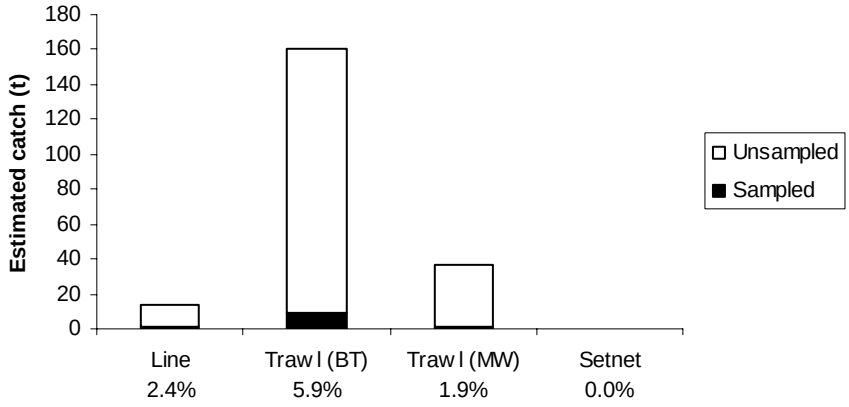

Figure 8: The composition, by fishing method, of the commercial catch and sampled catch of gemfish from FMA 2 in the 2007–08 fishing year. Percentages on the bottom axis show the amount of the catch sampled.

Most trawl-caught gemfish was stated to have been taken as a bycatch of targeting tarakihi; the sampled landings were mainly tarakihi bycatch (Figure 10). None of the samples were from trips targeting gemfish, but targeting for the species produced only about 8% of the landings. Sampling by target species is reasonably representative of the fishery. Most of the samples were taken from Statistical Area 014, which also produced most of the landings (Figure 10). Four of the areas were quite consistently sampled (i.e., 5.5–7.1% of landings), but Area 012 was under-sampled and Area 015 was over-sampled. Landings by month exhibited a major peak in November–January, with a secondary peak in April (Figure 10). The proportions of landings sampled each month varied widely (0–14.6%). While the sampling over time did cover much of the fishery, November, December, and April were under-sampled.

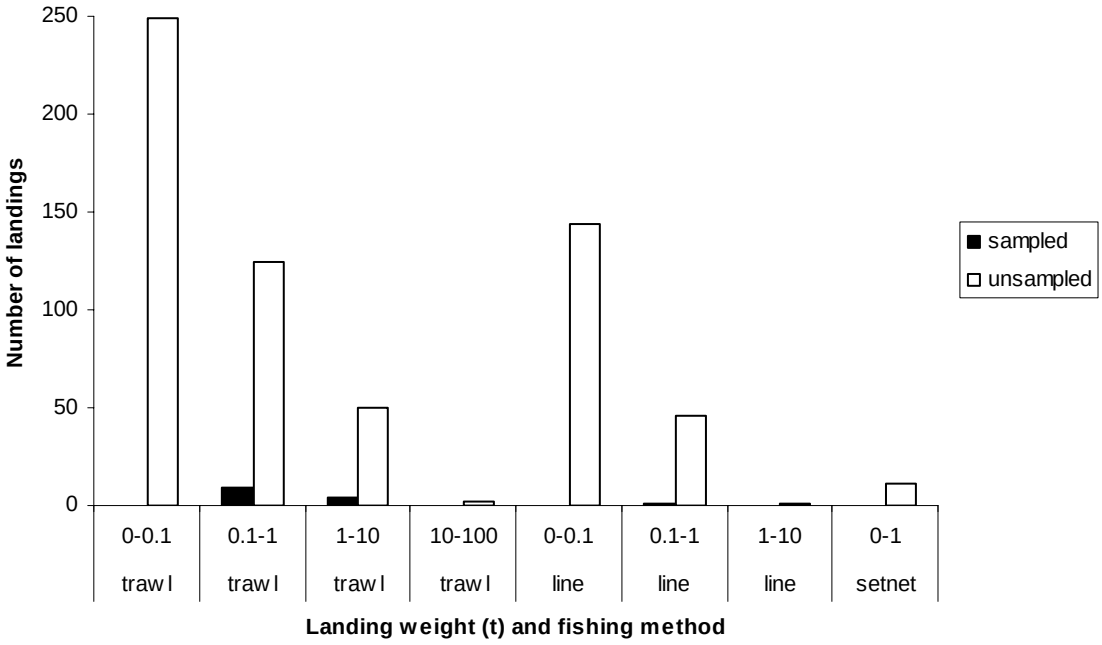

Figure 9: The distribution of sampled and unsampled gemfish landings, by fishing method and landing weight.

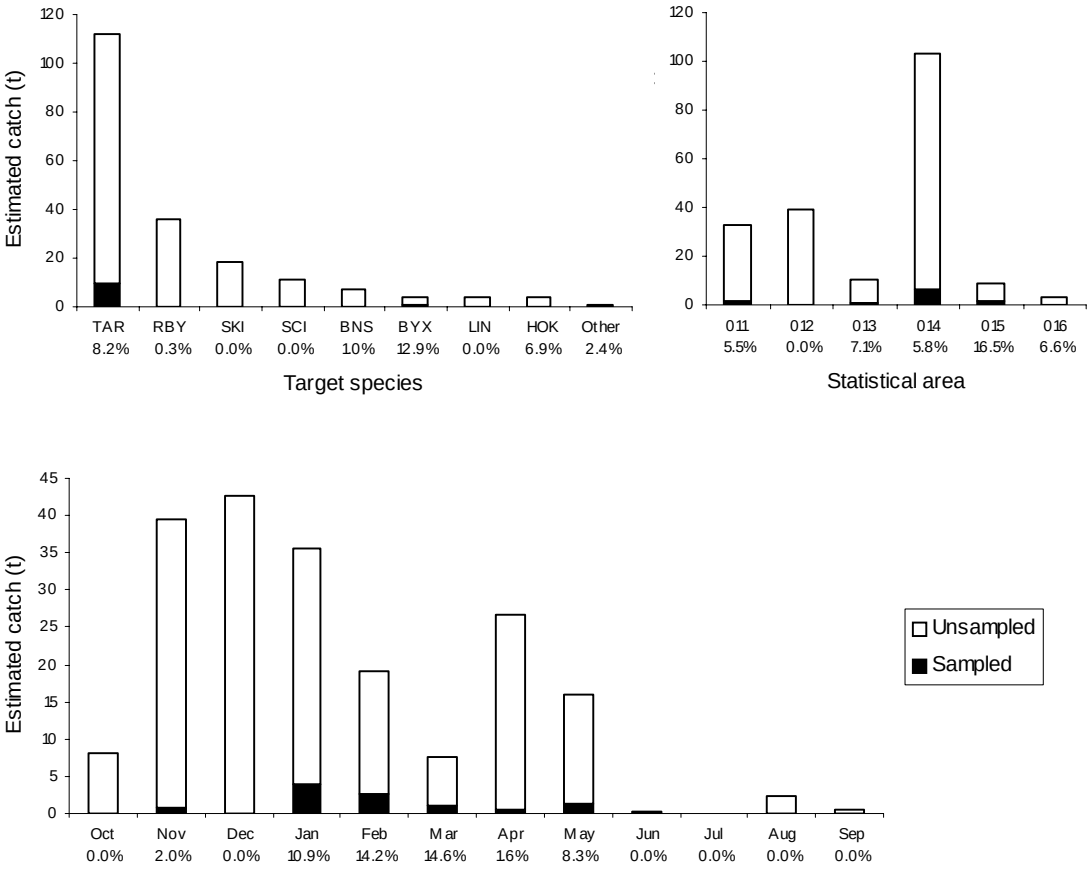

Figure 10: The composition (by target species, statistical area, and month) of the commercial trawl catch and sampled trawl catch of gemfish from FMA 2 in the 2007–08 fishing year. Percentages on the bottom axis show the amount of the catch sampled. Species codes: TAR, tarakihi; RBY, rubyfish; SKI, gemfish; SCI, scampi; BNS, bluenose; BYX, alfonsino; LIN, ling; HOK, hoki.

Length frequencies from SKI 2 for 2007–08 are shown in Figure 11. The distribution ranges from 41 to 107 cm FL, with modes at about 46, 55, 64, and 72 cm for males and 54, 65, and 78 cm for females. Both distributions are only moderately spiky. The catch was numerically dominated by females (62%).

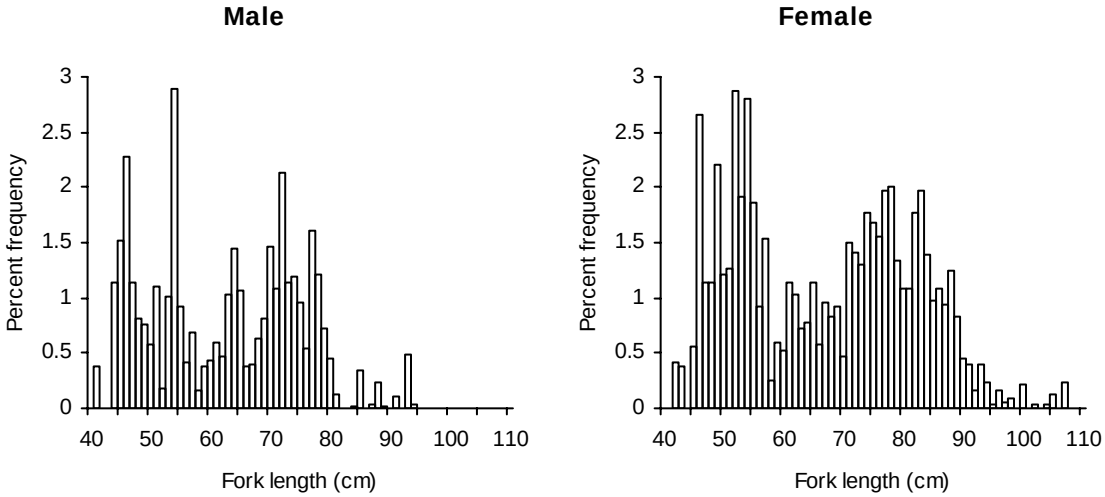

Figure 11: Scaled length-frequency distributions of male and female gemfish from SKI 2, in the 2007–08 fishing year.

The estimated catch-at-age, by sex, for 2007–08 is listed in Table 4. The mean weighted c.v. over all age classes was 39%, which was outside the target value of 30%. Plots of the age frequencies from the 1995–96 to 2004–05 and 2006–07 to 2007–08 fishing years are presented in Figures 12a and 12b. No exceptionally strong or weak year classes are apparent in the current population, although 3-year-old fish are clearly dominant. Most captured fish are less than 8 years old, which is expected given that the SKI 2 fishery targets non-spawning gemfish, including young, immature fish.

Table 4: Estimated catch-at-age (numbers and percentage) and calculated c.v.s from catch sampling in SKI 2 in 2007–08. The numbers of fish measured and aged, and the estimated mean weighted c.v.s, are also presented.

	Male			Female		
Age	Number	%	c.v.	Number	%	c.v.
2	5 568	6.74	1.064	6 157	7.45	0.949
3	7 393	8.95	0.407	12 662	15.32	0.397
4	3 650	4.42	0.453	5 983	7.24	0.318
5	3 275	3.96	0.356	4 070	4.92	0.339
6	3 165	3.83	0.283	3 391	4.10	0.269
7	2 942	3.56	0.318	5 597	6.77	0.215
8	1 932	2.34	0.286	3 775	4.57	0.245
9	1 436	1.74	0.420	3 399	4.11	0.253
10	837	1.01	0.461	3 146	3.81	0.282
11	342	0.41	1.044	1 524	1.84	0.375
12	156	0.19	0.994	856	1.04	0.506
13	0	0.00	–	417	0.50	0.611
14	232	0.28	1.098	303	0.37	0.630
15	0	0.00	–	0	0.00	–
16	94	0.11	1.547	90	0.11	1.693
17	0	0.00	–	218	0.26	1.390
18	0	0.00	–	33	0.04	2.249
Total measured			244			467
Total aged			242			465
Mean weighted c.v. (by sex)			52.4			40.7
Mean weighted c.v. (both sexes)						39.2

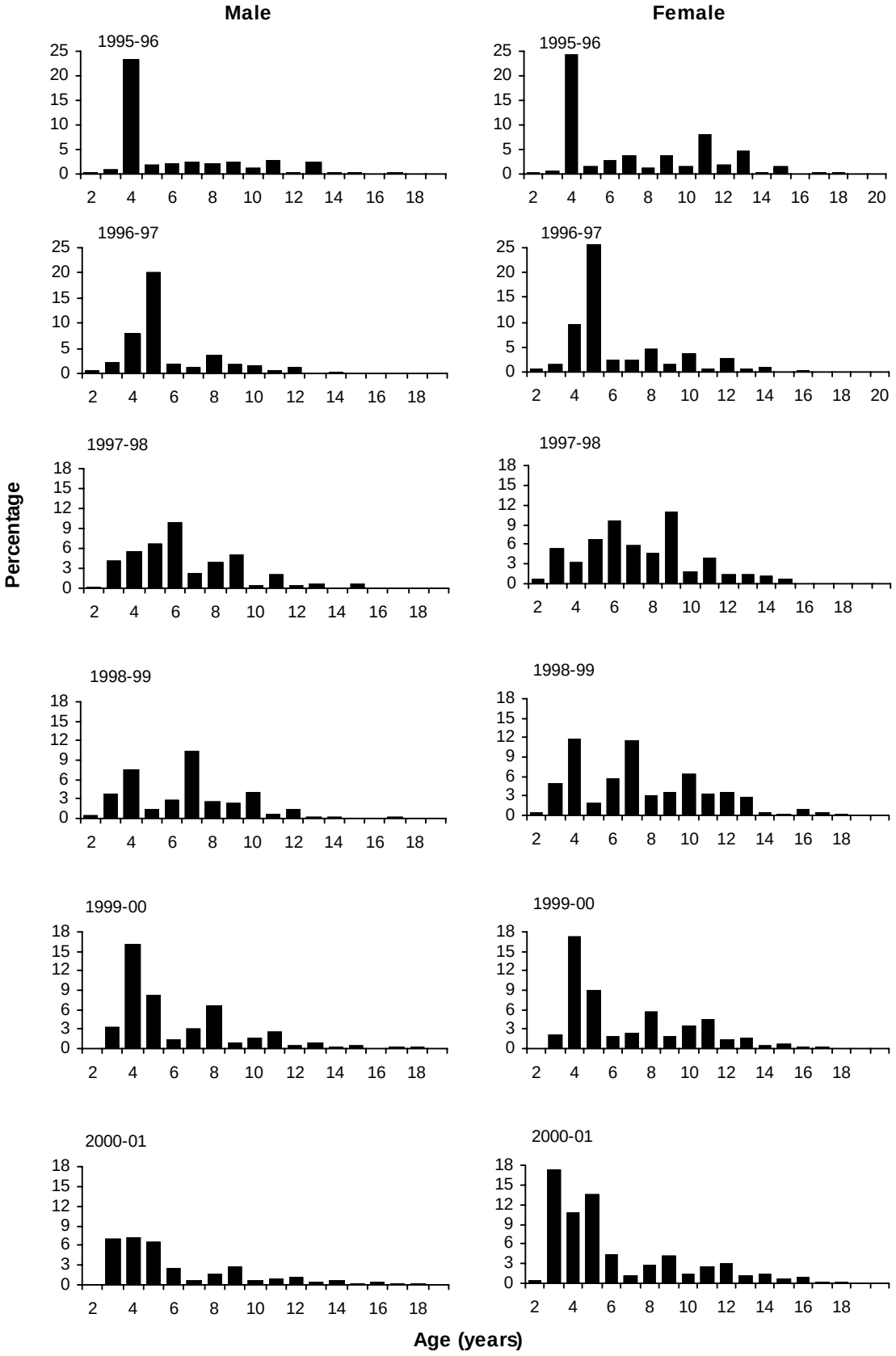

Figure 12a: Estimated age-frequency distributions, by sex, of the gemfish catch from SKI 2 in fishing years 1995–96 to 2000–01.

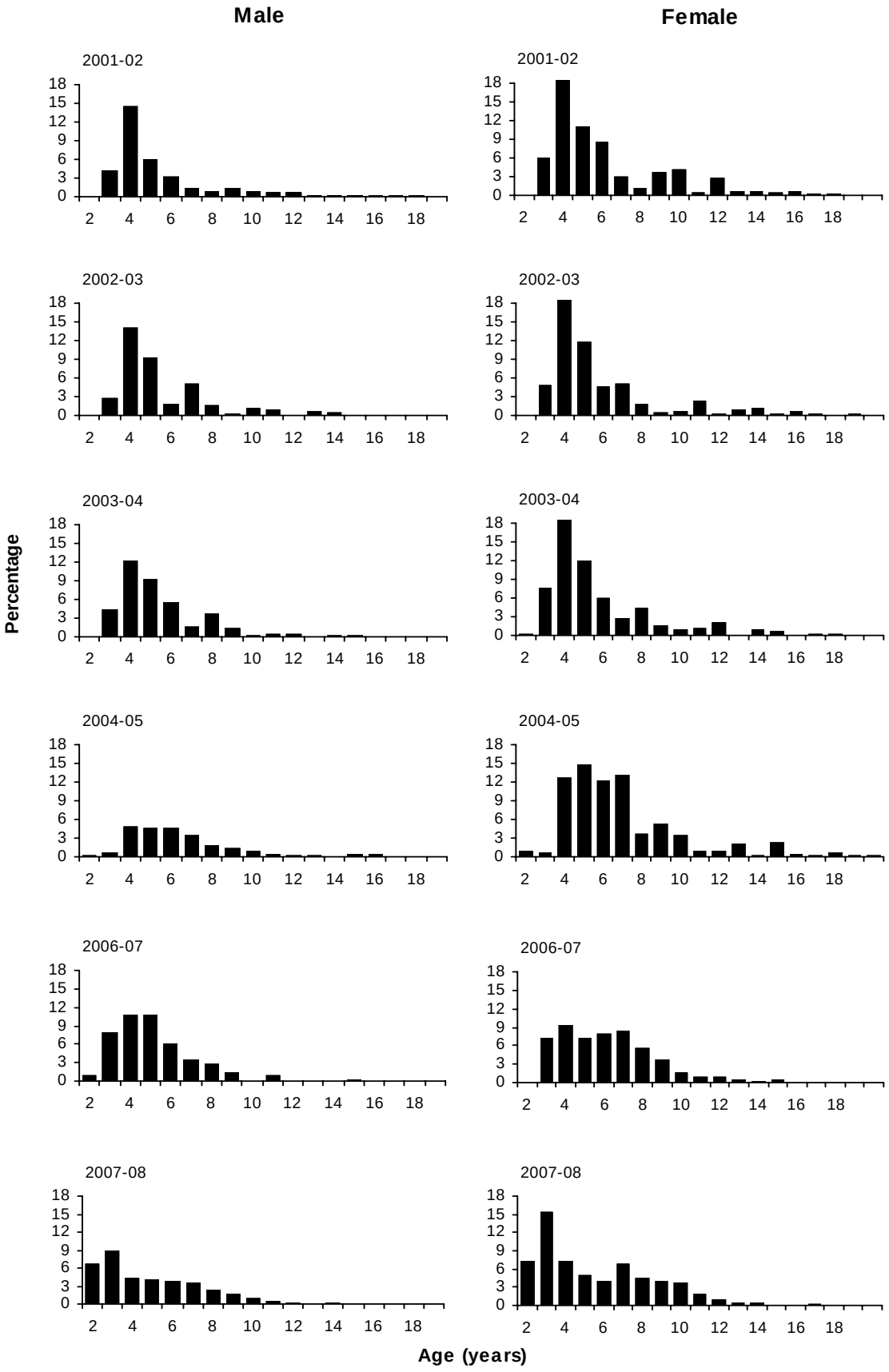

Figure 12b: Estimated age-frequency distributions, by sex, of the gemfish catch from SKI 2 in fishing years 2001–02 to 2004–05 and 2006–07 to 2007–08.

3.2 Sampling of alfonsino in BYX 2

3.2.1 Alfonsino in 2006–07

Catch sampling for alfonsino from BYX 2 was carried out on landings at Nelson. Fifteen landings, comprising a total of 369 t, were sampled between 4 October 2006 and 24 January 2007. However, it was later established that one sampled landing of 54 t in January was from a trip that had taken alfonsino in BYX 2 and BYX 3, so it was excluded from the analysis. The remaining 14 samples produced a total of 721 measured, sexed, and otolithed fish, and accounted for 19% of the total landings from the fishing year.

Sampling was relatively even by fishing method, with samples concentrated on midwater and bottom trawl landings, the methods that produce most of the catch (Figure 13). The distribution of landings by fishing method and landing weight shows that most fishing trips (particularly by line vessels) produced less than 1 t of alfonsino (Figure 14). The sampled landings ranged from 0.8 to 39 t, but were mostly greater than 10 t.

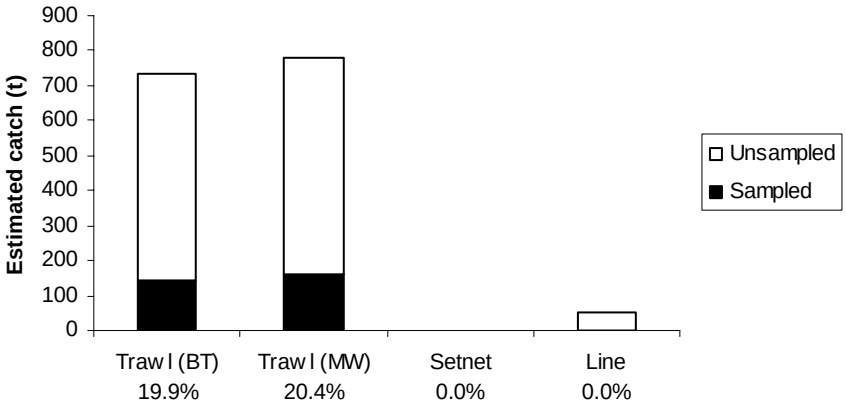

Figure 13: The composition, by fishing method, of the commercial catch and sampled catch of alfonsino from FMA 2 in the 2006–07 fishing year. Percentages on the bottom axis show the amount of the catch sampled.

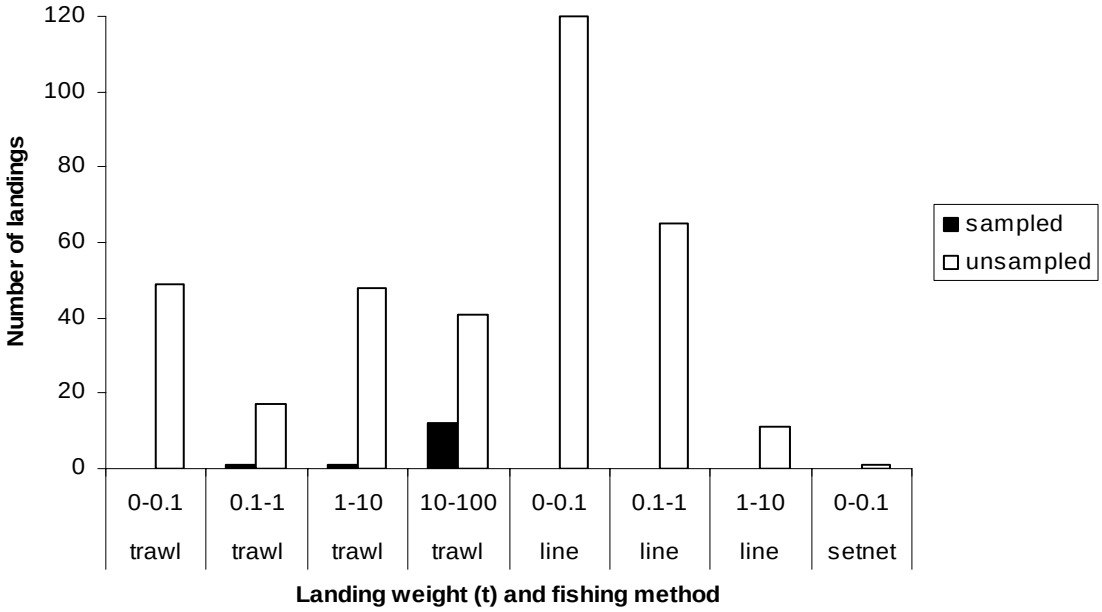

Figure 14: The distribution of sampled and unsampled alfonsino landings, by fishing method and landing weight, in the 2006–07 fishing year.

Most trawl-caught alfonsino was stated to have been taken as the target species, with a smaller proportion taken as a bycatch of hoki (Figure 15). The sampled landings were mainly target alfonsino, although the hoki bycatch was also well sampled (Figure 15), so sampling by target species represented the fishery well. Most of the samples were taken from Statistical Areas 015 and 204, which also produced most of the landings (Figure 15). So sampling by area also represented the fishery well, although Areas 013 and 014 are probably slightly under-sampled. Significant landings were taken in most months (Figure 15), unlike previously sampled years when the fishery was more concentrated at the beginning of the fishing year. The proportions of landings sampled each month varied widely (0–79%). The sampling was concentrated at the start of the fishing year; consequently, October–November was over-sampled, and other months were under-sampled.

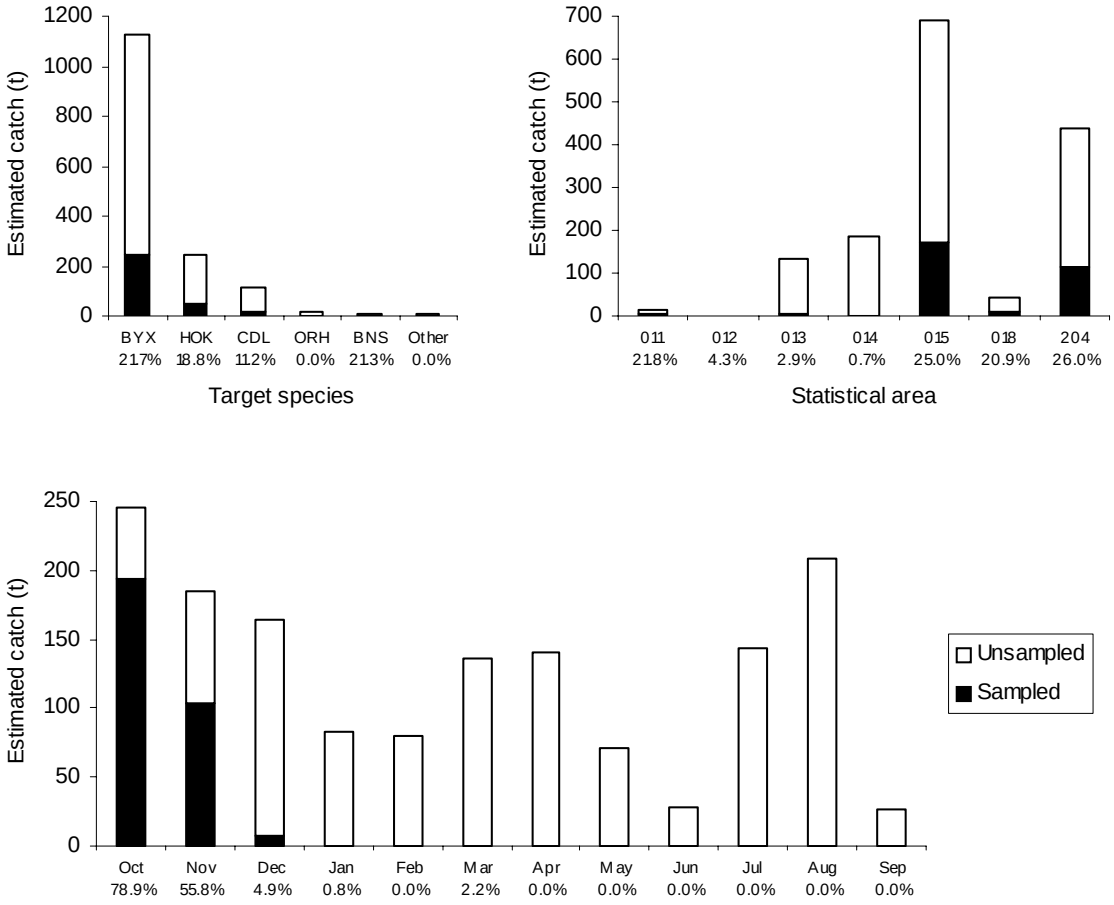

Figure 15: The composition (by target species, statistical area, and month) of the commercial trawl catch and sampled trawl catch of alfonsino from FMA 2 in the 2006–07 fishing year. Percentages on the bottom axis show the amount of the catch sampled. Species codes: BYX, alfonsino; HOK, hoki; CDL, cardinalfish; ORH, orange roughy.

Length-frequency distributions, scaled to represent the sampled catch, show the male length range to be 21–48 cm FL and the female range to be 26–50 cm FL (Figure 16). The male length mode (31–34 cm) is smaller than the female mode (32–36 cm).

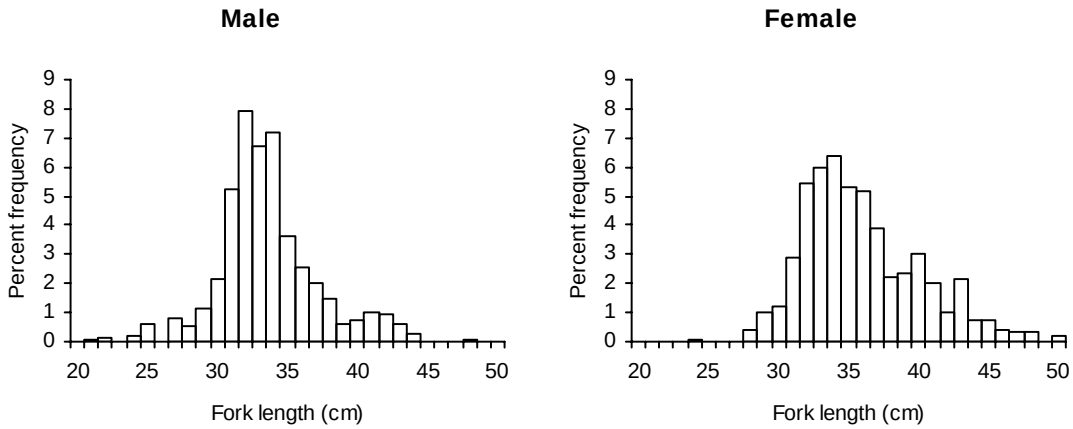

Figure 16: Scaled length-frequency distributions of male and female alfonsino from BYX 2, in the 2006–07 fishing year.

The age-frequency distributions from 2006–07 are noticeably different from the three samples from 1998–99 to 2000–01 (see Figure 21). The most abundant age classes in 2006–07 were 4 and 5. In the earlier samples, age classes 5–9 dominated the catches. The mean weighted c.v. over all age classes for the 2006–07 sample was 19%, which was well within the target value of 30% (Table 5).

Table 5: Estimated catch-at-age (numbers and percentage) and calculated c.v.s from catch sampling in BYX 2 in 2006–07. The numbers of fish measured and aged, and the estimated mean weighted c.v.s, are also presented.

	Male			Female		
Age	Number	%	c.v.	Number	%	c.v.
1	4 005	0.25	1.176	0	0.00	–
2	12 592	0.78	0.924	1 327	0.08	1.920
3	87 053	5.36	0.294	72 051	4.44	0.302
4	300 634	18.52	0.167	232 747	14.34	0.177
5	148 119	9.12	0.165	199 966	12.32	0.133
6	78 535	4.84	0.203	61 532	3.79	0.220
7	32 068	1.98	0.295	72 162	4.45	0.221
8	41 075	2.53	0.330	81 572	5.03	0.202
9	31 735	1.95	0.360	56 472	3.48	0.276
10	14 606	0.90	0.529	37 099	2.29	0.341
11	4 402	0.27	0.950	16 019	0.99	0.513
12	3 544	0.22	1.127	14 547	0.90	0.449
13	0	0.00	–	13 331	0.82	0.592
14	0	0.00	–	6 107	0.38	1.031
Total measured			337			384
Total aged			337			380
Mean weighted c.v. (by sex)			24.1			22.5
Mean weighted c.v. (both sexes)						18.8

3.2.2 Alfonsino in 2007–08

Catch sampling for alfonsino from BYX 2 was carried out on landings at Nelson. Sixteen landings, comprising a total of 343 t, were sampled between 24 October 2007 and 10 April 2008. However, it was later established that one sampled landing of 31.4 t in February was from BYX 3, so it was excluded from the analysis. The remaining 15 samples produced a total of 751 measured, sexed, and otolithed fish. The sampled landings accounted for 23% of the total landings from the fishing year.

Sampling was relatively even by fishing method, with samples concentrated on midwater and bottom trawl landings, the methods that produce most of the catch (Figure 17). The distribution of landings by

fishing method and landing weight shows that most fishing trips (particularly by liners) produced less than 1 t of alfonsino (Figure 18). The sampled landings ranged from 0.5 to 38 t, but were mostly greater than 10 t.

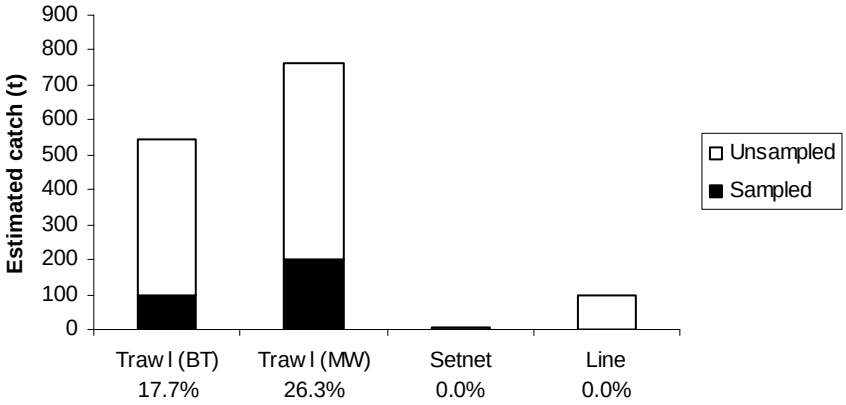

Figure 17: The composition, by fishing method, of the commercial catch and sampled catch of alfonsino from FMA 2 in the 2007–08 fishing year. Percentages on the bottom axis show the amount of the catch sampled.

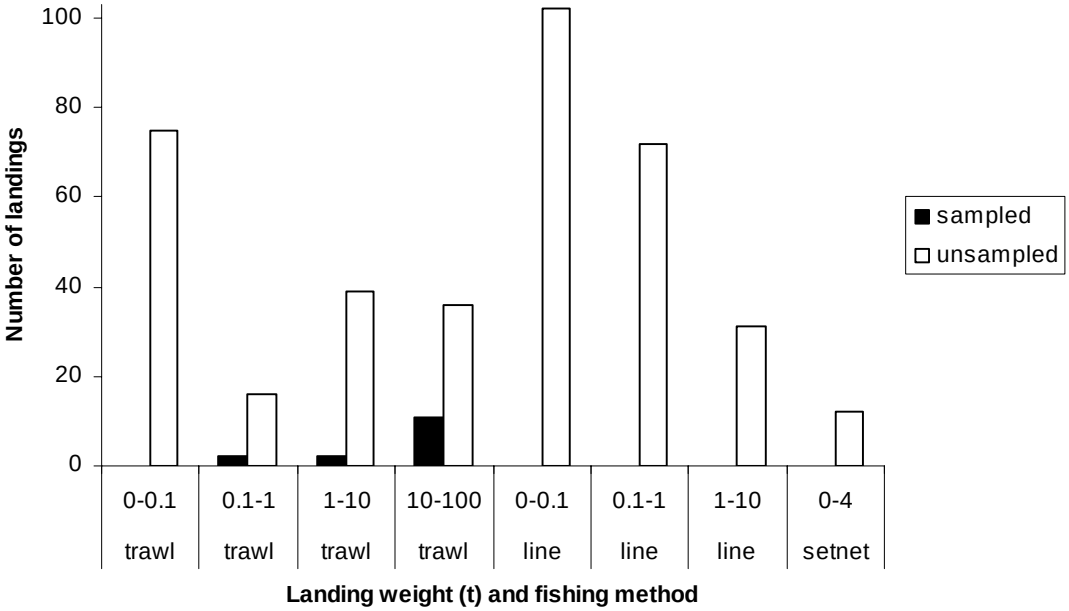

Figure 18: The distribution of sampled and unsampled alfonsino landings, by fishing method and landing weight.

Most trawl-caught alfonsino was stated to have been taken as the target species, with a smaller proportion taken as a bycatch of hoki (Figure 19). The sampled landings were mainly target alfonsino, although the hoki bycatch was also well sampled (Figure 19), so sampling by target species represented the fishery well. Most of the samples were taken from Statistical Area 015, which also produced most of the landings (Figure 19). Four of the areas were quite consistently sampled (i.e., 19–28% of landings), so sampling by area also represented the fishery well. Although significant landings were taken in all months, as in most previous years the fishery was more concentrated at the beginning of the fishing year; 79% of landings were taken between November and April (Figure 19). The proportions of landings sampled each month varied widely (0–82%). While the sampling over time did cover much of the fishery, it appears that November was over-sampled, and March–April was under-sampled.

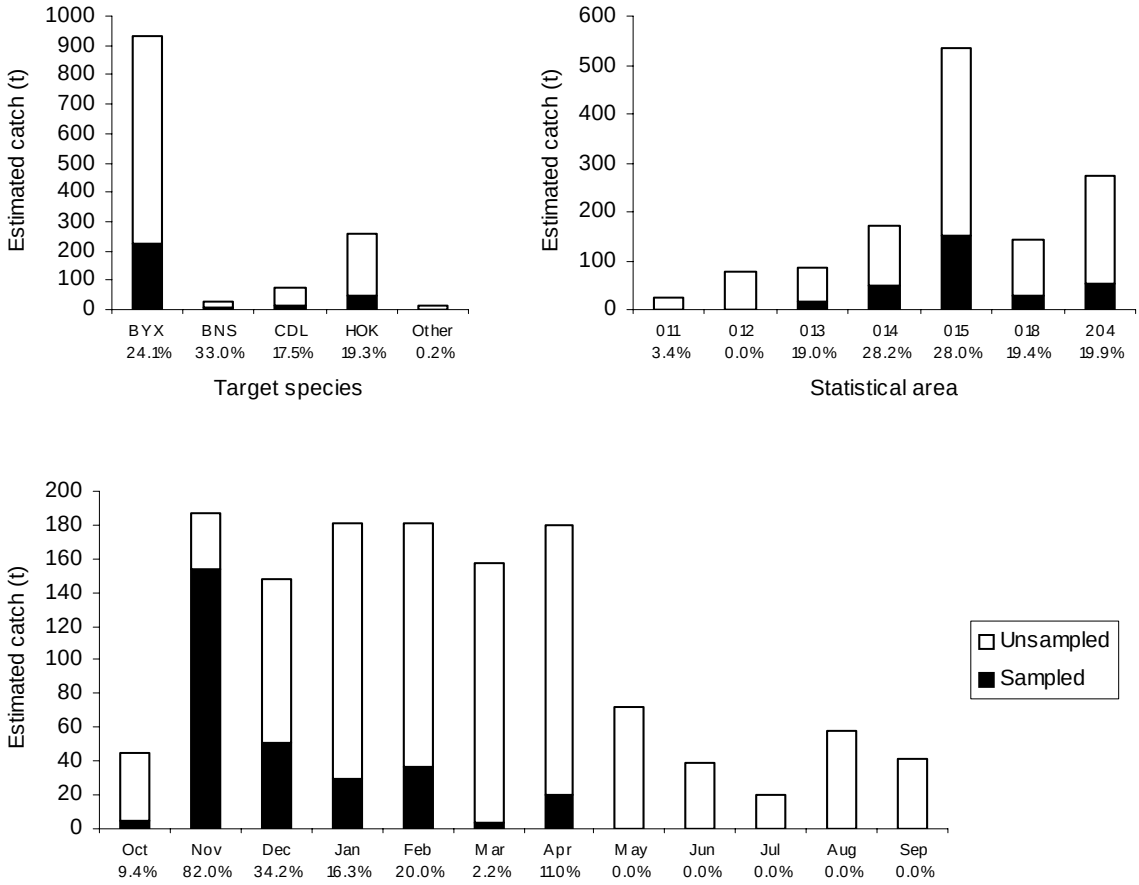

Figure 19: The composition (by target species, statistical area, and month) of the commercial trawl catch and sampled trawl catch of alfonsino from FMA 2 in the 2007–08 fishing year. Percentages on the bottom axis show the amount of the catch sampled. Species codes: BYX, alfonsino; BNS, bluenose; CDL, cardinalfish; HOK, hoki.

Length-frequency distributions, scaled to represent the sampled catch, show the male length range to be 20–44 cm FL and the female range to be 21–49 cm FL (Figure 20). The male length mode (31–35 cm) is smaller than the female mode (33–36 cm).

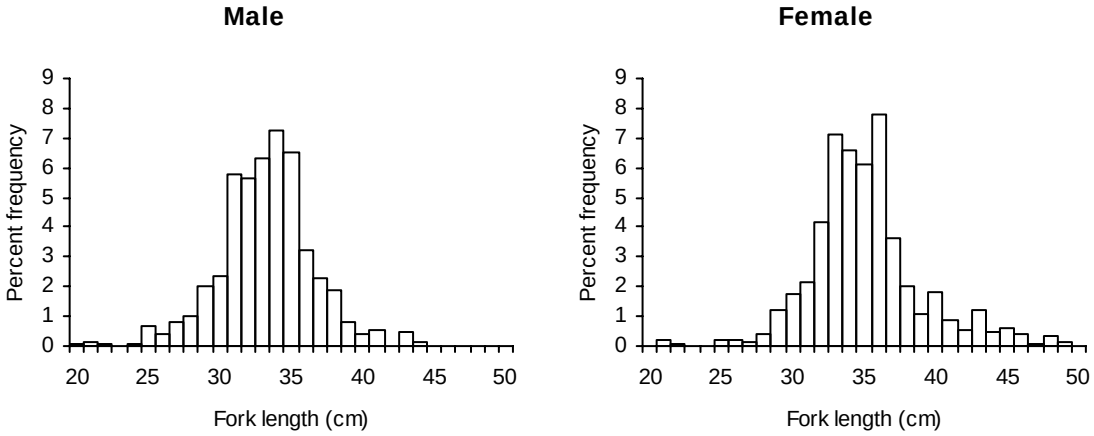

Figure 20: Scaled length-frequency distributions of male and female alfonsino from BYX 2, in the 2007–08 fishing year.

The age-frequency distributions from the 2007–08 fishing year are noticeably different from the three samples from 1998–99 to 2000–01, but quite similar to the 2006–07 distributions (Figure 21). The most abundant age classes in 2007–08 were 4 and 5 (the same as in 2006–07), but it appears that the dominant 4-year-old fish in 2006–07 have progressed to a dominant 5-year age class in 2007–08. In the earlier samples, age classes 5–9 dominated the catches. The mean weighted c.v. over all age classes for the 2007–08 sample was 16%, which was well within the target value of 30% (Table 6).

Table 6: Estimated catch-at-age (numbers and percentage) and calculated c.v.s from catch sampling in BYX 2 in 2007–08. The numbers of fish measured and aged, and the estimated mean weighted c.v.s, are also presented.

	Male			Female		
Age	Number	%	c.v.	Number	%	c.v.
1	3 818	0.25	1.201	3 641	0.24	1.096
2	40 201	2.61	0.388	15 855	1.03	0.594
3	114 199	7.40	0.197	77 297	5.01	0.277
4	172 110	11.15	0.143	184 123	11.93	0.147
5	227 524	14.75	0.127	219 640	14.23	0.125
6	99 023	6.42	0.159	122 537	7.94	0.157
7	56 490	3.66	0.220	53 123	3.44	0.237
8	17 948	1.16	0.408	48 254	3.13	0.275
9	10 701	0.69	0.641	26 436	1.71	0.411
10	4 662	0.30	0.715	29 307	1.90	0.376
11	4 694	0.30	1.113	5 211	0.34	0.819
12	845	0.06	2.047	1 549	0.10	1.350
13	0	0.00	–	3 851	0.25	1.199
Total measured			374			377
Total aged			374			375
Mean weighted c.v. (by sex)			19.8			21.1
Mean weighted c.v. (both sexes)						15.6

Past investigations of alfonsino landings have indicated that length-frequency distributions (and hence, age-frequency distributions) can vary markedly between fishing grounds in the same year (Horn & Massey 1989, Massey & Horn 1990). Consequently, it has been suggested that sampling should take account of this variation by stratifying for fishing ground. In considering the feasibility of this we have plotted the positions of trawls contributing an estimated weight of more than 100 kg of alfonsino to the 2007–08 sampled landings (Figure 22). Each of the 15 sampled trips had fished in from one to four statistical areas (mean = 2.3). The locations of all potentially sampled tows are widely distributed. Positions of tows from two selected sampled trips indicate how wide-ranging a trip can be (Figure 22).

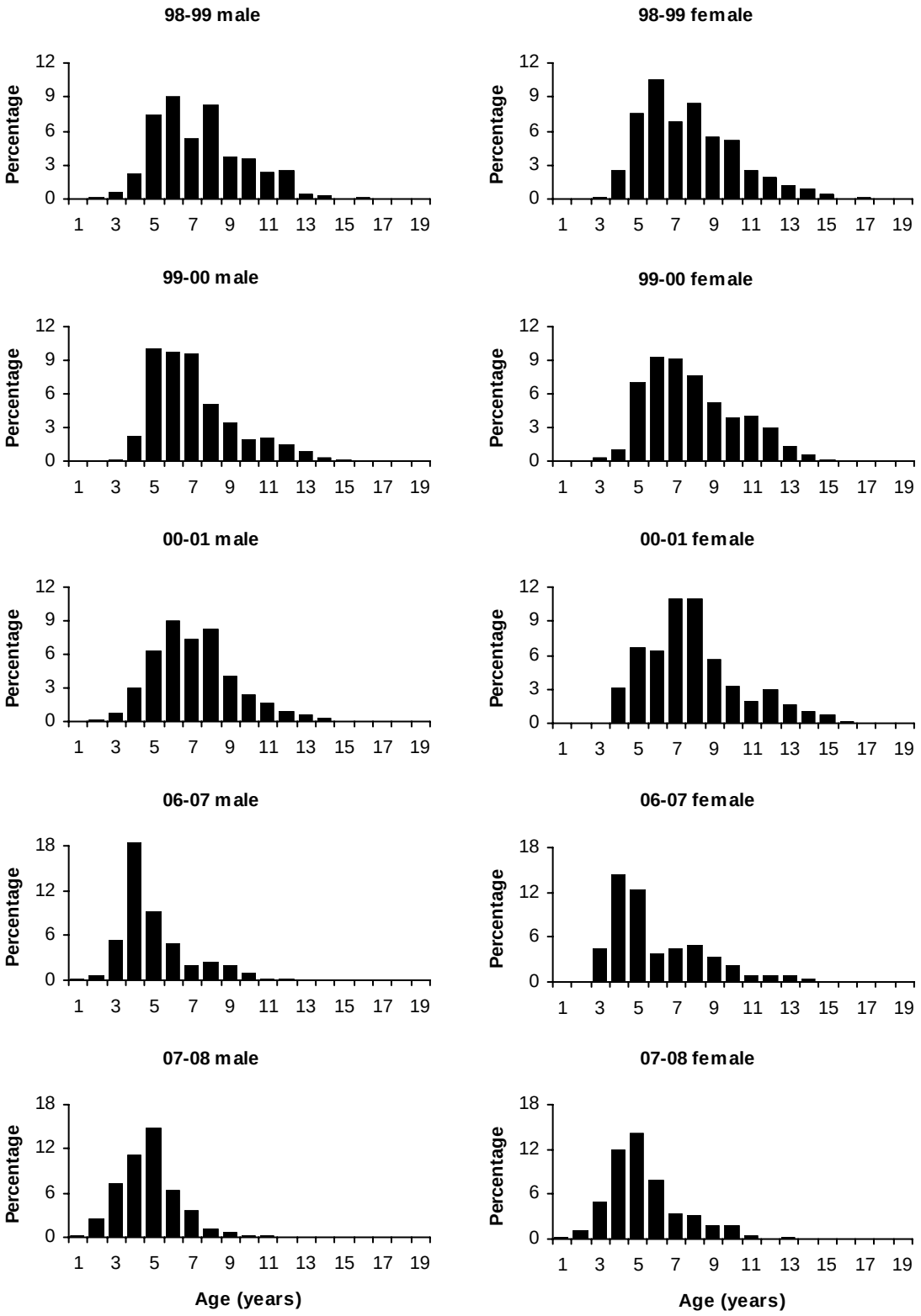

Figure 21: Estimated age-frequency distributions of male and female alfonsino from the BYX 2 trawl fishery, in the 1998–99 to 2000–01 and 2006–07 to 2007–08 fishing years.

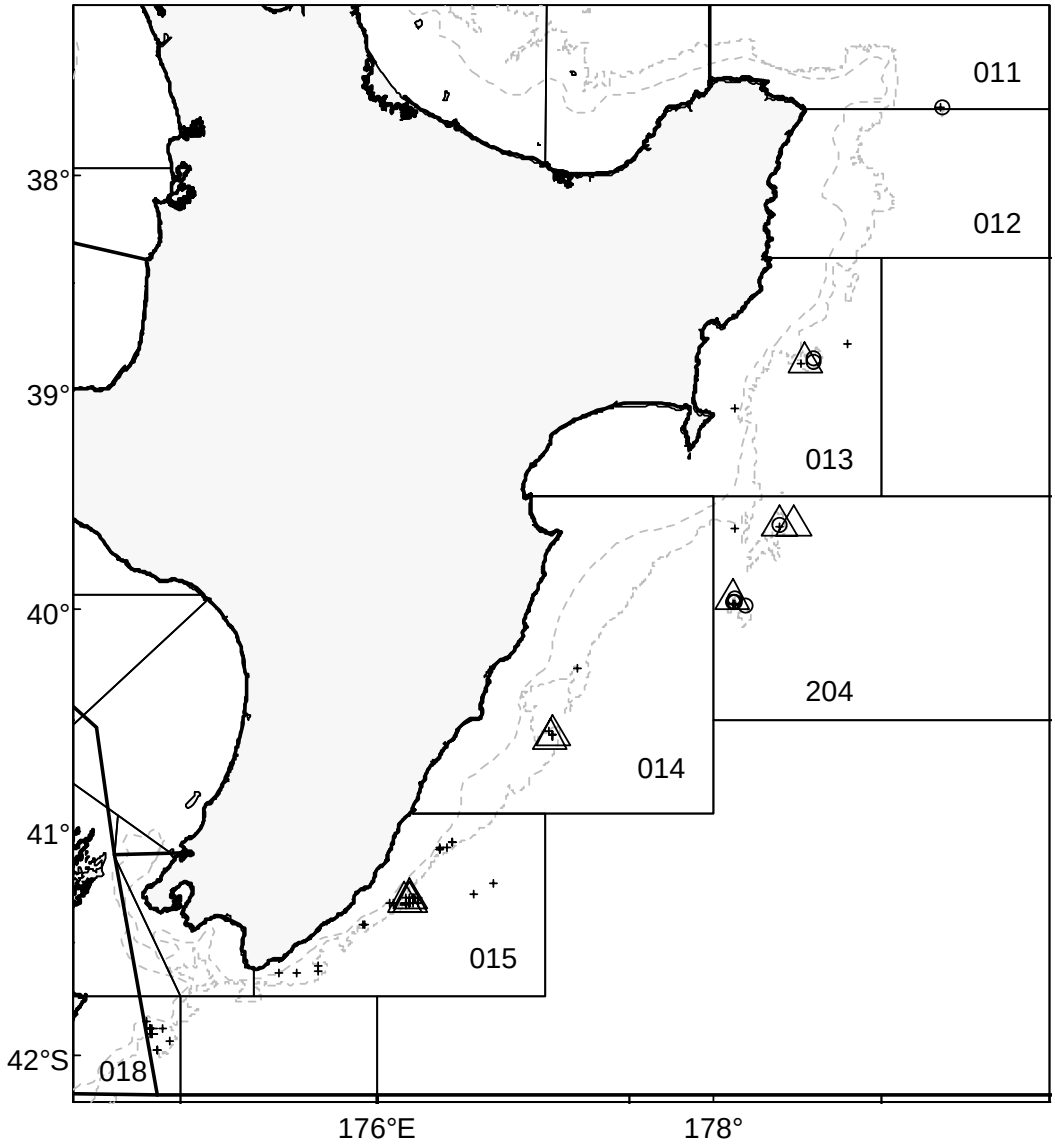

Figure 22: Positions of trawl tows estimated to have caught more than 100 kg of alfonsino, contributing to landings sampled from 2007–08. Large triangles show positions from the trip producing market sample number 20071659, medium circles show positions from the trip producing sample 20071656, small crosses show positions contributing to all other samples. Thick lines are QMA boundaries, thin lines are statistical area boundaries (with Areas 011–015, 018 and 204 labelled). Depth contours are at 200 and 750 m.

3.2.3 Mortality rates for alfonsino

To date, no reliable estimates of instantaneous natural mortality (*M*) are available for any population of *Beryx splendens* in New Zealand or elsewhere. *M* was estimated here using Hoenig's (1983) equation of

$$M = -(\log_e 0.01)/A,$$

where 0.01 is the proportion of the population that reaches age *A* or older. Ageing studies of alfonsino from various locations in the North and South Pacific Ocean have indicated that the maximum age for this species probably is about 20 years (e.g., Lehodey & Grandperrin 1996). The oldest alfonsino aged from New Zealand waters was 18 years (Massey & Horn 1990, NIWA unpublished data). Using *A*=18 in the equation above gives an *M* of 0.26; using *A*=20 gives and *M* of 0.23. None of the ageing studies

have examined unexploited populations, so the possibility that the true *A* is slightly greater than 20 years must be allowed. Hence, we assume that *M* is in the range 0.20 to 0.26.

Total instantaneous mortality, *Z*, (fishing (*F*) plus natural (*M*)) was estimated from the age structure of the catch using the method of Chapman & Robson (1960) and the R1 regression model of Dunn et al. (1999). Estimates, by sex, were made for each of the fishing years of BYX 2 catch sampling (Table 7). Estimated ranges of *F* in those sampled years were derived after subtracting the range of *M* (0.20–0.26) from total mortality (Table 7). *F* is estimated to have increased over time during the sampled period, and also to be higher for males than females.

Table 7: Estimates of instantaneous total mortality (*Z*), and the resulting estimated ranges of instantaneous fishing mortality (*F*) (assuming *M* ranges from 0.20 to 0.26), by sex, for each sampled year.

Sample year	*Z*				*F*	
	Chapman-Robson		R1 regression			
	male	female	male	female	male	female
1998–99	0.37	0.35	0.39	0.34	0.11–0.19	0.08–0.14
1999–2000	0.47	0.38	0.42	0.35	0.16–0.27	0.09–0.18
2000–01	0.49	0.41	0.48	0.35	0.22–0.29	0.09–0.21
2006–07	0.56	0.37	0.53	0.34	0.27–0.36	0.08–0.17
2007–08	0.77	0.55	0.69	0.57	0.43–0.57	0.29–0.37

3.3 Sampling of rubyfish in RBY 2

3.3.1 Rubyfish in 2006–07

In 2006–07, catch sampling for rubyfish from RBY 2 was conducted in Auckland, Tauranga, Wellington, and Nelson. Samples were obtained from only seven trawl landings between 12 October 2006 and 20 August 2007, comprising 68 t, to produce a total of 311 measured and otolithed fish. However, on one occasion the sample was allowed to be otolithed, but not body-cut, so the 50 sampled fish could not be sexed. The sampled landings accounted for 34% of the total reported RBY 2 landings from the fishing year (although the sum of estimated landings by fishing event was much higher than reported landings by Fishstock, i.e., 290 t compared with 202 t). The weights of sampled landings varied by more than three orders of magnitude (from 25 kg to 64.4 t). The second largest sampled landing (1.75 t) was the one that was unsexed. So the 2006–07 catch-at-age is essentially derived from a single landing which produced about 32% of the total landings for that year. Unfortunately, that landing was not over-sampled (i.e., only the standard sample of 50 fish was measured and sexed).

Sampling was not well distributed by fishing method; while the one very large midwater trawl landing was sampled, the significant bottom trawl landing component was poorly sampled (Figure 23). The distribution of landings by fishing method and landing weight shows that most fishing trips produce less than 100 kg of rubyfish (Figure 24). The bulk of the catch is taken by a very small number of trawling trips.

Most trawl-caught rubyfish (70%) was stated to have been taken as a bycatch of targeting for cardinalfish, with most of the remainder taken as the target species (Figure 25). No cardinalfish bycatch landings were sampled (Figure 25), so this component of the catch is clearly under-represented. The largest sampled landing was from Statistical Area 011. No samples were obtained from Areas 013 and 204, which both produced significant landings (Figure 25). Consequently, sampling by area was also clearly unrepresentative. Significant trawl landings (92% of all landings) were taken only in January, February, and September (Figure 25). Only one of these months (September) was sampled; clearly, January–February was under-sampled.

Length-frequency distributions, scaled to represent the sampled catch, show the male length range to be 29–45 cm FL and the female range to be 29–48 cm FL, although fish shorter than 35 cm FL were

rare (Figure 26). The male distribution has a clear mode at 41 cm; the female distribution is broader and more spiky. Fish from the six small sampled landings were, on average, 37 cm FL, compared with a mean length of 42 cm FL from the single large landing. The large landing was a result of target fishing for rubyfish, whereas the other samples were from bycatch landings.

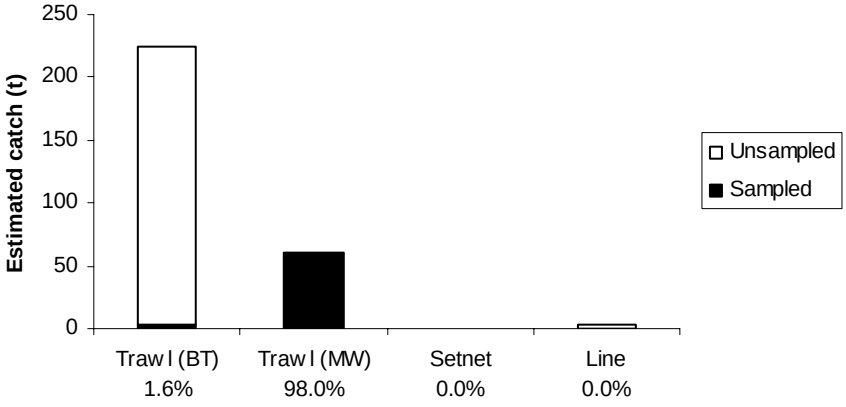

Figure 23: The composition, by fishing method, of the commercial catch and sampled catch of rubyfish from FMA 2 in the 2006–07 fishing year. Percentages on the bottom axis show the amount of the catch sampled.

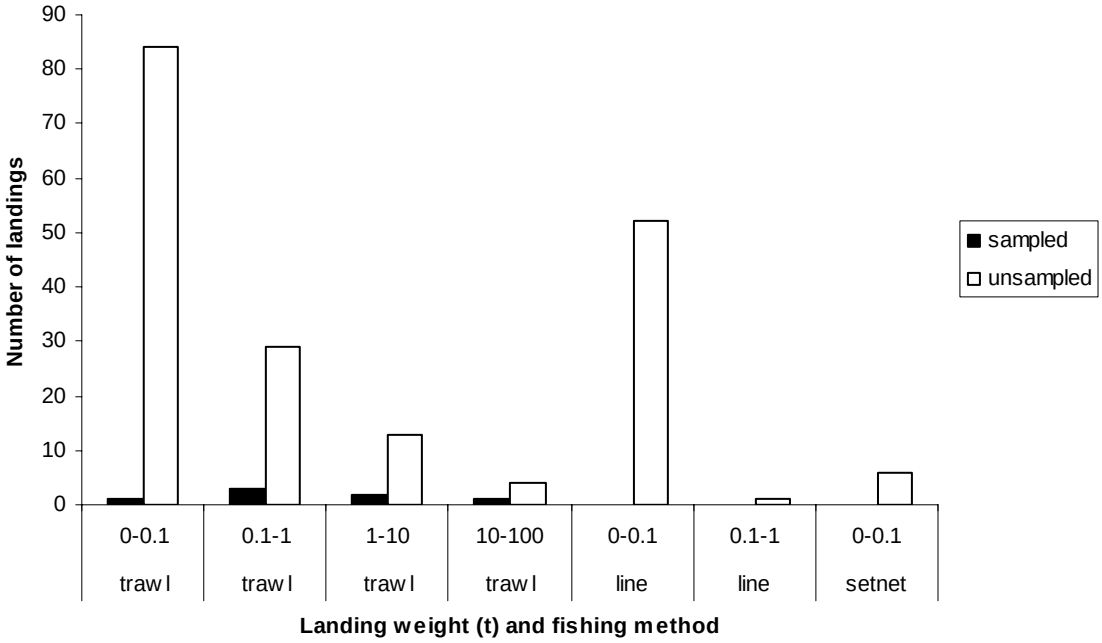

Figure 24: The distribution of sampled and unsampled rubyfish landings, by fishing method and landing weight, in the 2006–07 fishing year.

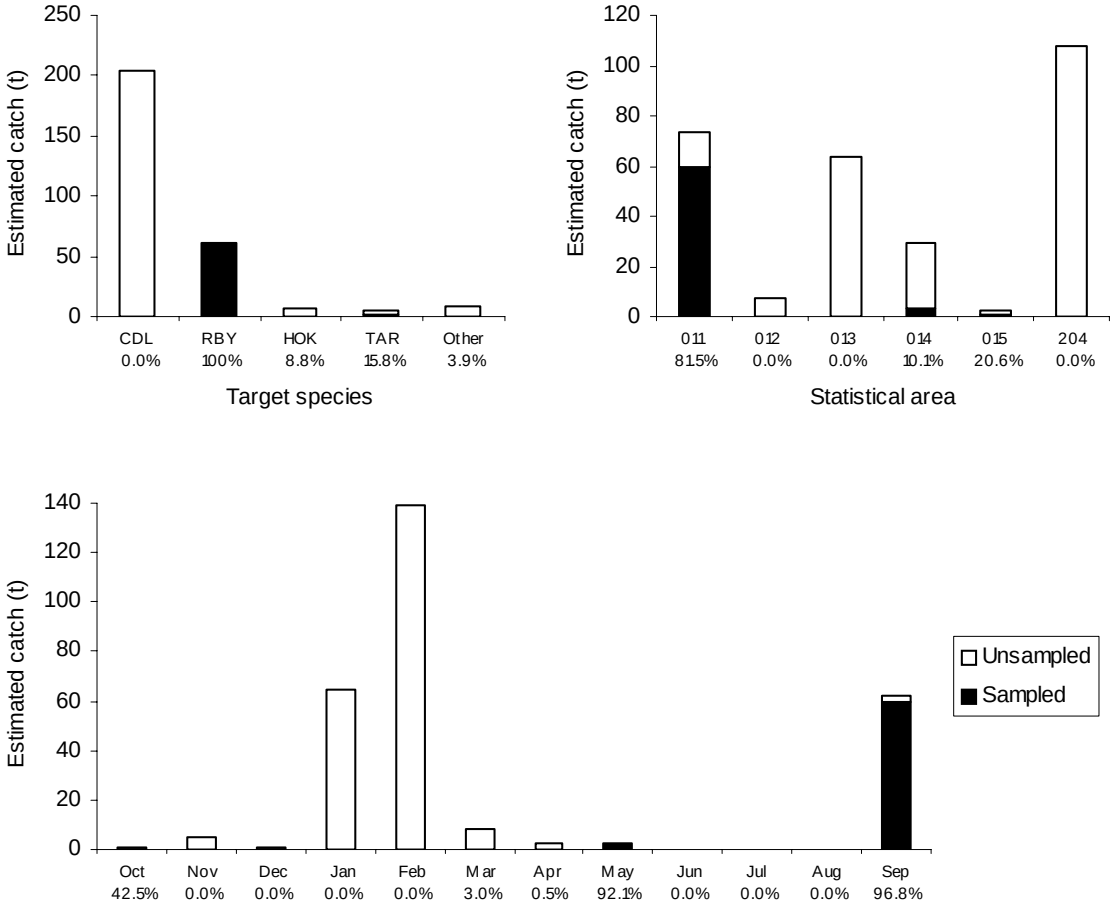

Figure 25: The composition (by target species, statistical area, and month) of the commercial trawl catch and sampled trawl catch of rubyfish from FMA 2 in the 2006–07 fishing year. Percentages on the bottom axis show the amount of the catch sampled. Species codes: CDL, cardinalfish; RBY, rubyfish; HOK, hoki; TAR, tarakihi.

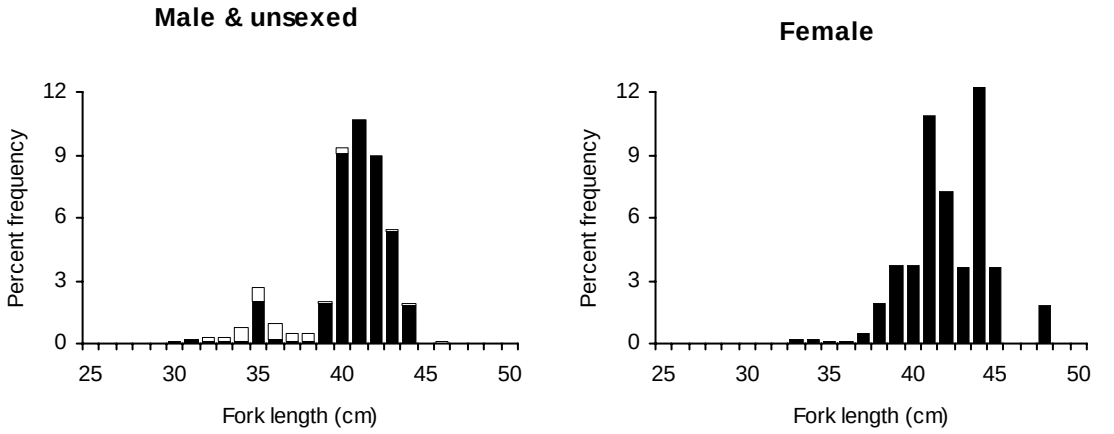

Figure 26: Scaled length-frequency distributions of male, female, and unsexed rubyfish from RBY 2, in the 2006–07 fishing year. Unsexed fish are depicted as unshaded bars on the male distribution.

Of the 311 otolith preparations, 309 were classified as readable and were used to estimate catch-at-age (Table 8). The 2006–07 distribution was very spiky and imprecise (see Figure 31). It had a mean weighted c.v. of 101%, markedly higher than the 30% target. The rubyfish fishery is clearly based on a wide range of age classes; the distributions from the 1998–99 to 2000–01 fishing years are dominated by fish between 8 and 28 years old (see Figure 31). The 2006–07 catch-at-age distributions for both sexes are so spiky and imprecise that it is not possible to draw any sound conclusions on the catch composition from that year, or on whether it is different from that of previous sampled years.

Table 8: Estimated catch-at-age (numbers and percentage) and calculated c.v.s from catch sampling in RBY 2 in 2006–07. The numbers of fish measured and aged, and the estimated mean weighted c.v.s, are also presented. (Table 8 continued over page.)

	Male			Female			Unsexed	
Age	Number	%	c.v.	Number	%	c.v.	Number	%
4	62	0.04	2.297	22	0.02	2.480	446	0.32
5	271	0.19	1.516	1595	1.14	1.012	1213	0.86
6	806	0.57	1.555	183	0.13	1.769	1322	0.94
7	1064	0.76	1.597	253	0.18	1.695	768	0.55
8	467	0.33	1.608	372	0.26	1.792	339	0.24
9	740	0.53	1.372	799	0.57	1.408	322	0.23
10	247	0.18	1.647	1716	1.22	0.965	108	0.08
11	992	0.71	1.105	612	0.44	1.334	108	0.08
12	1009	0.72	1.297	962	0.68	1.137	215	0.15
13	239	0.17	1.579	22	0.02	2.336	0	0.00
14	22	0.02	2.870	1764	1.26	1.038	0	0.00
15	1542	1.10	0.806	585	0.42	1.420	0	0.00
16	0	0.00	–	2077	1.48	0.849	0	0.00
17	1108	0.79	1.115	1603	1.14	1.027	0	0.00
18	980	0.70	1.109	4743	3.38	0.583	108	0.08
19	1056	0.75	1.273	7056	5.02	0.630	0	0.00
20	0	0.00	–	5276	3.76	0.677	0	0.00
21	3919	2.79	0.734	1715	1.22	1.025	0	0.00
22	3074	2.19	1.054	866	0.62	1.539	108	0.08
23	0	0.00	–	3153	2.24	0.763	0	0.00
24	3529	2.51	0.844	1269	0.90	1.366	0	0.00
25	0	0.00	–	0	0.00	–	0	0.00
26	980	0.70	1.274	0	0.00	–	0	0.00
27	2485	1.77	1.091	3057	2.18	0.801	0	0.00
28	2498	1.78	1.486	2949	2.10	1.038	0	0.00
29	7206	5.13	0.907	0	0.00	–	0	0.00
30	980	0.70	1.334	0	0.00	–	0	0.00
31	1569	1.12	1.367	1269	0.90	1.304	1	0.00
32	1569	1.12	1.575	0	0.00	–	0	0.00
33	2498	1.78	1.412	0	0.00	–	0	0.00
34	0	0.00	–	1018	0.72	1.309	0	0.00
35	1505	1.07	1.508	2949	2.10	1.062	0	0.00
36	1569	1.12	1.428	1929	1.37	1.286	0	0.00
37	2498	1.78	1.471	0	0.00	–	0	0.00
38	0	0.00	–	1929	1.37	1.417	0	0.00
39	2498	1.78	1.358	5587	3.98	0.794	108	0.08
40	2498	1.78	1.316	1269	0.90	1.267	0	0.00
41	1505	1.07	1.405	1018	0.72	1.176	0	0.00
42	0	0.00	–	0	0.00	–	0	0.00
43	19	0.01	2.662	1269	0.90	1.175	108	0.08
44	0	0.00	–	0	0.00	–	0	0.00
45	1266	0.90	1.733	1018	0.72	1.305	0	0.00
46	0	0.00	–	1929	1.37	1.446	0	0.00
47	0	0.00	–	1929	1.37	1.381	0	0.00
48	0	0.00	–	0	0.00	–	0	0.00
49	0	0.00	–	0	0.00	–	0	0.00
50	0	0.00	–	1020	0.73	1.516	0	0.00
51	1505	1.07	1.515	0	0.00	–	0	0.00
52	0	0.00	–	0	0.00	–	0	0.00
53	1266	0.90	1.641	0	0.00	–	0	0.00
54	0	0.00	–	1929	1.37	1.316	107	0.08
55	0	0.00	–	2949	2.10	1.130	0	0.00
56	0	0.00	–	0	0.00	–	0	0.00
57	0	0.00	–	0	0.00	–	0	0.00

Table 8 ctd.

	Male			Female			Unsexed	
Age	Number	%	c.v.	Number	%	c.v.	Number	%
58	0	0.00	–	0	0.00	–	0	0.00
59	0	0.00	–	1929	1.37	1.431	0	0.00
60	19	0.01	2.367	0	0.00	–	0	0.00
61	0	0.00	–	0	0.00	–	0	0.00
62	0	0.00	–	0	0.00	–	0	0.00
63	0	0.00	–	1929	1.37	1.347	0	0.00
93	0	0.00	–	2498	1.78	1.758	0	0.00
Total measured			125			136		50
Total aged			125			135		49
Mean weighted c.v. (by sex)			129.0			108.5		–
Mean weighted c.v. (both sexes)								101.1

3.3.2 Rubyfish in 2007–08

In 2007–08, catch sampling for rubyfish from RBY 2 was conducted in Auckland, Gisborne, and Napier. Samples were obtained from only five landings between 3 November 2007 and 10 September 2008, comprising 26 t, to produce a total of 228 measured and otolithed fish. The sampled landings accounted for 7% of the total RBY 2 landings from the fishing year, but the weights of sampled landings varied by more than two orders of magnitude (from 32 kg to 21.2 t). So the 2007–08 catch-at-age is largely derived from a single landing which produced about 6% of the total landings for that year. Unfortunately, that landing was not over-sampled (i.e., only the standard sample of 50 fish was measured and sexed).

Sampling was relatively even by fishing method, i.e., between 4 and 7% of the midwater trawl, bottom trawl, and line landings were sampled (Figure 27). However, virtually all rubyfish were taken by midwater trawl, so this method was clearly under-sampled. The distribution of landings by fishing method and landing weight shows that most fishing trips produce less than 100 kg of rubyfish (Figure 28). The bulk of the catch is taken by a very small number of trawling trips.

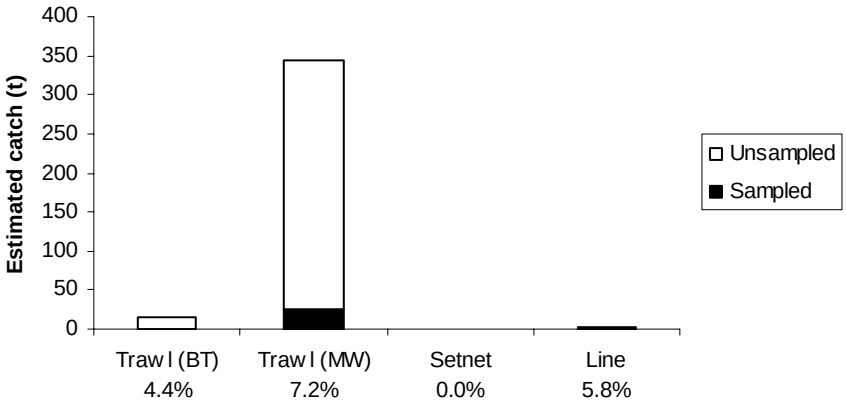

Figure 27: The composition, by fishing method, of the commercial catch and sampled catch of rubyfish from FMA 2 in the 2007–08 fishing year. Percentages on the bottom axis show the amount of the catch sampled.

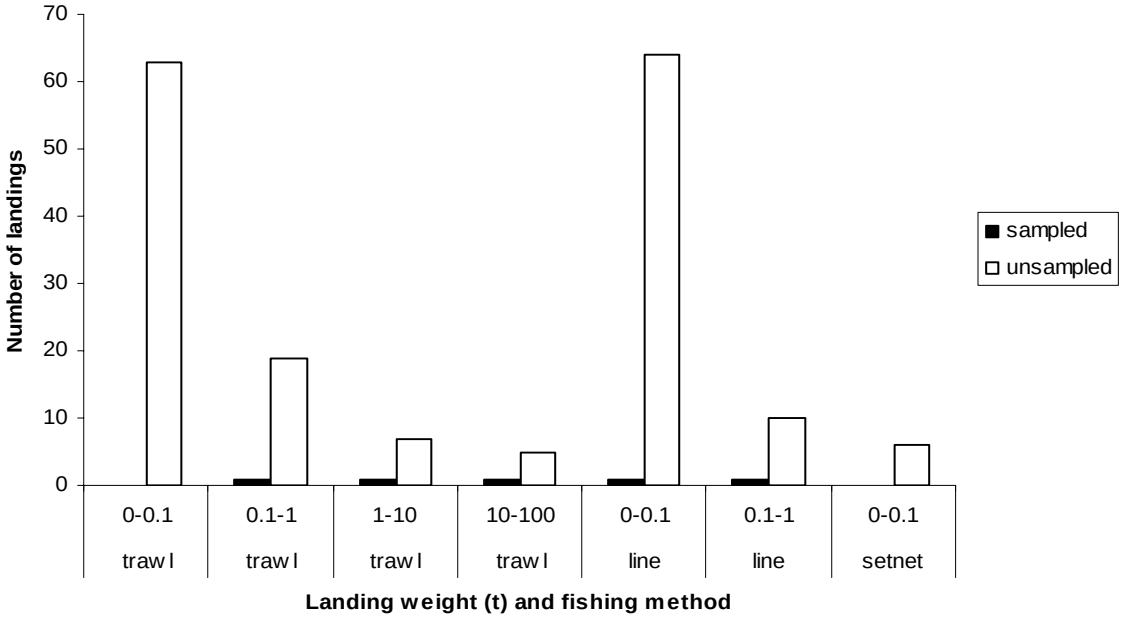

Figure 28: The distribution of sampled and unsampled rubyfish landings, by fishing method and landing weight.

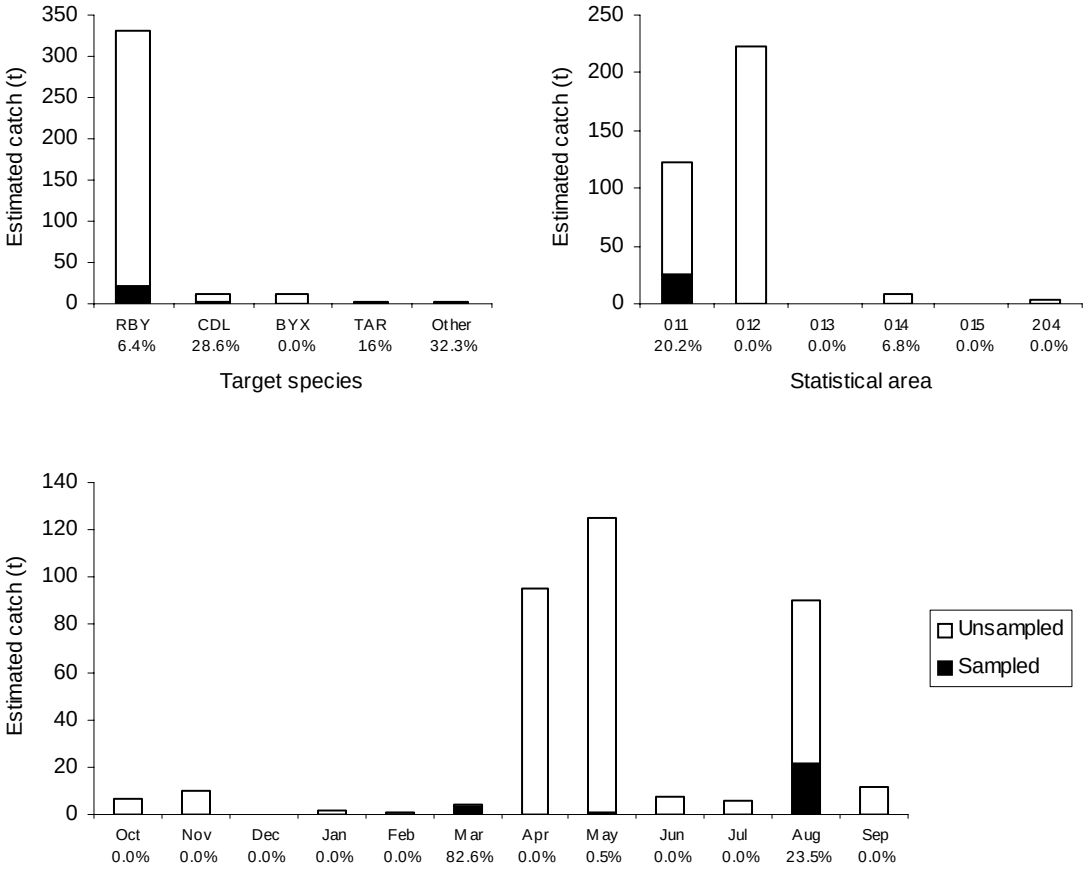

Figure 29: The composition (by target species, statistical area, and month) of the commercial trawl catch and sampled trawl catch of rubyfish from FMA 2 in the 2007–08 fishing year. Percentages on the bottom axis show the amount of the catch sampled. Species codes: RBY, rubyfish; CDL, cardinalfish; BYX, alfonsino; TAR, tarakihi.

Most trawl-caught rubyfish (92%) was stated to have been taken as the target species, with the remainder taken as a bycatch of other species, but mainly cardinalfish and alfonsino (Figure 29). Only

one of the sampled landings was from a rubyfish target trip; two of the samples were of line fishing bycatch (Figure 28). Samples of target rubyfish are clearly under-represented. Four of the samples were taken from Statistical Area 011; none were obtained from Area 012 which produced most of the landings (Figure 29). Consequently, sampling by area was also clearly unrepresentative. Significant trawl landings (86% of all landings) were taken only in April, May and August (Figure 29). Only one of these months (August) was significantly sampled; clearly, April–May was under-sampled.

Length-frequency distributions, scaled to represent the sampled catch, show the male length range to be 30–48 cm FL and the female range to be 29–48 cm FL, although fish shorter than 39 cm FL were uncommon (Figure 30). The male distribution has a clear mode at 41 cm; the female distribution is more spiky with no clear modes. Fish from the four small sampled landings were, on average, 39 cm FL, compared with a mean length of 41 cm FL from the single large landing. The large landing was a result of target fishing for rubyfish, whereas the other samples were from bycatch landings.

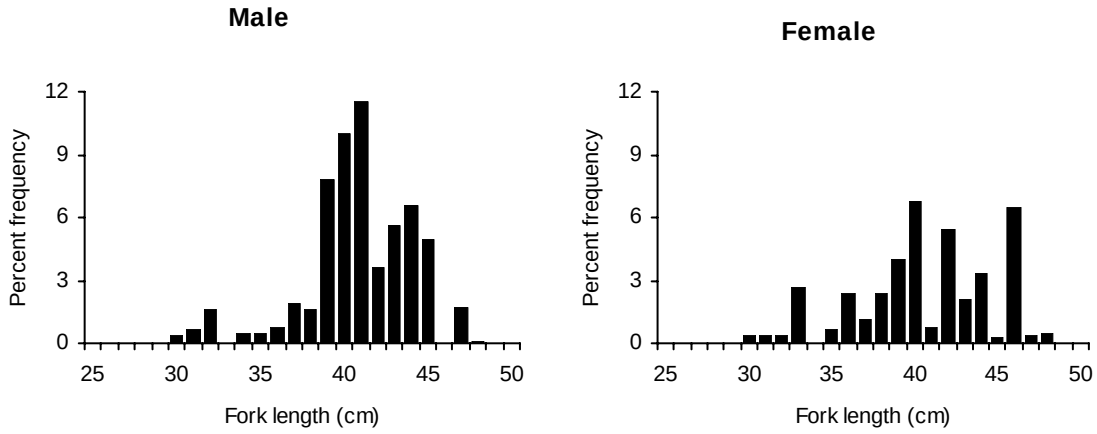

Figure 30: Scaled length-frequency distributions of male, female, and unsexed rubyfish from RBY 2, in the 2007–08 fishing year.

Of the 228 otolith preparations, 221 were classified as readable and were used to estimate catch-at-age (Table 9). The 2007–08 distribution was very spiky and imprecise (Figure 31). It had a mean weighted c.v. of 80%, markedly higher than the 30% target.

The rubyfish fishery is clearly based on a wide range of age classes; the distributions from the 1998–99 to 2000–01 fishing years are numerically dominated by fish between 8 and 28 years old (Figure 31). The 2007–08 catch-at-age distributions for both sexes are quite spiky and imprecise so it is difficult to draw any sound conclusions on the catch composition from that year, or on whether it is different from previous sampled years. However, there does appear to be a difference between the sexes, with the catch of males dominated by 17–31 year old fish, compared to dominant 6–15 year old females.

Table 9: Estimated catch-at-age (numbers and percentage) and calculated c.v.s from catch sampling in RBY 2 in 2007–08. The numbers of fish measured and aged, and the estimated mean weighted c.v.s, are also presented. (Table 9 continued over page.)

	Male			Female		
Age	Number	%	c.v.	Number	%	c.v.
5	1 787	0.69	1.600	0	0.00	–
6	2 817	1.09	1.287	4 343	1.69	1.126
7	3 289	1.28	1.002	2 832	1.10	0.898
8	4 396	1.71	0.787	3 913	1.52	0.928
9	2 819	1.09	0.897	7 545	2.93	0.708
10	702	0.27	1.435	5 132	1.99	0.704

Table 9 ctd.

	Male			Female		
Age	Number	%	c.v.	Number	%	c.v.
11	880	0.34	1.309	1 750	0.68	1.089
12	3 829	1.49	0.952	3 809	1.48	0.837
13	3 407	1.32	0.969	932	0.36	1.354
14	3 390	1.32	1.119	4 657	1.81	0.820
15	0	0.00	–	3 358	1.30	0.948
16	2 151	0.84	1.314	932	0.36	1.426
17	8 313	3.23	0.643	1 338	0.52	1.353
18	2 151	0.84	1.207	7 091	2.75	0.787
19	6 308	2.45	0.724	2 435	0.95	1.098
20	5 395	2.09	0.833	4 341	1.69	0.756
21	7 062	2.74	0.765	2 173	0.84	1.281
22	5 633	2.19	0.757	1 701	0.66	0.934
23	7 994	3.10	0.871	4 347	1.69	1.062
24	3 307	1.28	1.344	932	0.36	1.223
25	12 228	4.75	0.668	1 701	0.66	0.925
26	7 062	2.74	0.776	1 226	0.48	1.353
27	3 684	1.43	0.973	233	0.09	2.512
28	3 383	1.31	1.284	2 797	1.09	0.912
29	5 760	2.24	0.835	1 226	0.48	1.453
30	3 481	1.35	0.871	457	0.18	1.898
31	8 218	3.19	0.876	768	0.30	1.514
32	4 571	1.77	0.961	0	0.00	–
33	0	0.00	–	2 927	1.14	0.871
34	4 413	1.71	1.138	885	0.34	1.670
35	2 535	0.98	1.425	3 877	1.51	0.902
36	0	0.00	–	1 567	0.61	1.200
37	7 859	3.05	0.776	1 309	0.51	1.230
38	0	0.00	–	0	0.00	–
39	1 878	0.73	1.586	3 144	1.22	1.118
40	1 878	0.73	1.371	3 385	1.31	0.859
41	1 604	0.62	1.367	493	0.19	1.825
42	0	0.00	–	0	0.00	–
43	1 604	0.62	1.351	116	0.05	2.628
44	1 773	0.69	1.298	0	0.00	–
45	978	0.38	1.576	2 768	1.07	1.448
46	0	0.00	–	0	0.00	–
47	4 413	1.71	1.229	0	0.00	–
48	0	0.00	–	932	0.36	1.289
49	0	0.00	–	2 768	1.07	1.538
50	0	0.00	–	768	0.30	1.599
51	0	0.00	–	0	0.00	–
52	886	0.34	1.824	0	0.00	–
53	0	0.00	–	0	0.00	–
54	0	0.00	–	0	0.00	–
55	0	0.00	–	0	0.00	–
56	0	0.00	–	0	0.00	–
57	0	0.00	–	1 226	0.48	1.708
58	0	0.00	–	0	0.00	–
59	75	0.03	3.259	2 768	1.07	1.674
60	0	0.00	–	0	0.00	–
61	0	0.00	–	2 768	1.07	1.511
Total measured			106			122
Total aged			103			118
Mean weighted c.v. (by sex)			95.1			104.8
Mean weighted c.v. (both sexes)						79.9

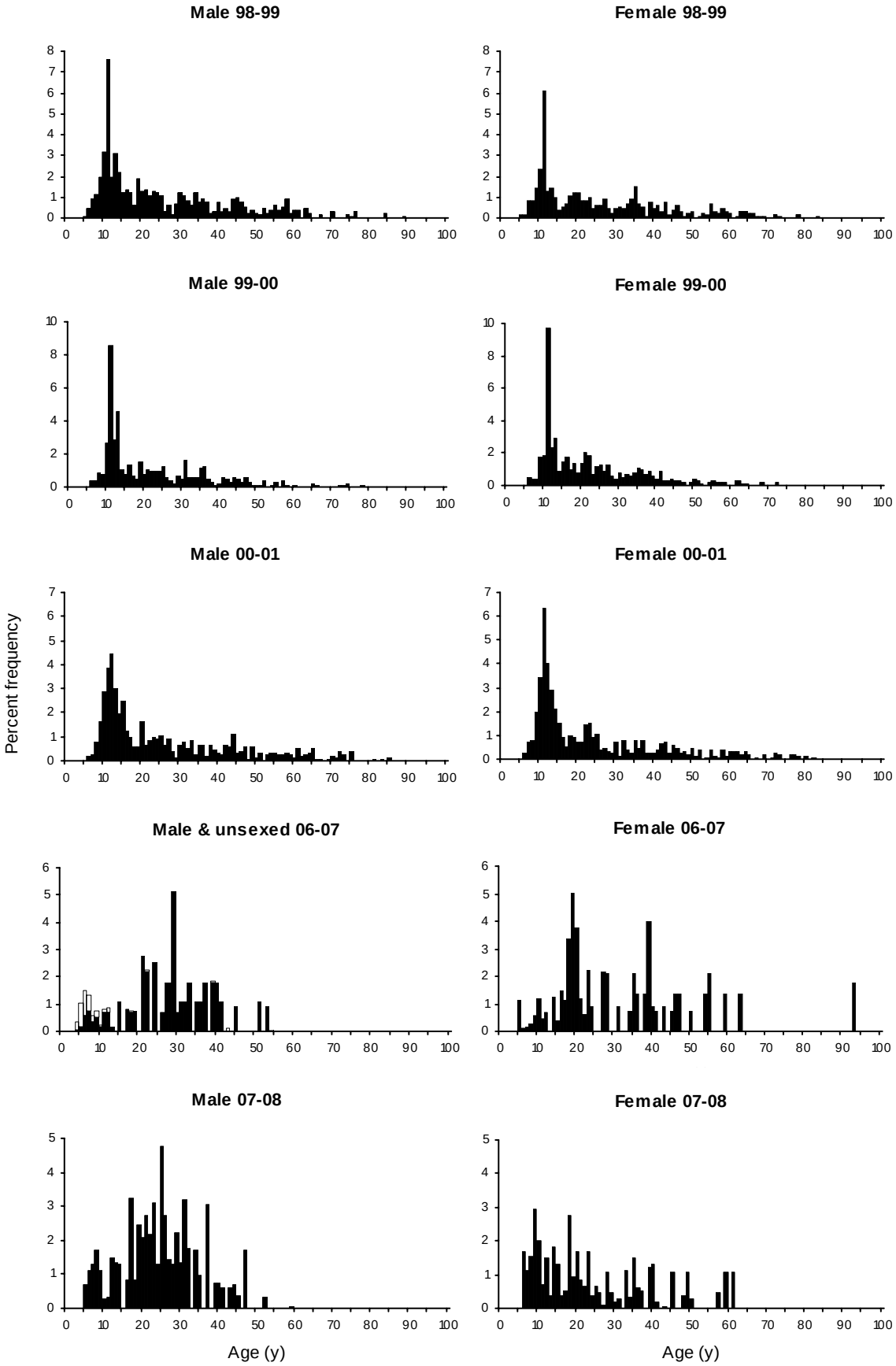

Figure 31: Estimated age-frequency distributions of male and female rubyfish from the RBY 2 trawl fishery, in the 1998–99 to 2000–01 and 2006–07 to 2007–08 fishing years. For 2006–07, unsexed fish are depicted as clear bars on the male distribution.

4. DISCUSSION

This report presents the results of the eleventh and twelfth years of sampling of the gemfish fishery in SKI 2, and the fourth and fifth years of sampling of alfonsino from BYX 2 and rubyfish from RBY 2. The targeted number of samples was met for alfonsino in both years, and for gemfish in 2007–08. It was very difficult to arrange sampling of significant catches of rubyfish in both years. The mean weighted c.v.s for the calculated catch-at-age distributions in both years were within the target of 30% for alfonsino (19% and 16%), and nearly met for gemfish (38% and 39%).

For gemfish, the relatively high c.v. in 2007–08 is surprising given that more fish were aged than in any previously sampled year. However, the catch distributions up to 2005 tended to be dominated by a small number (1–4) of relatively strong year classes, all with relatively low c.v.s. Since 2005, there have been a greater number of moderate strength year classes in the catch, each with moderate c.v.s, resulting in a higher mean weighted c.v. The 2007–08 distribution was unusual in that 2+ and 3+ fish are abundant. While these age classes are often sampled in this fishery, they are seldom abundant (particularly 2+ fish) or dominant. It is not yet apparent whether this indicates two particularly strong year classes, or is a quirk of the fishery in 2007–08 resulting in greater than normal catches of small (young) gemfish. Fish of these ages were abundant in 3 of the 13 sampled trawl landings. It is believed that the calculated gemfish catch composition probably provides a reasonable representation of the 2007–08 commercial catch. Onshore sampling of this fishery is probably a suitable method to monitor commercial catch-at-age, but it appears likely that the current age distribution of the population (i.e., numerous moderately abundant year classes) necessitates a greater sampling intensity than in the last two years to achieve the target c.v. This can probably be achieved by collecting (and ageing) the same number of otoliths, but measuring more fish per sample (e.g., 100 per sample, instead of 50).

For alfonsino, a comparison of the 2007–08 and 2006–07 catch-at-age distributions indicated the progression of a relatively strong 2003 year class (i.e., 5 years old in 2007–08). This is suggestive of some level of sampling consistency between years, and that the calculated catch compositions probably provide reasonable representations of the 2006–07 and 2007–08 commercial catches. Similarly, modal progression of two relatively strong year classes was also apparent in the earlier samples; the 1993 and 1994 year classes progressed from ages 5 and 6 in 1998–99 to ages 7 and 8 in 2000–01. The two recent years of catch sampling produced age distributions generally younger (i.e., most fish were 3–6 years old) than those calculated for the 1998–99 to 2000–01 fishing years (most fish were 5–9 years old). Although length and age distributions of alfonsino have been shown to vary between grounds (Horn & Massey 1989, Massey & Horn 1990), it is uncertain whether this has affected current or past estimates of the commercial catch composition. It is clear that if fishing ground was to be included as a stratum in future analyses, then on-shore sampling is unlikely to provide reliable data for this purpose, because most single trips involve fishing on several grounds.

Estimates of instantaneous fishing mortality rates (F) for alfonsino in the five sampled years were produced assuming that instantaneous natural mortality (M) for this species was in the range 0.20–0.26. The results indicated that F increased over the sampled period, being (for males) probably less than M from 1999 to 2001, but greater than M in 2007 and 2008. F was estimated to be consistently lower for females than males. However, if the true M for females is lower than that for males (as has often been shown for teleosts), then the real difference will be less than that indicated in Table 7. If the trend of an increasing F over time is real, then it is indicative of a declining stock size as annual landings since 1990 have been relatively constant at 1400–1800 t per year. It must be stressed that the accuracy of the mortality estimates, and any comparisons between them, assumes that the sample from each year is representative of the recruited population. While this assumption has not been shown to hold for the data collected here, the consistency within each of the early (1999–2001) and late (2006–2007) groups of samples provides encouraging support that sampling was representative.

Sampling of rubyfish in 2006–07 and 2007–08 was completely inadequate to describe the catch composition. Most landings were of small volumes of bycatch. These are quickly on-sold, with the processing sheds preferring them to be uncut. In both years there were apparent differences in mean

fish size between the small (bycatch) landings and the large (target) landings. We believe that sampling of rubyfish will only be successful with the active participation of industry. The vast majority of rubyfish are landed from a very small number of trawl trips; in 2007–08 three trips produced about 75% of the total RBY 2 landings. A small number of these large landings need to be heavily sampled, thus providing a good representation of the commercial catch. Unless industry notifies the contracted sampler, or conducts the sampling themselves, there is a high probability that these landings will be missed.

This work has also highlighted some difficulties associated with catch sampling in processing sheds (in addition to species-specific problems noted in the Discussion above). The samplers are reliant on the shed for providing accurate information on the Fishstock caught, fishing method, and total weight of the landing. For most samples, the provided data were accurate and enabled an easy and unequivocal linkage to QMS landing and effort data. But for some samples, the landed weight reported in the QMS was markedly different from that provided by the shed, the method was different, or the Fishstock was different. An incorrect landing weight does not impact negatively on the sampling programme, as the sample is still valid. However, an incorrectly reported Fishstock nullifies the sample. This occurred for alfonsino in both years; one sample in 2006–07 was from a trip entirely in BYX 3, and another in 2007–08 was from a trip where 25 of the 31 fishing events were in BYX 3 with the remaining 6 events in BYX 2. An incorrect fishing method can nullify the sample, or (at best) allows the sample data to be included in the analysis representing the small proportion of the catch taken by that method. It was also apparent that there can be discrepancies between the positional data recorded in the 'effort by tow' records and the landings weight by Fishstock for a trip, particularly when fishing occurs in several FMAs. For example, one trip was noted to have caught a very significant weight of rubyfish, with high estimated catches from several tows positioned in the RBY 2 Fishstock area, yet no landing of RBY 2 was reported for the trip.

5. ACKNOWLEDGMENTS

We thank members of the Inshore Fishery Assessment Working Group for comments and suggestions. This work was funded by the Ministry of Fisheries under project INS2005-01.

6. REFERENCES

Blackwell, R.G.; McMillan, P.J.; Horn, P.L.; Paul, L.J. (2001). Commercial catch sampling of alfonsino, bluenose, gemfish and rubyfish in QMA 2 in 1999–2000. Final Research Report for Ministry of Fisheries Research Project INS1999-01. 25 p. (Unpublished report held by MFish, Wellington.)

Blackwell, R.G.; Horn, P.L.; McMillan, P.J. (2002). Commercial catch sampling of alfonsino, bluenose, gemfish and rubyfish in QMA 2 in 2000–01. Final Research Report for Ministry of Fisheries Research Project INS2000-01, Objectives 1–3. 24 p.

Bull, B.; Dunn, A. (2002). Catch-at-age: User manual v1.06.2002/09/12. NIWA Internal Report 114. 23 p. (Unpublished report held in NIWA library, Wellington.)

Chapman, D.G.; Robson, D.S. (1960). The analysis of a catch curve. *Biometrics 16*: 354–368.

Dunn, A.; Francis, R.I.C.C.; Doonan, I.J. (1999). The sensitivity of some catch curve estimators of mortality to stochastic noise, error, and selectivity. New Zealand Fisheries Assessment Research Document 99/5. 23 p. (Unpublished report held in NIWA library, Wellington.)

Hoenig, J.M. (1983). Empirical use of longevity data to estimate mortality rates. *Fishery Bulletin 82*: 898–902.

Horn, P.L. (2008). Commercial catch sampling for length and age of gemfish, alfonsino and rubyfish in QMA 2 in the 2006–07 fishing year. Final Research Report for Ministry of Fisheries Research Project INS2005-01, Objective 1. 21 p. (Unpublished report held by MFish, Wellington.)

Horn, P.L.; Hurst, R.J. (1999). Age and stock structure of gemfish (*Rexea solandri*) in New Zealand waters. *Marine and Freshwater Research 50*: 103-115.

Horn, P.L.; Massey, B.R. (1989). Biology and abundance of alfonsino and bluenose off the lower east coast North Island, New Zealand. *New Zealand Fisheries Technical Report 15*. 32 p.

Horn, P.L.; McMillan, P.J.; Manning, M.J.; Sutton, C.P. (2006). Commercial catch sampling for length and age of John dory in JDO 1, grey mullet in GMU 1, red gurnard in GUR 1 and GUR 2, gemfish in SKI 2, and alfonsino in BYX 3, in the 2004–05 fishing year. Final Research Report for Ministry of Fisheries Project INS2003-01, Objectives 8, 9, 10, 11, 12, & 13. 42 p. (Unpublished report held by MFish, Wellington.)

Horn, P.L.; McMillan, P.J.; Phillips, N.L. (2004). Commercial catch sampling for length and age of John dory in JDO 1, gemfish in SKI 2, and alfonsino in BYX 3 in the 2003–04 fishing year, and rubyfish in RBY 2 in the 2000–01 fishing year. Final Research Report for Ministry of Fisheries Project INS2003-01, Objectives 2, 4, 6, & 7. 28 p. (Unpublished report held by MFish, Wellington.)

Lehodey, P.; Grandperrin, R. (1996). Age and growth of the alfonsino *Beryx splendens* over the seamounts off New Caledonia. *Marine Biology 125*: 249–258.

Massey, B.R.; Horn, P.L. (1990). Growth and age structure of alfonsino (*Beryx splendens*) from the lower east coast, North Island, New Zealand. *New Zealand Journal of Marine and Freshwater Research 24*: 121–136.

Paul, L.J.; Horn, P.L.; Francis, M.P. (2000). Development of an ageing methodology, and first estimates of growth parameters and natural mortality for rubyfish (*Plagiogeneion rubiginosum*) off the east coast of the North Island (QMA 2). *New Zealand Fisheries Assessment Report 2000/22*. 28 p.

Paul, L.J.; Sparks, R.; Neil, H.L.; Horn, P.L. (2004). Maximum ages for bluenose (*Hyperoglyphe antarctica*) and rubyfish (*Plagiogeneion rubiginosum*) determined by the bomb chronometer method of radiocarbon ageing, and comments on the inferred life history of these species. Final Research Report for Ministry of Fisheries Project INS2000-02, Objectives 1 & 2. 69 p. (Unpublished report held by MFish, Wellington.)

Appendix A: Summaries of the sampled landings

Table A1: Details of sampled alfonsino landings in 2006–07 and 2007–08. Trip, QMS trip identifier; sample no., sample identifier in the *market* database; events, number of fishing events reported to have contributed to the sampled catch — where method is 'trawl' the numbers are (bottom trawls, midwater trawls); weight, green weight (kg) of sampled catch; days, number of fishing days contributing to sampled catch; statistical areas, areas reported to have contributed to the sampled catch (numbers in brackets indicate the number of fishing events attributed to each area).

Trip	Sample no.	Landing date	Method	Events	Weight	Days	Statistical areas
4773608	20061611	2006-10-04	trawl	2, 5	39 078	2	15(7)
4638530	20061612	2006-10-12	trawl	7, 0	28 172	5	15(3), 14(1), 204(3)
4692357	20061613	2006-10-15	trawl	1, 6	27 275	3	204(7)
4773613	20061614	2006-10-24	trawl	2, 4	17 966	2	15(6)
4638532	20061615	2006-10-24	trawl	14, 0	34 544	7	11(2), 12(2), 13(1), 14(2), 204(8)
4773616	20061616	2006-10-31	trawl	1, 2	35 761	2	14(1), 15(2)
4638533	20061617	2006-11-02	trawl	13, 0	15 724	4	15(2), 204(11)
4346716	20061618	2006-11-08	trawl	3, 2	14 227	7	15(2), 204(3)
4773620	20061619	2006-11-13	trawl	4, 0	24 981	2	15(2), 18(2)
4638531	20061620	2006-11-13	trawl	21, 0	24 280	7	11 (3), 13 (4), 15 (6), 204 (8)
4773623	20061621	2006-11-20	trawl	0, 3	35 132	2	15(3)
4638535	20061622	2006-11-27	trawl	20, 0	7 057	8	11(3), 12(2), 13(6), 15(6), 204(3)
4638536	20061623	2006-12-05	trawl	8, 2	10 075	6	204(10)
4830353	20071611	2007-01-17	trawl	1, 1	844	1	18(2)
4956869	20071651	2007-10-23	trawl	0, 3	1 691	1	16(1), 18(2)
4769424	20071652	2007-11-04	trawl	10, 5	25 509	9	11(3), 13(1), 14(2), 15(7), 204(2)
4956874	20071653	2007-11-05	trawl	6, 10	20 411	4	15(2), 18(4)
4769425	20071654	2007-11-14	trawl	6, 5	23 007	7	13(1), 14(5), 15(4), 204(1)
4956878	20071655	2007-11-19	trawl	1, 5	28 878	3	15(5), 18(1)
4769427	20071656	2007-11-26	trawl	16, 1	26 346	6	11(4), 13(4), 14(1), 204(8)
4956880	20071657	2007-11-26	trawl	1, 6	36 162	4	15(5), 18(2)
4956883	20071658	2007-12-02	trawl	1, 4	14 547	3	15(3), 18(2)
4769429	20071659	2007-12-06	trawl	10, 2	38 326	8	11(1), 13(2), 14(2), 15(3), 204(4)
4769433	20081611	2008-01-21	trawl	7, 2	32 278	5	13(3), 14(1), 15(1), 204(4)
5045076	20081613	2008-02-05	trawl	2, 7	38 086	4	15(4), 18(5)
4769435	20081614	2008-02-13	trawl	0, 1	430	1	18(1)
5045092	20081615	2008-03-13	trawl	2, 0	4 006	2	18(2)
4346752	20081616	2008-03-13	trawl	3, 0	608	3	11(1), 15(1), 204(1)
4346758	20081617	2008-04-10	trawl	4, 9	21 779	7	13(2), 14(2), 15(7), 204(2)

Table A2: Details of sampled rubyfish landings in 2006–07 and 2007–08. Trip, QMS trip identifier; sample no., sample identifier in the *market* database; events, number of fishing events reported to have contributed to the sampled catch — where method is 'trawl' the numbers are (bottom trawls, midwater trawls); weight, green weight (kg) of sampled catch; days, number of fishing days contributing to sampled catch; statistical areas, areas reported to have contributed to the sampled catch (numbers in brackets indicate the number of fishing events attributed to each area).

Trip	Sample no.	Landing date	Method	Events	Weight	Days	Statistical areas
4638530	20061711	2006-10-12	trawl	1, 0	25	1	14(1)
4638532	20061712	2006-10-24	trawl	1, 0	332	1	15(1)
4657772	20070301	2007-01-26	trawl	1, 0	283	1	14(1)
4830372	20070311	2007-03-07	trawl	1, 0	252	1	15(1)
4533089	20070321	2007-05-05	trawl	3, 0	1 257	3	14(3)
4533096	20070322	2007-06-11	trawl	2, 0	1 265	2	14(2)
4698555	20070323	2007-08-20	trawl	0, 4	64 396	3	11(4)
4793366	20070303	2007-11-03	line	10	245	6	13(1), 204(9)
4698585	20080341	2008-03-19	trawl	0, 1	3 520	1	14(3)
5055994	20080321	2008-03-26	line	4	32	3	11(1)
4738281	20080301	2008-05-18	trawl	3, 0	459	5	14(1), 204(3)
4698601	20080311	2008-08-10	trawl	0, 1	11 425	1	11(1)

Table A3: Details of sampled gemfish landings in 2006–07 and 2007–08. Trip, QMS trip identifier; sample no., sample identifier in the *market* database; events, number of fishing events reported to have contributed to the sampled catch — where method is 'trawl' the numbers are (bottom trawls, midwater trawls); weight, green weight (kg) of sampled catch; days, number of fishing days contributing to sampled catch; statistical areas, areas reported to have contributed to the sampled catch (numbers in brackets indicate the number of fishing events attributed to each area).

Trip	Sample no.	Landing date	Method	Events	Weight	Days	Statistical areas
4773608	20060211	2006-10-04	trawl	0, 1	82	1	16(1)
4638530	20060212	2006-10-12	trawl	1, 0	58	1	14(1)
4638532	20060213	2006-10-24	trawl	4, 0	1 326	4	14(2), 15(1), 204(1)
4773616	20060214	2006-10-31	trawl	6, 1	1 520	3	14(4), 15(3)
4773620	20060215	2006-11-13	trawl	0, 1	73	1	16(1)
4657753	20060241	2006-11-18	trawl	11, 0	2 675	4	14(7), 15(4)
4662193	20060271	2006-11-08	trawl	2, 0	780	2	13(2)
4657770	20070201	2007-01-18	trawl	12, 0	14 084	4	14(11), 15(1)
4657772	20070202	2007-01-26	trawl	14, 0	11 584	5	14(13), 15(1)
4830372	20070211	2007-03-07	trawl	0, 1	714	1	15(1)
4778007	20070204	2007-11-12	trawl	8, 0	842	4	14(5), 15(3)
4956883	20070251	2007-12-02	trawl	0, 6	159	5	15(1), 16(5)
4778019	20070203	2008-01-10	trawl	7, 0	1 552	3	14(3), 15(4)
5031906	20080212	2008-02-04	trawl	11, 0	2 414	4	13(1), 14(10)
4984497	20080211	2008-02-05	trawl	4, 0	1 855	2	11(4)
5045076	20080214	2008-02-05	trawl	1, 3	474	2	15(3), 16(1)
5054926	20080213	2008-02-07	trawl	3, 0	192	3	12(1), 13(1), 14(1)
5003790	20080216	2008-03-01	line	6	333	3	14(6)
5054345	20080215	2008-03-27	trawl	6, 0	1 138	2	14(6)
5031911	20080217	2008-04-07	trawl	3, 0	104	3	14(3)
4833826	20080218	2008-04-16	trawl	2, 0	201	2	14(1), 15(1)
4833828	20080219	2008-04-28	trawl	8, 0	450	5	14(3), 15(5)
4738281	20080220	2008-05-18	trawl	12, 0	386	7	14(12)
5054361	20080221	2008-06-01	trawl	9, 0	378	5	13(1), 14(8)