TAR 3 catch sampling in 2009–10 and fishery characterisation (1989–90 to 2009–10)

M.P. Beentjes

NIWA
P O Box 6414
Dunedin

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EXECUTIVE SUMMARY

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This report describes the results of the 2009–10 tarakihi (*Nemadactylus macropterus*) catch sampling programme carried out in TAR 3 during which landings from commercial vessels were sampled for length, otoliths collected, and reproductive status recorded. This is the first of a two year sampling programme (2009–10 and 2010–11). Two fishery methods were sampled; the set net fishery in statistical area 018 (Kaikoura), and the bottom trawl fishery in statistical areas 020 (Pegasus Bay), 022 (Canterbury Bight), and 024 (Oamaru to Taieri Mouth). In addition a fishery characterisation was carried out for the fishing years 1989–90 to 2009–10 to assess representativeness of the catch sampling programme.

Set net fishery

A total of 16 set net landings from statistical area 018 were sampled between December 2009 and June 2010. Sampling allocation was proportional to historical monthly catches over the period 2002–03 to 2007–08. Analysis of the sampled vessels and all vessel catches over the sampling period, and vessel characteristics, indicated that sampling was representative of the commercial fishery in 2009–10.

The target was to sample 60 fish per landing. A total of 967 fish were measured for length, had otoliths removed, and had reproductive status recorded. Length data (344 males and 623 females) were scaled by landed weights of tarakihi from the sampled vessels, and by commercial catch from the sampling strata, i.e., commercial catch by two month blocks in statistical area 018. Both male and female distributions were unimodal with peaks at 33 cm fork length, with most fish between 30 and 40 cm. Mean lengths were 33.1 cm, 33.9 cm, and 33.6 cm (M, F, overall). The mean weighted c.v.s (MWCV) were 25.6%, 19.2%, and 15.9% (M, F, overall). The sex ratio was 33% male.

Of the 967 otolith sets collected, 345 were aged. The number of aged otoliths per landing was proportional to the relative landing weight, but ensuring at least 10 otolith pairs from each sampled landing were included. Otoliths were then randomly selected from each landing. Aged fish for the set net fishery are not as well matched with the 2009–10 catch data as the sampling of landings, but this is partly a result of weighting the otolith selection by weight of each sampled landing. Thin sections were prepared and an age assigned independently by two readers without reference to length. Where there was disagreement, a third reader conferred with the other readers to produce an overall agreed age. Average percent error (APE) was 4.4, c.v. 6.2%, and percent agreement was 67%. There was no age estimation bias across the age range. The range of final agreed age estimates was 3–39 years, although 98% of ages were less than 9 years old. Catch at age was estimated using the direct ageing method, and age data were scaled in the same way as length data. Both male and female distributions were unimodal with peaks at about 5 years, with most fish (89% for males and 95% for females) between 4 and 7 years old. Mean ages were 5.6 y, 5.2 y, and 5.3 y (males, females, overall). The MWCVs were 32.7%, 22.2%, and 19.2% (males, females, overall).

Total mortality estimates (*Z*) for the set-net fishery in 2009–10 for age at full recruitment of 5 and 6 years were 0.70 and 0.62, respectively.

Spawner per recruit analyses (SPR) for the set net fishery for the default natural mortality (*M)* of 0.10 and fishing mortality (*F*) of 0.60 (estimated from Z where age at full recruitment = 5 y) resulted in an estimate of $F_{2.9\%}$. This indicates that at the 2009–10 levels of fishing mortality, the life-time spawning biomass of a cohort is reduced to less than 3% of what it would be in the absence of fishing.

The gonad staging indicated that only a small proportion of the set-net fish were in spawning condition and this was not substantially greater than the proportion spawning in the bottom trawl fishery in

Pegasus Bay and the Canterbury Bight. Spawning that was observed, tended to be in the late summer-autumn period, consistent with the findings from previous studies.

Bottom trawl fishery

A total of 26 bottom trawl landings were sampled from statistical areas 020, 022, and 024 between October 2009 and September 2010. Sampling allocation was proportional, both temporally and spatially, to historical catches over the period 2002–03 to 2007–08. Analysis of the sampled vessels and all vessel catches over the sampling period, and vessel/depth characteristics indicated that sampling was representative of the commercial fishery in 2009–10.

The target was to sample 60 fish per landing. A total of 1510 fish were measured for length, had otoliths removed, and had reproductive status recorded. Length data (656 males and 854 females) were scaled by landed weights of tarakihi from the sampled vessels, and by commercial catch from the sampling strata, i.e., commercial catch by two month blocks in each of the three statistical areas. Both male and female distributions were unimodal with peaks at 28 cm fork length, with most fish between 25 and 35 cm. Mean lengths were 29.0 cm, 29.8 cm, and 29.5 cm (M, F, overall). The MWCVs were 19.7%, 20.2%, and 15.5% (M, F, overall). The sex ratio was 44% male.

Of the 1510 otolith sets collected, 502 were randomly selected, prepared and read as for the set net fishery. Aged fish for the bottom trawl fishery are not as well matched with the 2009–10 catch data as the sampling of landings, but this is partly a result of weighting the otolith selection by weight of each sampled landing. APE was 1.15, c.v. 1.6%, and percent agreement was 92%. There was no age estimation bias across the age range. The range of final agreed age estimates was 2–19 years, although 97% of ages were less than 8 years old. Catch at age was estimated as per the set net fishery. Both male and female distributions were unimodal with peaks at 3 years, with most fish (90% for males and 86% for females) between 3 and 5 years old. Mean ages were 3.8 y, 3.9 y, and 3.85 y (male, female, overall). The MWCVs were 25.1%, 27.7%, and 19.7% (male, female, overall).

Total mortality estimates (Z) for the bottom trawl fishery in 2009–10 for age at full recruitment of 3 and 4 years were 0.71 and 0.93, respectively.

Spawner per recruit analyses (SPR) for the bottom trawl fishery for the default natural mortality (M) of 0.10 and fishing mortality (F) of 0.61 (estimated from Z where age at full recruitment = 3 y) resulted in an estimate of $F_{2.8\%}$. This indicates that at the 2009–10 levels of fishing mortality the expected contribution to the spawning biomass over the lifetime of an average recruit has been reduced to less than 3% of the contribution in the absence of fishing.

The gonad staging indicated that only a small proportion of the bottom trawl caught fish were spawning. Spawning that was observed, tended to be in the late summer-autumn period, consistent with the findings from previous studies.

1. INTRODUCTION

This report describes the results of the 2009–10 catch sampling programme carried out on tarakihi (*Nemadactylus macropterus*) in TAR 3. Landings of tarakihi from commercial vessels were sampled during which length and reproductive condition were recorded, and otoliths collected. In addition, a fishery characterisation was carried out for the fishing years 1989–90 to 2009–10. This is the first catch sampling programme carried out for TAR 3 and is the first year of a two-year sampling programme that includes 2010–11 (TAR201002).

1.1 Distribution and depth range of tarakihi

Tarakihi are found throughout New Zealand including the Snares, Chatham Islands, and Three Kings Islands (Francis 2001), and are most common on the continental shelf (Ayling & Cox 1982). The mean depth of tarakihi from research trawl surveys throughout New Zealand is 182 m (range 11 to 486 m) (Anderson et al. 1998) which probably defines the minimum and maximum depths of this species, with a mean that is probably biased by the number of deepwater surveys. In contrast, east coast south Island (ECSI) research trawl surveys show a depth distribution of between about 30 to 250 m (Beentjes & Stevenson 2009). In the TAR 3 (Figure 1) bottom trawl commercial fishery, capture depth depends on the target species. Most tarakihi (about 80%) in TAR 3 is taken when targeting red cod, barracouta, or tarakihi and during these fishing events the mean depth is about 80 m (data from vessels completing TCEPRs; before 2007–08 only TCEPR forms recorded depth). However, catches of tarakihi, albeit small, are also taken when targeting hoki (mean depth 278 m) and elephantfish (mean depth 45 m) (Starr et al. 2009). Hence, in Canterbury Bight and Pegasus Bay, tarakihi are distributed from the shallow inshore to the continental slope, but are most common in the mid shelf depths of about 80 m.

A target tarakihi set net fishery in statistical area 018 operates off Kaikoura during summer/autumn, on the spawning migration of tarakihi, using 125 mm mesh size (5 inch). There is no published depth data from this fishery because depth is not a required field for the CELRs or the more recent NECLR introduced in 2006–07, but anecdotal information indicates that the target set net fishery operates in depths of between 100 and 160 m (pers. comm. Dick Cleall, Kaikoura commercial set net fisher). This is distinct from the deeper water mixed species set-net fishery which operates all year round and uses a larger mesh (175 mm or 200 mm), with the main catch comprising hapuku, ling, spiny dogfish, school shark, tarakihi, blue moki, and seal shark (Langley 2010).

1.2 Age and growth

Vooren & Tong (1973) indicated a maximum age of about 18 years for tarakihi males and 22 years for females from the East Cape fishery in 1971. Vooren (1977) subsequently looked at age and growth of tarakihi from the west coast of the South Island and the Chatham Islands, areas considered to be lightly exploited at that time, and estimated maximum ages of 33 years for males and 35 years for females for the west coast, and 39 and 41 years for the Chathams. In 1987 a research trawl survey between Cook Strait and Banks Peninsula using R.V. *James Cook* was undertaken specifically to study the biology of tarakihi (Annala et al. 1990), and maximum ages of tarakihi were estimated at 42 years for both males and females. More recently an ageing project with the objective of validating the ageing methodology and assessing the between reader precision for otolith annual increment readings was carried out by Stevenson & Horn (2004); they found that tarakihi from the west coast of the South Island had maximum ages of 38 and 44 years for males and females, respectively, although calculation of population numbers-at-age in the fishery produced few fish older than 15 years. Hence tarakihi are potentially relatively long-lived and the fishery is likely to comprise many cohorts.

From an historical perspective, early records from Otago indicate that the largest tarakihi caught off Otago in the 1930s was 28 inches (71 cm) and weighed 9 Ib. (4 kg) (Graham 1953). However, Graham’s length and weight do not match since a fish of 71 cm would be about 7.7 kg (not 4 kg), based on the known length weight from the ECSI trawl surveys (Beentjes et al. 2010). A 4 kg fish would be about 57 cm, which seems more likely. By comparison the largest fish caught in the early 1970s from the west coast was about 52 cm and from the Chathams was 50 cm (Vooren 1977).

1.3 Spawning

Tarakihi spawn in summer/autumn off the outer continental shelf (McKenzie 1961, Ayling & Cox 1982). Known spawning areas include Bay of Plenty (Vooren & Tong 1973), outer Pegasus Bay, Conway Ridge, Cape Campbell, Cook strait (Tong & Vooren 1972, Robertson 1973, Fenaughty & Bagley 1981), and the west coast South Island (Vooren 1975). Robertson (1973) was of the view that spawning did not occur south of Banks Peninsula, although this was not the conclusion of Vooren (1975). Juvenile tarakihi (less than 3 years old and 24 cm) are known to aggregate in nursery grounds in 20–100 m depth in Tasman Bay, the south west coast North Island, the Chatham Islands, and the east coast South Island (Vooren 1975). Catches of tarakihi from ECSI *Kaharoa* trawl surveys are consistent with this observation (Beentjes & Stevenson 2000, 2001, 2008, Beentjes et al. 2010) and are generally smaller than those from the WCSI trawl survey (Stevenson & Hanchet 2000). Indeed most tarakihi caught on the ECSI trawl surveys are less than 30 cm length (Beentjes & Stevenson 2008, Beentjes et al. 2010). Size at 50% maturity was estimated at around 27 cm and 28 cm for males and females respectively (Tong & Vooren 1972) and more recently by Parker & Fu (in press) at 32 and 33 cm. This indicates that most tarakihi caught by *Kaharoa* are immature pre-spawning fish.

1.4 Movement

Tagging studies of tarakihi around the Bay of Plenty indicate that these fish moved only short distances within the first year, but later recaptures showed much greater movements with some fish recaptured 100 to 200 NM from the tagging site (Crossland 1982). Tagging of tarakihi is carried out every two years during the WCSI trawl surveys, but there are no returns yet.

1.5 TAR 3 commercial landings

In TAR 3 catches have averaged about 1000 t over the last 10 years (up to 2009–10) but have ranged between 757 t and 1244 t (Figures 1 and 2). The TACC was exceeded in three consecutive years (1999–2000, 2000–01 and 2001–02) and then was subsequently increased by 20 % in 2004–05 (1169 to 1403 t) under the Adaptive Management Programme (AMP) (Ministry of Fisheries 2008b). Following this increase, catches have been substantially less than the revised TACC in all fishing years with 2009–10 the lowest at 46% less than the TACC. Indeed catches have been trending down since 2001–02 (Figure 2).

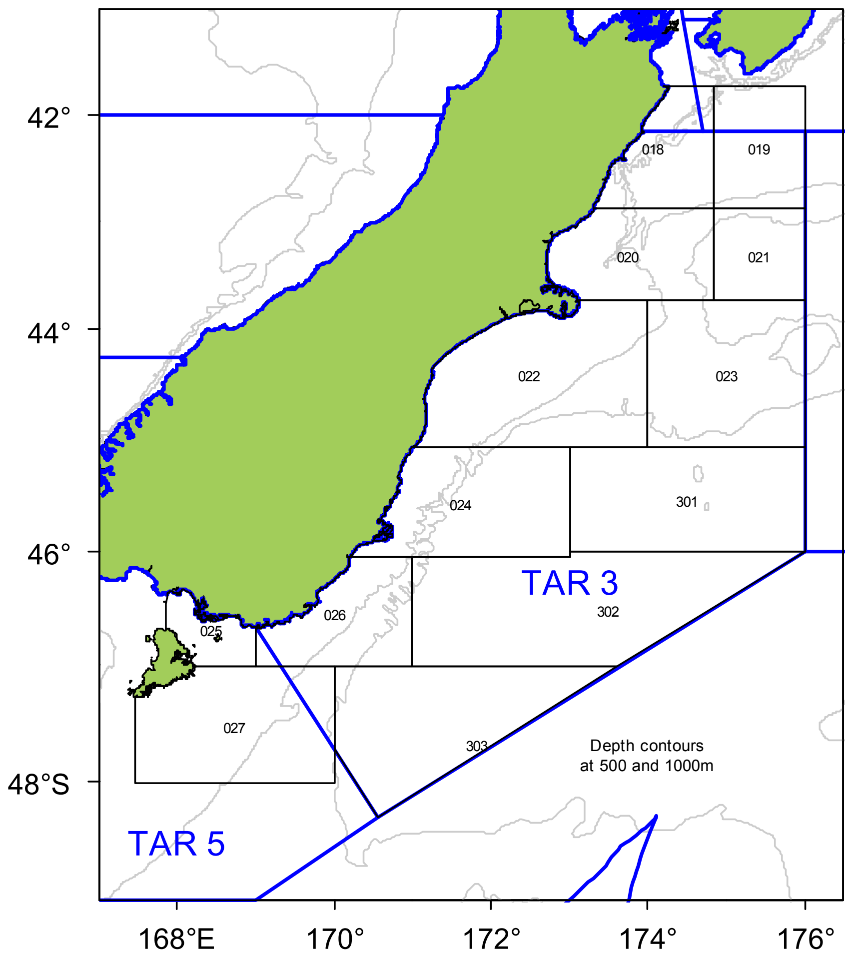


Figure 1: TAR 3 Quota Management Area and statistical areas.

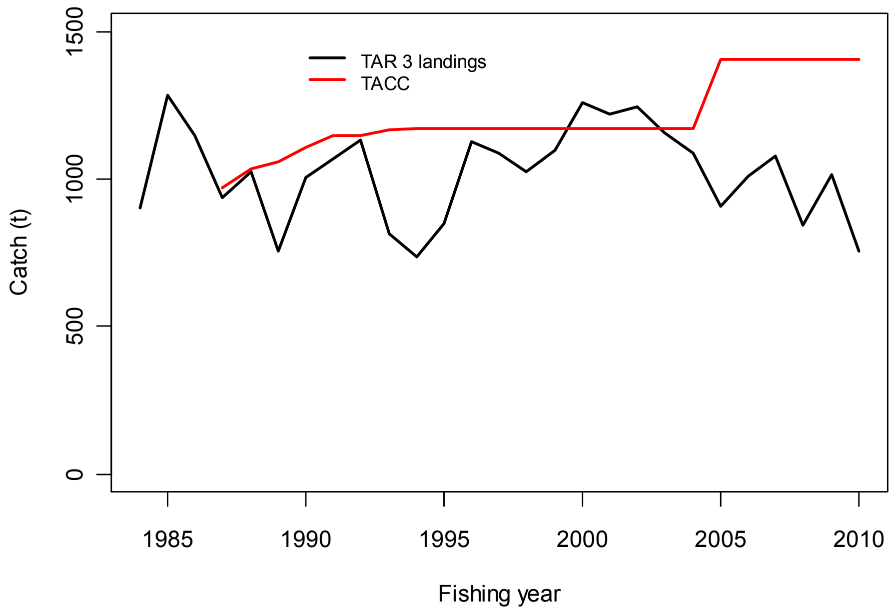


Figure 2: Catch of tarakihi in TAR 3 and TACC from 1983–84 to 2009–10. TAR3 landings and TACCs are from the tarakihi plenary summary document (Table 3) (Ministry of Fisheries 2011). 2010 = 2009–10 fishing year.

Starr et al. (2007) carried out a detailed characterisation of the TAR 3 fishery for the 17 year period from 1989–90 to 2005–06 as part of the AMP reporting requirements. This was subsequently updated with 2006–07 and 2007–08 (Starr et al. 2009). A brief summary of the latter report is provided below:

- **Method**–about 69% of the landed catch is from bottom trawl and 29% from set netting, and 1% from Danish seine. Danish seining is a relatively new method in TAR 3.
- **Statistical area**–The bulk (92%) of the landings are from three statistical areas: 018 (Kaikoura, 34%), 020, (Pegasus Bay, 26%) and 022 (Canterbury Bight, 32%).
- **Statistical area/method**–Landings of tarakihi by method of set netting are virtually all from 018 (99%) whereas landings from bottom trawling are predominantly from 020 (37%), and 022 (45%), and to a lesser extent from 024 (9%) and 018 (7%).
- **Target**– Tarakihi was declared the target species in 92% of all landed set net catch of tarakihi in TAR 3. For bottom trawling, 91% of all landed tarakihi was taken with one of the following species declared as the target: TAR (32%), RCO (37%), BAR (12%), and FLA (9%).
- **Season**– There is no strong seasonal pattern in landings from the trawl fishery, although landings are greatest from February to June and also in September. The set net fishery displays a strong seasonal pattern with virtually all landings from December to June, but with peak landings between December and February, and again in May.
- **Spawning migration**–The set net fishery mainly targets spawning migrating fish and peaks from December to May.
- **Reporting forms**–the use of reporting form type changed with the introduction of the set net form in 2006–07 (NCELR, net catch effort landing return) and the inshore trawl form the following year (TCER, trawl catch effort return). Until 2005–06, 94% of landings were recorded on CELRs (catch effort landing returns) and 6% from CLRs (catch landing returns) (landing data from TCEPRs). In 2007–08 the landings from CELRs had dropped to 15% with the introduction of the TCERs, with NCELRs accounting for 17% of landings, and CLRs 68%. The increase in landings by CLRs is because the new TCER form does not include landed data on this form as did the previous CELR, and it is recorded on CLRs.

Overall objective

1. To determine the catch-at-age for the TAR 3 commercial catch.

Specific objectives

1. To characterise the TAR 3 fisheries.

2. To conduct representative sampling to determine the length, sex and age structure of the commercial catch of tarakihi in TAR 3. The target coefficient of variation (CV) for the catch-at-age is 30% (mean weighted CV across all age classes).

3. To age tarakihi otoliths collected during the above sampling programme.

2. METHODS

2.1 Sampling design

The design of the 2009–10 catch sampling programme adhered to the recommendations documented in "Guidelines to the design, implementation and reporting of catch sampling" (Ministry of Fisheries 2008c). The Northern Inshore Working Group (8th October 2009, NINS-WG-2009-45) agreed to the following sampling design for tarakihi landings in TAR 3.

Based on the characterisation of the TAR 3 fishery (2002–03 to 2007–08) (Starr et al. 2009) sampling of the tarakihi landings was stratified by method, statistical area, and season to allocate sampling effort in proportion to the catch from these strata. At the time, the most recent data available was up to and including 2007–08. The six most recent years (2002–03 to 2007–08) of catch data were used to guide the design because this was more likely to be representative of the fishery to be sampled in 2009–10. The two main methods are bottom trawl (about three-quarters of the catch), and set net (about one-quarter of the catch) (Figure 3). Because both methods account for considerable catch they were sampled independently. Danish seine was not sampled as it is a relatively new method in TAR 3 and accounts for a small proportion of the total catch (4%) (Figure 3).

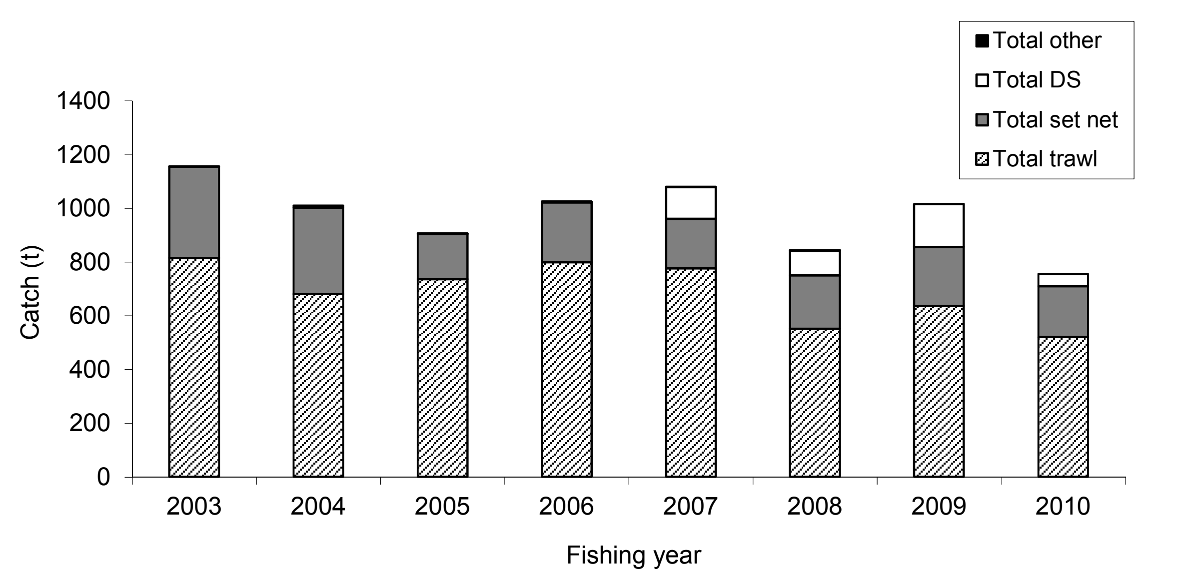


Figure 3: Catch of tarakihi in TAR 3 by method for the years 2002–03 to 2007–08. DS, Danish seine.

Set net fishery

Virtually all the set net catch is from statistical area 018 (Figure 4). The set net fishery is seasonal with all landings from December to June, but with peak landings between December and February, and again in May (Figure 5). Based on this, sampling of the set net fishery was confined to statistical area 018 and allocated samples based on the temporal distribution of catches for the set net landings over the fishing year.

Bottom trawl fishery

Tarakihi bottom trawl landings are predominantly from statistical areas 020 and 022 with lesser amounts from 024 (Figure 6). There is no strong seasonal pattern in landings from the trawl fishery, although landings are greatest from February to June and also in September (Figure 5). Based on this, sampling of the bottom trawl fishery was confined to statistical areas 020, 022, and 024, and allocated samples based on the temporal distribution of catches for the bottom trawl landings within each statistical area.

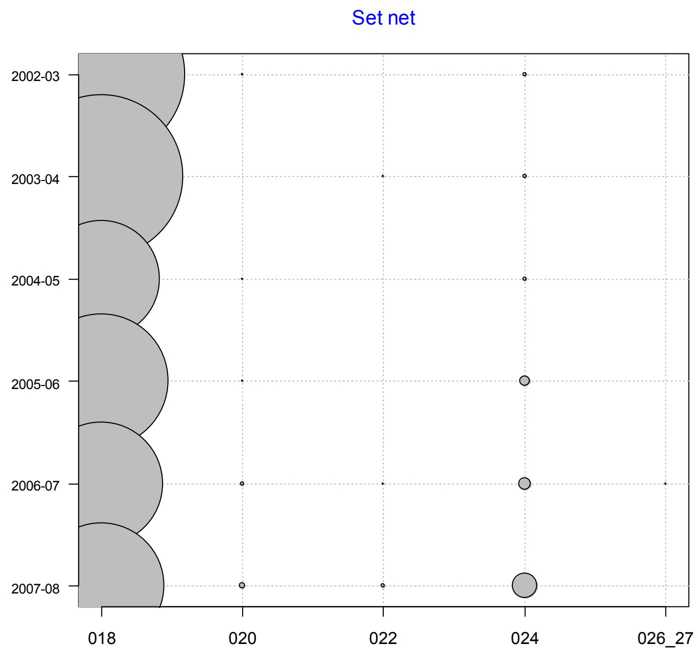


Figure 4: Catch of tarakihi in TAR 3 by method set net and statistical area for the years 2002–03 to 2007–08. Data from Starr et al. (2009).

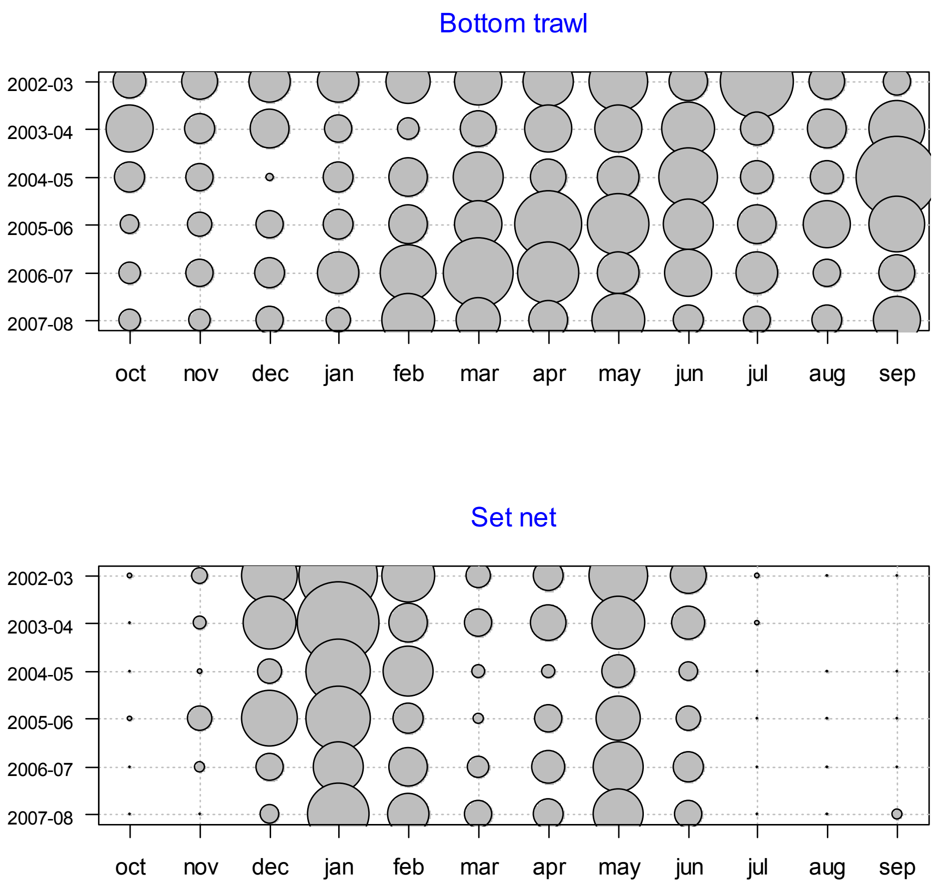


Figure 5: Catch of tarakihi in TAR 3 by method and month for bottom trawl and set net for the years 2002–03 to 2007–08. Data from Starr et al. (2009).

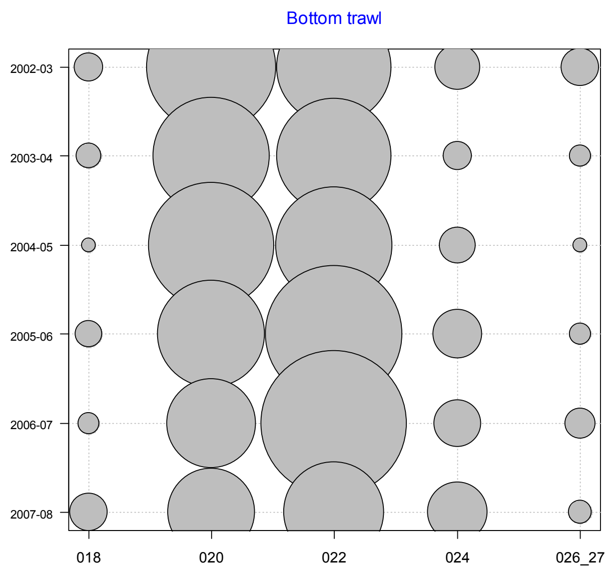


Figure 6: Bottom trawl catch of tarakihi in TAR 3 by statistical area for the years 2002–03 to 2007–08. Data from Starr et al. (2009).

How many landings to sample

There was no previous catch sampling programme in TAR 3 to estimate the optimal number of landings to sample, so the sample number was based on the TAR 7 catch sampling programme in 2004–05 which aimed to sample 60 landings (Manning et al. 2008). They achieved 47 landings with overall mean weighted coefficients of variation (MWCV) of 23% for length and 29% for age. Hence, the initial aim was to sample a maximum of 60 landings for the TAR 3 catch sampling programme, split between the set net and bottom trawl fisheries. One-third of the samples was allocated to set netting (15) and two-thirds (45) to bottom trawling, based on the relative landings of these methods (see Figure 3).

How to allocate landings

Manning et al. (2008) stratified their sampling effort in TAR 7 by point of landing, and time of year (2-month blocks) based on the proportions of catches from these strata. Following this method, 15 set net samples were allocated in proportion to the landings partitioned by 2-month blocks in statistical area 018 (Table 1). Most samples were allocated to the period between December 2009 and May 2010.

Table 1: The proportion (%) by 2-month block of the set net catch landed in statistical area 018 from 2002–03 to 2007–08. The number of targeted samples and the actual number achieved in 2009–10 are also shown.

	Oct-Nov	Dec-Jan	Feb-Mar	Apr-May	Jun-Jul	Aug-Sept	Total
% catch (2003–08)	1.7	48.6	17.9	25.1	6.7	0	100
Sample target	0	7	3	4	1	0	15
Sample actual	0	8	2	5	1	0	16

The 45 bottom trawl samples were allocated in proportion to the landings partitioned by 2-month blocks in each of the three statistical areas 020, 022 and 024 (Table 2). Most samples were allocated to statistical areas 020 and 022, and between February and September.

Table 2: The percent of the bottom trawl catch landed in statistical areas 020, 022, and 024 from 2002–03 to 2007–08, partitioned into 2-month blocks. The number of targeted samples and the actual number achieved in 2009–10 are also shown.

Stat area		Oct-Nov	Dec-Jan	Feb-Mar	Apr-May	Jun-Jul	Aug-Sept	Total
020	% catch (2007–08)	2.7	2	5.3	10.3	13.6	7.6	42
	Sample target	1	1	2	5	6	4	19
	Sample actual	1	0	3	3	5	2	14
022	% catch (2007–08)	5.2	4.8	9.8	13	6	12.3	51
	Sample target	2	2	4	5	3	6	22
	Sample actual	2	1	0	1	2	2	8
	% catch (2007–08)	0.3	1.4	4.3	1.1	0.1	0	7
024	Sample target	0	1	2	1	0	0	4
	Sample actual	0	1	2	0	0	1	4
020,022,024	% catch (2007–08)	8.2	8.2	19.4	24.4	19.7	19.9	99.8
	Total target	3	4	8	11	9	10	45
	Total actual	3	2	5	5	7	4	26

Sampled processors

Processing sheds were contacted at least weekly or when samples were required to meet the sampling allocation target. The sheds sampled were:

Set net fishery– Talley's Nelson, Talley's Motueka, and Guyton's Nelson. Landings from Kaikoura were trucked to these processors in Nelson and Motueka.

Bottom trawl fishery –United Fisheries Christchurch, Sanford Timaru, Talley's Timaru, Harbour Fish Dunedin.

Factory sampling procedure (instructions to samplers)

1. Allocate Ministry of Fisheries *market* database landing number to the landing:
    - Set net landing numbers for 2009 (20091101 – 20091130), and 2010 (20101101 – 20101130)
    - Bottom trawl landing numbers for 2009 (20091131 – 20091199), and 2010 (20101131 – 20101199)
2. Landings sampled must be from a single vessel for a single trip (nearly always the case), and not graded by size.
3. Randomly select 60 fish from the landing–sample about 6 fish from each randomly selected bin, taking fish closest to the right hand corner of the bin.
4. Measure length (FL), and assign sex and gonad stage (stock monitoring 5 stage method; 1, immature or resting; 2, maturing (oocytes visible in females, thickening gonad but no milt expressible in males); 3, mature (hyaline oocytes in females, milt expressible in males); 4, running ripe (eggs and milt free flowing); 5, spent (gonads flaccid and bloodshot).
5. Remove both sagittal otoliths and place in plastic eppendorf vials, then inside otolith envelopes.
6. After the landing has been sampled, obtain the following vessel details from the processor: landing weight, landing date, location where fish caught, etc.

Minimum landing size to sample

The minimum landing weight is inversely proportional to the number of samples available to sample (Figures 7 and 8). In selecting a minimum landing weight to sample, if the cut off is too large there is a risk of disqualifying too many landings as potential samples. Too low, and the chances increase of sampling small landings that are potentially less representative of the fishery. For bottom trawl, 300 kg was initially selected as the minimum landing weight to qualify for sampling. In 2007–08 this would have qualified 31% of tarakihi landings for sampling. However, it was clear that the sampling programme was not achieving the target and in early May 2010 the Southern Inshore Working Group (SINS-2010-41) reduced this minimum landing weight to 100 kg, theoretically qualifying about 50% of landings for sampling. The set net minimum landing weight to sample was 100 kg which would have qualified about 37% of tarakihi landings for sampling in 2007–08. The set net minimum landing weight to sample did not change throughout the year.

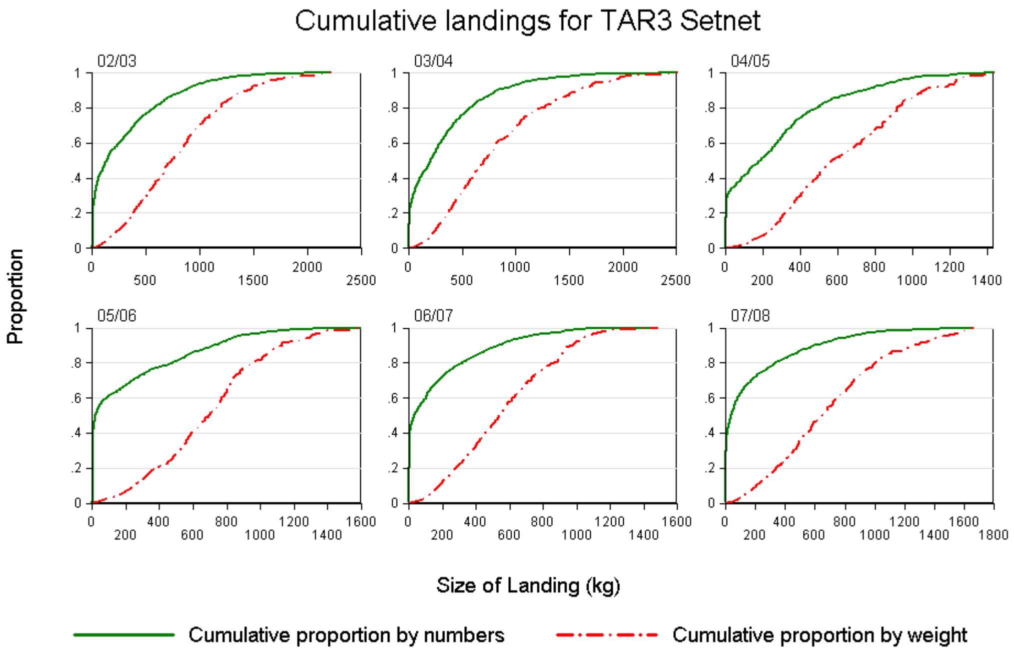


Figure 7: Cumulative landings of TAR 3 by number and weight for set net fishery for fishing years 2002–03 to 2007–08.

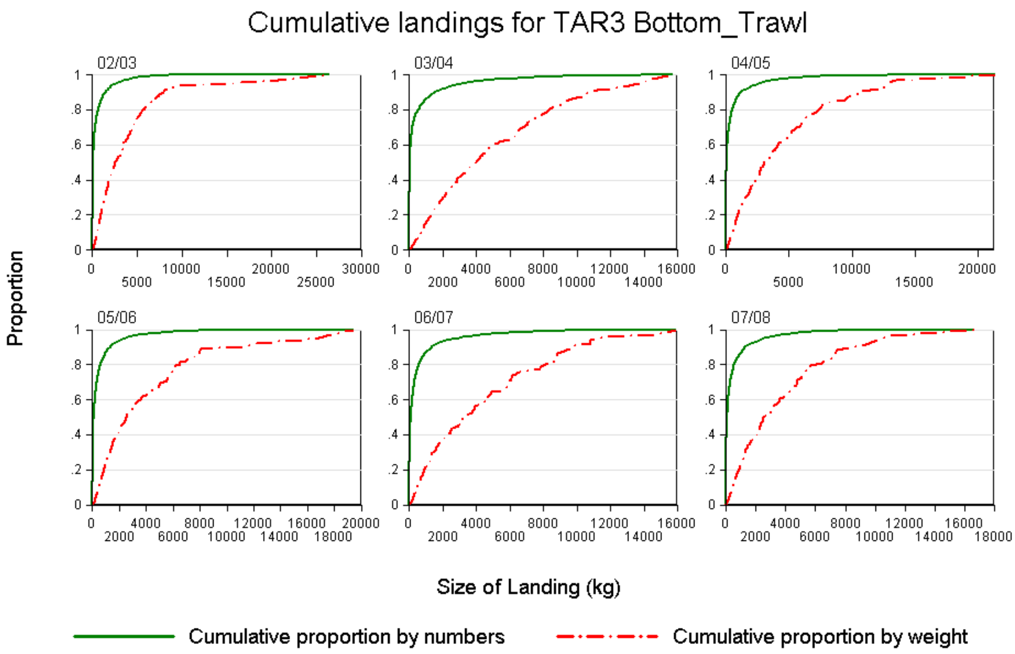


Figure 8: Cumulative landings of TAR 3 by number and weight for bottom trawl fishery for fishing years 2002–03 to 2007–08.

2.2 Storage of data

Catch sampling data were loaded into the Ministry of Fisheries *market* and *age* databases at the completion of sampling. Otoliths are stored at NIWA Greta Point in the otolith library collection.

2.3 Size distribution

For each fishery (set and bottom trawl), estimated scaled numbers-at-length were calculated using Catch-at-age software, developed by NIWA (Bull & Dunn 2002). Length data were scaled by landed weights of tarakihi from the sampled vessels, and by commercial catch from the sampling strata, i.e., for bottom trawl this was the catch by two-month blocks in statistical areas 020, 022, and 024. For set net it was for commercial catch by two month blocks in statistical area 018. Scaled length-frequency distributions were estimated by sex, and overall for all strata combined. The mean-weighted coefficients of variation (MWCV) were estimated by sex and overall using a bootstrapping routine (300 bootstraps).

2.4 Ageing

Direct ageing was used to estimate the age composition of the fishery. Unlike indirect-ageing where about 300 otoliths would routinely be used to construct an age-length key applied to a much larger set of length data, in direct ageing many more ages are generally required to be estimated and the age structure is based entirely on the lengths of these aged fish. The target was 15 set net landings so the expectation was that about 900 individual lengths and otoliths would be collected (15 landings × 60 fish = 900). Similarly, for the bottom trawl fishery the expectation was that about 2700 lengths and otoliths would be collected (45 landings × 60 fish = 2700).

2.4.1 Selection of otoliths for ageing

Without a previous catch sampling programme in TAR 3 it was not possible to predict the number of ages that would be required to confidently meet the target MWCV of 30% (see specific objective 2). However, the results of the 2004–05 TAR 7 catch sampling programme were used as a guide to the number that were likely to be required, with the knowledge that there are significantly fewer cohorts present in TAR 3 fishery than were present in TAR 7 in 2004–05. Thus it was likely that similar MWCVs could be achieved with less otoliths.

About 500 otoliths from the bottom trawl fishery and about 350 from the set net fishery were randomly sub-sampled. Otolith selection was done by post stratifying the otoliths weighted by the landing size, but ensuring that at least 10 otoliths from each sampled landing were included—the resulting sub-set included 345 otoliths from the set net fishery and 502 from the trawl fishery which were prepared and aged using the methods described below.

2.5 Otolith preparation and reading

In February 2010 NIWA held an ageing workshop on several species including tarakihi, attended by NIWA staff that prepared and aged the otoliths from this catch sampling programme. An output from the meeting was the production of a tarakihi ageing standards and protocols document (NIWA 2011). This document provides details of ageing protocols and methodology and is a guide to how tarakihi ageing is to be carried out. Based on this document the following methods were used.

1. All otoliths were rendered into thin-section preparations as follows: Tarakihi sagittal otoliths were individually marked on their distal faces with a fine sectioning line guide, under a stereomicroscope. The sectioning line followed the straightest dorso-ventral axis, orientated through the primordium. Otoliths were then embedded in an epoxy resin mold with standard curing @50 ºC. Thin sections were taken using a Struers Secotom-10 digital sectioning

machine, with a section thickness of ~350 µm. Resulting thin section wafers were cleaned and embedded on microscope slides under a few drops of epoxy resin with a coverslip. Finally, these slides were oven cured @50ºC.

2. Otoliths were read using transmitted light under a binocular microscope at a magnification of 100× Under transmitted light the wide opaque zone appears dark and the narrow translucent zone (hyaline) appears light.
3. Two elected core tarakihi "expert" readers (Mike Stevenson and Dane Buckthought) read all otoliths without reference to fish length.
4. Readers conformed to the documented protocols (above) when interpreting ring counts.
5. The forced margin method was used (see below).
6. A subsequent rereading of otoliths with discrepant age estimates was carried out by the two readers and a third adjudicating reader (Cameron Walsh) jointly with conferring.

Forced margin method

The forced margin method is described in the NIWA tarakihi ageing standards and protocols document (NIWA 2011) and also defined in the glossary of the MFish guidelines for New Zealand fish ageing protocols (MFish ageing workshop on 25 and 26 May 2011, unpublished document of meeting notes) as follows: **Forced Margin /Fixed Margin** – Otolith margin description (Line, Narrow, Medium, Wide) is determined according to the margin type anticipated *a priori* for the season/month in which the fish was sampled. The otolith is then interpreted and age determined based on the forced margin. The forced margin method is usually used in situations where fish are sampled throughout the year and otolith readers have difficulty correctly interpreting otolith margins.

In this report age conforms to the "fishing year age-class" of tarakihi which is defined in MFish guidelines for New Zealand fish ageing protocols as the age of an age group at the beginning of the NZ fishing year (1 October). It does not change if the fish have a birthday during the fishing season.

Fishing year age-class was assigned as follows: the wide margin (W) was assigned to otoliths collected in October–March. The resulting age of a fish recorded as 6W, for example, is 7 years. Otoliths collected from April–May were interpreted as L (Line), or N (Narrow) if collected between June and September. Hence 7L and 7N were assigned ages of 7 years. The nominal birthday of tarakihi is taken as 1 May but has no bearing on the assignment of fishing year age-class.

2.5.1 Ageing precision

Between-reader ageing precision was assessed by the application of the methods and graphical techniques documented in Campana el al. (1995) and Campana (2001). APE (average percent error) and coefficient of variation (c.v.) across ages were estimated.

2.6 Catch at age estimation

For each fishery (set net and bottom trawl), estimated scaled numbers-at-age were calculated using the NIWA programme Catch-at-length-and-age (CALA). Age data were scaled in the same way as length data, i.e., by landed weights of tarakihi from the sampled vessels, and by commercial catch from the sampling strata (see Section 2.3). Scaled age-frequency distributions were estimated by sex, and overall for all strata combined. The mean-weighted coefficients of variation (MWCV) were estimated by sex and overall using a bootstrapping routine (300 bootstraps).

2.7 Growth estimation

A von Bertalanffy growth model (von Bertalanffy 1938) was fitted to the length-age data, by sex, for the set net and trawl fisheries separately and fishing year age-class ages were used (see definition on section 2.50).

$$L_t = L_\infty (1 - \exp^{-K[t - t0]})$$

Where L_t is the length (cm) at age t, L_∞ the asymptotic mean maximum length, K is a constant (growth rate coefficient), t_0 hypothetical age (years) that fish has zero length.

2.8 Z estimates

Total mortality (Z) was estimated from catch-curve analysis using the Chapman Robson estimator (CR) (Chapman & Robson 1960). The CR method has been shown to be less biased than the simple regression catch curve analysis (Dunn et al. 2002). Catch curve analysis assumes that the right hand descending part of the curve declines exponentially and that the slope is equivalent to the total mortality Z ($M + F$). Implicit are the assumptions that recruitment and mortality are constant, that all recruited fish are equally vulnerable to capture, and that there are no age estimation errors.

The method of Dunn et al. (2002) was used to estimate the variance (95% confidence intervals) associated with Z under three different parameters of recruitment, ageing error, and Z estimate error. Estimates of Z and 95% confidence intervals were made for age at full recruitment of 5 and 6 years for the set net fishery (peak age = 5 years), and 3 and 4 years for the bottom trawl fishery (peak age = 3 years), for both sexes combined.

Estimates of total mortality, Z, were calculated for age at recruitment (a_{rec}) using the maximum-likelihood estimator

$$\hat{Z} = \log_e \left(\frac{1 + \overline{a} - a_{\text{rec}}}{\overline{a} - a_{\text{rec}}} \right)$$

where $\overline{a} = \left(\sum_a^{\text{rec}} af_a\right) \Big/ \left(\sum_a^{\text{rec}} f_a\right)$ is the mean age of recruited fish in the sexes-combined age frequency, and $\sum_a^{\text{rec}}$ denotes summation across all recruited ages.

The estimation of c.v.s around the Z estimates is described in detail in Appendix 1.

2.9 Spawner per recruit analyses

A spawner per recruit analysis was used to estimate the $F_{\%SPR}$ for the set net and bottom trawl fisheries separately. Spawner per recruit calculations were carried out using CASAL (Bull et al. 2005). The calculations involve simulating fishing with constant fishing mortality (F) in a population with deterministic recruitment, and determining the equilibrium spawning biomass per recruit (SPR) associated with that value of F. The %SPR for that F is then simply that SPR, expressed as a percentage of the equilibrium SPR when there is no fishing (i.e., when $F = 0$).

The following input parameters were used in the SPR analysis.

Growth parameters — The von Bertalanffy growth curve parameters from the 2009–10 TAR 3 catch sampling programme were not used in the SPR calculations because they were considered to be unrepresentative of either the set net or bottom trawl fishery (see Results Section 3.8 growth parameters). Instead the parameters estimated by Annala et al. (1990) from a 1987 R.V. *James Cook* trawl survey of the ECSI between Banks Peninsula and Cook Strait were used (males, n = 275, range 19–49 cm and 2 to 42 years; females, n = 324, range 12–51 cm and 1–42 years) (see below). Length-weight data collected from the ECSI 2009 trawl survey (Beentjes et al. 2010) were used to generate the length-weight parameters (length in cm and weight in g) (see below).

Parameter	Males	Females
L_{inf}	42.1	44.6
t_0	-1.397	-1.103
K	0.2085	0.2009
A	0.0118	0.0118
B	3.1287	3.1287

Natural mortality — default assumed to be 0.10 (Ministry of Fisheries 2010). Sensitivities were carried out for M values 20% above and below the default (0.08 and 0.12).

Maturity — Age at maturity was estimated from the length at maturity logistic model values of $L_{50\%}$ and $L_{95\%}$ (Parker & Fu in press). The ages that corresponded to these parameters were estimated from the von Bertalanffy curves of Annala et al. (1990). Maturity was entered as a logistic function using age at $A_{50\%}$ (age at 50% maturity) and $Ato_{95\%}$ ($A_{95\%}$ minus $A_{50\%}$). The values of $A_{50\%}$ and $Ato_{95\%}$ were: males 5.2 and 7.4; females 5.8 and 4.5, respectively.

Selectivity — Selectivity to the commercial fishery is described as knife-edge equal to age at MLS. i.e., 25 cm and age 3 years.

Fishing mortality (*F*) — fishing mortality is estimated from the catch curve analyses and assumed estimate of M ($F = Z - M$). The Z value is for age at full recruitment = 5 years for set net and 3 years for bottom trawl).

Maximum age — Assumed to be 44 years based on the oldest age recorded for tarakihi from the west coast South Island by Stevenson & Horn (2004).

Because this is a ‘per-recruit’ analysis, it doesn’t matter what stock-recruit relationship is assumed. However, the calculations are simpler, and the simulated population reaches equilibrium faster, if recruitment is treated as independent of spawning biomass (i.e., a steepness of 1).

2.10 Fishery characterisation (1989–90 to 2009–10)

The previous fishery characterisation (Starr et al. 2009) was updated to include 2008–09 and 2009–10 and was submitted to the Northern Inshore Working Group in October 2010 (Prepared by Paul Starr, NINS WG2010/54A). This updated characterisation was carried out under this project and is included in this report in Appendix 2. The updated characterisation was used to assess the representativeness of the catch sampling in 2009–10.

3. RESULTS

3.1 Data collection

Sampling achieved compared to the sampling design

For the set net fishery, 16 landings were sampled, exceeding the target of 15, and they were also collected in proportion to the monthly targets (see Table 1).

For bottom trawl fishery 26 of 45 targeted landings were sampled with only the Oct–Nov target allocation met (Table 2). The least well sampled stratum was statistical area 022 (Canterbury Bight) in which only 8 of 22 planned landing were sampled, whereas statistical area 024 (Oamaru to Taieri Mouth) met all sampling targets. Statistical area 020 (Pegasus Bay) was reasonably well sampled (14 of 19 landings) and in proportion to the temporal allocations. The target number for the bottom trawl fishery was not achieved because there were insufficient qualifying landings to sample. Frequent contact was made with all processors and all landings that were made available were sampled. The lack of samples dictated the reduction from 300 kg to 100 kg in the qualifying minimum landing weight to sample.

Set net fishery lengths, and otoliths collected and aged

A total of 967 lengths were measured and otolith pairs collected from 16 set net landings in statistical area 018 in 2009–10 (MFish *market* research database landing numbers are 20091101 to 20091103 and 20101101 to 20101113) (Table 3). Of these 967 fish, 345 were randomly selected for ageing. The unscaled raw data sex ratio was 36% male (all lengths), and 36% for the aged fish. There was little difference in mean length of males and females overall (Table 3).

Relative to the proportion of the 2009–10 set net catch by strata, the numbers of otoliths aged from Feb–Mar and Apr–May are large, whereas aged otoliths from Dec–Jan are small (Table 4). However, the mismatch is largely a result of the weighting method used to select otoliths from each landing, i.e., the number selected is based on the landed weight of each landing as a proportion of the total landed weight sampled over the year. Hence, small landings have fewer otoliths while large landings have proportionally more otoliths selected for ageing.

Table 3: Set net fishery raw length statistics for tarakihi sampled in the 2009–10 catch sampling programme, and for those that were aged. N= 16 landings.

	All lengths (cm) collected				Lengths (cm) of aged fish			
	N	Mean	Minimum	Maximum	N	Mean	Minimum	Maximum
Total	967	33.7	26	48	345	33.8	27	45
Male	344	33.3	27	48	123	33.1	27	45
Female	623	33.9	26	45	222	34.1	29	45

Table 4: The proportion (%) by 2-month block of the set net catch landed in statistical area 018 in 2009–10 and the proportion of otoliths aged. N= 345 aged otoliths.

	Oct-Nov	Dec-Jan	Feb-Mar	Apr-May	Jun-Jul	Aug-Sept	Total
% catch (2009–10)	0.2	47.3	20.4	27.9	4.2	0	100
% otoliths aged	0	67.2	10.7	18.8	3.1	0	100

Bottom trawl fishery lengths and otoliths collected

A total of 1510 lengths were measured and otolith pairs collected from 26 bottom trawl landings in statistical areas 022, 022, and 024, in 2009–10 (MFish *market* research database landing numbers 20091131 to 20091134 and 20101131 to 20101152) (Table 5). Of these 1510 fish, 502 were randomly selected for ageing. The unscaled raw sex ratio was 43% male (all lengths), and 44% for the aged fish. There was little difference in mean length of males and females overall (Table 5).

Relative to the proportion of the 2009–10 bottom trawl catch by strata, the numbers of otoliths aged from stat area 020 are about 16 % more than the catch from this area (Table 4). Conversely, numbers aged from stat area 022 are about 14% less than the catch proportion. Overall, for all three stat areas combined, numbers of otoliths aged relative to the catch by two-month blocks were low for Feb–Jan, and high for Jun–Jul and Aug–Sep. (Table 6). Like the set net otoliths, the mismatch is largely a result of the weighting method used to select otoliths from each landing.

Table 5: Bottom trawl fishery raw length statistics for tarakihi sampled in the 2009–10 catch sampling programme, and for those that were aged. N= 26 landings.

	All lengths (cm) collected				Lengths (cm) of aged fish			
	N	Mean	Minimum	Maximum	N	Mean	Minimum	Maximum
Total	1510	29.8	23	49	502	30.2	24	49
Male	656	29.1	23	40	220	29.3	24	37
Female	854	30.3	23	49	282	30.9	24	49

Table 6: The proportion (%) by 2-month block of the bottom trawl catch landed in statistical areas 020, 022, 024, and combined in 2009–10, and the proportion of otoliths aged. N= 279, 181, 42, and 502 aged otoliths for stat areas 020, 022, 024, and total, respectively.

Stat area		Oct-Nov	Dec-Jan	Feb-Mar	Apr-May	Jun-Jul	Aug-Sept	Total
020	% catch (2009–10)	1.6	4.8	9.9	8.0	10.1	5.5	39.9
	% otoliths aged	2.2	0.0	18.1	8.2	21.5	5.6	55.6
022	% catch (2009–10)	3.0	11.1	8.7	8.9	9.4	8.9	50.1
	% otoliths aged	4.0	2.0	0.0	2.0	8.2	19.9	36.1
024	% catch (2009–10)	0.1	7.0	2.0	0.8	0.1	0.1	10.1
	% otoliths aged	0.0	2.0	4.4	0.0	0.0	2.0	8.4
020,022,024	% catch (2009–10)	4.7	22.9	20.5	17.7	19.7	14.5	100
	% otoliths aged	6.2	4.0	22.5	10.2	29.7	27.5	100

3.2 Fishery characterisation (1989–80 to 2009–10)

The updated fishery characterisation (updated to include 2008–09 and 2009–10, NINS WG2010/54A) indicated that overall there was no real change in the catch of tarakihi by method, area and season compared to the previous analyses up to 2007–08 (Appendix 2). The 2009–10 data were used to determine how representative the catch sampling in 2009–10 was of the set net and bottom trawl fisheries. The reporting form type for bottom trawling changed in 2007–08, and the set net form the following year. In 2009–10 the percentages of days reported by form type were as follows: CELR 9%, TCER, 53%, TCEPR, 19%, and NCELR, 17% (Appendix 2, Table 9).

3.3 Representativeness

Set net fishery

The sampling design aimed to collect samples in proportion to the set net catch in statistical area 018 by month, using the catch data from 2002–03 to 2007–08 (Figure 9). The equivalent catch in 2009–10 shows a similar pattern to the historic data and hence the allocation of samples used was acceptable and representative of the temporal catch.

The proportion of the catch landed from the sampled vessels followed the same trend as that of the all vessel catch for both target species and statistical area in 2009–10 (Figure 10). Virtually all the tarakihi set net catch is targeted and caught in statistical area 018.

The aged fish from the set net fishery were reasonably representative of the 2009–10 catch by strata, although more ages from Dec–Jan would have been desirable (Table 4).

The fleet vessel characteristics of the sampled vessels are similar to those of all vessels with the exception of duration in the last two years, although the medians are similar (Figure 11). Similarly, the median mesh size (bottom of box plot) by sampled vessels and all vessels in 2009–10 was 125 mm which is to be expected because this was the mesh size used by all of the 16 landings that were sampled in which the target species was tarakihi. The top of the interquartile box corresponds to a mesh size of 175 mm which is used when targeting, rig or school shark. The lack of whiskers indicates that there were no other mesh sizes used.

There are no plots of depth fished by sampled and all vessels because this variable is not recorded by the set net recording forms, including the new NCELR form introduced in 2006–07.

In summary, the overall characteristics of the sampled vessels and their fishing patterns were similar to the all vessels (Figures 9 to 11) indicating that that sampling was representative of the fishery.

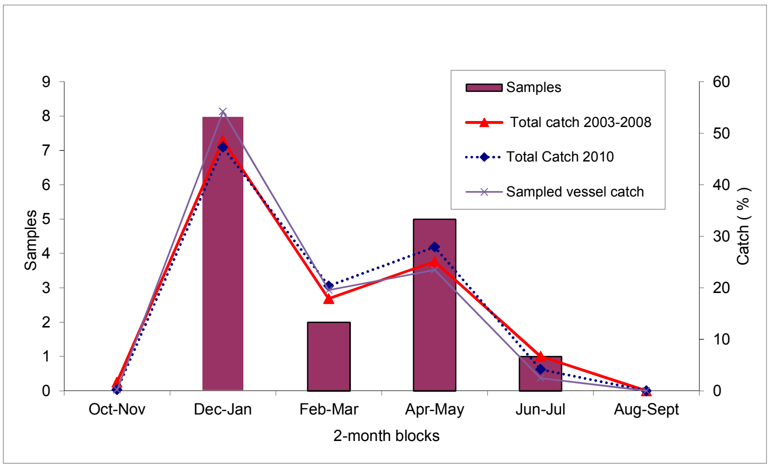


Figure 9: Set net landings sampled in 2-month blocks in statistical area 018 in 2009–10, and the percentage of landed catch in 1) all vessels from 2002–03 to 2007–08, 2) all vessels in 2009–10, 3) sampled vessels in 2009–10.

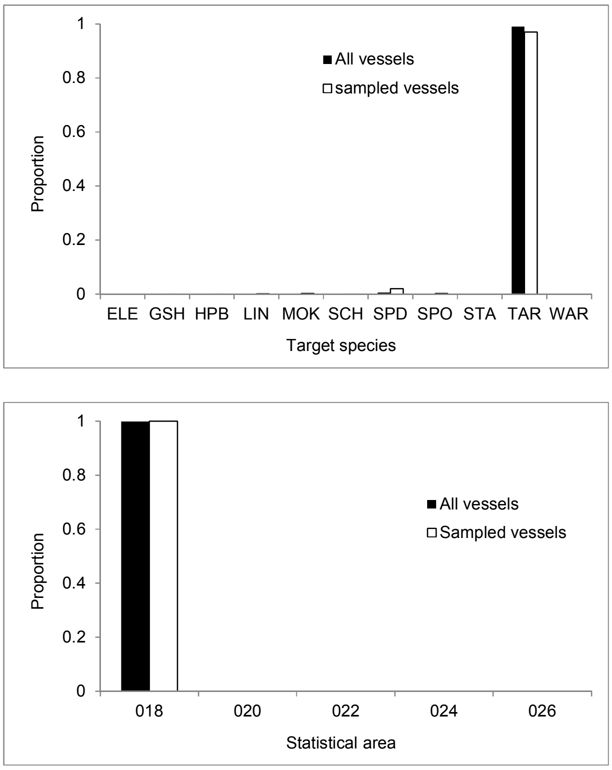


Figure 10: Proportion of set net landed tarakihi catch by target species (top panel) and statistical area (bottom panel) by all vessels and by sampled vessels in 2009–10.

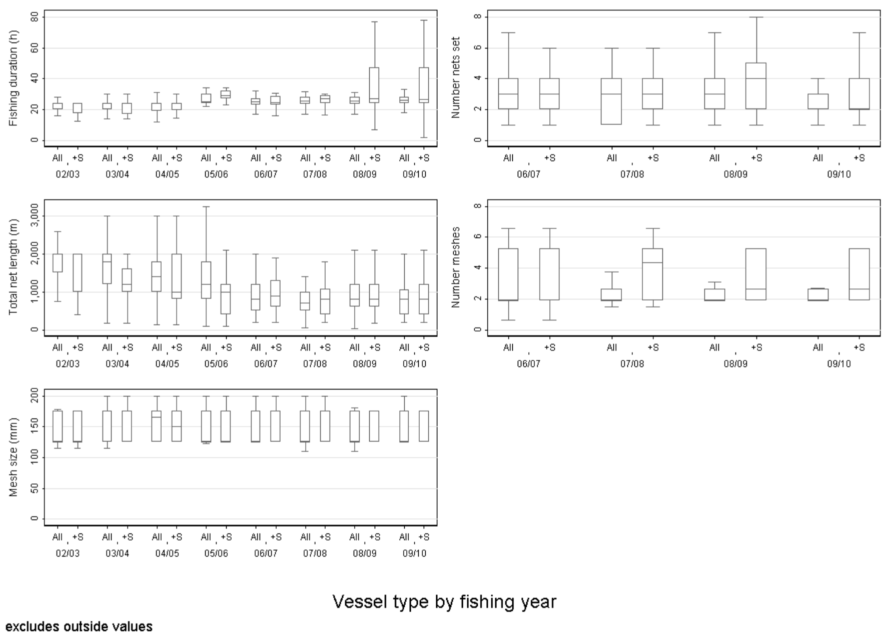


Figure 11: Fishing effort descriptors for vessels landing TAR 3 between 2002–03 to 2009–10 using the set net method and targeting LIN, SCH, SPO, or TAR. Distributions for each effort type by fishing year are paired, with the values for all vessels shown on the left and the distribution of values for sampled vessels on the right. For each bar, the horizontal line indicates the median, top and bottom of the bar indicate the interquartile (25th to 75th) range, error bars indicate the upper and lower "adjacent" values (i.e., the largest value below the upper inner fence and the smallest value above the lower inner fence (where each "fence" is 1.5 × interquartile range). Note that the form type changed between 2005–06 and 2006–07, with two new effort data types added and the reporting requirement changed from the day of fishing to the fishing event.

Bottom trawl fishery
The sampling design aimed to collect samples in proportion to the bottom trawl catch in statistical areas 020, 022 and 024 by month, using the catch data from 2002–03 to 2007–08 (Figure 12). The equivalent catch in 2009–10, surprisingly, shows a different pattern to the historic data and overall the 2009–10 catch peaked in Dec-Jan, and not Apr–May. Hence the sampling allocation, based on the historic data, has under-sampled the summer peak, but appears reasonable for the other months.

The aged fish from the bottom trawl fishery were reasonably representative of the 2009–10 catch by strata, although more ages from stat area 022 and the Dec–Jan for all stat areas period would have been desirable (Table 6).

The proportion of the tarakihi catch landed by declared target species and statistical area in 2009–10 from the sampled vessels followed the same trend as that of the all vessel catch (Figure 13). Over 80% of the tarakahi catch was taken by vessels declaring TAR as the target species. Statistical area 022 accounted for the largest proportion of the landed catch of tarakihi followed by 020 and 024 (Figure 13).

The fleet vessel characteristics of the sampled bottom trawl vessels are similar to those of all vessels including in 2009–10 (Figure 14).

The 2009–10 depth distribution of sampled vessels is very close to that of the all vessels and has two peaks, at about 50 m and 90 m (Figure 15). A breakdown of depth distribution by target species indicates that the shallower peak reflects targeting for elephantfish and flatfish, whereas the deeper peak is associated with targeting tarakihi, red cod, and barracouta, and that there is no difference between sampled and all vessels (Figure 16). Depth distribution broken down by statistical area also indicates that there is no difference between sampled and all vessels, and that overall depth fished is shallower in statistical area 024 (Figure 16).

In summary, the overall characteristics of the bottom trawl sampled vessels and their fishing patterns were similar to all vessels (Figures 12 to 16) indicating that sampling was representative of the fishery.

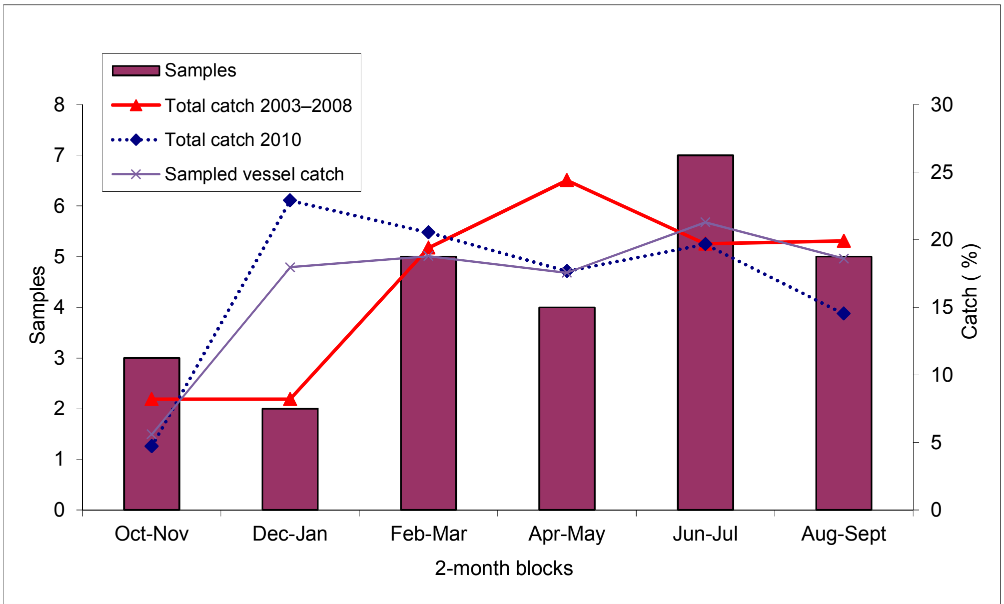


Figure 12: Number of bottom trawl landings sampled in 2-month blocks from statistical areas 020, 022, and 024 in 2009–10, and the proportion of landed catch in 1) all vessels from 2002–03 to 2007–08, 2) all vessels in 2009–10, 3) sampled vessels in 2009–10.

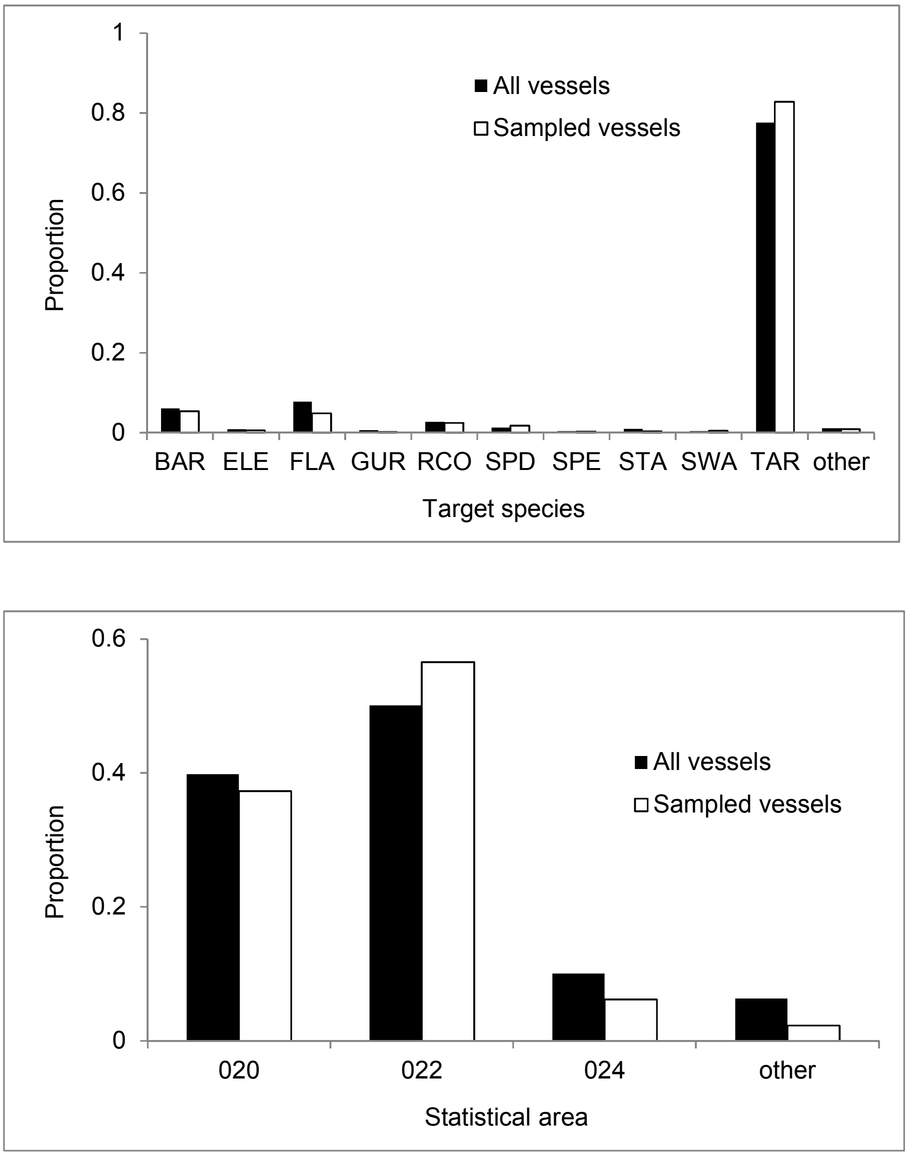


Figure 13: Proportion of bottom trawl landed tarakihi catch by target species (top panel) and statistical area (bottom panel) by all vessels and sampled vessels in 2009–10.

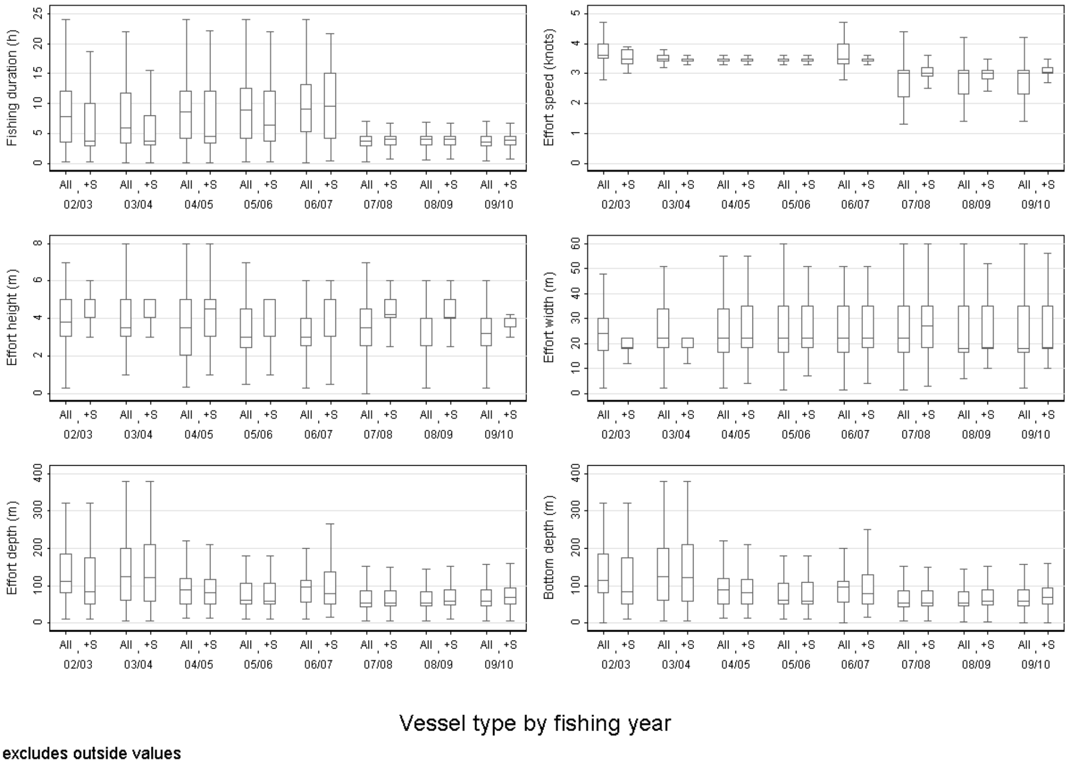


Figure 14: Fishing effort descriptors for vessels landing TAR 3 between 2002/03–2009/10 using the bottom trawl method and targeting BAR, ELE, FLA, RCO, TAR or WAR. Distributions for each effort type by fishing year are paired, with the values for all vessels shown on the left and the distribution of values for sampled vessels on the right. For each bar, the horizontal line indicates the median, top and bottom of the bar indicate the interquartile (25th to 75th) range, error bars indicate the upper and lower "adjacent" values (i.e., the largest value below the upper inner fence and the smallest value above the lower inner fence (where each "fence" is 1.5 × interquartile range). Note that these plots include a range of form types which are not consistent between years. Excludes outside values means that points (outliers) that lie outside the whiskers are not shown.

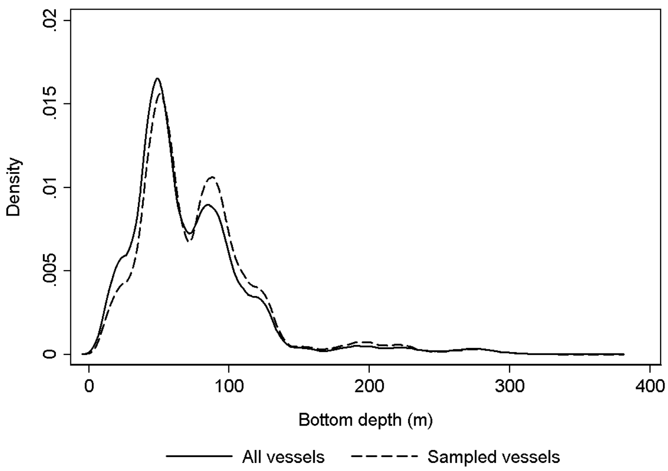
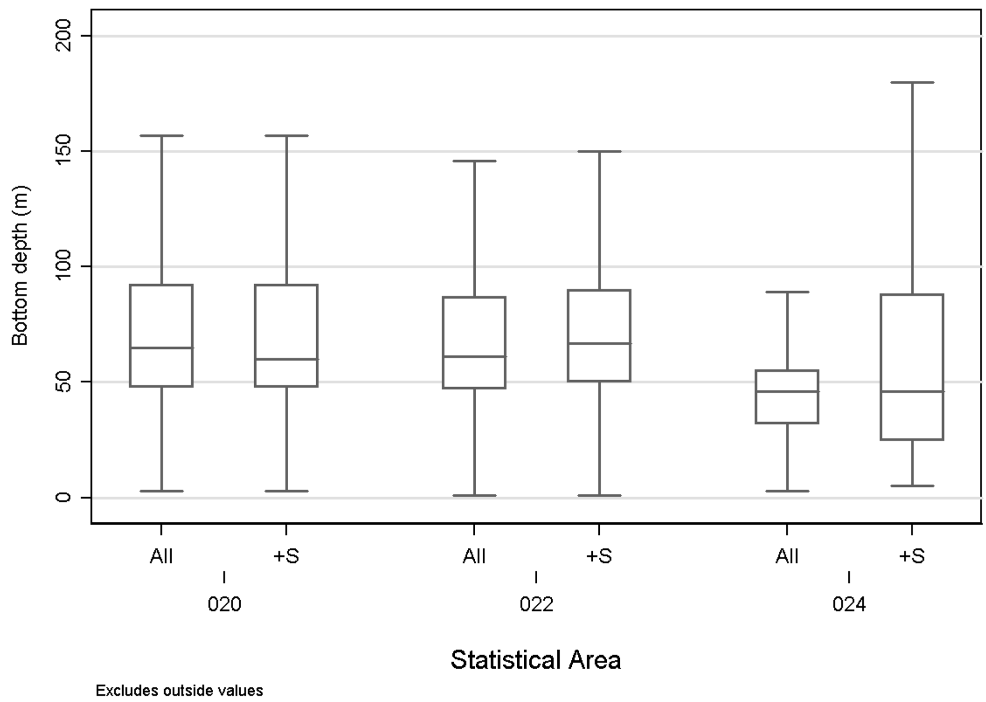


Figure 15: Bottom depth (m) distribution in 2009–10 for vessels landing TAR 3 and target fishing for BAR, ELE, FLA, RCO, TAR, or WAR, for all vessels and for sampled vessels.



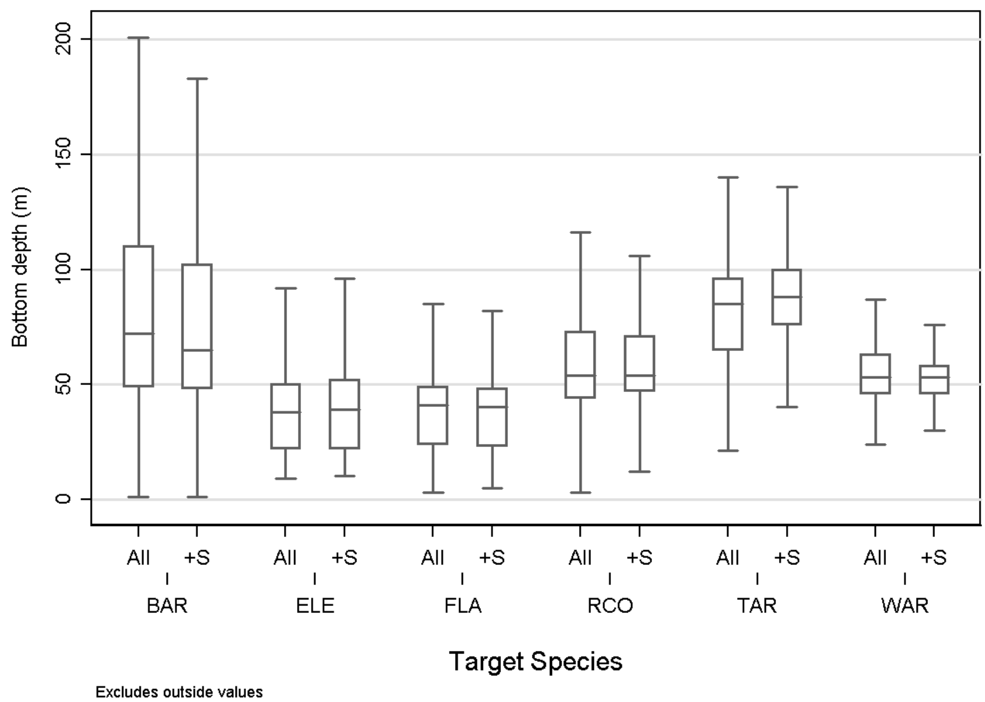


Figure 16: Distribution of bottom depth (m) by primary statistical area (top panel) and by target species (bottom panel) for vessels landing TAR 3 summarised over the period 2007–08 to 2009–10 using the bottom trawl method and targeting BAR, ELE, FLA, RCO, TAR or WAR. Distributions are paired, with the values for all vessels shown on the left (All) and the distribution of values for sampled vessels on the right (+S). For each bar, the horizontal line indicates the median, top and bottom of the bar indicate the interquartile (25th to 75th) range, error bars indicate the upper and lower "adjacent" values (i.e., the largest value below the upper inner fence and the smallest value above the lower inner fence (where each "fence" is 1.5 × interquartile range). Note that these plots begin in 2007–08, the year that the new TCER form was introduced, which requires tow-by-tow reporting from all vessels greater than 6 m. Excludes outside values means that points (outliers) that lie outside the whiskers are not shown.

3.4 Scaled length distribution

Set net fishery

The scaled length frequency distributions from the set net fishery are shown in Figure 17. Both male and female distributions were unimodal with peaks at about 33 cm fork length, with most fish between 30 and 40 cm. Minimum and maximum lengths were 27 and 48 cm for males, and 26 and 45 cm for females (see Table 3). Mean lengths of scaled length distributions were 33.1 cm for males, 33.9 cm for females, and 33.6 cm overall. The mean weighted c.v.s were 25.6% for males, 19.2% for females, and 15.9% overall. The sex ratio was 33% male.

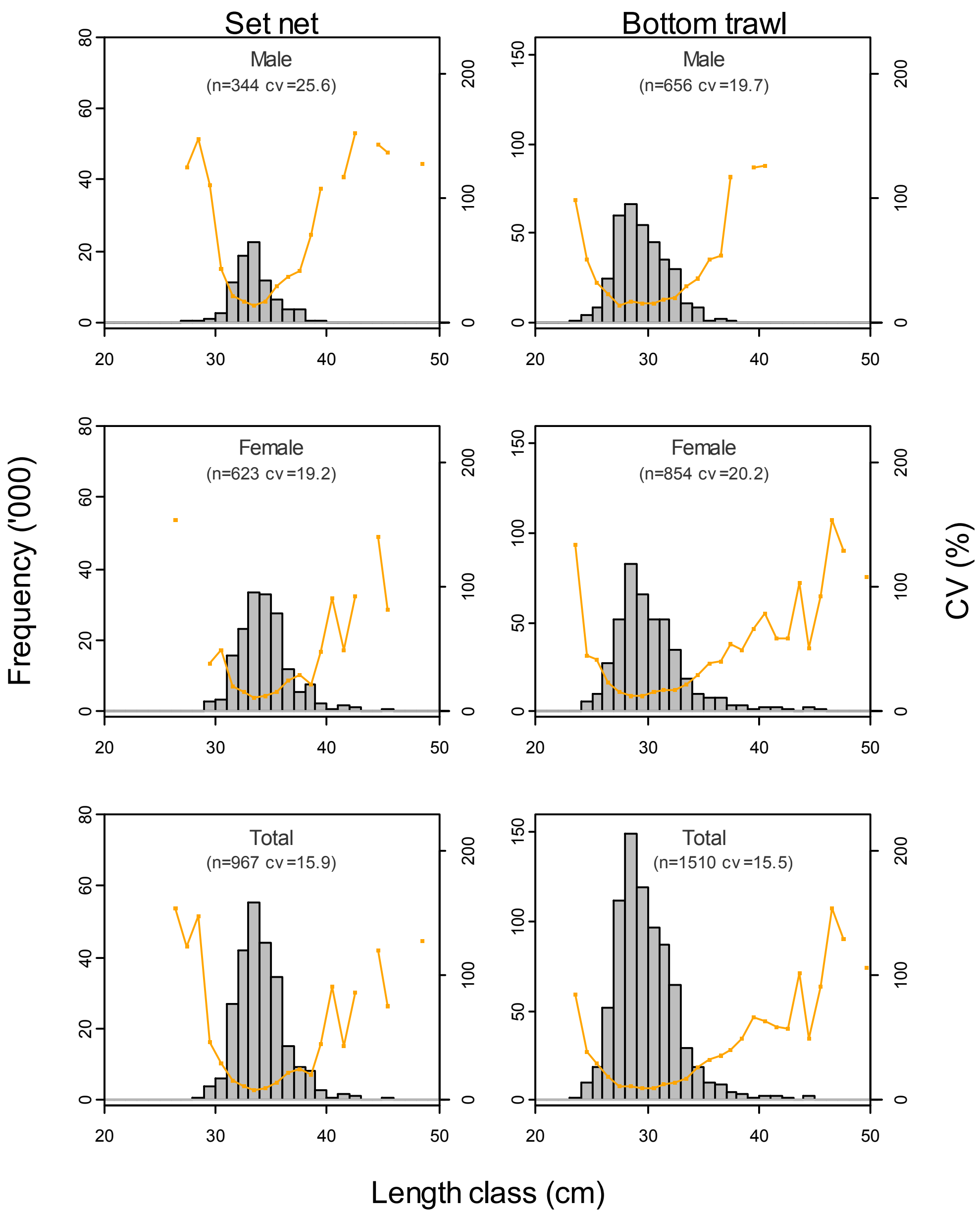


Figure 17: Scaled length frequency distributions for the commercial set net and bottom trawl fisheries in TAR 3 in 2009–10. The peak length is 33 cm for set net and 28 cm for bottom trawl.

Bottom trawl fishery

The scaled length frequency distribution from the bottom trawl fishery is shown in Figure 17. Both male and female distributions were unimodal with peaks at 28 cm fork length, with most fish between 25 and 35 cm. Minimum and maximum lengths were 23 and 40 cm for males, and 23 and 49 cm for females (Table 5). Mean lengths of scaled distributions were 29.0 cm for males, 29.8 cm for females, and 29.5 cm overall. The mean weighted c.v.s were 19.7% for males, 20.2% for females, and 15.5% overall. The sex ratio was 44% male.

3.5 Ageing precision

Set net fishery

Age readings were very consistent between the two readers, with an average percent error (APE) of 4.38 and a c.v. of 6.2% (Figure 18). Percent agreement was 67% and only 19 of 345 readings (5.5%) disagreed by more than 1 year. There was no age estimation bias across the age range. The range of final agreed age estimates was 3–39 years, although 98% of ages were less than 9 years old.

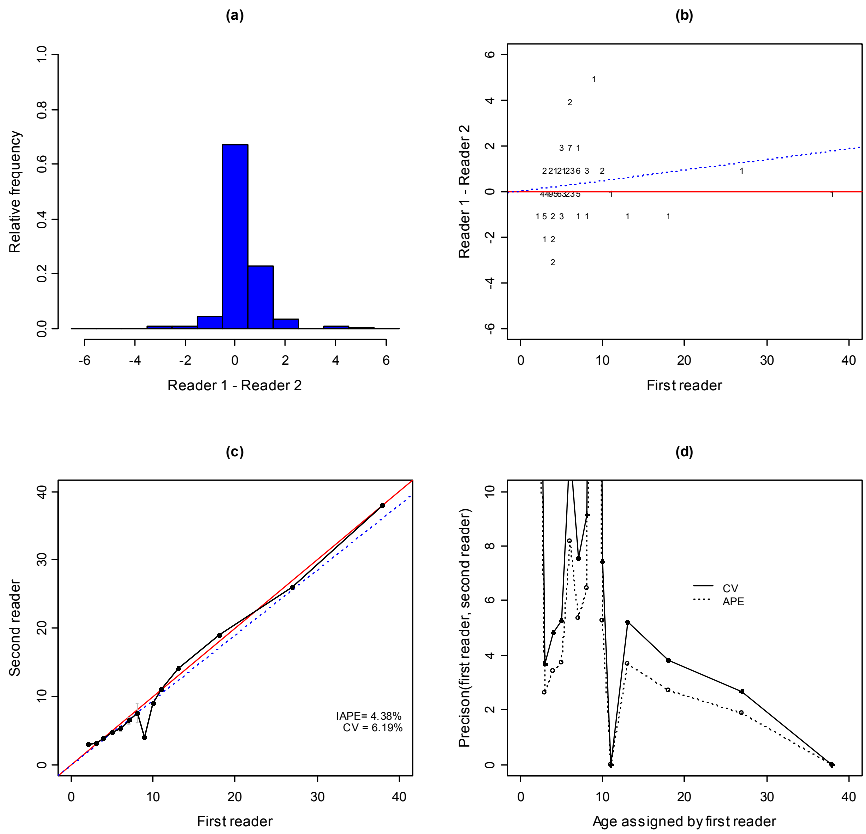


Figure 18: Age comparison plots for the set net fishery catch sampling in 2009–10. a) Histogram of differences in age readings between readers. b) Differences in ages between two readers plotted against the age estimate of reader 1. The number of fish in each bin is plotted as the plot symbol. Solid red lines show perfect agreement, and dashed blue lines show the trend of a linear regression of the data points. c) Age bias graph showing correspondence of ages between reader 1 and reader 2 for all ages. Error bars of 95% confidence intervals about the mean age of reader. The index of APE and the mean c.v. across all ages are shown. Red and blue lines as for graph (c). d) Plot of the c.v. and the average percent error (APE) for each age as assigned by the first reader. n = 345 age readings.

Bottom trawl fishery

Age readings were very consistent between the two readers, with an average percent error (APE) of 1.15 and a c.v. of 1.62% (Figure 19). Percent agreement was 92% and only 4 of 502 readings (0.8%) disagreed by more than 1 year. There was no age estimation bias across the age range, (Figure 19). The range of final agreed age estimates was 2–19 years, although 97% of ages were less than 8 years old.

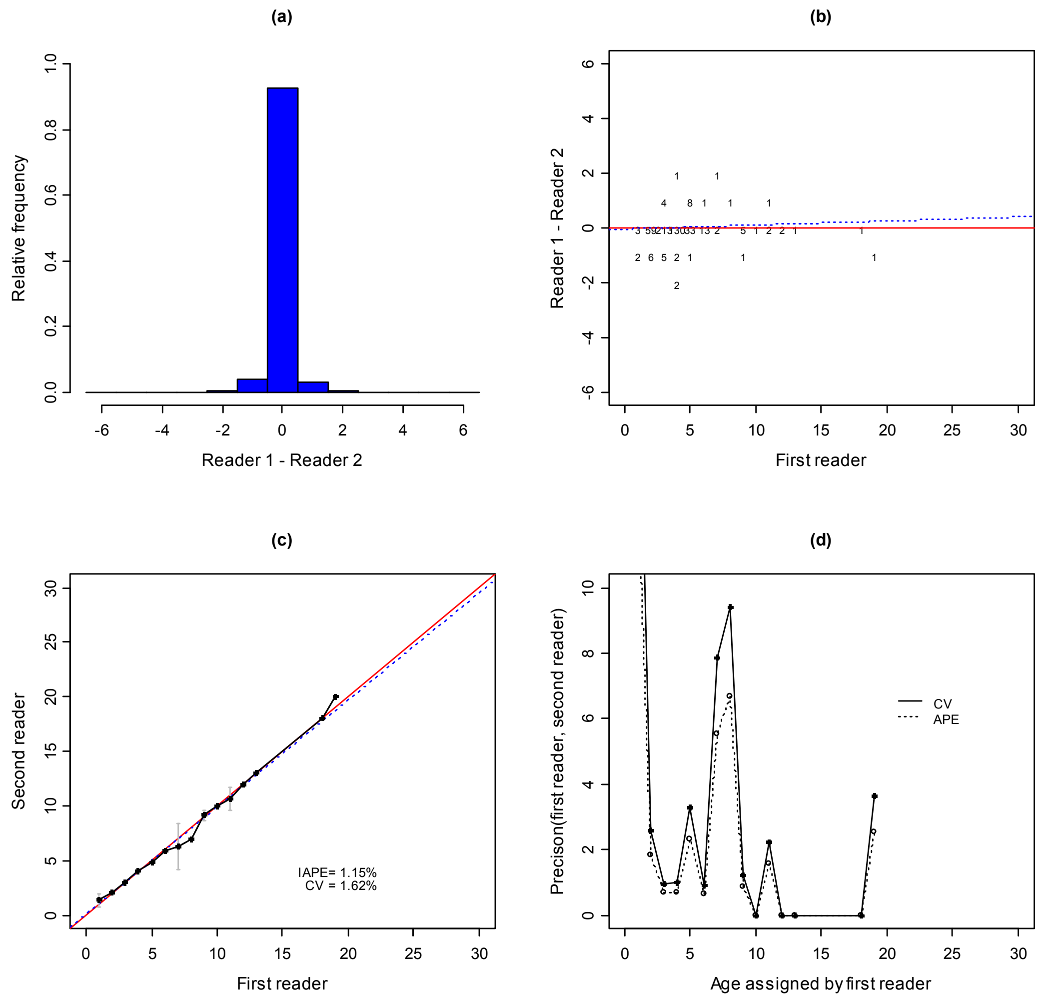


Figure 19: Age comparison plots for the bottom trawl fishery catch sampling in 2009–10. See caption in Figure 18 for explanation. N = 502 age readings.

3.6 Catch at age

Set net fishery

The set net scaled age frequency distributions are shown in Figure 20. Both male and female distributions were unimodal with peaks at 5 years, with most fish (89% for males and 95% for females) between 4 and 7 years old. Minimum and maximum ages were 3 and 39 years for males, and 3 and 10 years for females. Mean ages of scaled distributions were 5.6 years for males, 5.2 years for females, and 5.3 years overall. The mean weighted c.v.s were 32.7% for males, 22.2% for females, and 19.2% overall.

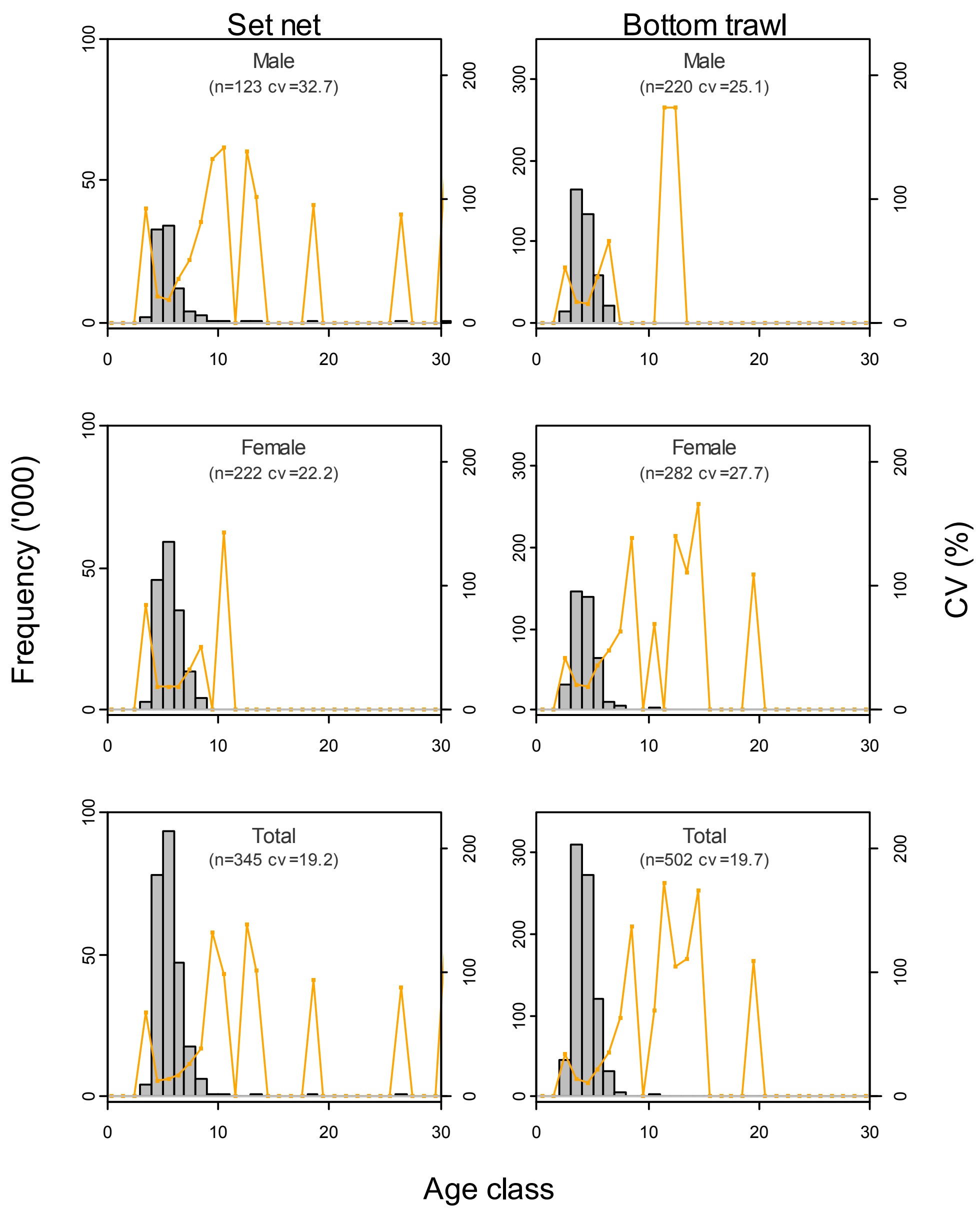


Figure 20: Scaled age frequency distributions for the commercial set net and bottom trawl fisheries in TAR 3 in 2009–10. For the set net ages, 30 represents a plus group within which there was one male aged 38 years. The peak age is 5 years for set net and 3 years for bottom trawl.

Bottom trawl fishery

The bottom trawl scaled age frequency distributions are shown in Figure 20. Both male and female distributions were unimodal with peaks at 3 years, with most fish (90% for males and 86% for females) from 3 to 5 years old. Minimum and maximum ages were 2 and 12 years for males, and 2 and 19 years for females. Mean ages of scaled distributions were 3.8 years for males, 3.9 years for females, and 3.85 years overall. The mean weighted c.v.s were 25.1% for males, 27.7% for females, and 19.7% overall.

3.7 Reproductive condition

Set net

The gonad stages are shown for set net fishery sampled tarakihi in statistical area 018 in Figures 21 and 22. The maturing gonad stage was dominant in both sexes. In males there were fewer numbers of immature (or resting) and mature gonads, and the latter became more common in the January to March period. In females the mature stage was the next most common, with small numbers of running ripe and spent fish. The mature and spawning females (running ripe) were most common between January and March, with small proportions of spent fish throughout the period December to May.

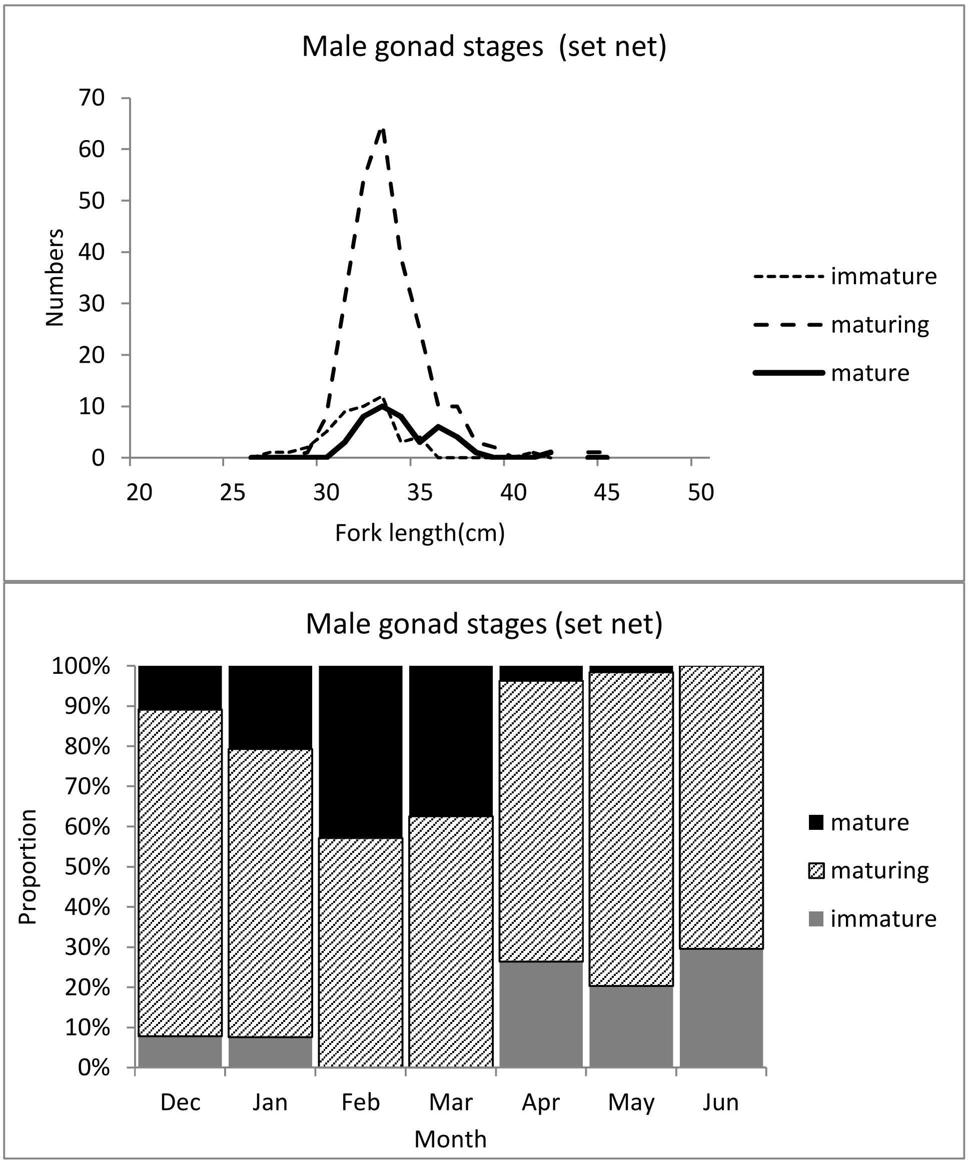


Figure 21: Gonad stages of male tarakihi sampled from the set net fishery in statistical area 018 in 2009–10 shown as a function of length (top panel) and month (bottom panel). n = 344 fish.

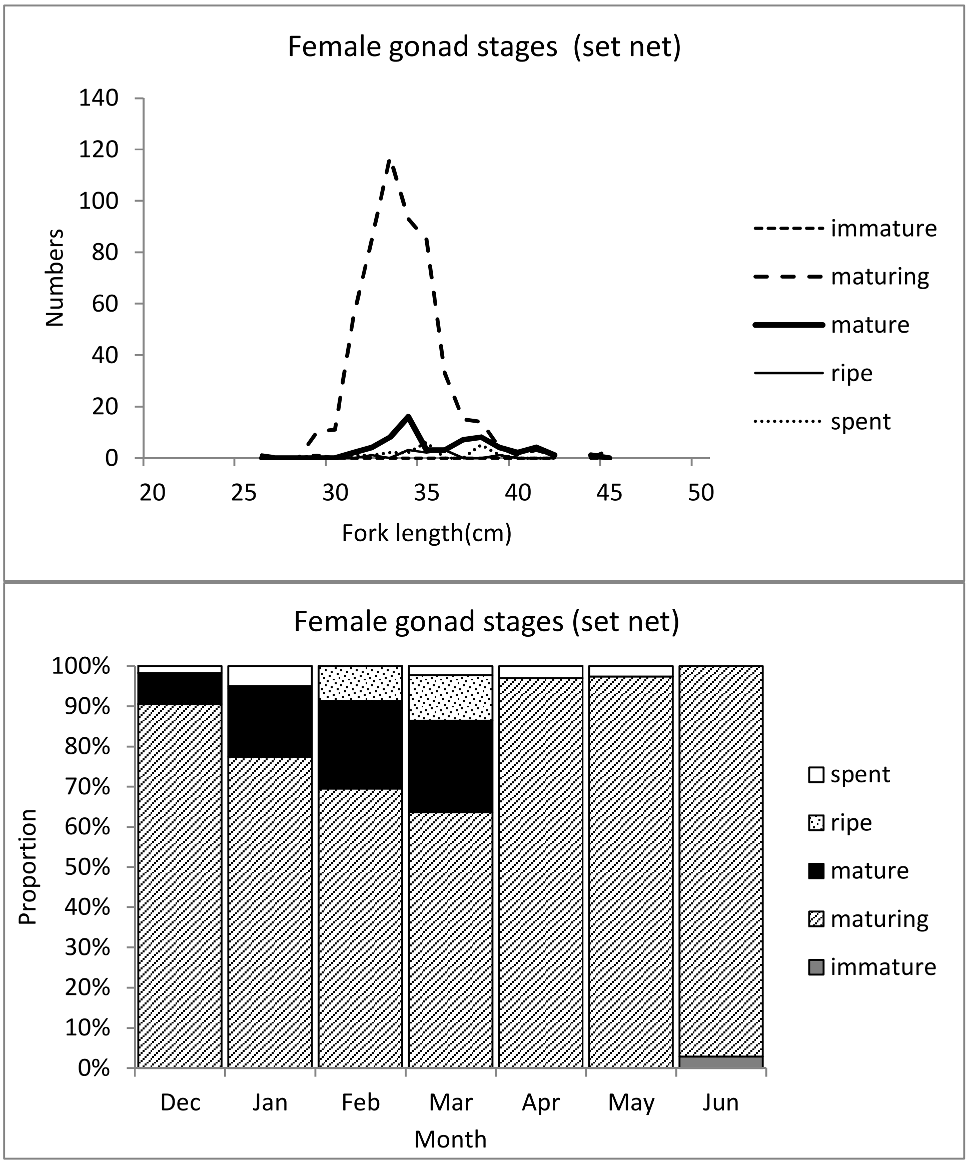


Figure 22: Gonad stages of female tarakihi sampled from the set net fishery in statistical area 018 in 2009–10 shown as a function of length (top panel) and month (bottom panel). n = 623 fish.

Bottom trawl

The gonad stages are shown for bottom trawl fishery sampled tarakihi in statistical areas 020, 022, and 024 in Figures 23 and 24. For males, the immature stage was dominant with fewer numbers of maturing and just 12 fish that were mature. The latter stage was most common in the February– March period. For females maturing fish were dominant followed by immature, with fewer numbers of mature, and just 16 fish recorded as running ripe. The mature and spawning females (running ripe) were most common in February and March. However, no fish were sampled in April.

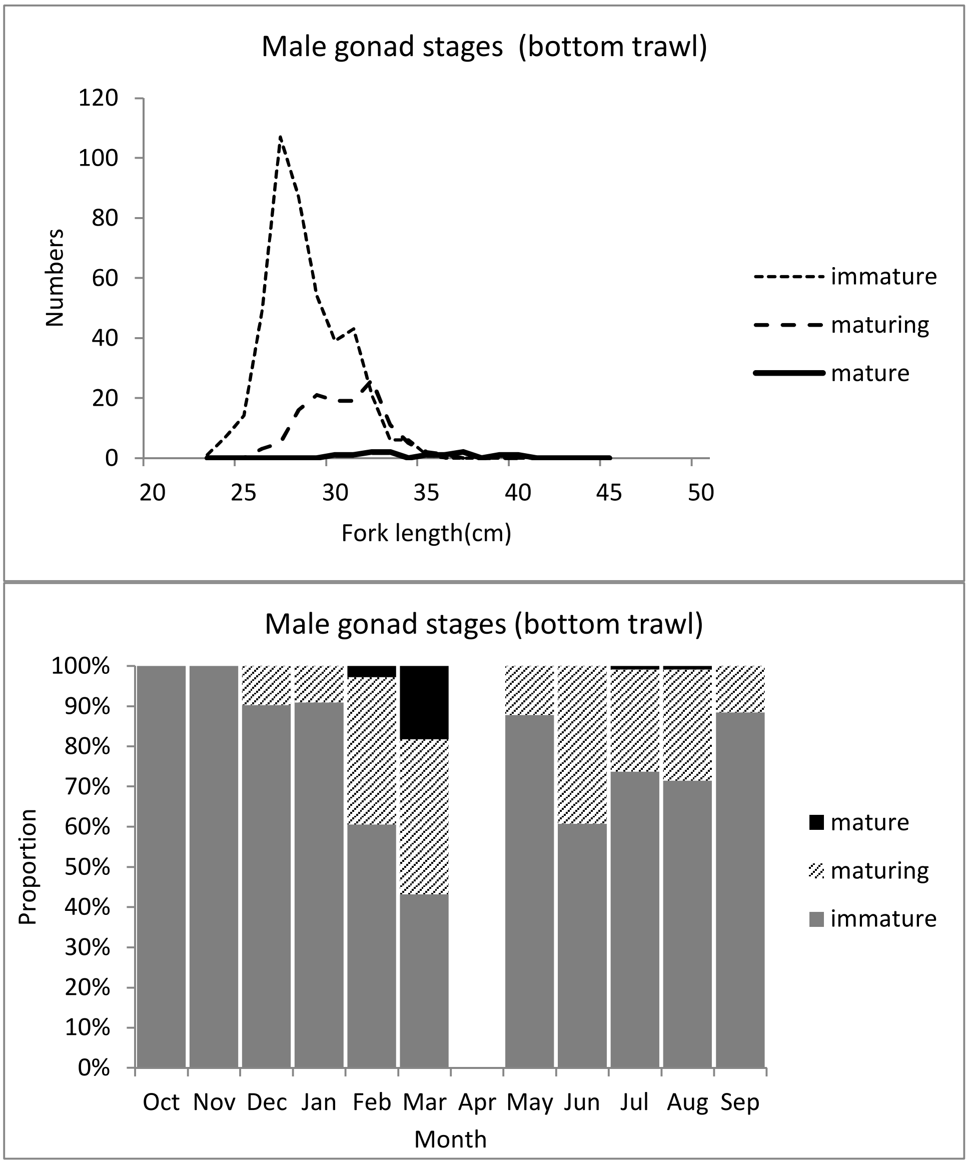


Figure 23: Gonad stages of male tarakihi sampled from the bottom trawl fishery in statistical areas 020, 022, and 024 in 2009–10 shown as a function of length (top panel) and month (bottom panel). n = 575 fish.

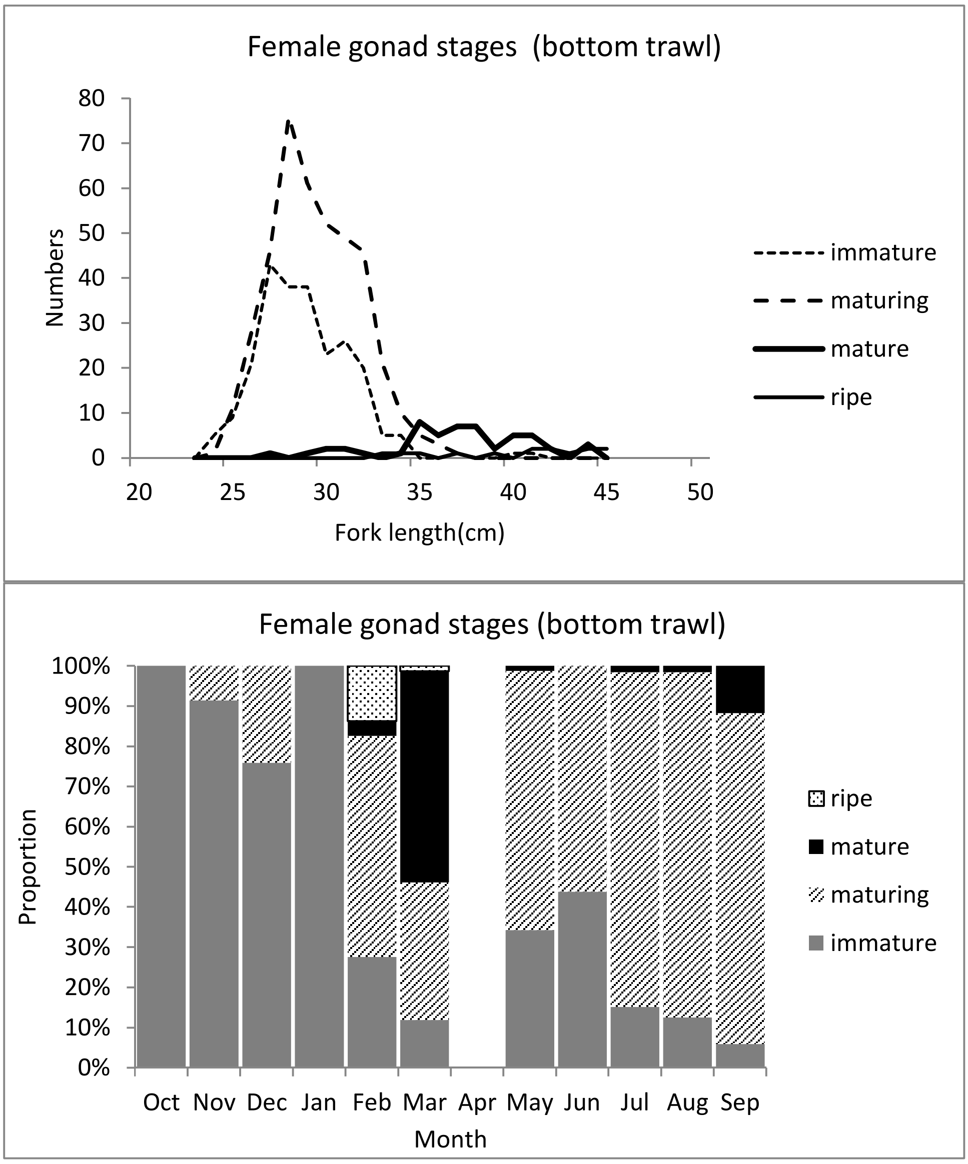


Figure 24: Gonad stages of female tarakihi sampled from the bottom trawl fishery in statistical areas 020, 022, and 024 in 2009–10 shown as a function of length (top panel) and month (bottom panel). n = 715 fish.

3.8 Growth parameters

The estimated growth parameters (K, t_0 and L_∞) are shown in Table 7 and the age-length data and fitted models in Figures 25 and 26.

Table 7. von Bertalanffy growth parameters, and lower and upper bounds of 95% confidence intervals ( ) for the set net and bottom trawl fisheries. Age input data are fishing year age-class.

	Set net		Bottom trawl	
Parameter	Males	Females	Males	Females
L_∞	38.6	102.6	39.1	49.4
	(35.6–41.6)	(78.6–126.6)	(34.4– 43.9)	(46.5–52.2)
K	0.194	0.020	0.191	0.138
	(0.039–0.349)	(0.014–0.026)	(0.089–0.292	(0.111–0.165
t_o	-4.90	-14.48	-3.62	-3.19
	(-10.71– 0.903)	(-17.60– -11.37)	(-5.65– -1.59)	(-3.95– -2.45)
Age range (y)	3–39	3–10	2–12	2–19
N	123	222	220	282

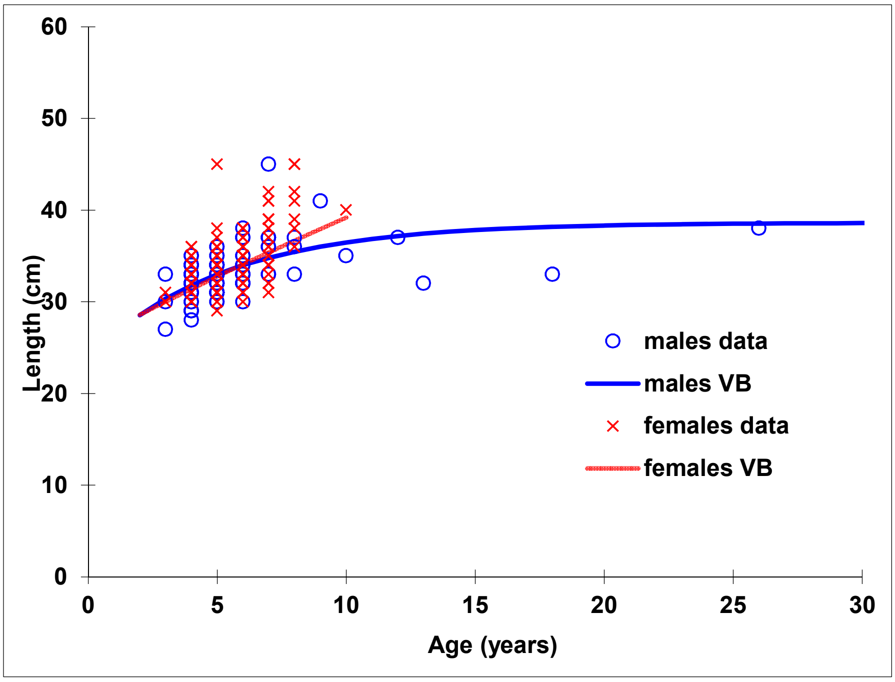


Figure 25: Observed age and length data by sex for the set net fishery in 2009–10 with von Bertalanffy growth models fitted to the data. See Table 7 for von Bertalanffy parameters.

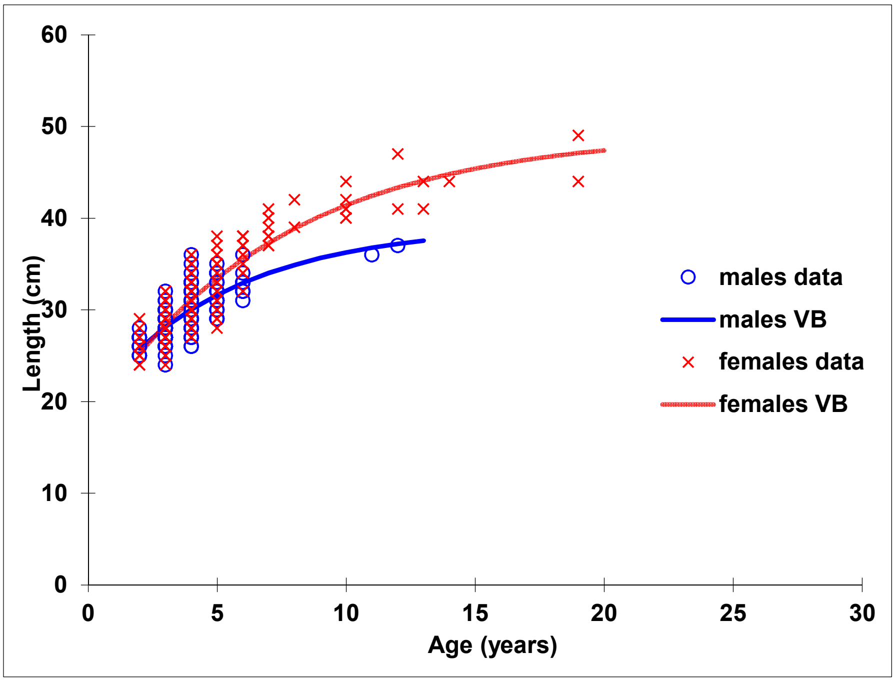


Figure 26: Observed age and length data by sex for the bottom trawl fishery in 2009–10 with von Bertalanffy growth models fitted to the data. See Table 7 for von Bertalanffy parameters.

The length-age data (age-classes) used to estimate the von Bertalanffy growth parameters are the same data used in the catch at age estimates, i.e., these were randomly selected from the total data set to be representative of the population age composition in each fishery. These age data are, however, not necessarily useful for estimating growth parameters because there are too few ages of older fish and the largest fish may not have been selected for ageing. Further, there are few old fish in the current fishery relative to the historic populations. To produce meaningful growth parameters, fish representative of all lengths for both sexes would need to have been selected and aged, as would occur in indirect ageing (age-length-key). The result is that the growth parameters are unlikely to be a true representation of growth rates of tarakihi in TAR 3. Growth parameters for the set net fishery are particularly poorly estimated as shown by the confidence intervals (Table 7).

3.9 Total mortality (*Z*) estimates

Total mortality estimates (*Z*) and 95% confidence intervals for the TAR 3 set net and bottom trawl fisheries in 2009–10 are given in Table 8. Estimates are 0.70 and 0.62 for the set net fishery, and 0.71 and 0.93 for the bottom trawl fishery.

Table 8: Total mortality estimates (*Z*) and 95% confidence intervals (CIs) of TAR 3 from the set net and bottom trawl fisheries in 2009–10. AgeR is age at full recruitment to the fishery.

	Set net			Bottom trawl	
AgeR	*Z*	CIs	AgeR	*Z*	CIs
5	0.70	0.47–0.97	3	0.71	0.48–1.02
6	0.62	0.43–0.85	4	0.93	0.60–1.32

3.10 Spawner per recruit analyses

Spawner per recruit analyses (SPR) were carried out separately for the set net and bottom trawl fisheries. The SPR curve is based on the relationship between %SPR and fishing mortality (Figure 27). Mortality parameters used in the analyses and the resulting $F_{\%SPR}$ values are shown in Table 9. For the default M of 0.10 the fishing mortality was 0.60 for set net and 0.61 for bottom trawl, corresponding to $F_{2.9\%}$ and $F_{2.8\%}$, respectively. This indicates that at the 2009–10 levels of fishing mortality for both fisheries, the expected contribution to the spawning biomass over the lifetime of an average recruit has been reduced to less than 3% of the contribution in the absence of fishing.

Table 9: Mortality parameters (*Z*, *F*, and *M*) and spawner per recruit ($F_{SPR\%}$) estimates at three values of M for TAR 3 set net and bottom trawl fisheries in 2009–10. The *Z* value is for age at full recruitment = 5 years for set net and 3 years for bottom trawl. *F*, fishing mortality; *M*, natural mortality; Z, total mortality.

M	Z	*F*	SPR
			Set net
0.12	0.70	0.58	$F_{3.9\%}$
0.10	0.70	0.60	$F_{2.9\%}$
0.08	0.70	0.62	$F_{2.1\%}$
			Bottom trawl
0.12	0.71	0.59	$F_{3.8\%}$
0.10	0.71	0.61	$F_{2.8\%}$
0.08	0.71	0.63	$F_{2.0\%}$

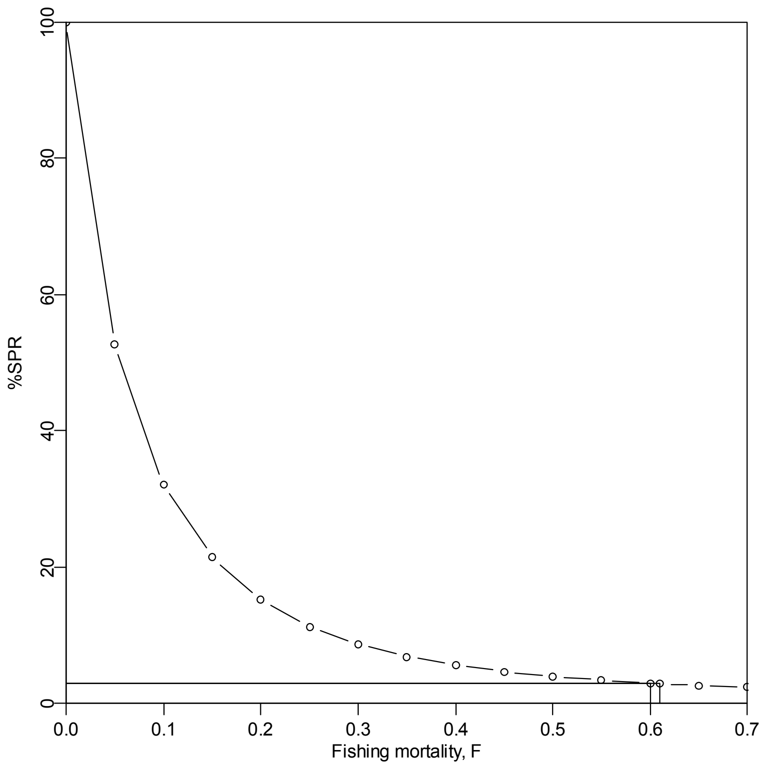


Figure 27: Plot of spawner per recruit (SPR) curve as a function of fishing mortality (F) for the TAR 3 set net and bottom trawl fisheries in 2009–10 (M = 0.1). The corresponding F and %SPR value are shown on the curve for the set net (F = 0.60) and bottom trawl fisheries (F = 0.61). The values of %SPR are $F_{2.9\%}$ and $F_{2.8\%}$ respectively. See Table 9 for fishing mortalities and $F_{SPR\%}$ values where M was set at 0.08 and 0.12.

4. DISCUSSION

This report presents the results of the 2009–10 TAR 3 catch sampling for the set net fishery in statistical area 018 (Kaikoura), and the inshore bottom trawl fishery in statistical areas 020 (Pegasus Bay), 022 (Canterbury Bight), and 024 (north Otago). This is the first year of a two year sampling programme that covers 2009–10 and 2010–11 (TAR201002). In addition, a characterisation of the commercial fishery in TAR 3 was carried out for the period 1989–90 to 2009–10 to determine if sampling was representative.

4.1 Representativeness of sampling

The design of the catch sampling programme aimed to ensure that the sampled landings were representative of the catch of the entire fleet and hence that there was minimal bias in the length and age compositions estimated for the TAR 3 fisheries. For example, if all landings were sampled at the beginning or at the end of the season, there is a risk of introducing bias in the size and age of fish measured.

The set net fishery catch sampling appears to be representative of the tarakihi population landed by the set net vessels in statistical area 018 in 2009–10. Evidence to support this conclusion is based on the following: (1) the sampling allocation followed the same trend as the proportion of total tarakihi catch throughout the year, (2) the catch from the sampled vessels followed the same trend as that of the total 2009–10 catch, (3) vessel characteristics were similar for sampled vessels and all vessels. Aged fish for the set net fishery are not as well matched with the 2009–10 catch data, but this is a partly a result of weighting the otolith selection by weight of each sampled landing.

The bottom trawl fishery catch sampling was spread throughout the year in proportion to commercial catch over the period 2003–03 to 2007–08, and samples were reasonably well matched to this pattern. However the temporal proportion of the catch in 2009–10 deviated from the previous six years and there was a potential under-sampling in the December-January period. However, the catch from the sampled vessels followed the same trend as that of the total 2009–10 catch and the sampled vessel characteristics and depth distributions were similar to that of all vessels. This is strong evidence that the catch sampling was representative of the tarakihi population landed by the east coast South Island bottom trawl fishery in 2009–10. Aged fish for the bottom trawl fishery are not as well matched with the 2009–10 catch data, but this is a partly a result of weighting the otolith selection by the weight of each sampled landing.

4.2 Length and age composition of TAR 3

The set net fishery shows single and narrow modes for both the length and age distributions for both sexes, with most fish between 30 to 40 cm and 4 and 7 years old, and few older fish (see Figures 17 and 20). The MWCV of 19% for age is considerably less than the target c.v. of 30%, and combined with that for length (16%), indicates that adequate numbers of fish were measured and aged for the set net fishery.

Similarly, the bottom trawl fishery also shows single and narrow modes for both the length and age distributions for both sexes with most fish between 25 and 35 cm and 3 and 5 years old, and few older fish (see Figures 17 and 20). These fish were on average about 4 cm smaller and a year or two younger than those from the set net fishery. The MWCV of 20% for age is considerably less than the target c.v. of 30%, and combined with that for length (15%), indicates that adequate numbers of fish were measured and aged from the bottom trawl fishery.

Comparison with other areas and historic surveys

The 2009–10 catch sampling programme indicates that tarakihi from the ECSI, and particularly the bottom trawl fishery, are considerably smaller and younger than those in TAR 7 in 2004–05 (Manning et al. 2008), and to a lesser extent those in TAR 2 in 2009–10 (Parker & Fu in press). The main difference is that in TAR 3 there are very few fish older than about 6 years. The length distributions from the ECSI *Kaharoa* trawl survey winter time series from 1991 (Beentjes & Wass 1994) through to the most recent survey in 2009 (Beentjes et al. 2010) have shown a consistent length distribution with few fish over 35 cm and the largest mode similar to that observed in the catch sampling in 2009–10, although no ageing has been carried out. These findings tend to support the view that this area has been predominantly a nursery ground for tarakihi since at least the early 1990s, and although spawning by the larger fish was found to occur in 2009–10, this was very limited. In contrast, research trawl surveys of Pegasus Bay in 1970 and 1978 show a good representation of older fish with 20% of fish older than 10 years (Tong 1979). Similarly, research trawl surveys from Kaikoura to Cape Campbell in 1970 (Vooren 1973) and 1978 (Tong 1979) also showed tarakihi populations with more than 20% of fish older than 10 years. This age composition appears to have remained reasonably stable until to the late 1980s as the 1987 James Cook survey between Banks Peninsula and Cook Strait showed that length and ages of both sexes were reasonably well represented out to 45 cm and about 30 years or more (Annala et al. 1990). These findings suggest that there has been a marked change in the age composition of the TAR 3 fishery between the 1970s/80s and what was observed in 2009–10, with the loss of virtually all fish above 10 years of age, and casts doubt on the commonly held view that the ECSI, south of Pegasus Bay, was always exclusively a nursery ground for juvenile tarakihi.

4.3 Spawning

The set net tarakihi catch off Kaikoura is thought to be based on a spawning migration, giving rise to the seasonal nature of the fishery. However, the gonad staging indicates that only a small proportion of the set net fish were spawning and this was not substantially greater than the proportion spawning in the bottom trawl fishery in Pegasus Bay and the Canterbury Bight. The larger and older tarakihi sampled from the set net fishery (on average about 4 cm larger and a year or two older) could be a result of gear selectivity – the set net fishery uses 125 mm mesh size compared to a 100 mm codend in the bottom trawl fishery. Spawning that was observed, tended to be in the late summer-autumn period, consistent with the findings from earlier studies (Tong & Vooren 1972, Vooren & Tong 1973, Vooren 1975). It is noteworthy that spawning was confined to females, although many males were in the mature condition and it is possible that some of these fish could have been ripe.

The tarakihi larval stage is followed by a pelagic postlarval stage, presumed to be initially confined to offshore waters, although no specimens have been located (Vooren 1972). After 8–10 months they metamorphose into juvenile tarakihi at about 70–90 mm, at which time they become demersal (Vooren 1972). Postlarval tarakihi (60–90 mm) were caught in the shallows of Pegasus Bay and Blue skin Bay in the late 1960s indicating that spawning may have been occurring in this region (Vooren 1972) and this is supported by the age composition around this time (Vooren 1973, Tong 1979). Given the prevailing surface currents around the ECSI, which travel from south to north and east along the Chatham Rise, it seems unlikely that that the ECSI population is connected to the tarakihi spawning sites known to exist around east Cape and Cape Campbell, and it seems more plausible that recruitment of postlarvae/juvenile tarakihi into the inshore ECSI originates from a spawning ground to the south and possibly the southern west coast South Island, an area which has consistently large fish.

4.4 Stock status

Mortality estimates (*Z*) with age at full recruitment of 5 years for the set net fishery and 3 years for the bottom trawl fishery are very high at 0.70 and 0.71, respectively (see Table 8).

The Ministry of Fisheries *Harvest Strategy Standard* (Ministry of Fisheries 2008a) specifies that a Fishery Plan should include a fishery target reference point, and this may be expressed in terms of biomass or fishing mortality. The more appropriate target reference point is F_{MSY}, which is the amount of fishing mortality that results in the maximum sustainable yield. The recommended proxy for F_{MSY} is the level of spawner per recruit $F_{\%SPR}$. The *Harvest Strategy Standard* (Ministry of Fisheries 2008a) includes the following table of recommended default values for F_{MSY} (expressed as $F_{\%SPR}$ levels from spawning biomass per recruit analysis), and also for B_{MSY} (expressed as $\%B_0$).

Productivity level	**$\%B_0$**	**$F_{\%SPR}$**
High productivity	25%	$F_{30\%}$
Medium productivity	35%	$F_{40\%}$
Low productivity	40%	$F_{45\%}$
Very low productivity	≥ 45%	≤ $F_{50\%}$

Tarakihi can be regarded as an exploited species with medium productivity and hence the recommended default proxy for F_{MSY} is $F_{40\%}$. Our SPR estimates for the set net and bottom trawl fisheries using the default M value of 0.10 indicate that the expected contribution to the spawning biomass over the lifetime of an average recruit has been reduced to 3% of the contribution in the absence of fishing, for both fisheries (see Table 9, Figure 27). Further, the level of exploitation (F) of TAR 3 stocks is substantially less than F_{MSY} target reference point of $F_{40\%}$. The estimates of Z are based on the assumption that this is a closed population or a single stock with no emigration of the larger fish, and further the estimation of $F_{\%SPR}$ is based on a maximum age of 44 years for TAR 3.

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Appendix 1: Methodology for estimating c.v.s for total mortality (*Z*) (from Beentjes & Francis 2011)

For each age at recruitment, a_{rec}, a 95% confidence interval for the associated total mortality estimate, $\hat{Z}$, was calculated using the following simulation procedure, adapted from that of Dunn et al. (2002). This involves drawing a simple random sample of ages from the recruited part of each of 1000 simulated population in which there is annual variation in Z (described by a lognormal distribution with mean $\hat{Z}$ and c.v. $c_Z = 0.10$) and in recruitment (R) (where log recruitment is normally distributed with standard deviation $\sigma_{\text{R}} = 0.7$). In such a population, the relative frequency of fish at age a = 1,...,50 is given by

$$f_a = e^{-(Z_a + R_a)}$$

where Z_a is the cumulative mortality defined by

$$Z_1 = 0, \quad Z_a = \sum\nolimits_{a'=2}^{a} \hat{Z} d_{a'}$$

the d_a are lognormally distributed with mean 1 and c.v. c_Z, and the R_a are normally distributed with mean 0 and s.d. σ_{R}.

With ageing errors assumed to be normally distributed with c.v. $c_{\text{age}} = 0.15$, the relative frequency of fish at *apparent* age a is given by

$$f'_a = \sum\nolimits_{a'=1}^{50} f_{a'} E_{a'a}$$

where E is an ageing-error matrix, calculated by setting $E_{a'a} = \text{F}\left(a + 0.5, a', c_{\text{age}}\right) - \text{F}\left(a - 0.5, a', c_{\text{age}}\right)$ [and $\text{F}(x,\mu,c)$ is the cumulative probability function for the normal distribution with mean μ and c.v. c] and then normalizing the rows of this matrix to sum to 1.

The size, n, of the sample of ages from the recruited population was calculated, as follows, to mimic the sampling error in the real data. The mean-weighted c.v. for the recruited part of the real data is calculated as

$$c_{\text{samp}} = \frac{\sum_{a \ge a_{rec}} f_{a,\text{obs}} c_{a,\text{obs}}}{\sum_{a \ge a_{rec}} f_{a,\text{obs}}}$$

where $f_{a,\text{obs}}$ is the age frequency from the real (unsimulated) data, and $c_{a,\text{obs}}$ is its c.v. The mean-weighted c.v. is used to calculate n as

$$n = \left(\frac{\sum_{a \ge a_{rec}} \sqrt{f''_a (1 - f''_a)}}{c_{\text{samp}}} \right)^2$$

where, to maintain consistency in sample sizes across simulated populations, the proportions at age f''_a were calculated as for the f_a above, except that c_Z and σ_{R} were set to zero; then f''_a was set to 0 for

$a < a_{\text{rec}}$, and the f''_a are normalised to sum to 1. Finally, a random sample of size n is selected from the AF f''_a; a maximum-likelihood estimate of Z is calculated from this sample; the set of 1000 Z estimates is scaled to have mean $\hat{Z}$; and the bounds of the 95% confidence interval for $\hat{Z}$ are set to the 0.025 and 0.975 quantiles of the scaled Z estimates (the scaling is necessary because the maximum-likelihood estimate can be biased, particularly when there is ageing error).

Appendix 2: Characterisation of the TAR 3 Fishery (1989–90 to 2009–10) prepared by Paul Starr (SeaFic) as part of this project and submitted to the Northern Inshore Working Group in October 2010 (NINS WG 2010/54A).

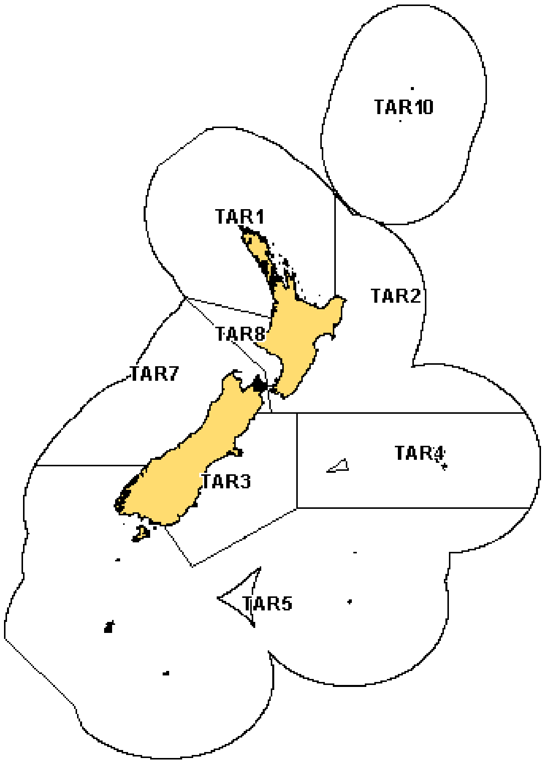

Figure A1: Map of TAR QMAs

1. Description of the Report

The TAR 3 TACC was raised on 1 October 2004 by 20% from 1169 tonnes to 1403 tonnes under the conditions of the Adaptive Management Programme (AMP) as specified by the Ministry of Fisheries in the "*Draft Frameworks for Exploratory, Developing, and Established Fisheries under the Adaptive Management Programme*", dated December 1999. Allowances for the combined recreational and customary catches of 100 t per year were also made at the time of the introduction of TAR 3 into the AMP, resulting in a total TAR 3 TAC of 1503 t.

The TAR 3 AMP is no longer active, having been discontinued by MFish in 2009–10, but the TACC and allowances described above have remained unchanged (Figure A1, Figure A2).

2. Information about the stock/fishery

2.1 Catches

There is a long catch history available for TAR 3, starting from 1931. Documentation of this catch history is available in Starr et al. (2009) and is not repeated here. However, these annual catch estimates are plotted in Figure A2 for comparison with current catch and TACC levels.

The TACC for tarakihi in TAR 3 was set at 988 t when this Fishstock was first put in the QMS in 1986. It was raised in the following year to 1036 t, most likely through the process of quota appeals which gradually lifted the TACC to 1169 t by 1993–94 (Table A1). Catch levels declined to below 750 t in 1993–94 (the lowest since TAR 3 entered the QMS), but showed a steady increase to over

1200 t per year from 1999–00 to 2001–02, catch levels which were above the TACC of 1169 t (Figure A2; Table A1). Landings since the TAR 3 TACC was raised to 1403 t in 2004–05 have not even reached the previous TACC, indicating that there has been no apparent response by fishers to the increased availability of potential catch. Recent landings exceeded 1000 t in 2008–09, but then dropped to the lowest annual total since 1993–94, recording only 757 t in 2009–10 (Table A1).

Table A1: Total landings (t) and TACCs (t) for tarakihi in TAR 3 from 1989–90 to 2009–10. Landings from 1989–00 to 2000–01 are from Quota Management Returns (QMR). Landings from 2001–02 to 2009–10 are from Monthly Harvest Returns (MHR); '–': not set

Fishing year	Landings	TACC
83/84	902	–
84/85	1 283	–
85/86	1 147	–
86/87	938	988
87/88	1 025	1 035
88/89	759	1 061
89/90	1 007	1 107
90/91	1 070	1 148
91/92	1 132	1 148
92/93	813	1 169
93/94	735	1 169
94/95	849	1 169
95/96	1 111	1 169
96/97	1 087	1 169
97/98	1 024	1 169
98/99	1 098	1 169
99/00	1 260	1 169
00/01	1 218	1 169
01/02	1 241	1 169
02/03	1 156	1 169
03/04	1 009	1 169
04/05	905	1 403
05/06	1 024	1 403
06/07	1 080	1 403
07/08	844	1 403
08/09	1 017	1 403
09/10	757	1 403

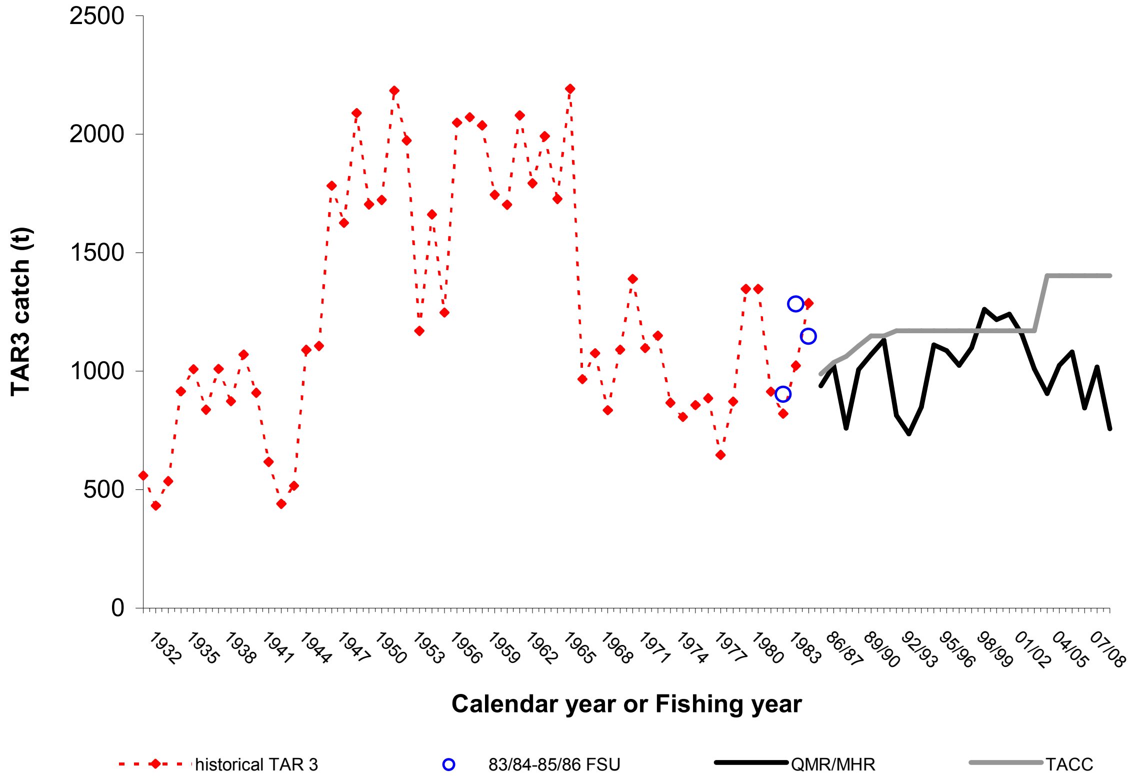

Figure A2: Plot of TAR 3 landings and TACCs from 1931 to 2009–10. Historical estimates of TAR 3 catch (Starr et al. 2009) are plotted from 1931 to 1985. The early QMR fishing year estimates for 1983–84 to 1985–86 (Starr et al. 2009) are plotted as open circles for comparison with the calendar year TAR 3 reconstructions. The QMR/MHR landings from 1986–87 to 2009–10 (Table A1) are plotted separately.

2.1.1 Recreational catches

Recreational catches in TAR 3 are not well known but it is likely that they are not large. Three recreational surveys based on phone interviews and diaries given to volunteers spanning the period from 1992 to 2000 have estimated the recreational catch of TAR 3 from 1000 to 25 000 fish (Table A2). The Ministry of Fisheries Recreational Technical Working Group (RTWG) recommended that the harvest estimates from the diary surveys should be used only with the following qualifications: (a) they may be very inaccurate; (b) the 1996 and earlier surveys contain a methodological error; and, (c) the 2000 and 2001 harvest estimates are implausibly high for many important fisheries.

The mean weight of recreational caught tarakihi is unknown, but a small sample of 22 fish weighed during the 1996 recreational survey indicated a mean weight of 0.51 kg and a mean length of 30 cm for these fish (Bradford 1998). Even if the mean weight of recreational caught tarakihi was 1 kg (which is probably a high value), the total annual landed recreational catch of TAR 3 is unlikely to exceed 10 t per year, or less than 1% of the commercial catch.

2.2 Regulations Affecting the Fishery

There have been no significant changes to the management regulations affecting tarakihi in recent years. Most tarakihi are landed unprocessed (green), so there are no problems with changing conversion factors (see Section 2.3.2).

Table A2: Estimated catch of TAR 3 by recreational fisheries based on three diary surveys conducted in the indicated years. Data for 1994 and 1996 from Teirney et al. (1997) and 2000 survey results from Boyd & Reilly (2005).

Year of recreational survey	Estimated number caught	c.v.(%)	Estimated survey harvest (t)	Range (t)
1994	1 000	–	–	0–5
1996	3 000	–	–	–
2000	25 000	51	15.4	7.5-23.2

2.3 Analysis of TAR 3 Catch and Effort Data

2.3.1 Methods used for 2010 analysis of MFish catch and effort data

The methods used to prepare the MFish catch/effort data have remained essentially unchanged since 2002, except for some refinements. The current methodology used to prepare these data for both the characterisation analysis has been documented elsewhere (Starr 2007).

However, there are still shortcomings with analysing the catch and effort data using the procedure described by Starr (2007), because of the following issues:

- Trips which land to more than one Fishstock are discarded if they fish in "straddle" statistical areas which are valid for each of the Fishstocks landed. All trips which land multiple Fishstocks and fish in these ambiguous statistical areas have been dropped from the analysis.
- The most detailed level of area attributable for any trip is the statistical area because of a limitation in the design of the CELR system and the requirement to merge the CELR and TCEPR data for this species. Trips with missing statistical areas have used the predominant (most frequent) statistical area to fill in the missing datum. The few trips which had no statistical area information were dropped.
- Landed greenweight catch is attributed to specific statistical areas, method, and target species by assuming that the estimated catches in these categories are distributed correctly. This will lead to some error because small catches from some strata are often not included in the tarakihi data. If no estimated catch is available for a trip, the procedure uses the distribution of effort to partition the landed catch for that trip, a procedure which could lead to some bias because it assumes equal catchability in all strata.
- Trips with missing method codes are filled in with the method from the remaining events if only one method is reported for that trip. If a trip with a missing method code reports more than one method, the entire trip is dropped.
- Trips which report no target species codes are dropped but events within a trip which have missing target species codes are filled in with the predominant (most frequent) target species for the trip.
- New forms which have been designed to provide more detailed spatial and other information have been introduced: the NCELR (netting catch-effort landing return) on 1 October 2006 and the TCER (Trawl catch-effort return) on 1 October 2007. These forms have been treated in this analysis similarly to the TCEPR (trawl catch-effort processing returns) by collapsing the information to a level consistent with the CELR forms. More detailed information will be extracted from these forms as years progress.

Table A3: Comparison of the sum of the landed catch totals (t) (bottom part of the MFish CELR form) with the total catch (t) reported by QMR/MHR for TAR 3 by fishing year across all reporting trips (Table A1). Also shown are the total landings from the analysis dataset and the sum of the estimated catches from the trips included in the analysis dataset. N_y =number trips/year in total dataset; A_y =number trips/year in analysis dataset; $L_{i,y}$ =landed catch from trip stratum *i* in year *y*; $C_{i,y}$ =estimated catch from trip stratum *i* in year *y*. Data origins: MFish replog 7351: 1989–90 to 2001–02; MFish replog 7972: 2002–03 to 2009–10.

Fishing Year	$\mathbf{QMR}_y$ [Table A1] (t)	$SL_y = \sum_{i=1}^{N_y} L_{i,y}$ (t)	$\frac{SL_y}{\mathbf{QMR}_y}$ (%)	$AL_y = \sum_{i=1}^{A_y} L_{i,y}$ (t)	$\frac{AL_y}{SL_y}$ (%)	$AC_y = \sum_{i=1}^{A_y} C_{i,y}$ (t)	$\frac{AC_y}{AL_y}$ (%)
89/90	1 007	797	79	762	96	680	85
90/91	1 070	944	88	910	96	828	88
91/92	1 132	1 082	96	1 067	99	996	92
92/93	813	775	95	756	97	663	86
93/94	735	726	99	690	95	651	90
94/95	849	854	101	788	92	737	86
95/96	1 111	1 056	95	1 009	96	970	92
96/97	1 087	1 045	96	991	95	938	90
97/98	1 024	995	97	975	98	944	95
98/99	1 098	1 094	100	1 035	95	995	91
99/00	1 260	1 253	99	1 224	98	1 190	95
00/01	1 218	1 178	97	1 153	98	1 153	98
01/02	1 241	1 197	96	1 064	89	1 032	86
02/03	1 156	1 165	101	1 142	98	1 060	91
03/04	1 009	1 004	100	984	98	981	98
04/05	905	876	97	853	97	843	96
05/06	1 024	1 006	98	985	98	935	93
06/07	1 080	1 085	100	1 043	96	1 020	94
07/08	844	835	99	787	94	789	94
08/09	1 017	1 003	99	953	95	942	94
09/10	757	756	100	716	95	692	92

The catch totals (Table A3; Figure A3) resulting from the dataset used for this analysis may not be the same as those reported to the QMS system because the QMS is a reporting system separate from the MFish catch/effort reporting system. The data are further modified during the preparation procedure described above because trips are dropped with a corresponding loss of data, including dropping trips which have large landings of the target Fishstock without sufficient effort to corroborate the large landing. The most important source of data loss in this procedure results from dropping trips which fished in straddling statistical areas and which report more than one valid Fishstock for that statistical area (Table A3).

Catch totals in the fishery characterisation tables have been scaled to the QMR/MHR totals reported in Table A1 by calculating the ratio of these catches with the total annual landed catch in the analysis dataset and scaling all the landed catch observations (*i*) within a trip using this ratio:

$$L'_{i,y} = L_{i,y} \frac{\mathbf{QMR}_y}{AL_y} \qquad \text{Eq. 1}$$

where $\mathbf{QMR}_y$, $L_{i,y}$ and AL_y are defined in Table A3.

Two data extracts from the MFish Warehou database (documented in MFish 2010) were used in this analysis: a recent (late November 2010) extract (MFish replog 7972) which covered the period from 1 October 2002 to 30 September 2010. This extract was combined with an earlier extract obtained in

January 2009 (MFish replog 7351) to fill in the period from 1 October 1989 to 30 September 2002. These two data sets were not exactly equivalent, with replog 7351 extracting considerably more landings from Fishstocks other than TAR 3, indicating that the data outside of TAR 3 were more complete for the earlier extract. However, MFish replog 7972 appears to be complete with respect to TAR 3 and nearly all the summary tables and figures in this report have been restricted to this QMA.

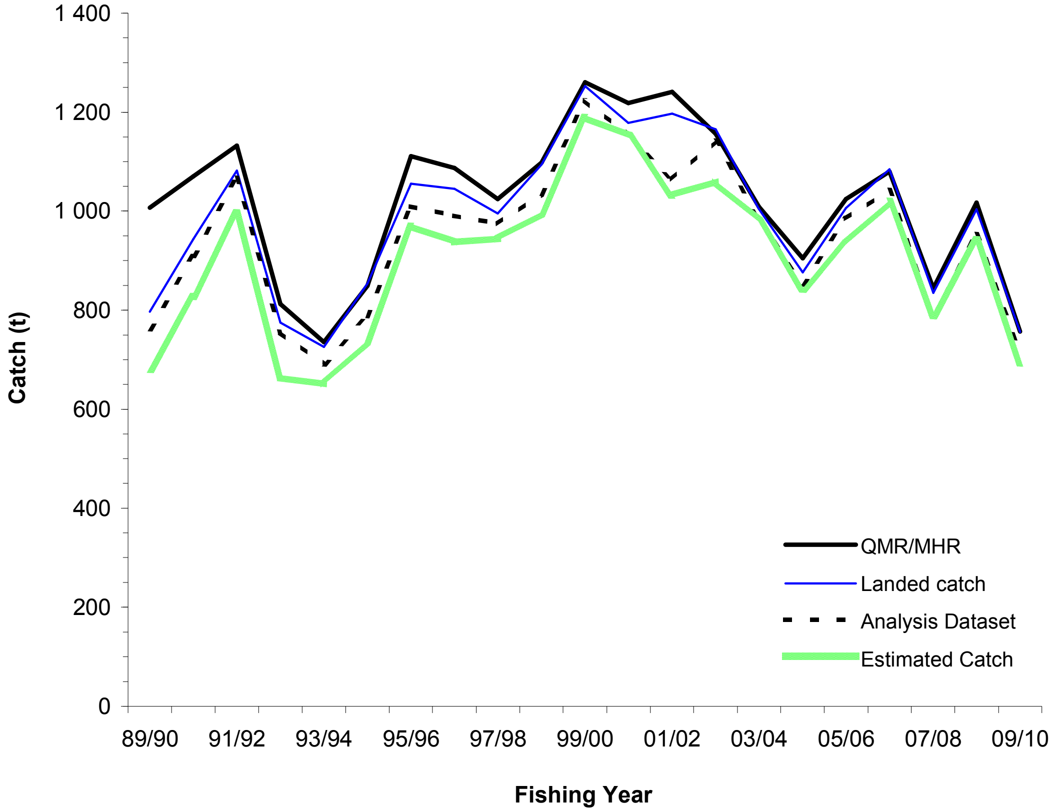

Figure A3: Plot of catch datasets presented in Table A3. The estimated catch total is the sum of the estimated catch in the analysis dataset.

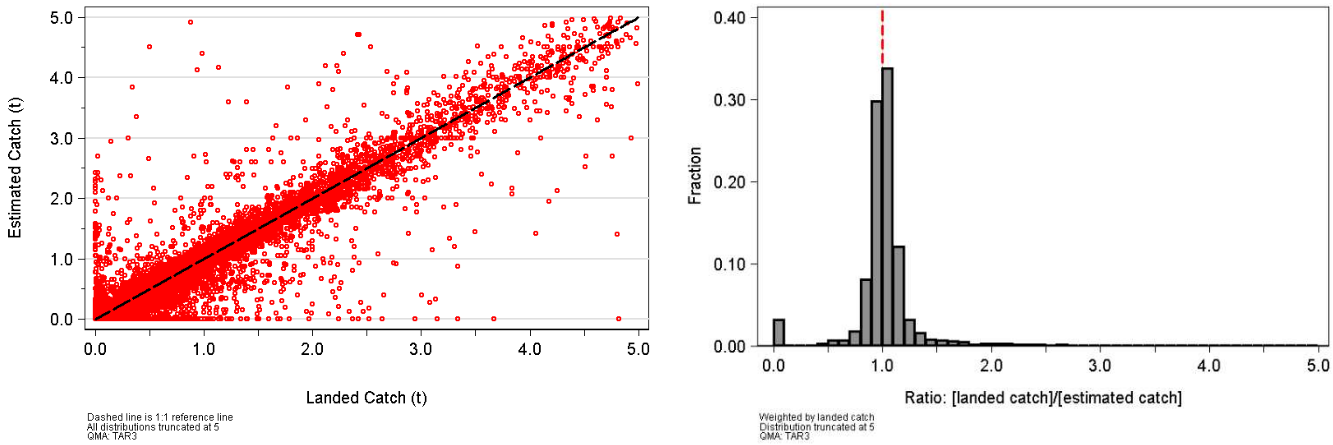

Figure A4: [left panel]: Scatter plot of the sum of landed and estimated tarakihi catch for each trip in the TAR 3 analysis dataset. [right panel]: Distribution (weighted by the landed catch) of the ratio of landed to estimated catch per trip. Trips where the estimated catch=0 have been assigned a ratio=0.

Table A4: Summary statistics pertaining to the reporting of estimated catch from the TAR 3 analysis dataset. A_y, $L_{i,y}$, AL_y, and AC_y are defined in Table A3 Error! Reference source not found.**; $L^{'}_{i,y}$ is defined in Eq.1; Z_y: number of trips in year *y* with no estimated catch; 5%: fifth percentile; 50%: median; 95%: ninety-fifth percentile. Data origins: MFish replog 7351: 1989–90 to 2001–02; MFish replog 7972: 2002–03 to 2009–10.**

Fishing year	Trips with landed catch but which report no estimated catch			Dataset statistics (excluding 0s) for the ratio of landed/estimated catch by trip			
	$\frac{Z_y}{A_y}$ (%)	$\frac{\sum_{i=1}^{Z_y} L_{i,y}}{AL_y}$ (%)	$\sum_{i=1}^{Z_y} L^{'}_{i,y}$ (t)	$\left(\frac{AL_y}{AC_y}\right)_{5\%}$	$\left(\frac{AL_y}{AC_y}\right)_{50\%}$	$\left(\frac{AL_y}{AC_y}\right)_{\text{Mean}}$	$\left(\frac{AL_y}{AC_y}\right)_{95\%}$
89/90	27	5	53	0.70	1.02	1.15	1.72
90/91	27	3	31	0.70	1.03	1.12	1.68
91/92	31	3	39	0.70	1.02	1.09	1.61
92/93	38	8	67	0.67	1.03	1.13	1.65
93/94	41	5	35	0.60	1.01	1.08	1.63
94/95	42	4	38	0.70	1.02	1.10	1.58
95/96	37	4	44	0.60	1.03	1.65	1.53
96/97	41	4	48	0.60	1.02	1.20	1.55
97/98	35	4	40	0.61	1.01	1.05	1.48
98/99	37	5	54	0.56	1.00	1.04	1.45
99/00	31	3	35	0.53	1.00	1.06	1.60
00/01	34	3	32	0.59	1.00	1.03	1.43
01/02	34	2	28	0.70	1.01	1.06	1.42
02/03	36	3	32	0.75	1.01	1.11	1.67
03/04	38	2	19	0.67	0.99	1.05	1.49
04/05	40	3	25	0.65	0.99	1.06	1.55
05/06	34	2	20	0.65	1.04	1.14	1.68
06/07	29	2	20	0.62	1.04	1.13	1.73
07/08	19	1	7	0.53	1.02	1.15	2.00
08/09	18	1	6	0.53	1.00	1.25	2.05
09/10	17	1	5	0.40	1.01	1.62	2.86
Total	34	3	674	0.62	1.01	1.15	1.66

Annual totals from this dataset are compared with the annual QMR/MHR totals in Table A3 and Figure A3. Total landings from the bottom part of the CELR form are similar to the landings in the QMR/MHR system, ranging from 88 to 101% of the official QMR/MHR system over the 19 years of available data (excluding the 79% value in 1989–90 which was the first year of the present catch/effort data collection system and is thought to be data deficient). Estimated catches by trip for TAR 3 track the landed catches very closely (Table A3; Figure A3), with the sum of the estimated catches ranging from 85 to 98% of the landed catch for the trips included in the analysis dataset Table A3. A comparison scatter plot of the estimated and landed catch by trip shows that trips both over and under-estimate the landing total for the trip and that the majority of the trips centre near the 1:1 line (Figure A4 [left panel]). The distribution of the ratios of the landed to estimated catch showed that the majority of the ratios are grouped near one, with little in the way of long tails in either direction (Figure A4 [right panel]). There is a small mode at zero which represents landings from trips which did report any estimated catch of tarakihi.

The 5% to 95% percentiles (excluding trips where there is no estimated catch) for the ratio of landed to estimated catch range from 0.62 to 1.66 for TAR 3, with the median ratio of the landings at 101% of the estimated catch and the mean ratio 15% higher than the estimated catch (Table A4). About one-third of the trips which land tarakihi have no accompanying estimated catch, but the landings in these trips were small, totalling less than 700 t over the 21 years of available data which is only 3% of the total landings for this Fishstock (Table A4). The introduction of the new inshore forms (NCELR and TCER), which record fishing activity at the event level, have nearly halved the proportion of trips which estimate nil tarakihi while landing this species, with the TAR landings in this category accounting for less than 1% of the total TAR 3 landings in the most recent three years (Table A4).

2.3.2 Description of TAR 3 landing information

Landing data for tarakihi were provided for all trips which landed TAR 3 at least once, with one record for every reported TAR landing (including landings from all TAR Fishstocks landed by a trip that also landed TAR 3) from the trip. Each of these records contained a reported green weight (in kg), a code indicating the processed state of the landing, along with other auxiliary information such as the conversion factor used, the number of containers involved and the average weight of the containers. Every landing record also contained a "destination code" (Table A5), which indicated the category under which the landing occurred. The majority of the landings were made using destination code "L" (landed to a Licensed Fish Receiver; Table A5). However, other codes (e.g., A, O and C; Table A5) also potentially described valid landings and were included in this analysis. A number of other codes (notably R, Q and T; Table A5) were not included because it was felt that these landing were likely to have been reported at a later date under the "L" destination category. Two other codes (D and NULL) represented errors which could not be reconciled without making unwarranted assumptions and these were not included in the landing data set.

Table A5: Destination codes in the unedited landing data received for the TAR 3 analysis. The "how used" column indicates which destination codes were included in the characterisation analysis. These data summaries were derived from combining two MFish data extracts (replog 7351 and replog 7972) and include the period 1989–90 to 2009–10, but have been restricted to TAR 3.

Destination code	Number events	Greenweight (t)	Description	How used
L	62 966	21 056.0	Landed in NZ (to LFR)	Keep
C	117	67.2	Disposed to Crown	Keep
A	190	18.8	Accidental loss	Keep
E	294	5.9	Eaten	Keep
O	5	4.1	Conveyed outside NZ	Keep
W	80	0.5	Sold at wharf	Keep
U	62	0.3	Bait used on board	Keep
F	58	0.2	Section 111 Recreational Catch	Keep
X	1	0.0	QMS returned to sea, except 6A	Keep
S	2	0.0	Seized by Crown	Keep
T	240	317.6	Transferred to another vessel	Drop
Q	560	133.5	Holding receptacle on land	Drop
R	225	46.7	Retained on board	Drop
D	25	3.7	Discarded (non-ITQ)	Drop
B	70	0.7	Bait stored for later use	Drop
NULL	20	0.4	Nothing	Drop

Almost all of the valid landing data for TAR 3 were reported using state code GRE with a minority of reported landings using the state codes DRE and HGU (Table A6).

A calculated greenweight $\left(\varpi_{i,y}\right)$ was inferred from the landings dataset using the following equation:

$$\varpi_{i,y} = U_{i,y} \, W_{i,y} cf_{i,y} \qquad \text{Eq. 2}$$

where

$U_{i,y}$ is the "unit number" of containers associated with the record;

$W_{i,y}$ is the "unit weight" associated with the record;

$cf_{i,y}$ is the conversion factor associated with the record.

Table A6: Total greenweight reported and number of events by state code in the landing file used to process the TAR 3 characterisation and CPUE data, arranged in order descending landed weight (only for destination codes indicated as "Keep" in Table A5. These data summaries were derived from combining two MFish data extracts (replog 7351 and replog 7972) and include the period 1989–90 to 2009–10, but have been restricted to TAR 3.

State code	Number Events	Total reported greenweight (t)	Description
GRE	62 643	20 516.8	Green (or whole)
DRE	526	532.0	Dressed
HGU	240	54.1	Headed and gutted
MEA	70	24.5	Fish meal
GUT	212	20.3	Gutted
Other	83	5.3	Other[1]

[1] includes (in descending order): dressed-V cut (stargazer), unknown, fillets: skin-on, gilled and gutted tail-on, fillets: skin-off, fins, squid wings, headed, gutted, and tailed

Table A7: Median conversion factor for the five most important state codes reported in Table A6 (in terms of total landed greenweight) and the total reported greenweight by fishing year in the edited file used to process TAR 3 landing data. Data have been restricted to TAR 3 landings. Data origins: MFish replog 7351: 1989–90 to 2001–02; MFish replog 7972: 2002–03 to 2009–10. '–': no observations

Fishing					Landed State Code	
Year	GRE	DRE	HGU	MEA	GUT	OTH
	Median Conversion Factor					
89/90	1		1.5	–	1.1	–
90/91	1	1.6	1.5	–	1.1	–
91/92	1	1.6	1.55	–	1.05	–
92/93	1	1.6	1.55	5.6	1.05	–
93/94	1	1.6	1.55	5.6	1.05	2.4
94/95	1	1.6	1.55	–	1.05	–
95/96	1	1.6	1.55	–	1.05	2.4
96/97	1	1.6	1.55	–	1.05	2.8
97/98	1	1.6	1.55	–	1.05	2.6
98/99	1	1.6	1.55	5.6	1.05	2.8
99/00	1	1.6	1.55	5.6	1.05	2.8
00/01	1	1.6	1.55	5.6	1.05	–
01/02	1	1.6	1.55	5.6	1.05	–
02/03	1	1.6	1.55	5.6	1.05	2.4
03/04	1	1.6	1.55	5.6	1.05	2.4
04/05	1	1.6	1.55	5.6	1.05	2.4
05/06	1	1.6	1.55	5.6	1.05	2.4
06/07	1	1.6	1.55	5.6	1.05	2.8
07/08	1	1.6	1.55	5.6	1.05	2.4
08/09	1	1.6	1.55	5.6	1.05	2.6
09/10	1	1.6	1.55	5.6	1.05	–

Table A7 (cont.)

Fishing					**Landed State Code**	
Year	**GRE**	**DRE**	**HGU**	**MEA**	**GUT**	**OTH**
	Total Landings (t)					
89/90	836.4		9.9	–	0.5	–
90/91	900.3	43.4	7.4	–	0.0	–
91/92	1 045.4	30.1	7.0	–	2.6	–
92/93	744.1	4.7	2.6	22.6	2.4	–
93/94	719.3	6.3	1.9	0.0	2.6	0.2
94/95	847.7	5.1	1.4	–	0.4	–
95/96	1 028.2	21.0	5.5	–	1.3	0.1
96/97	1 013.3	48.3	0.1	–	0.6	2.4
97/98	979.3	16.9	0.7	–	0.4	0.1
98/99	1 060.7	32.3	0.8	0.0	0.3	1.5
99/00	1 215.7	38.0	1.1	0.0	0.6	0.2
00/01	1 155.5	22.3	0.1	0.0	0.6	0.2
01/02	1 110.1	85.3	0.4	0.0	1.2	0.0
02/03	1 101.6	55.6	7.6	0.1	0.5	0.0
03/04	991.9	2.3	6.5	0.5	3.0	0.1
04/05	863.5	12.4	0.1	0.1	0.0	0.0
05/06	988.7	16.4	0.4	0.1	0.7	0.0
06/07	1 045.3	38.8	0.1	0.0	0.6	0.0
07/08	810.2	37.2	0.1	0.1	0.4	0.0
08/09	1 001.0	12.3	0.0	0.0	1.1	0.4
09/10	754.1	3.4	0.9	0.8	0.4	–
Total	20 212.5	532.0	54.7	24.5	20.2	5.3

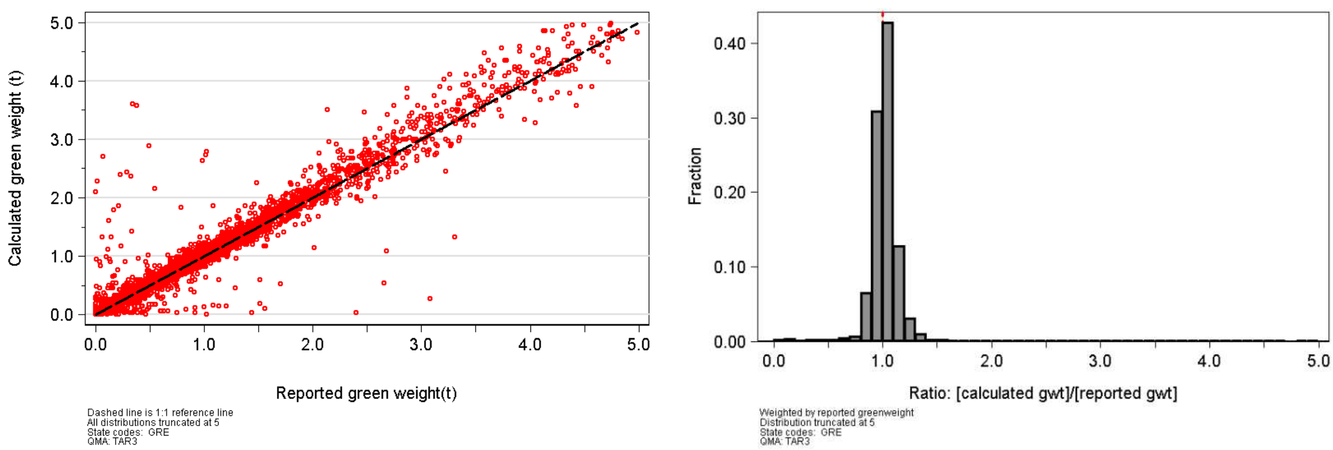

Figure A5: [left panel]: Scatter plot of the calculated greenweight (Eq. 3) compared to the reported greenweight for state code GRE; [right panel]: Distribution (weighted by the reported greenweight catch) of the ratio of calculated greenweight relative to reported greenweight for state code GRE. Only TAR 3 landings beginning in 2002–03 have been used.

A comparative scatter plot of the calculated greenweight relative to the reported greenweight for the primary state codes reported in (Table A6) (GRE) shows relatively small amounts of scatter around these two quantities, which is not surprising because the majority of the landings indicate that this species is landed green with no conversion factor required (Figure A5 [left panel]). A histogram of the ratio of the calculated greenweight relative to the reported greenweight indicates that the central tendency for this ratio for the GRE landed state code is near one (median=1.01 and mean=1.05 when the ratio is truncated at 5), but that there is a lot of variation (CV~40%). This analysis indicates that it is probably not possible to reconstruct the greenweights using the detailed data provided in the individual records. The best use of the Eq. 2 calculation would be to corroborate the reported greenweight in situations when the reported greenweight appears to be in doubt.

Table A8: Distribution of total landings (t) by tarakihi Fishstock and by fishing year for the set of trips that recorded TAR 3 landings. Landing records with improbable greenweights have been dropped. Data origins: MFish replog 7351: 1989–90 to 2001–02; MFish replog 7972: 2002–03 to 2009–10.

Fishing year	TAR1	TAR2	TAR3	TAR4	TAR5	TAR7	TAR8	Total
89/90	3	11	847	77	9	100	5	1 053
90/91	1	6	951	38	4	157	14	1 172
91/92	0	24	1 085	1	1	120	5	1 236
92/93	3	6	776	6	5	171	8	975
93/94	1	24	730	2	4	143	17	921
94/95	3	16	855	23	5	195	8	1 104
95/96	0	22	1 056	22	2	171	4	1 277
96/97	3	32	1 065	23	1	149	0	1 273
97/98	16	24	997	40	3	145	12	1 238
98/99	1	27	1 096	6	4	140	17	1 290
99/00	32	36	1 256	7	4	163	7	1 505
00/01	1	28	1 179	56	8	292	13	1 577
01/02	1	26	1 197	19	30	266	33	1 572
02/03	0	8	1 165	10	4	47	1	1 235
03/04	0	3	1 004	6	1	41	0	1 056
04/05	0	3	876	1	1	14	0	896
05/06	0	4	1 006	0	3	8	0	1 022
06/07	1	3	1 085	11	8	20	0	1 127
07/08	0	7	848	28	2	26	4	914
08/09	0	3	1 015	10	1	19	1	1 049
09/10	1	1	760	0	0	44	1	807
Total	67	315	20 849	387	101	2 432	150	24 301

In preparing the landing data for this report, large reported landing records (single events greater than 500 kg for both bottom trawl and setnet methods) were compared with the total calculated greenweight (Eq. 2) and the total estimated tarakihi catch for each trip, as well as calculating the trip CPUE for comparison with the empirical distribution of the trip CPUE (Starr 2007). On this basis, 19 trips representing 307 t of landings were dropped from the analysis over the period of data. Of these trips, 6 had landings greater than 20 t, representing 210 t and with the largest dropped trip having 63 t. No trips were dropped from the replog 7972 data extract, covering the period 2002–03 to 2009–10.

Total landings available in the data set are primarily for TAR 3, with lesser amounts reported for TAR 2, and TAR 4 to TAR 7 (Table A8). The landings for the TAR QMAs other than for TAR 3 are from trips which also reported landings to TAR 3 or from trips that fished in valid TAR 3 statistical areas. This latter criterion was used in the January 2009 extract so that effort which potentially might have caught TAR, but did not, would be present in the file for the purposes of CPUE analysis. The November 2010 extract (MFish replog 7972) was only obtained for characterisation work and therefore did not request trips which only expended effort in the TAR 3 QMA. Table A8 clearly demonstrates this difference, showing a large drop in amount of landings from TAR QMAs other than TAR 3.

Seventy-six percent of the TAR 3 landings have been reported on CELR forms (Catch Effort Landing Return) over the 21 years of record, with 22% of the remaining landings reported using CLR forms (Catch Landing Returns) and 2% on NCELR forms (Netting Catch Effort Landing Returns) (Table A9). The CLR form is used by vessels using the TCEPR forms to report their effort as well as the new TCER form developed specifically for small inshore trawl vessels. The NCELR form is used exclusively to report setnet effort and landings, and the combined use of these new forms, beginning with 2006–07, has resulted in a substantial drop in the use of the CELR form, which only accounted for 14–28 percent of the TAR 3 landings in the three complete fishing years since 2007–08 (Table A9).

Table A9: Distribution by form type for landed catch by weight for each fishing year in TAR 3. Also provided are the number of days fishing and the associated distribution of days fishing by form type for the effort data using statistical areas consistent with TAR 3. CELR: Catch, effort, landing return; CLR: catch landing return; NCELR: netting catch effort landing return; TCEPR: trawl catch effort processing return; TCER: trawl catch effort return. Forms other than CELR and NCELR report their landings on CLR forms. Data origins: MFish replog 7351: 1989–90 to 2001–02; MFish replog 7972: 2002–03 to 2009– 10.

	Landings[1]			Days Fishing (%)[2]			Days Fishing					
Year	CELR	CLR	NCELR	CELR	TCEPR	TCER	CELR	TCEPR	TCER	NCELR	Other[3]	Total
89/90	84	16	0.0	71	29	0	3 472	1 423	0	0	0	4 895
90/91	83	17	0.0	76	24	0	3 906	1 214	0	0	0	5 120
91/92	85	15	0.0	75	25	0	4 261	1 433	0	0	0	5 694
92/93	85	15	0.0	74	26	0	3 861	1 346	0	0	0	5 207
93/94	92	8	0.0	82	18	0	4 087	922	0	0	4	5 013
94/95	94	6	0.0	78	22	0	3 948	1 092	0	0	13	5 053
95/96	86	14	0.0	70	30	0	3 501	1 495	0	0	9	5 005
96/97	82	18	0.0	74	25	0	3 528	1 210	0	0	11	4 749
97/98	90	11	0.0	78	22	0	3 983	1 124	0	0	0	5 107
98/99	93	7	0.0	82	18	0	3 949	854	0	0	0	4 803
99/00	88	12	0.0	75	25	0	4 091	1 366	0	0	0	5 457
00/01	95	5	0.0	76	24	0	4 312	1 397	0	0	0	5 709
01/02	83	17	0.0	77	23	0	3 438	1 054	0	0	0	4 492
02/03	87	13	0.0	69	31	0	3 321	1 500	0	0	0	4 821
03/04	91	9	0.0	81	19	0	2 777	656	0	0	0	3 433
04/05	91	9	0.0	80	20	0	2 955	725	0	0	0	3 680
05/06	94	6	0.0	82	18	0	3 497	744	0	0	7	4 248
06/07	71	16	13.2	62	20	0	2 755	912	0	728	72	4 467
07/08	14	70	16.1	15	15	48	561	558	1 759	691	69	3 638
08/09	28	63	9.7	14	15	49	513	537	1 743	624	130	3 547
09/10	21	68	11.2	9	19	53	349	692	1 952	613	82	3 688
Total	76	22	2.0	69	23	6	67 065	22 254	5 454	2 656	397	97 826

1 Percentages of landed greenweight
2 Percentages of number of days fishing
3 includes 37 days for SJC (squid jigging), 185 days for LCER (lining), and 175 days for LTCER (lining trip)

2.3.3 Description of the TAR 3 fishery

Distributions by statistical area, major fishing method and target species in this section are provided by summarised statistical areas, methods and target species as described in (Table A10).

Table A10: Definitions of statistical area (see Appendix 2A for the locations of the indicated statistical areas), major method codes and target species codes used in the distribution tables and plots in this report. Number events=number of effort records in analysis dataset; number records=number of records in analysis dataset after rolling up to trip/statistical area/method/target species

Code used in report	Statistical area definition	Number events	Number records
018	018 & 019	38 638	31 956
020	020 & 021	29 800	11 720
022	022 & 023	54 737	18 110
024	024 & 301	20 822	13 310
026-027	026–027, 302 & 303	14 543	3 777

Table A10 (cont.)

Code used in report	Methods included	Number events	Number records
BT	Bottom trawl	119 504	46 633
SN	Setnet	32 804	29 340
DS	Danish seine	535	343
OTH	Other (methods reporting >1 t of TAR 3: bottom longline, midwater trawl, cod potting (possibly in error?), Dahn line)	5 697	2 557
Code used in report [1]	**Target species definition**	**Number events**	**Number records**
TAR	Tarakihi	8 870	4 655
RCO	Red cod	34 644	16 213
BAR	Barracouta	15 274	4 781
FLA	Flatfish (including all related species)	22 991	11 378
SQU	Squid	12 898	2 375
SPE	Sea perch	1 425	1 114
WAR	Blue warehou	1 051	565
SPD	Spiny dogfish (includes Northern spiny dogfish and "other" spiny dogfish)	942	428
HOK	Hoki	12 992	1 342
STA	Stargazer	868	550
ELE	Elephantfish	1 656	755
OTH	All other species > 10 t of total TAR 3 bottom trawl landings in ranked descending order: red gurnard, gemfish, jack mackerel, blue cod, silver warehou, and ghost shark	5 893	2 477
Code used in report [2]	**Target species definition**	**Number events**	**Number records**
TAR	Tarakihi	15 304	13 438
RCO	Red cod	5 534	5 099
BAR	Barracouta	2 810	2 670
FLA	Flatfish (including all related species)	3 213	2 870
SQU	Squid	2 211	2 021
OTH	All other species > 5 t of total TAR 3 setnet landings in ranked descending order: bluenose, blue warehou, school shark, red cod, and moki	3 732	3 242

[1] trawl methods
[2] setnet method

TAR 3 shares several statistical areas with other tarakihi Fishstocks, including Area 018 with TAR 2 and TAR 7, Area 019 with TAR 2, and Areas 026 and 027 with TAR 5 (Appendix 2A). The TAR 3 Fishstock is taken primarily by the bottom trawl and setnet methods, with virtually no landings by any other method than a developing Danish seine fishery which has appeared in the four most recent fishing years (Table 11; Figure A6). About 70 % of the total landings have been taken by the bottom trawl fishery and most of the remainder by the setnet fishery over the 21 years of available catch history (the Danish seine fishery only accounts for 2% of the landings). TAR 3 landings are approximately divided in thirds between Area 018 (Kaikoura), Area 020 (Pegasus Bay) and Area 022 (Canterbury Bight; Table 12), with Pegasus Bay having lower landings than Kaikoura and Canterbury Bight. Less than 10% of the landings of TAR 3 are taken in the lower half of the South Island (statistical areas 024, 026 and 027) in most years.

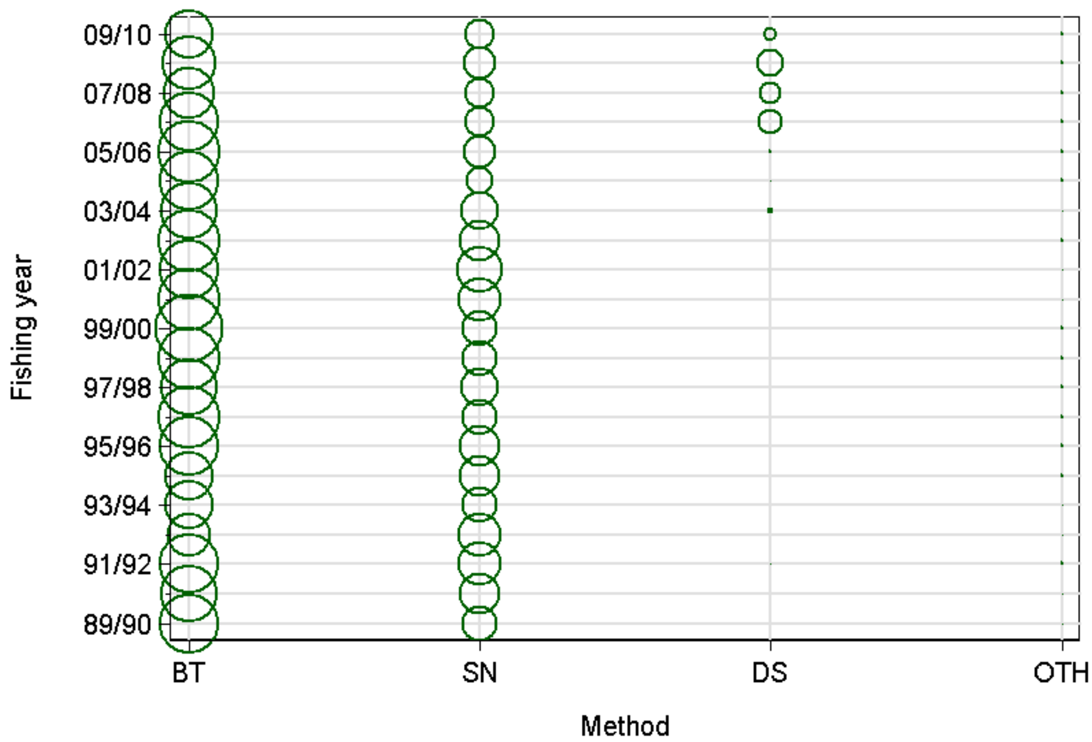

Figure A6: Distribution of catches for the major fishing methods by fishing year from trips which landed TAR 3 from 1989–90 to 2009–10. Circles are proportional to the catch totals by method and fishing year, with the largest circle representing: 990 t (99/00; BT).

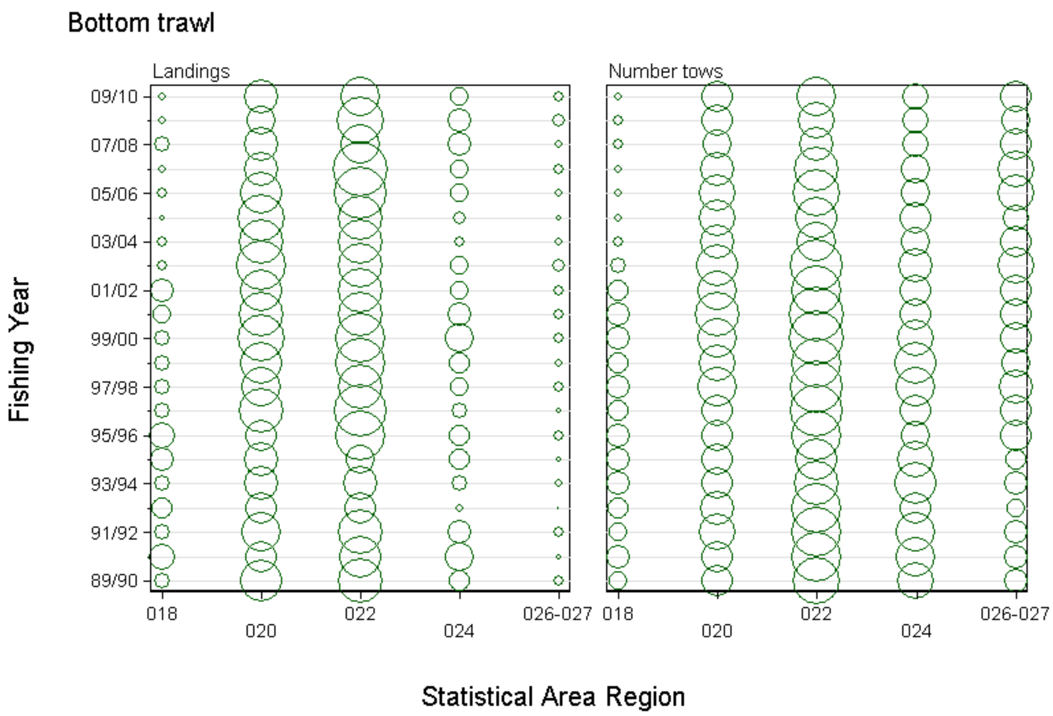

Figure A7: Distribution of landings and number tows for the bottom trawl method by statistical area and fishing year from trips which landed TAR 3. Circles are proportional within each panel: [catches] largest circle=500 t for Area 022 in 06/07; [number tows] largest circle=6 007 tows for Area 022 in 99/00.

Table A11: Total landings (t) and distribution of landings (%) of tarakihi from trips which landed TAR 3 by statistical area group and important fishing methods (Table 10), summed from 1989–90 to 2009–10. Landings (t) have been scaled to the QMR totals $\left(\mathrm{QMR}_y\right)$ using Eq. 1.

Statistical Area Region	Method of capture					Method of capture				
	BT	SN	DS	Other	Total	BT	SN	DS	Other	Total
	Total landings (t)					Distribution (%)				
018	955	6 118	2	5	7 080	4.5	28.5	0.0	0.0	33.0
020	5 366	13	118	7	5 503	25.0	0.1	0.6	0.0	25.7
022	6 821	2	299	3	7 126	31.8	0.0	1.4	0.0	33.2
024	1 384	39		5	1 429	6.5	0.2	0.0	0.0	6.7
026-027	300	0		1	301	1.4	0.0	0.0	0.0	1.4
Total	14 826	6 172	420	21	21 439	69.2	28.8	2.0	0.1	100.0

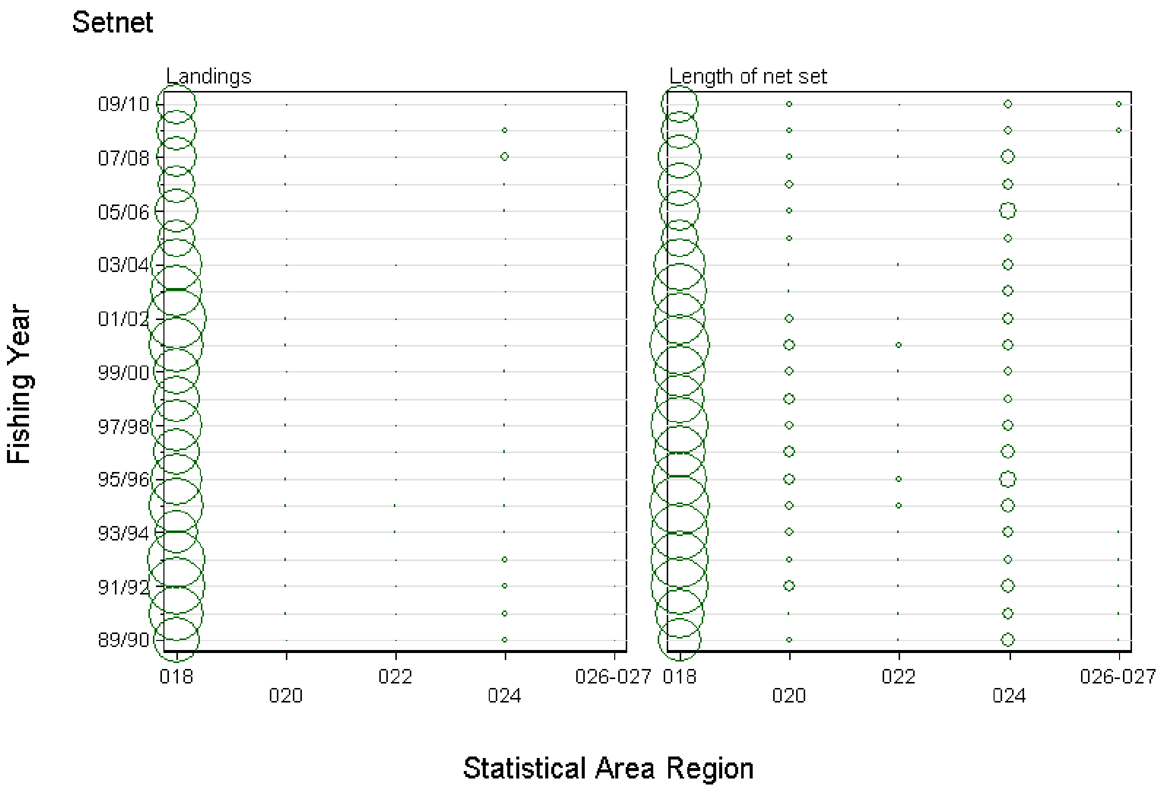

Figure A8: Distribution of landings and length of net set for the setnet method by statistical area and fishing year from trips which landed TAR 3. Circles are proportional within each panel: [catches] largest circle=463 t for Area 018 in 01/02; [length of net set] largest circle=2 583 km for Area 018 in 00/01.

The TAR 3 bottom trawl fishery takes place primarily in Pegasus Bay (Area 020) and Canterbury Bight (Area 022), with landings split approximately evenly between these two areas (Figure A7; Table A13**Error! Reference source not found.**). The entire TAR 3 setnet fishery takes place in Area 018 (Kaikoura), where it is thought to target migrating spawning tarakihi (Annala 1988) (Figure A8; Table A13). The distribution of bottom trawl effort is similar to the distribution of the catch, except that effort in Areas 024 to 027 appears to catch a disproportionately small amount of tarakihi compared to effort in the more northerly statistical areas (Figure A7). The distribution of setnet effort by year is, as for the landings, also almost entirely in Area 018 (Figure A8). Landings and effort for the Danish seine method are greatest in Area 022, with the balance occurring in Area 020 (Figure A9).

There does not appear to be any trend in the distribution of bottom trawl catch or effort by statistical area, with the Area 022 generally predominating over Area 020 in terms of both catch and effort in most years (Figure A7). Both of these statistical areas appear to have similar patterns in the year-to-year distribution of catch and effort: effort and catch increase and decrease in relative synchrony. The setnet fishery is concentrated in Area 018; however, the amount of catch and effort in this fishery appears to vary somewhat from year to year, with smaller amounts of catch and effort observed in the early 1990s and from 2004–05 to 2009–10 (Figure A8). Danish seine effort has almost the same distribution between statistical areas in all four years since 2006–07. However, there was a marked diminution of tarakihi catch in 2009–10 in Area 022 for the same amount of expended effort (Figure A9).

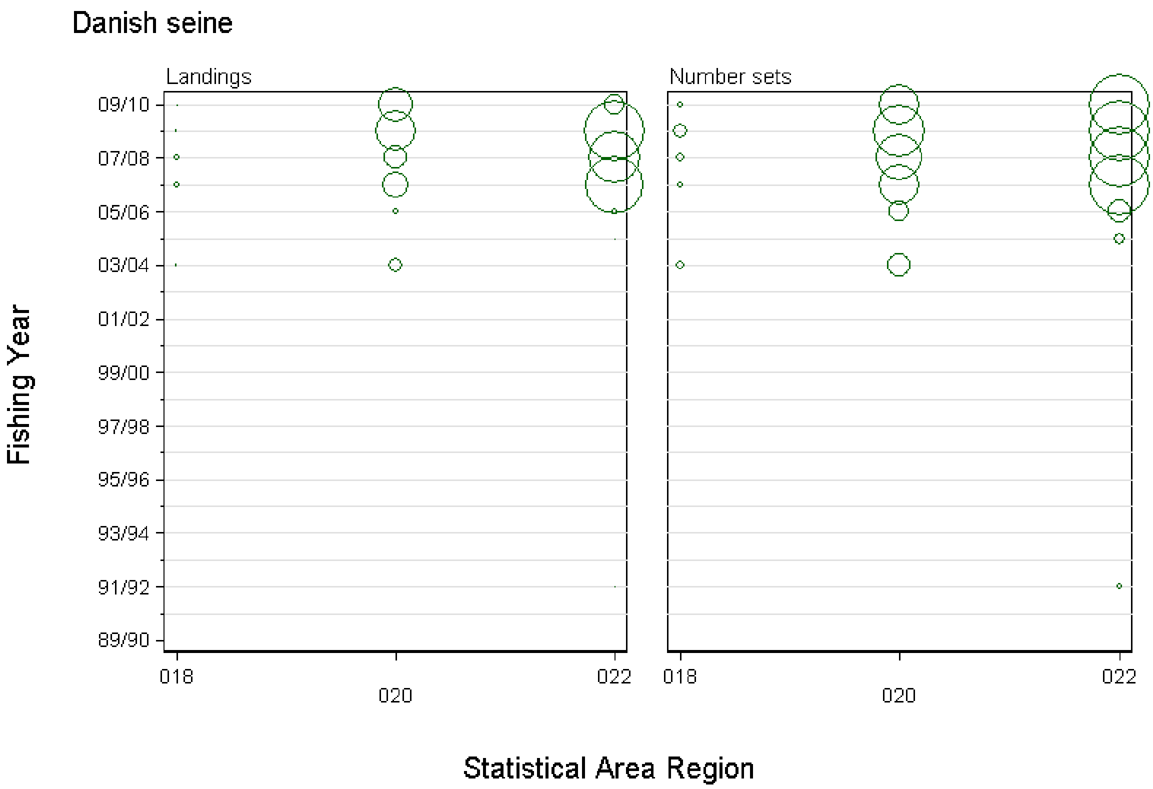

Figure A9: Distribution of landings and number of sets for the Danish seine method by statistical area and fishing year from trips which landed TAR 3. Circles are proportional within each panel: [catches] largest circle=111 t for Area 022 in 08/09; [number sets] largest circle=255 for Area 022 in 06/07 and 09/10.

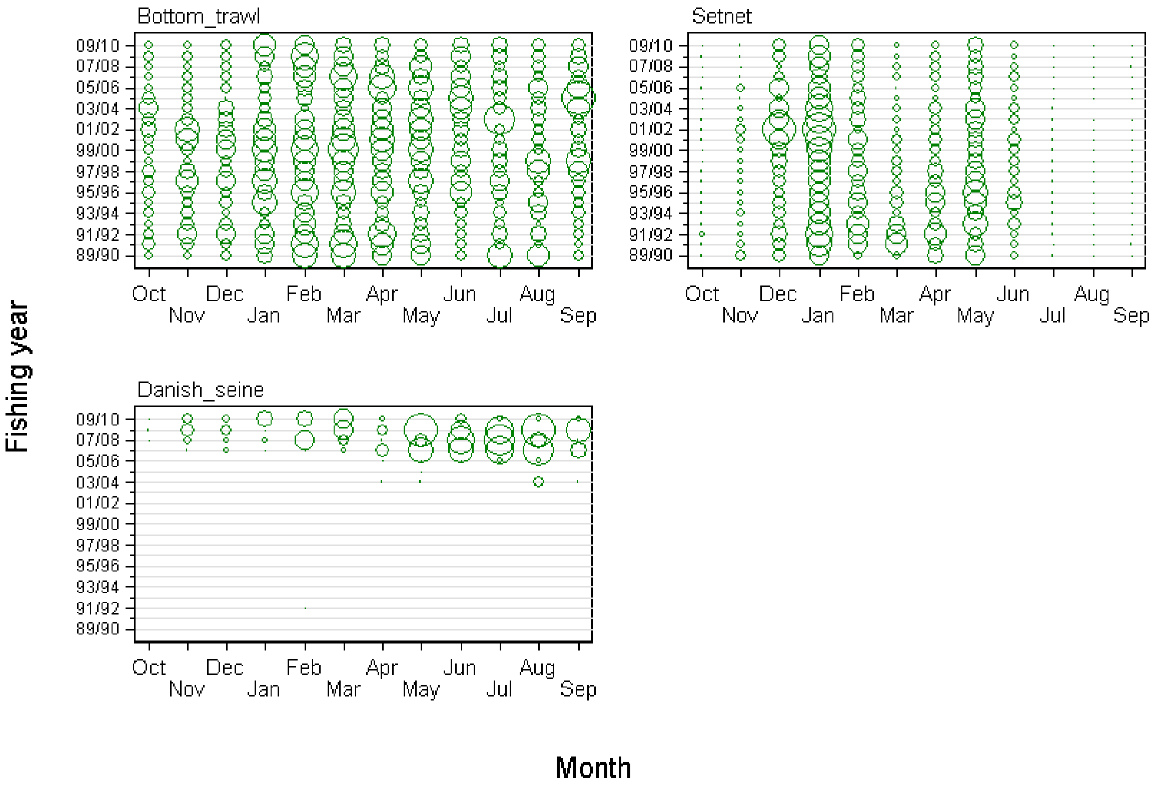

Figure A10: Total landings by month and fishing year for bottom trawl, setnet and Danish seine based on trips which landed TAR 3. Circles sizes are proportional within each panel: [BT] = 220 t in 04/05 for September; [SN]: 180 t in 01/02 for January; [DS]: 38 t in 08/09 for May.

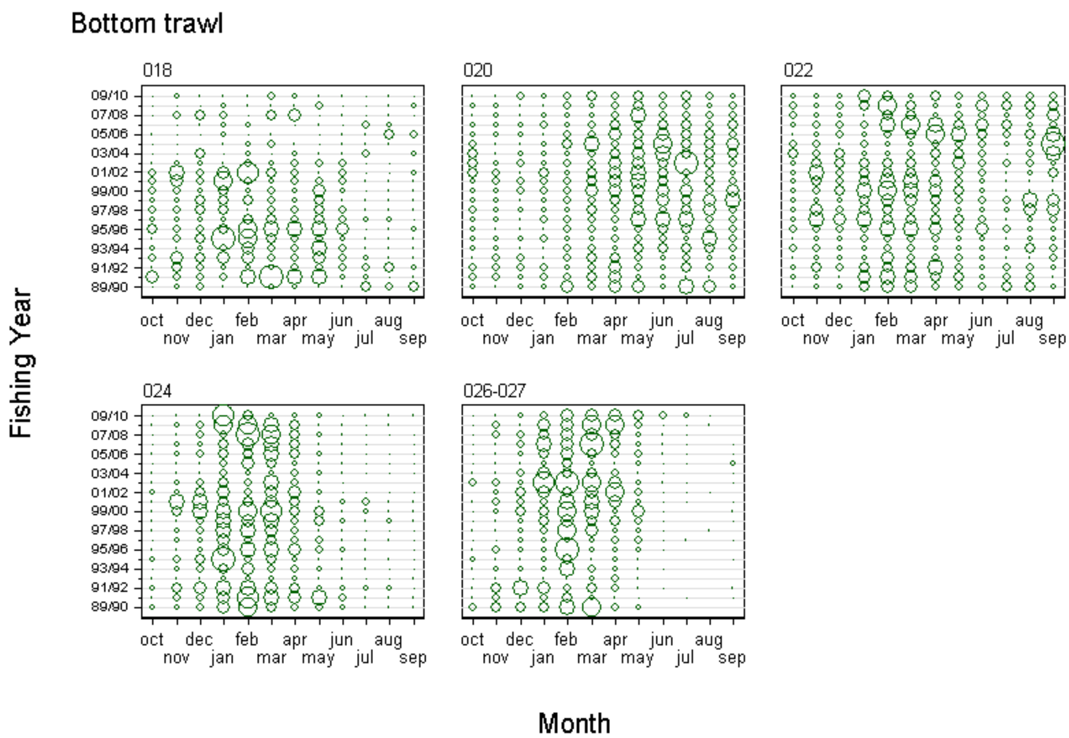

Figure A11: Distribution of landings for the bottom trawl method by grouped statistical area for month and fishing year from trips which landed TAR 3. Circles sizes are proportional within each panel: maximum values: 018 (35 t in 90/91 for Mar); 020 (148 t in 02/03 for Jul); 022 (171 t in 04/05 for Sep); 024(42 t in 07/08 for Feb), and 026–027 (11 t in 02/03 for Feb).

Table A12: Percent distribution of landings by statistical area group (Table A10) and total annual landings (t) from 1989–90 to 2009–10 for trips which landed TAR 3. Landings (t) have been scaled to the QMR totals $\left(\mathrm{QMR}_y\right)$ using Eq. 1.

Fishing	1784153			Statistical Area						Statistical Area Region	
Year	018	020	022	024	026–027	Total	018	020	022	024	026–027
	QMR/MHR landings (t)						Distribution (%)				
89/90	294	302	309	79	22	1 007	29.2	30.0	30.7	7.9	2.2
90/91	478	157	302	128	6	1 070	44.7	14.7	28.2	12.0	0.5
91/92	445	256	318	97	16	1 132	39.3	22.6	28.1	8.6	1.4
92/93	469	162	165	15	2	813	57.7	19.9	20.3	1.8	0.2
93/94	288	202	193	43	8	735	39.2	27.5	26.3	5.9	1.1
94/95	449	186	134	75	5	849	52.9	21.9	15.8	8.8	0.5
95/96	438	161	418	79	15	1 111	39.5	14.5	37.6	7.1	1.3
96/97	297	321	424	41	4	1 087	27.3	29.5	39.0	3.8	0.3
97/98	359	259	329	63	14	1 024	35.1	25.3	32.1	6.1	1.4
98/99	303	298	407	77	13	1 098	27.6	27.2	37.1	7.0	1.1
99/00	311	374	424	130	21	1 260	24.7	29.7	33.6	10.3	1.7
00/01	438	339	336	87	19	1 218	35.9	27.8	27.5	7.1	1.5
01/02	548	293	319	63	19	1 241	44.1	23.6	25.7	5.1	1.5
02/03	360	402	311	49	34	1 156	31.1	34.8	26.9	4.3	2.9
03/04	338	325	315	19	12	1 009	33.5	32.3	31.2	1.9	1.2
04/05	174	372	322	33	5	905	19.2	41.1	35.5	3.6	0.5
05/06	240	273	441	59	11	1 024	23.4	26.6	43.1	5.8	1.1
06/07	197	208	598	55	22	1 080	18.2	19.2	55.4	5.1	2.1
07/08	227	193	316	95	13	844	26.9	22.8	37.5	11.2	1.6
08/09	225	192	485	91	23	1 017	22.1	18.9	47.7	8.9	2.3
09/10	202	228	259	50	18	757	26.7	30.2	34.2	6.6	2.3
Total	7 080	5 503	7 126	1 429	301	21 439	33.0	25.7	33.2	6.7	1.4

Table A13: Percent distribution of landings by statistical area group (Table A10) from 1989–90 to 2009–10 for the bottom trawl and setnet methods for trips which landed TAR 3. Annual landings by method are available in Table 14 and the rows sum to 100%.

Fishing			Statistical Area Region						Statistical Area Region	
Year	018	020	022	024	026–027	018	020	022	024	026–027
	Bottom Trawl (%)					Setnet (%)				
89/90	4.6	40.5	41.5	10.3	3.0	99.0	0.1	0.0	0.9	0.0
90/91	16.6	22.1	42.8	17.7	0.8	98.7	0.3	0.0	0.9	0.0
91/92	5.7	35.2	44.2	12.7	2.2	98.4	0.3	0.0	1.3	0.0
92/93	18.4	38.6	39.7	2.9	0.4	98.8	0.5	0.0	0.7	0.0
93/94	9.6	41.1	39.3	8.4	1.7	98.4	0.4	0.3	0.9	0.0
94/95	18.3	37.9	27.6	15.2	0.9	99.4	0.1	0.1	0.3	0.0
95/96	14.0	20.5	53.8	9.9	1.9	99.0	0.4	0.0	0.6	0.0
96/97	5.1	38.5	51.2	4.7	0.5	98.8	0.4	0.0	0.8	0.0
97/98	5.9	36.6	46.7	8.9	2.0	99.5	0.4	0.0	0.1	0.0
98/99	5.0	35.6	48.7	9.2	1.5	99.6	0.3	0.0	0.1	0.0
99/00	4.3	37.8	42.8	13.1	2.1	99.5	0.1	0.0	0.4	0.0
00/01	7.1	40.4	40.0	10.3	2.2	99.9	0.1	0.0	0.0	0.0
01/02	11.0	37.5	41.1	8.0	2.4	99.7	0.3	0.0	0.1	0.0
02/03	2.5	49.3	38.1	6.0	4.1	100.0	0.0	0.0	0.0	0.0
03/04	2.3	47.0	46.2	2.8	1.7	99.9	0.0	0.0	0.1	0.0
04/05	0.8	50.5	43.7	4.4	0.6	99.9	0.1	0.0	0.1	0.0
05/06	2.3	34.0	55.1	7.2	1.4	99.5	0.0	0.0	0.5	0.0
06/07	1.5	24.4	64.4	6.7	2.9	99.3	0.1	0.0	0.6	0.0
07/08	6.3	32.2	43.4	15.7	2.4	96.1	0.2	0.1	3.6	0.0
08/09	1.6	22.5	58.9	13.3	3.7	97.4	0.0	0.0	2.6	0.0
09/10	2.4	37.5	47.2	9.5	3.4	99.9	0.0	0.0	0.1	0.0
Total	6.4	36.2	46.0	9.3	2.0	99.1	0.2	0.0	0.6	0.0

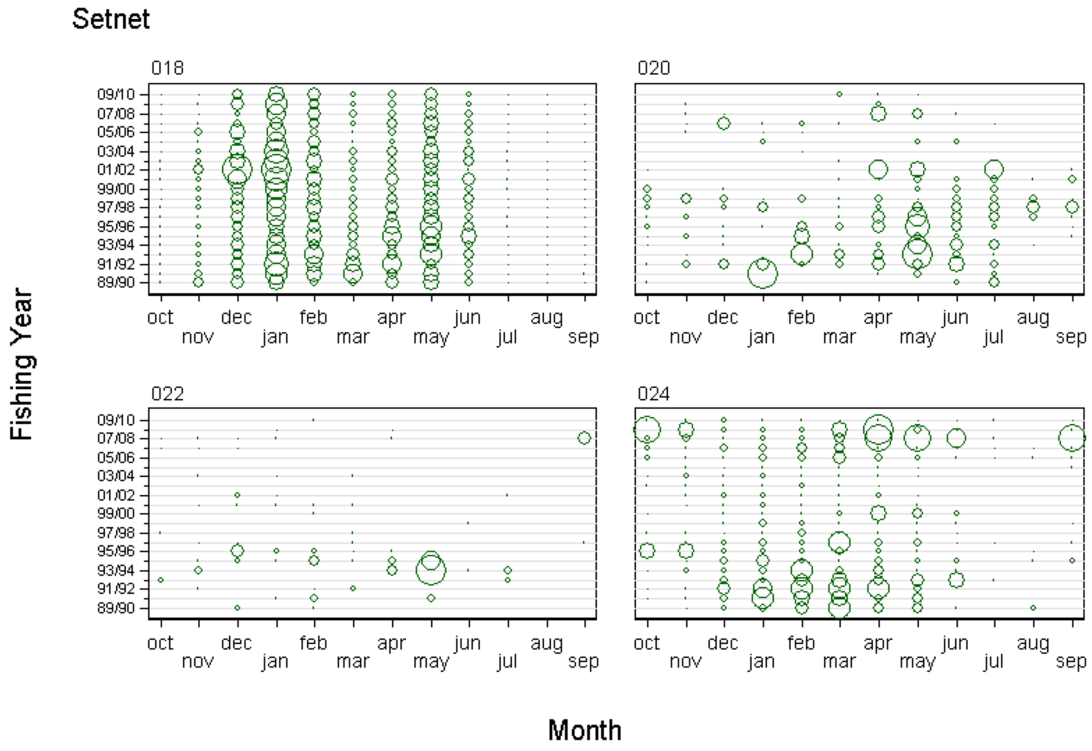

Figure A12: Distribution of landings for the setnet method by grouped statistical area (Table A10) for month and fishing year from trips which landed TAR 3. Circles sizes are proportional within each panel: maximum values: 018 (180 t in 01/02 for Jan); 020 (1.0 t in 90/91 for Jan); 022 (0.6 t in 93/94 for May); 024 (2.2 t in 08/09 for Apr).

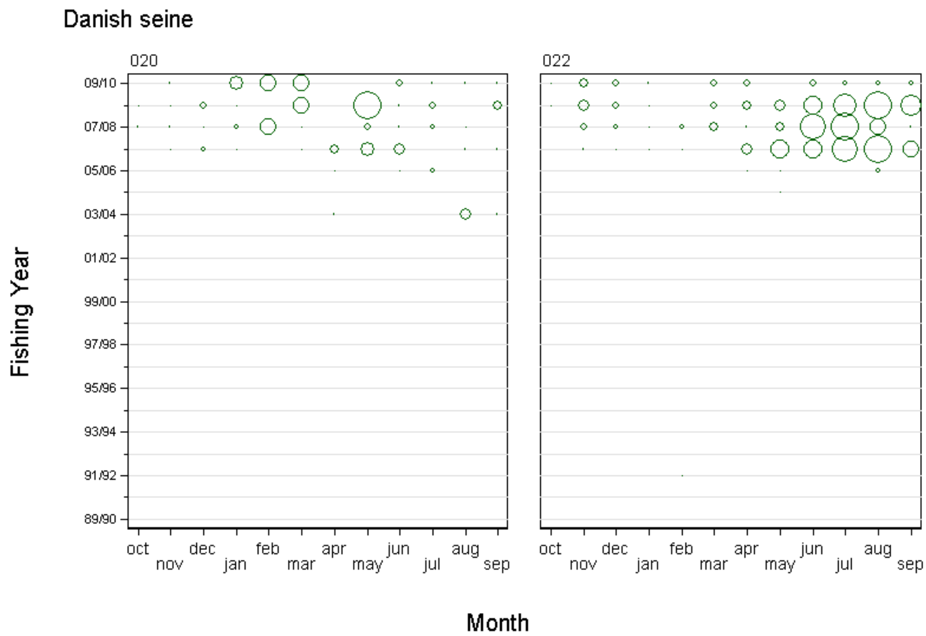

Figure A13: Distribution of landings for the Danish seine method by grouped statistical area (Table A10) for month and fishing year from trips which landed TAR 3. Circles sizes are proportional within each panel: maximum values: 020 (31 t in 08/09 for May); 022 (34 t in 08/09 for Aug).

Table A14: Percent distribution of landings by month and total annual landings (t) of TAR 3 from 1989–90 to 2009–10 for the bottom trawl and setnet methods for trips which landed TAR 3. Landings (t) have been scaled to the QMR totals $\left(\mathrm{QMR}_y\right)$ using Eq. 1.

Fishing Year												Month	
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (t)
	Bottom Trawl (%)												
89/90	1.5	2.3	3.9	6.4	17.3	14.5	8.7	9.8	3.9	15.6	12.6	3.5	745
90/91	5.1	4.6	3.2	11.5	20.5	19.3	14.7	10.3	2.8	3.4	2.5	2.1	704
91/92	4.2	9.0	10.1	10.6	9.7	9.7	18.8	7.1	2.8	7.9	6.6	3.5	720
92/93	2.5	9.7	9.7	6.2	21.6	12.4	11.9	9.8	4.5	5.0	1.6	5.2	415
93/94	4.5	6.7	3.5	5.9	13.3	9.0	6.9	12.0	9.2	9.0	11.2	8.9	489
94/95	2.4	5.7	6.8	23.2	12.6	9.3	7.4	5.7	5.3	3.1	13.6	4.8	485
95/96	4.2	4.3	3.9	6.5	18.4	15.7	12.6	6.9	13.2	6.3	3.4	4.7	777
96/97	2.5	11.0	8.0	13.1	7.9	8.3	7.8	14.7	9.8	8.4	3.6	4.9	828
97/98	4.3	8.7	5.1	10.8	10.3	10.7	7.7	7.6	5.3	5.0	14.3	10.3	705
98/99	1.5	1.5	2.7	7.9	11.7	10.9	9.5	8.4	7.7	6.8	16.0	15.5	836
99/00	2.8	4.4	8.4	11.5	15.4	17.4	10.7	10.8	5.6	5.0	2.8	5.1	990
00/01	2.6	11.3	8.5	11.3	12.5	14.7	13.8	9.4	4.9	2.8	5.3	2.8	839
01/02	5.9	14.0	5.9	11.0	9.1	11.6	12.0	10.8	7.5	2.6	3.4	6.1	777
02/03	5.0	5.4	6.7	7.2	7.8	8.8	10.1	13.5	6.0	20.6	5.5	3.4	815
03/04	10.5	4.2	7.1	4.0	2.5	6.9	11.6	11.2	13.5	5.6	7.2	15.7	681
04/05	4.6	3.7	0.4	4.2	6.4	11.2	5.7	8.2	15.5	4.9	5.4	29.8	736
05/06	1.7	2.5	3.4	3.6	6.2	9.9	18.2	15.2	10.3	6.7	9.1	13.2	799
06/07	1.9	3.4	3.9	7.6	13.2	20.1	16.4	7.3	9.9	7.8	3.0	5.5	777
07/08	3.2	3.2	4.4	3.5	16.7	12.7	9.8	16.6	5.8	4.5	5.7	14.0	551
08/09	3.9	2.9	3.3	11.1	22.0	10.0	6.4	6.8	11.1	8.8	5.8	7.8	636
09/10	2.2	2.7	5.0	17.3	12.6	9.1	9.9	8.5	8.9	10.1	6.8	6.9	520
Mean	3.7	5.8	5.4	9.1	12.4	12.2	11.2	10.1	7.8	7.2	6.8	8.2	14 826
	Setnet (%)												
89/90	0.5	8.3	12.3	24.1	5.0	5.4	15.6	23.0	5.7	0.1	0.0	0.0	262
90/91	0.3	3.0	8.1	28.2	14.6	21.5	7.6	13.7	2.8	0.0	0.0	0.2	366
91/92	0.8	1.3	9.4	27.8	14.7	15.4	20.0	6.9	3.6	0.1	0.1	0.0	410
92/93	0.4	0.9	5.1	20.2	19.8	11.1	7.9	27.4	6.9	0.1	0.0	0.0	398
93/94	0.2	3.7	15.0	29.7	12.1	5.6	8.7	20.4	4.6	0.1	0.1	0.0	245
94/95	0.1	0.8	7.2	16.7	14.9	7.0	18.5	20.5	14.1	0.1	0.0	0.0	362
95/96	0.4	1.3	6.0	17.8	12.5	8.5	16.5	28.9	7.6	0.4	0.0	0.0	332
96/97	0.5	1.3	13.8	28.0	11.1	4.2	11.6	24.2	4.9	0.3	0.0	0.0	258
97/98	0.3	1.3	10.5	24.8	18.8	5.6	14.4	18.5	5.5	0.2	0.1	0.1	318
98/99	0.1	1.4	16.6	31.0	13.2	5.8	7.9	15.6	8.3	0.2	0.0	0.0	261
99/00	0.1	1.4	15.4	36.6	12.2	3.2	6.7	18.3	5.8	0.3	0.0	0.0	269
00/01	0.2	2.0	17.2	29.6	15.0	4.0	9.2	13.0	9.6	0.1	0.0	0.0	378
01/02	0.1	5.2	38.3	38.8	3.2	0.8	3.6	9.0	0.7	0.1	0.0	0.0	464
02/03	0.2	1.5	16.3	33.3	15.0	3.6	4.9	18.2	6.8	0.1	0.0	0.0	340
03/04	0.0	1.3	16.4	37.3	8.7	4.6	7.9	16.7	6.8	0.3	0.0	0.0	322
04/05	0.0	0.5	6.9	45.3	25.9	2.0	2.3	12.8	4.2	0.0	0.0	0.0	169
05/06	0.2	4.8	24.2	34.3	8.1	0.8	5.9	16.1	5.4	0.0	0.0	0.0	223
06/07	0.0	1.1	8.3	24.1	15.5	4.7	11.9	26.0	8.5	0.0	0.0	0.0	184
07/08	0.1	0.1	3.5	34.1	17.0	6.5	8.1	22.1	7.3	0.0	0.0	1.1	199
08/09	0.8	0.8	15.8	39.8	14.1	3.2	7.0	16.2	2.3	0.0	0.0	0.0	220
09/10	0.1	0.2	16.1	31.2	16.5	3.9	5.7	22.2	4.1	0.0	0.0	0.0	190
Mean	0.3	2.1	14.0	29.5	13.3	6.6	10.0	18.0	6.0	0.1	0.0	0.1	6 172

Bottom trawl catches from TAR 3 appear to be distributed relatively evenly across the entire year, with 6 to 10% of the annual landings taken in most months (Figure A10; (Table A14). The setnet fishery is clearly highly seasonal, being timed to the spawning migration of this species (Annala 1988). It begins in December or January, wanes in the months of March and April and then picks up again in May, apparently timed with the return of the spawning population (Figure A10; Table A14). The timing of the Danish seine fishery has been mainly in the winter months of May to September, with the exception of 2009–10 when the winter fishery disappeared (Figure A10).

Seasonal patterns of the bottom trawl fishery by statistical area seem to differ somewhat between Areas 020 and 022, with the Area 020 fishery more prevalent in the late autumn and winter months while the Area 022 fishery seems to be more active in the summer and autumn months (Figure A11). The seasonal pattern of landings of tarakihi in the Area 018 setnet fishery is the same as that described above, although April and May landings were stronger in the early 1990s than in recent fishing years (Figure A12). The Danish seine fishery in Area 020 is more sporadic than the fishery in Area 022, and the disappearance of the winter landings in 2009–10 entirely occurred in Area 022 (Figure A13). The high winter catches of tarakihi in Area 022 using the Danish seine method contrast with the primarily late summer-autumn catches in the same statistical area, indicating that tarakihi are available year-round in the Canterbury Bight, even though they are not fished as heavily in the winter.

More that one-half (53%) of the TAR 3 landings are taken by fisheries which target tarakihi, with nearly 100% of the Danish seine landings, over 90% of the setnet landings and about 30% of the bottom trawl landings targeted at tarakihi (Table A15). Ninety percent of the bottom trawl landings of the TAR 3 are made up by fisheries targeting tarakihi, red cod, barracouta and flatfish (Figure A14; (Table A15). The remaining 10% of the bottom trawl landings are made up of a wide range of fisheries operating on the east coast of the South Island. The only other setnet target fisheries of note that take tarakihi are ling and spiny dogfish (Figure A14). The recently developed Danish seine fishery is nearly exclusively targeted at tarakihi, with minor amounts of targeting at red cod (Figure A14).

Table A15: Landings (t) and distribution of landings (%) of tarakihi from trips which landed TAR 3 by target species and important fishing methods (Table A10), summed from 1989–90 to 2009–10. Landings (t) have been scaled to the QMR totals $\left(\mathrm{QMR}_y\right)$ using Eq. 1.

Statistical	Method of capture					Method of capture				
Area	BT	SN	DS	Other	Total	BT	SN	DS	Other	Total
Region	Total landings (t)					Distribution (%)				
TAR	5 286	5 734	388	1	11 408	24.7	26.7	1.8	0.0	53.2
RCO	5 113	9	28	1	5 150	23.8	0.0	0.1	0.0	24.0
BAR	1 758	0		2	1 760	8.2	0.0	0.0	0.0	8.2
FLA	1 351		1	0	1 352	6.3	0.0	0.0	0.0	6.3
SQU	392			1	394	1.8	0.0	0.0	0.0	1.8
SPD	109	134	1		244	0.5	0.6	0.0	0.0	1.1
LIN	9	152		4	166	0.0	0.7	0.0	0.0	0.8
SPE	162	0	0	0	162	0.8	0.0	0.0	0.0	0.8
WAR	113	22		0	135	0.5	0.1	0.0	0.0	0.6
HOK	101	0		2	103	0.5	0.0	0.0	0.0	0.5
STA	92	0			92	0.4	0.0	0.0	0.0	0.4
OTH	340	121	2	9	472	1.6	0.6	0.0	0.0	2.2
Total	14 826	6 172	420	21	21 439	69.2	28.8	2.0	0.1	100.0

The relative importance of the various bottom trawl target fisheries varies over the 21 years of data, most likely related to the relative abundance of the primary target fisheries, particularly red cod and tarakihi. For instance, the target tarakihi bottom trawl fishery has taken 50 to 80% of the landings between 2003–04 to 2008–09 after dropping to less than 10% in 1997–98 (Table A16). The mean percentage of target tarakihi taken by bottom trawl dropped to less than 40% with the inclusion of 2009–10 data, with tarakihi bycatch in the red cod, barracouta and flatfish fisheries rising in relative importance along with a sharp drop in overall tarakihi catch in this fishing year.

The Area 020 bottom trawl fisheries which take tarakihi are the tarakihi and red cod fisheries (Figure A15). The same two target fisheries are also important in Area 022, but the barracouta target fishery, which is relatively minor in Area 020, is important in Area 022. Bottom trawl target fishing for flatfish takes small amounts of tarakihi south of the Waitaki River in Areas 024 and 026 (Figure A15)). Landing information indicates that most setnet landings are taken in Area 018 while targeting tarakihi (Figure A16). The Danish seine fishery in both Area 020 and Area 022 primarily target tarakihi (Figure A17).

Table A16: Percent distribution of landings by target species (Table 10) from 1989–90 to 2009–10 for the two primary methods which landed TAR 3. Annual landings by method are available in Table 14.

Fishing												Declared Target Species
Year	TAR	RCO	BAR	FLA	SQU	SPD	LIN	SPE	WAR	HOK	STA	OTH
	Bottom Trawl (%)											
89/90	51.1	22.6	11.3	6.0	0.3	0.3	0.3	1.3	0.7	0.2	1.3	4.6
90/91	26.1	33.2	21.9	8.3	3.1	0.1	0.2	0.1	2.4	0.8	0.4	3.4
91/92	21.3	49.5	12.0	6.0	3.2	0.8	0.2	1.1	0.7	0.2	2.9	2.1
92/93	15.8	52.7	6.9	5.1	0.2	2.1	0.2	2.0	0.0	6.1	0.1	8.7
93/94	32.6	47.4	3.8	10.0	1.6	0.0	0.1	2.0	0.5	0.2	1.1	0.7
94/95	25.9	50.8	8.3	9.7	0.2	0.2	0.0	1.1	0.5	0.9	0.1	2.1
95/96	22.1	47.1	10.1	9.8	3.5	0.4	0.0	2.6	0.5	2.9	0.5	0.5
96/97	27.4	45.9	12.6	4.8	5.0	0.1	0.0	1.1	0.7	0.8	1.0	0.6
97/98	9.1	63.5	10.6	11.9	1.0	0.0	0.0	2.1	0.1	0.7	0.4	0.7
98/99	26.2	27.9	17.9	21.4	2.9	0.0	0.0	1.6	0.3	0.2	0.0	1.6
99/00	15.5	44.1	9.6	18.5	6.1	1.5	0.0	1.4	0.4	1.3	0.7	0.9
00/01	8.7	52.2	14.0	14.7	3.7	0.0	0.0	2.2	1.2	0.5	1.0	1.8
01/02	14.8	43.7	20.2	9.0	4.5	0.5	0.0	1.6	0.6	0.0	1.4	3.8
02/03	26.2	35.0	20.4	7.2	5.6	0.1	0.0	0.4	1.6	0.5	0.2	2.9
03/04	47.8	27.2	17.9	2.5	0.2	0.0	0.0	0.6	1.3	0.1	0.0	2.4
04/05	59.7	26.4	5.3	3.5	1.3	0.3	0.0	0.5	1.6	0.1	0.1	1.1
05/06	58.1	20.2	5.2	5.3	3.0	5.3	0.1	0.1	0.3	0.1	0.1	2.2
06/07	61.1	15.2	9.0	7.4	2.0	0.8	0.0	0.2	0.3	0.1	0.1	3.6
07/08	69.5	7.6	7.8	7.4	2.0	0.9	0.1	0.2	1.1	0.1	0.1	3.2
08/09	77.1	2.5	8.6	7.6	0.6	0.8	0.1	0.1	0.5	0.1	0.2	1.8
09/10	77.6	2.8	6.1	7.8	0.0	1.2	0.1	0.4	0.2	0.1	0.9	2.7
Mean	35.7	34.5	11.9	9.1	2.6	0.7	0.1	1.1	0.8	0.7	0.6	2.3
	Setnet (%)											
89/90	96.3	0.0	0.0	0.0	0.0	0.6	2.5	0.0	0.1	0.0	0.0	0.5
90/91	96.5	1.2	0.0	0.0	0.0	0.5	1.1	0.0	0.3	0.0	0.0	0.4
91/92	94.0	1.0	0.0	0.0	0.0	1.3	3.0	0.0	0.1	0.0	0.0	0.5
92/93	94.7	0.0	0.0	0.0	0.0	2.1	2.1	0.0	0.0	0.0	0.0	1.1
93/94	89.2	0.0	0.0	0.0	0.0	7.2	0.6	0.0	1.0	0.0	0.0	1.9
94/95	87.7	0.0	0.0	0.0	0.0	10.5	0.1	0.0	0.4	0.0	0.0	1.3
95/96	79.8	0.0	0.0	0.0	0.0	3.5	15.1	0.0	1.0	0.0	0.0	0.6
96/97	84.3	0.0	0.0	0.0	0.0	11.7	0.9	0.0	1.6	0.0	0.0	1.5
97/98	90.0	0.0	0.0	0.0	0.0	4.9	2.8	0.0	0.0	0.0	0.0	2.3
98/99	97.6	0.0	0.0	0.0	0.0	0.1	1.6	0.0	0.0	0.0	0.0	0.7
99/00	97.5	0.0	0.0	0.0	0.0	0.1	1.3	0.0	0.1	0.0	0.0	0.9
00/01	81.4	0.0	0.0	0.0	0.0	0.0	6.2	0.0	0.1	0.0	0.0	12.3
01/02	93.6	0.0	0.0	0.0	0.0	0.3	2.0	0.0	1.7	0.0	0.0	2.5
02/03	93.7	0.0	0.0	0.0	0.0	0.2	2.7	0.0	0.0	0.0	0.0	3.4
03/04	96.3	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	2.2
04/05	97.5	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.4
05/06	99.4	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.4
06/07	99.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
07/08	99.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.9
08/09	99.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
09/10	98.9	0.0	0.0	0.0	0.0	0.6	0.1	0.0	0.0	0.0	0.0	0.5
Mean	92.9	0.1	0.0	0.0	0.0	2.2	2.5	0.0	0.4	0.0	0.0	2.0

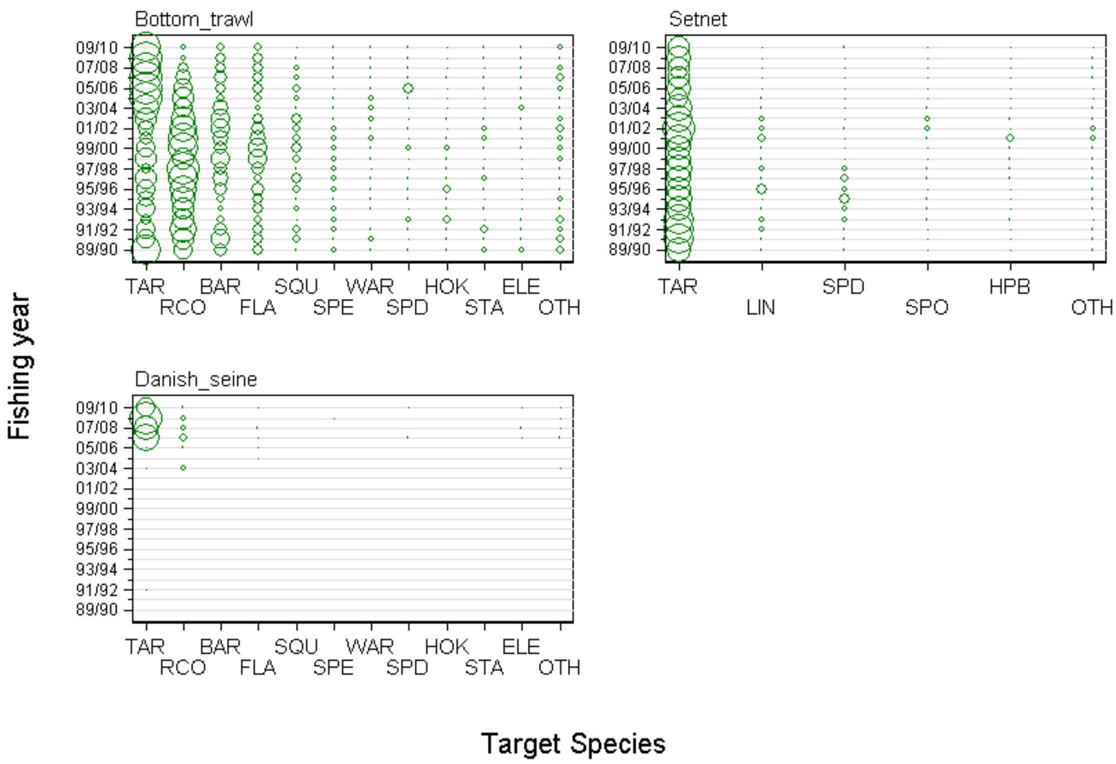

Figure A14: Total landings by target species and fishing year for bottom trawl, setnet and Danish seine based on trips which landed TAR 3. Circle sizes are proportional within each panel: [BT] = 491 t in 08/09 for TAR; [SN]: 434 t in 01/02 for TAR; [DS]: 153 t in 08/09 for TAR.

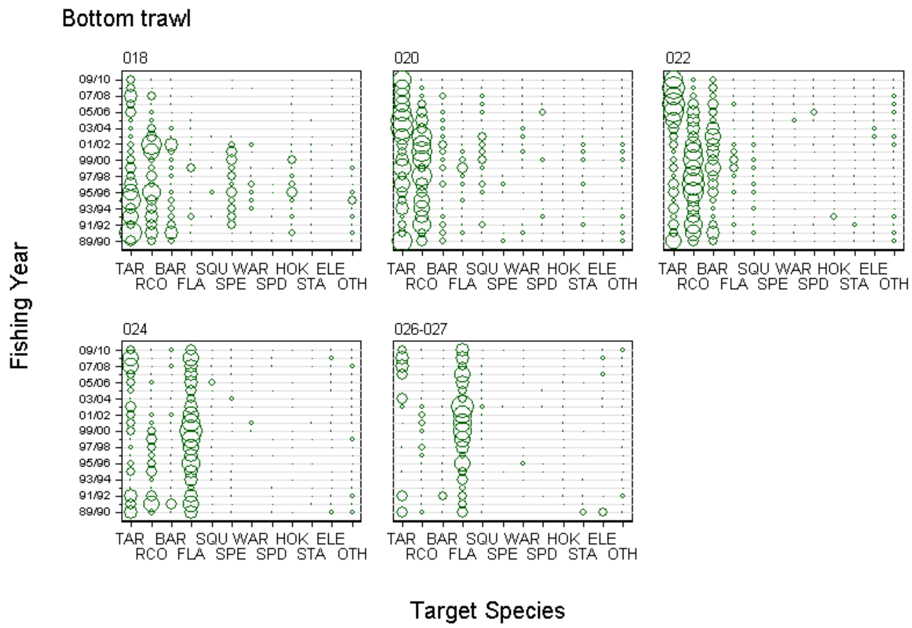

Figure A15: Distribution of landings for the bottom trawl method by grouped statistical area (Table A10) for target species and fishing year from trips which landed TAR 3. Circles sizes are proportional within each panel: maximum values: 018 (64 t in 90/91 for TAR); 020 (272 t in 04/05 for TAR); 022 (308 t in 06/07 for TAR); 024 (93 t t in 99/00 for FLA), and 026–027 (29 t in 02/03 for FLA).

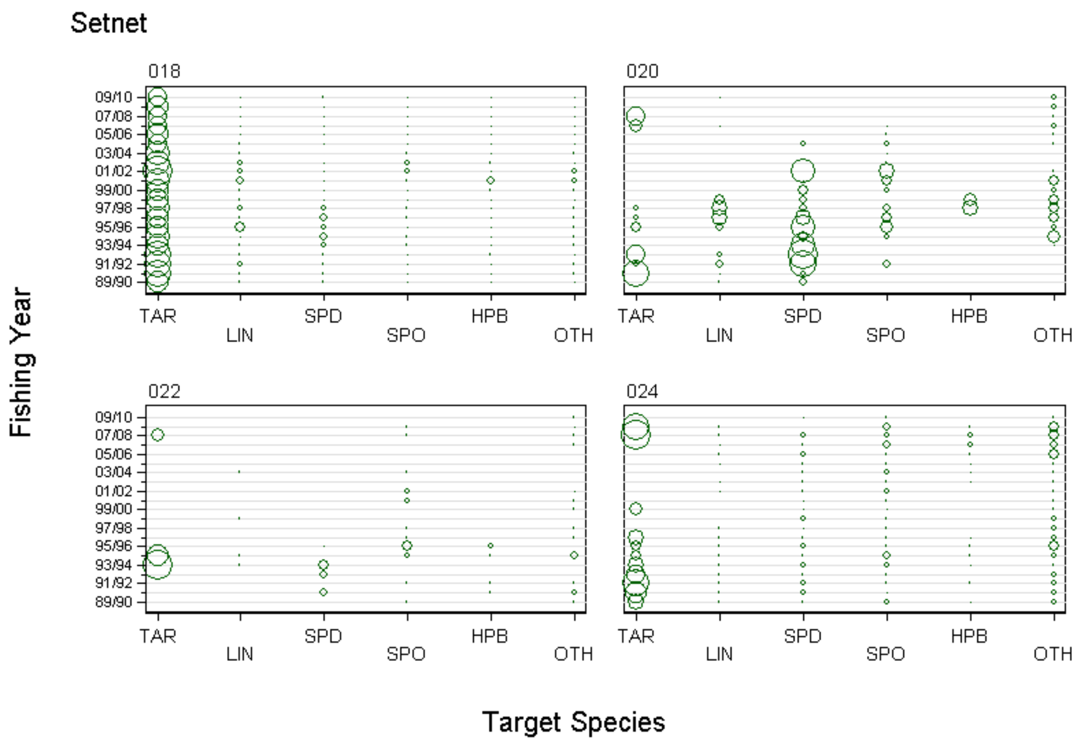

Figure A16: Distribution of landings for the setnet method by grouped statistical area (Table A10) for target species (Table A10) and fishing year from trips which landed TAR 3. Circle sizes are proportional within each panel: maximum values: 018 (434 t in 01/02 for TAR); 020 (1.3 t in 92/93 for SPD); 022 (0.7 t in 93/94 for TAR); 024(5.7 t in 07/08 for TAR).

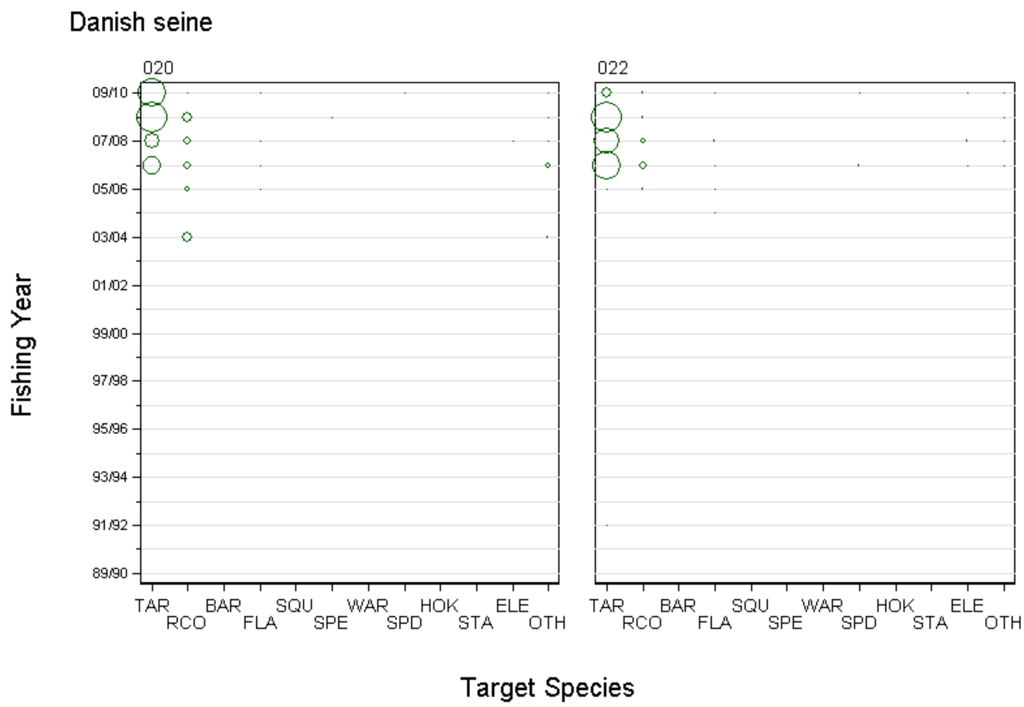

Figure A17: Distribution of landings for the Danish seine method by grouped statistical area (Table A10) for target species and fishing year from trips which landed TAR 3. Circles sizes are proportional within each panel: maximum values: 020 (43 t in 08/09 for TAR); 022 (110 t in 08/09 for TAR).

Table A17: Summary statistics from distributions from all records (combined TCER and TCEPR formtypes) using the bottom trawl method for effort that targeted or caught tarakihi by target species category in the TAR 3 dataset for the period 1989–90 to 2009–10.

		Depth (m)			
Target species category	**Number observations**	**Lower 5% of distribution**	**Mean of distribution**	**Median (50%) of distribution**	**Upper 95% of distribution**
Bottom trawl					
TAR	4 042	47	83	84	124
FLA	1 603	20	43	45	60
BAR	1 059	43	69	61	120
RCO	616	40	66	58	120
SQU	147	92	178	181	290
ELE	137	22	47	46	79
GUR	116	34	48	47	62
WAR	93	48	67	58	103
STA	90	55	98	100	145
SPD	73	55	93	89	131
SPE	62	63	93	90	130
Other	161	42	140	117	425
Total	8 199	32	74	68	125

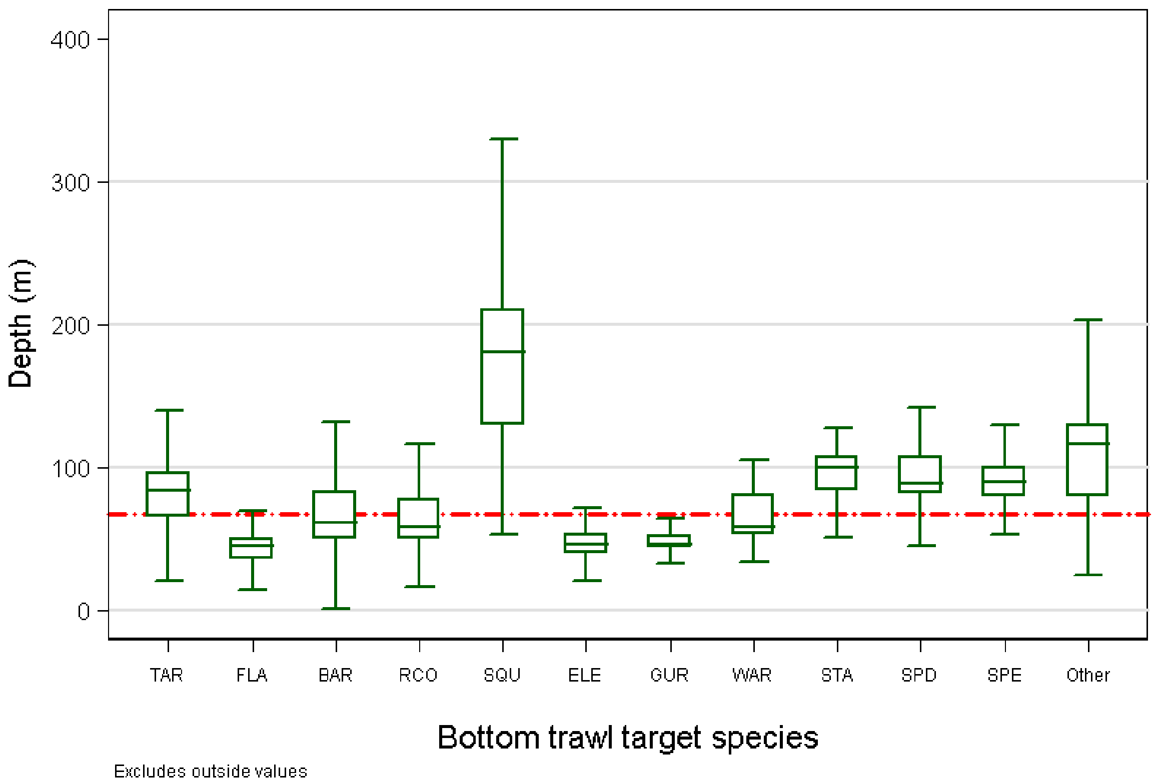

Figure A18: Box plot distributions of bottom depth from all records (combined TCER and TCEPR formtypes) using the bottom trawl method for effort that targeted or caught tarakihi by target species category in the TAR 3 dataset for the period 1989–90 to 2009–10. Horizontal line indicates the median depth from all tows which caught or targeted tarakihi.

Depth information is available from TCEPR and TCER forms which report bottom trawl catches pertaining to tarakihi (either recording an estimated catch of tarakihi or declaring tarakihi as the target species). These data come primarily from the recently introduced (1 October 2007) TECR forms, with 7150 of the 8200 depth observations reported in Table A17 coming from the TCER forms. This predominance of TCER reports reflects the inshore nature of the TAR 3 fishery, with the TCEPR form used primarily by the larger offshore vessels.

These reported depth observations show that the 5 and 95% quantiles for confirmed tarakihi trawl fishing ranges from 32 and 125 m, with the median value at 74 m (mean=68 m; Table A17). The distribution of tows which caught or targeted tarakihi varies according to the target fishery, with deep fisheries such as squid taking tarakihi at depths up to 300 m compared to the shallower depths for successful tarakihi catches for fisheries like red cod and flatfish (Figure A18). Tows which targeted and caught tarakihi had 5 and 95% quantiles of 50 m to 124 m, with mean and median depths of just over 80 m (Table A17).

The setnet forms (NCELR) introduced in 2006–07 do not request depth information from fishermen (MFish 2010).

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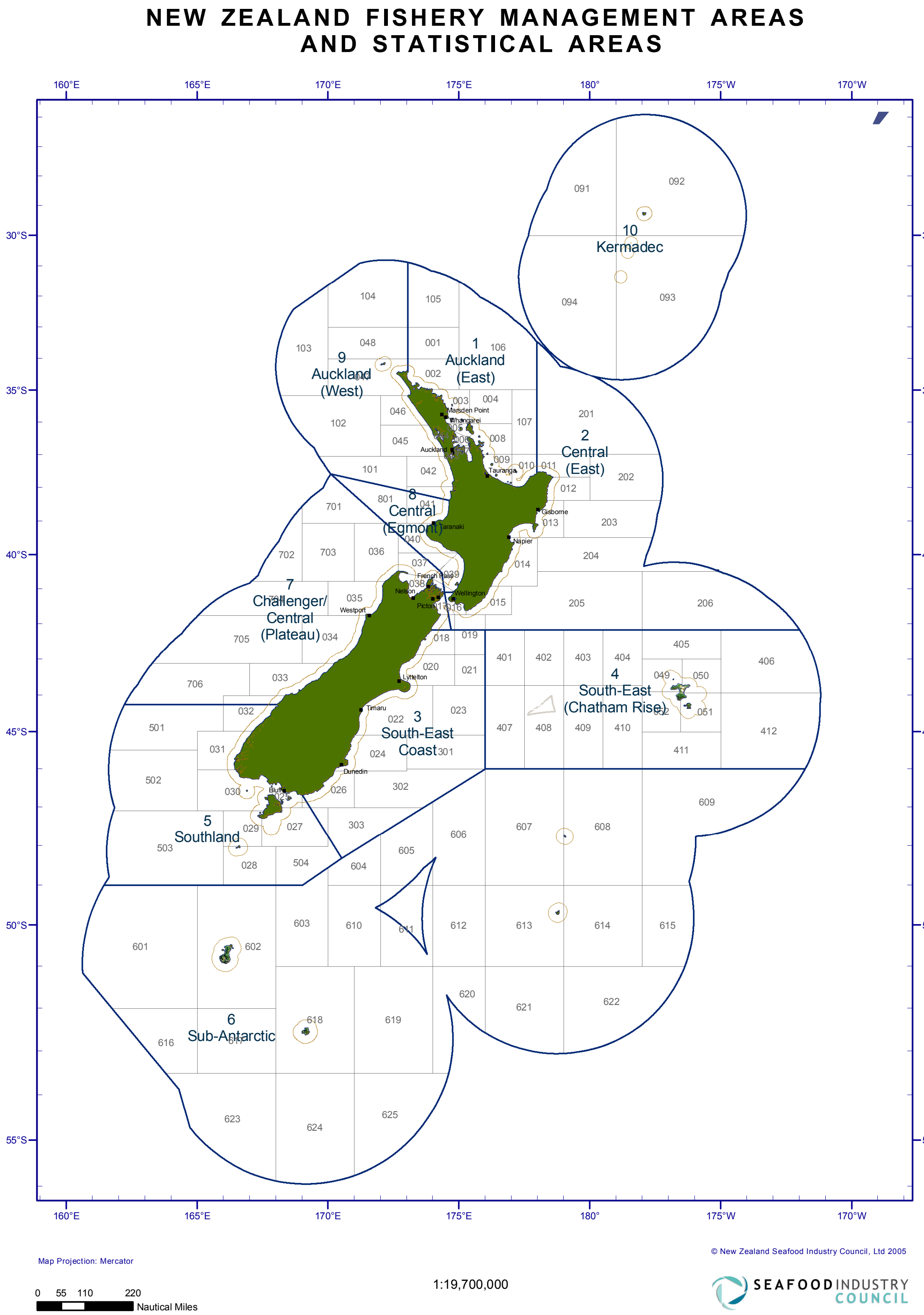

Appendix 2A: Map of MFish statistical areas and Quota Management Area (QMA) boundaries, showing locations where QMA boundaries are not contiguous with the statistical area boundaries