Monitoring the length structure of New Zealand commercial landings of albacore during the 2003/04 fishing year

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Monitoring the length structure of New Zealand commercial landings of albacore tuna during the 2003–2004 fishing year.

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Abstract

Albacore tuna caught by trolling in New Zealand waters during the 2003–04 fishing season were sampled in fish sheds to determine the length frequency composition and length-weight relationship. This season albacore were sampled from three ports, Auckland, New Plymouth and Greymouth.

Albacore sampled in the 2003–04 fishing year had a mean fork length of 64.3 cm, and ranged in size from 40–94 cm, with nearly all fish (99%) in the 52–76 cm range. Length:weight relationships were determined. Log of fork length plotted against log of green weight produced a significant linear relationship (R²=0.92).

Nearly all of the albacore sampled in the troll fishery over an eight year period from 1996–97 to 2003–04 were in the 47–81 cm size range (99%), with a mean fork length of 63.3 cm. There is considerable variability in the size composition from year to year.

Size frequency of the troll catch is compared with the New Zealand observed longline catch of albacore. Longline caught albacore are larger, with an average fork length of 80.0 cm, and most fish (99%) in the 56–104 cm size range.

Albacore caught by trolling around the New Zealand coast tend to be smaller than those caught by troll vessels from the U.S.A. fishing in the sub-tropical convergence zone, the only other surface fishery for the South Pacific albacore stock. Fish caught by longline throughout the South Pacific are all larger sub-adult and adult fish. Continued monitoring of the catch composition of juvenile albacore in the New Zealand troll fishery is a critical input to the length-based regional stock assessment of the South Pacific albacore stock. The New Zealand fishery catches up to half of the total removals of juveniles from this stock and is one of only a few target fisheries for this stock. Failure to monitor size composition in this stock would appreciably increase uncertainty of stock assessments.
Introduction

Albacore tuna (*Thunnus alalunga*) caught in the New Zealand EEZ are part of a single South Pacific Ocean stock that ranges from the equator to about 45° S. Female albacore mature at about 85 cm fork length and spawn in the austral summer from November to February in tropical and subtropical waters, between about 10° S and 20° S, west of 140° W (Ramon and Bailey 1996, Murray 1994, Murray *et al.* 1999).

Juveniles recruit to surface fisheries in New Zealand coastal waters and in the vicinity of the sub-tropical convergence zone (STCZ), at about 2 years of age, at 45–50 cm fork length. Albacore then appear to gradually disperse north (Hampton and Fournier 2000) where they are caught by longline fleets.

Longline fleets from Japan, Korea and Taiwan, and domestic fleets of several Pacific Island countries catch adult albacore throughout their range. Fish caught by longline in the southern part of the region are smaller than those caught further north (Hampton and Fournier 2000). The New Zealand longline fishery catches adult and sub-adult albacore (Murray *et al.* 1999).

A troll fishery for juvenile albacore has occurred in New Zealand coastal waters since the 1960s, and in the central region of the STCZ since the mid-1980s (Murray 1994, Hampton and Fournier 2000). The New Zealand troll fishery operated by domestic vessels mostly in New Zealand coastal waters, catches up to 6000 t of albacore annually, over half of the total South Pacific surface fishery catch (Murray *et al.* 2000). Trolling for albacore occurs primarily off the west coasts of the North Island and South Island with Onehunga (Auckland), New Plymouth, Westport and Greymouth being major landing ports.

Troll vessels from the United States of America have fished for albacore in the South Pacific since 1986, in the STCZ, approx. 39–41° S, 1000 n. miles east of New Zealand eastward to waters off South America. Landings from these vessels has fluctuated from 1986–87 to 1994–95 between 603 t and 2916 t, with no real trend (Childers and Coan 1996). From 1996–97 to 2000–01, U.S.A. catches in this region have ranged from 1241–2562 t (Ito *et al.* 2002). Canadian landings in this fishery from its inception in 1987–88 to 2000–01 are estimated to have ranged from 134 to 351 mt per season (Shaw & Stocker 2002). It has previously been noted (Labelle 1993) that STCZ albacore tend to be larger than those around New Zealand.

The size composition, sex ratio, and length:weight relationship of albacore caught by troll in New Zealand have previously been investigated (Griggs and Murray 2000, 2001a, 2001b, Griggs 2002a, 2002b, 2003a, 2003b). Fish sampled in the 2002–03 season, mostly juveniles, ranged in size from 42–92 cm fork length, with nearly all of the fish in the 47–76 cm range, and a mean of 60.9 cm (Griggs 2003a, 2003b). A significant linear relationship was found between albacore fork length and greenweight. Griggs and Murray (2000) previously found that the sex ratio was not statistically different from a 1:1 ratio.
The objective of the present study was to conduct sampling in fish sheds and determine and report the length composition and length-weight relationships of albacore tuna during the 2003/2004 fishing year. The target coefficient of variation (c.v.) for the length composition is 30 % (mean weighted c.v. across all length classes).

This objective extends the time series of albacore troll vessel sampling in New Zealand. This work is an extension to the sampling funded in 1996–97 and 1997–98 by the SPC, and 1998–99 to 2002–03 by the Ministry of Fisheries.

**Methods**

Characterisation of the size composition of the fishery requires regular sampling through the season (December–May) and should take account of any differences in size composition between areas and between boats.

Three ports were sampled: Auckland (port Onehunga, on the west coast), New Plymouth and Greymouth, from December/January to April/May. Fish were sampled from at least 5 vessel unloadings and selected at random from each unloading. At least 1000 fork lengths were measured in each port, each month, and at least 100 of these fish were sub-sampled for length and weight.

At each port, sampling was carried out when the troll vessel unloaded its catch. The fish were kept on ice while on the vessel and frozen once they were discharged into the fish receivers. Fish were sampled prior to freezing. Fork length was measured to the nearest whole cm, rounded down, and weight was recorded to the nearest 0.1 kg.

Otoliths were to be collected from fish of fork length 50 cm or less.

**Results**

During the 2003–04 fishing season, a total of 5485 fish were sampled, 1821 landed in Auckland, 998 in New Plymouth, and 2666 in Greymouth. In Auckland, fish were sampled from 4 boats in December 2003 and from 5 boats in January 2004. The season ended in the northern region by February. New Plymouth sampling was carried out during January, with sampling from 5 vessel landings. In Greymouth, fish were sampled from 3 boats in late January when the season started, 3 boats in February, 5 boats in March, and 4 boats in April. Very bad weather had a severe impact on fishing this season, particularly in February when storms prevented boats from leaving port for most of the month. The season ended in Greymouth in early April.

The area fished out of Greymouth extended from west of Cape Farewell (40°27’S, 171°44’E) to Paringa (43°37’S, 169°27’E) on the west coast of the South Island, while the area fished in the north extended from west of Tauroa Point (35°15’S, 172°10’E) to Farewell Spit (40°30’S, 172°50’E) at the top of the South Island.
Weights were recorded for 598 fish, 200 from Auckland, 99 from New Plymouth and 299 from Greymouth. There were few small fish and no otoliths were collected.

**Size composition**

Figures 1, 2 and 3 show the length frequency distribution of fork length, by month, for albacore sampled from troll vessels in the 2003–04 season, in Auckland, New Plymouth and Greymouth respectively. Fish sampled ranged in size from 40 cm to 94 cm, with almost all of the fish (99%) in the 52–76 cm range. The overall mean fork length was 64.3 cm. The distributions of the fish sampled in the three ports and their mean lengths were different: 65.1 cm in Auckland, 65.0 cm in New Plymouth and 63.6 cm in Greymouth. There were very few small fish of less than 50 cm fork length. In the 2002–03 season there were a lot of small fish landed in New Plymouth, where the mean was 57.9 cm. The fish landed in New Plymouth in the 2003–04 season were larger, but sampling only took place in January.

Table 1 shows mean length, standard deviation, minimum and maximum lengths and percentiles for each month for each port sampled in the 2003–04 season, and Table 2 shows the data for each port combined and for 2003–04 combined.

Table 3 summarises the length frequency statistics for the fishing years sampled from 1996–97 to 2003–04, while Figure 4 shows length frequency distributions for each of these years. In this eight year period, fork length of troll caught albacore ranged from 38 cm to 99 cm, with nearly all of the fish (99%) in the 47–81 cm range, and the mean was 63.3 cm (Table 3). Three modes are visible in most months of the years sampled. These modes tended to increase by about 1 cm each month during the sampling period. There is considerable variability in the distributions from year to year. In 1998–99 there was a large proportion of small fish (46–56 cm). There was one dominant mode centered around 60 cm in the fish sampled in the 1999–00 season. The greatest proportion of large fish (68–78 cm) were seen in the 2000–01 sample. In 2001–02, there are more small fish with the peak of the largest mode at 62 cm. The peak of the largest mode is at 61 cm in 2002–03, there are few fish over 75 cm, and more smaller fish (< 55 cm) and the lowest mean (60.9 cm) in the eight years sampled. In 2003–04 there are 2 prominent modes with peaks at 62 cm and 70 cm, few small fish and a large proportion of bigger fish.

Figure 5 shows length distributions of troll and longline caught albacore. Troll caught albacore are from 8 years sampling combined (1996–97 to 2003–04). The longline data (extracted from the *l_line* database), were collected by Ministry of Fisheries Observer Programme observers on New Zealand domestic and Japanese longliners, from 1987–2003. Albacore caught in New Zealand by longline are larger (mean fork length 80.0 cm) than troll caught fish, and are caught over a wider geographic area and in more months of the year (December to August). Albacore are usually caught as bycatch in longline operations targeting southern bluefin tuna and bigeye tuna.

Mean length, standard deviation, minimum and maximum lengths and percentiles are compared for troll and longline caught fish in Table 3.
Table 1: Summary of mean fork length, standard deviation, median and percentiles for albacore sampled each month during the 2003–04 season.

<table>
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<tr>
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</tbody>
</table>

Table 2: Summary of mean fork length, standard deviation, median and percentiles for albacore sampled during the 2003–04 season, summarized by area.

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<tr>
<th></th>
<th>Auckland data combined</th>
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<th>Greymouth data combined</th>
<th>All 2003-04 data combined</th>
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<tr>
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Table 3: Summary of length frequency statistics for albacore sampled during eight years of troll sampling, and albacore caught by longline.

<table>
<thead>
<tr>
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<td>92</td>
<td>94</td>
<td>99</td>
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Length: weight relationship

Figure 6 shows the length:weight relationship for albacore sampled during December 2003 – April 2004. Data are plotted as ln(greenweight) vs. ln(fork length).

Figure 7 shows the length:weight relationship for albacore sampled over 6 fishing years, 1998–99 to 2003–04. Length:weight relationships for albacore caught by troll and longline are shown in Figure 8.

Table 4 summarises the linear regression parameters and their standard errors, for the following equation:

\[ \ln(\text{greenweight}) = b_0 + b_1 \cdot \ln(\text{fork length}) \]

Table 4: Linear regression parameters for troll and longline length-weight relationships

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>(b_0)</th>
<th>SE(b_0)</th>
<th>(b_1)</th>
<th>SE(b_1)</th>
<th>(R^2)</th>
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<td>troll</td>
<td>1998-99</td>
<td>320</td>
<td>-10.44</td>
<td>0.16</td>
<td>2.91</td>
<td>0.03</td>
</tr>
<tr>
<td>troll</td>
<td>1999-00</td>
<td>397</td>
<td>-9.46</td>
<td>0.16</td>
<td>2.67</td>
<td>0.04</td>
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<td>2000-01</td>
<td>599</td>
<td>-9.86</td>
<td>0.12</td>
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<td>709</td>
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<td>0.16</td>
<td>2.76</td>
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<td>0.05</td>
<td>2.78</td>
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<td>longline</td>
<td>1997-2003</td>
<td>42736</td>
<td>-10.34</td>
<td>0.02</td>
<td>2.88</td>
<td>0.00</td>
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Target coefficient of variation

This project specified that “The target coefficient of variation (CV) for the length composition is 30 % (mean weighted CV across all length classes).”

Mean weighted CVs of length frequency estimates were calculated with the original port sampling data analysed in 1 cm length classes. The mean weighted CV was calculated as the average of the CVs for the individual length classes weighted by the proportion of fish in each class. CVs are calculated by bootstrapping with fish re-sampled within each landing and landings re-sampled within each month. While the resulting CVs would be smaller if the size classes were aggregated, we have maintained the finer resolution of the original data because the purpose of the data is for inferring growth rate within a length-based age-structured model, MULTIFAN-CL (Fournier et al. 1998). The following mean weighted CVs were calculated using the ‘catch.at.age’ software developed by NIWA for the analysis of mean weighted CVs across length classes:
December  24.6%
January    17.3%
February   28.4%
March      22.6%
April      19.8%
Pooled     11.2%

The target CV for this port sampling project of 30% as a mean weighted CV across all length classes was realised in each month.

Discussion and Conclusions

Troll caught albacore sampled in the 2003–04 fishing year from the landings of New Zealand troll vessels ranged in size from 40–94 cm fork length, with nearly all of the fish in the 52–76 cm range, and the mean length was 64.3 cm. As albacore reach sexual maturity at about 85 cm (Bailey 1991), almost all of these fish are juveniles.

Albacore sampled over a 8 year period from 1996–97 to 2003–04 are mostly in the 47–81 cm size range, with an average fork length of 63.3 cm. The size distribution varies over the 8 year period. There was a large proportion of small fish (46–56 cm) in 1998–99, one dominant mode centered around 60 cm in 1999–00, the greatest proportion of large fish (68–78 cm) in 2000–01, and more smaller fish (< 55 cm) in the 2002–03 season than in any of the other years. Few small fish and more large fish are seen in the 2003–04 sample.

Age classes tended to increase by about 1 cm each month during the sampling period, and that is similar to the growth rate seen in length-frequency analysis of South Pacific albacore carried out by Labelle et al. (1993).

New Zealand longline fisheries caught adult and sub-adult albacore, with a mean of 80.0 cm, mostly in the 56–104 cm size range, as shown by data in this report, and reported by Murray et al. (1999) and Griggs and Murray (2000, 2001a, 2001b) and Griggs (2003a, 2003b).

A significant linear relationship was found between albacore fork length and greenweight for troll caught fish sampled in 2003–04 ($R^2=0.92$). The length:weight relationships showed similar slopes and intercepts for fish sampled over a 6 year period, and for troll and longline caught fish.

Continued monitoring of the catch composition of juvenile albacore in the New Zealand troll fishery is a critical input to the length-based regional stock assessment of the South Pacific albacore stock. The New Zealand fishery catches up to half of the total removals of juveniles from this stock and is one of only a few target fisheries for this stock. Failure to monitor size composition in this stock would appreciably increase uncertainty of stock assessments.
Acknowledgments

Thanks to NIWA staff in Greymouth and Auckland who carried out the sampling, staff at Egmont Seafoods who sampled the fish in New Plymouth, licensed fish receiver companies who permitted us to sample fish in their sheds, and to the fishers who caught the albacore and co-operated with our sampling requirements.

The 1996–97 and 1997–98 troll data were sampled for the Secretariat of the Pacific Community. The longline data were collected by observers from the Ministry of Fisheries Observer Programme, and extracted from the $l$ _line_ database.

This work was funded by Ministry of Fisheries project ALB2003/01.

References

Bailey, K. 1991: Observations on South Pacific albacore spawning as indicated by gonad indices. Fourth South Pacific albacore research (SPAR 4) workshop working paper No. 4. 8 p.


Figure 1: Albacore length frequency distributions, Auckland 2003–2004

Figure 2: Albacore length frequency distributions, New Plymouth 2003–2004
Figure 3: Albacore length frequency distributions, Greymouth 2003–2004
Figure 4: Length frequency distributions for 8 years of troll sampling from 1996–1997 to 2003–2004

- **1996-97**:
  - Frequency distribution
  - Average fork length: 65.0 cm
  - Sample size: 4217

- **1997-98**:
  - Frequency distribution
  - Average fork length: 66.0 cm
  - Sample size: 3978

- **1998-99**:
  - Frequency distribution
  - Average fork length: 61.4 cm
  - Sample size: 3431

- **1999-00**:
  - Frequency distribution
  - Average fork length: 61.1 cm
  - Sample size: 3962
Figure 4 continued

2000-01

n=5192
mean=65.2 cm

2001-02

n=5170
mean=63.6 cm

2002-03

n=7606
mean=60.9 cm

2003-04

n=5484
mean=64.34 cm
Figure 5: Length frequency distribution for troll and longline caught albacore

![Length frequency distribution for troll and longline caught albacore](image-url)
Figure 6: Length:weight relationship for troll caught albacore sampled in 2003–04

\[ y = 2.89x - 10.33 \]

\[ R^2 = 0.92 \]

\[ n=598 \]

Figure 7: Length:weight relationship for troll caught albacore sampled in 1999–2003

\[ y = 2.78x - 9.92 \]

\[ R^2 = 0.93 \]

\[ n=3229 \]
Figure 8: Length:weight relationship for troll and longline caught albacore

\begin{align*}
\text{longline} & : y = 2.88x - 10.34 \\ R^2 & = 0.92 \\
\text{troll} & : y = 2.78x - 9.92 \\ R^2 & = 0.93
\end{align*}

Longline $n=42736$ \\
Troll $n=3229$