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commercial landings of albacore (*Thunnus alalunga*)
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EXECUTIVE SUMMARY

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Albacore tuna caught by trolling in New Zealand waters during the 2005–06 fishing season were sampled in fish sheds to determine the length frequency composition and length-weight relationship. Albacore were sampled from two ports, Auckland and Greymouth. New Plymouth was not sampled due to logistic difficulties.

Albacore sampled in the 2005–06 fishing year showed a multimodal distribution with three modes visible in most samples each month and port. The median fork length was 63 cm, the overall mean fork length was 63.3 cm, and the size range was 45–92 cm, with nearly all fish (99%) in the 50–83 cm range. Length-weight relationships were determined. Log of fork length plotted against log of green weight produced a significant linear relationship ($R^2=0.96$).

Nearly all of the albacore sampled in the troll fishery over a 10 year period from 1996–97 to 2005–06 were in the 47–81 cm size range (99%), with a mean fork length of 63.7 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 70.2 cm, and most fish (99%) in the 56–105 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 in the eastern Pacific, 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 the uncertainty of stock assessments.

1. 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 (Murray 1994, Ramon & Bailey 1996, Murray et al. 1999).

Juveniles recruit to surface fisheries in New Zealand coastal waters and in the vicinity of the subtropical convergence zone (STCZ) at about 2 years of age, at 45–50 cm fork length. Albacore then appear to gradually disperse north (Hampton & 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 & Fournier 2000). The New Zealand longline fishery catches adult and sub-adult albacore (Murray et al. 1999).

There has been a troll fishery for juvenile albacore in New Zealand coastal waters since the 1960s, and in the central region of the STCZ since the mid 1980s (Murray 1994, Hampton & 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 have fished for albacore in the South Pacific since 1986, in the STCZ, approx. 39–41° S, 1000 n. miles east of New Zealand east to waters off South America. Landings from these vessels have fluctuated between 603 t and 2916 t from 1986–87 to 1994–95, with no real trend (Childers & Coan 1996). Over the 5 years from 1999–2002 to 2003–04, American catches were highest in 1999–2000 (2562 t) and lowest in the 2003–04 season (955 t) (Ito et al. 2005). Canadian landings in this fishery from its inception in 1987–88 to 2000–02 are estimated to have ranged from 134 to 351 mt per season, with no reported catch in 2002–03 and an estimated catch for the 2003–04 fishing of 63 mt (Stocker & Shaw 2005). Labelle (1993) noted that STCZ albacore tend to be larger than those around New Zealand. Albacore sampled in the STCZ by the American fleet in 2003–04 had an average fork length of 66 cm, 5 cm less than the previous year (Ito et al. 2005).

The size composition, sex ratio, and length-weight relationship of albacore caught by troll in New Zealand have previously been investigated (Griggs & Murray 2000, 2001a, 2001b, Griggs 2002a, 2002b, 2003a, 2003b, 2004a, 2004b). Fish sampled in the 2004–05 season, mostly juveniles, ranged in size from 45 to 94 cm fork length, with nearly all of the fish in the 52–80 cm range, and a mean of 66.5 cm (Griggs 2005a, 2005b). A significant linear relationship was found between albacore fork length and greenweight. Griggs & Murray (2000) found that the sex ratio was not statistically different from 1:1.

The present study updates and extends those previous analyses for one more year which will be the tenth year in the time series. It addresses the following objectives:

1.1 Overall Objective

To determine the length composition of the commercial catch of albacore (*Thunnus alalunga*) in the New Zealand EEZ to support the stock assessment of the wider south Pacific stock.

1.2 Specific Objectives

Objective 1: To conduct sampling in fish sheds and determine and report the length composition and length-weight relationships of albacore tuna during the 2005/2006 fishing year from samples collected in fish sheds. The target coefficient of variation (c.v.) for the length composition is 20 % (mean weighted c.v. across all length classes).

Objective 4: To collect 50 pairs of otoliths from fish of 50 cm fork length or less per fishing year.

ALB2005/01 is a three year project with objectives 1, 2 and 3 for the 2005–06, 2006–07, and 2007–08 fishing years respectively. This work is an extension to the sampling funded in 1996–97 and 1997–98 by the SPC, and 1998–99 to 2004–05 by the Ministry of Fisheries.

2. METHODS

2.1 Catch sampling

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. Fish were sampled from at least five vessel unloadings and were 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 subsampled for length and weight.

Two ports, Auckland (port Onehunga, on the west coast) and Greymouth, were sampled during the 2004–05 troll fishing season from December/January to April/May. There were some landings in New Plymouth, but the licensed fish receiver in this port was unable to accommodate the disruption to their processing that would be caused by sampling.

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 before freezing. Fork length was measured to the nearest whole centimetre, rounded down, and weight was recorded to the nearest 0.1 kg. Otoliths were collected from fish of fork length 50 cm or less.

2.2 Size composition and length-weight relationships

Size composition and length-weight relationships for fish sampled during the 2005–06 troll season are summarised and presented, and are compared with those from the previous nine years of troll sampling, and with albacore caught by longline. 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 to 2005.

2.3 Target coefficient of variation

Mean weighted c.v.s were calculated using the ‘catch.at.age’ software developed by NIWA for the analysis of mean weighted c.v.s across length classes.

Mean weighted c.v.s of length frequency estimates were calculated with the original port sampling data analysed in 1 cm length classes. The mean weighted c.v. was calculated as the average of the c.v.s for the individual length classes weighted by the proportion of fish in each class. C.v.s were calculated by bootstrapping with fish resampled within each landing and landings resampled within each month. Although the resulting c.v.s would be smaller if the size classes were aggregated, the finer resolution of the original data has been maintained because the purpose of the data is for inferring growth rate within a length-based age-structured model, MULTIFAN-CL (Fournier et al. 1998).

3. RESULTS

During the 2005–06 fishing season, 4670 fish were sampled, 1600 landed in Auckland and 3070 in Greymouth. In Auckland, fish were sampled from five boats in January, two boats in February and one boat in March. The season ended in the northern region in mid February, but a few vessels fished further south in early March and one was sampled that landed into Auckland. In Greymouth, fish were sampled from five boats in January when the season started, five boats in February, and six boats in March. The season ended in Greymouth in late March. The target of 1000 fish was not met in Auckland in February or March due to the fishing season finishing.

The area fished out of Greymouth extended from Farewell Spit (40°30' S, 174°50' E) to Jackson's Bay (43°57' S, 168°37' E) on the west coast of the South Island, while the area fished in the north extended from off Tauroa Point (35°12' S, 172°24' E) to Westport (41°10' S, 171°33' E).

Weights were recorded for 600 fish, 300 from Auckland and 300 from Greymouth. Otoliths were collected from 56 fish, 52 from Auckland and 4 from Greymouth.

3.1 Size composition

The length frequency distribution of fork length, by month, for albacore sampled from troll vessels during the 2005–06 fishing season in Auckland and Greymouth are shown in Figures 1 and 2 respectively. Fish sampled ranged in size from 45 to 92 cm, with nearly all fish (99%) in the 50–83 cm range. The overall mean fork length was 63.3 cm and the median fork length was 63 cm. The distributions of the fish sampled in the two ports and their mean lengths were different: 64.2 cm in Auckland and 63.2 cm in Greymouth, and the medians were the same, 63 cm, in both ports. In most previous years of sampling, mean fish length had been greater in Greymouth than in Auckland. Dominant modes are seen in the Greymouth caught fish at 61 cm in January, 64 cm in February, and 63 in March, and there are fewer large fish than seen in the previous year.

The mean length, standard deviation, median, minimum and maximum lengths, and percentiles for each month for each port sampled in the 2005–06 season are shown in Table 1, and summaries for each port combined, and for all 2005–06 samples combined, are shown in Table 2.

The length frequency statistics for the fishing years sampled from 1996–97 to 2005–06 are summarised in Table 3, and the length frequency distributions for each of these years are shown in Figure 3. During this 10 year period, fork length of troll-caught albacore ranged from 38 to 99 cm, with nearly all of the fish (99%) in the 47–81 cm range; the mean was 63.7 cm and the median 63 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 centred around 60 cm in the fish sampled in the 1999–2000 season. The greatest proportion of large fish (68–78 cm) were seen in the 2000–01 sample. In 2001–02, there were more small fish with the peak of the largest mode at 62 cm, and there were also a significant number of large fish (over 75 cm). The peak of the largest mode was at 61 cm in 2002–03, and there were few fish over 75 cm, more smaller fish (less than 55 cm), and the lowest mean (60.9 cm) in the nine years sampled. In 2003–04 there were two prominent modes with peaks at 62 cm and 70 cm, few small fish (less than 55 cm) and a large proportion of bigger fish, but few over 75 cm. A larger proportion of both smaller and bigger fish was seen in 2004–05.

The 2005–06 distribution shows two distinct modes, one small one with a peak at 50 cm and a large mode with a peak at 61 cm. There were two other less distinct possible modes with peaks at 70 cm and 79 cm. Small fish (less than 55 cm) and large fish (over 75 cm) were both quite well represented (Figure 3).

Length distributions of troll- and longline-caught albacore are shown in Figure 4. This shows troll-caught albacore from 10 years of sampling combined (1996–97 to 2005–06) and longline-caught albacore measured by observers from 1987–2005. Albacore caught in New Zealand by longline are larger (mean fork length 80.28 cm) than troll-caught fish, are caught over a wider geographic area, and are caught all year round. Albacore are usually caught as bycatch in longline operations targeting southern bluefin tuna and bigeye tuna. Mean length, standard deviation, median, minimum and maximum lengths, and percentiles are compared for troll- and longline-caught fish in Table 3.

3.2 Length-weight relationship

The length-weight relationship for albacore sampled from January to March 2005 is shown in Figure 5. Data are plotted as $\ln(\text{greenweight})$ vs. $\ln(\text{fork length})$.

The length-weight relationship for albacore sampled over eight fishing years, 1998–99 to 2005–06, is shown in Figure 6. Length-weight relationships for albacore caught by troll and longline are shown in Figure 7. Note that longline-caught fish are measured by observers to the nearest kg, which is less precise than the troll-caught fish (measured to the nearest 0.1 kg).

A summary of the linear regression parameters and their standard errors is shown in Table 4, for the following equation:

$$\ln(\text{greenweight}) = b_0 + b_1 * \ln(\text{fork length})$$

3.3 Target coefficient of variation

This project specified that “The target coefficient of variation (c.v.) for the length composition is 20% (mean weighted c.v. across all length classes).”

The following mean weighted c.v.s were calculated using NIWA’s ‘catch.at.age’ software:

Auckland, January	28.4%	
Auckland, February	31.3%	(n=400)
Auckland, March	27.0%	(n=200)

Greymouth, January	24.5%
Greymouth, February	26.3%
Greymouth, March	27.5%
Pooled	13.3%

The target c.v. for this port sampling project of 20 % as a mean weighted c.v. across all length classes was realised in the pooled sample.

4. DISCUSSION

Troll caught albacore sampled in the 2005–06 fishing year from the landings of New Zealand troll vessels ranged in size from 45 to 92 cm fork length, with nearly all of the fish in the 50–83 cm range; the mean length was 63.3 cm. As albacore reach sexual maturity at about 85 cm (Bailey 1991), almost all of these fish were juveniles.

Albacore sampled over a 10 year period from 1996–97 to 2005–06 are mostly in the 47–81 cm size range, with an average fork length of 63.7 cm. The size distribution varied over the 10 year period. There was a large proportion of small fish (46–56 cm) in 1998–99, one dominant mode centred around 60 cm in 1999–2000, the greatest proportion of large fish (68–78 cm) in 2000–01, and more smaller fish (less than 55 cm) in the 2002–03 season than in any of the other years. Few small fish and more larger fish are seen in the 2003–04 sample, while in 2004–05 there is a big proportion of large fish, and more small fish than seen the previous year. Small fish (less than 55 cm) and large fish (over 75 cm) were both quite well represented in the 2005–06 distribution and there were two distinct modes, with peaks at 50 cm and 61 cm.

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

New Zealand longline fisheries caught adult and sub-adult albacore, with a mean of 80.2 cm, mostly in the 56–105 cm size range, as shown by data in this report, and reported by Murray et al. (1999) and Griggs & Murray (2000, 2001a, 2001b) and Griggs (2005a, 2005b).

A significant linear relationship was found between albacore fork length and greenweight for troll-caught fish sampled in 2004–05 ($R^2=0.96$). The length-weight relationships showed similar slopes and intercepts for fish sampled over a 7 year period, and for troll- and longline-caught fish.

Data from this albacore troll sampling programme are provided to the Secretariat of the Pacific Community (SPC) for incorporation into the stock assessment of south Pacific albacore. This was most recently described by Langley & Hampton (2005).

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 accounts for 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.

5. ACKNOWLEDGEMENTS

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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.

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6. 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.
- Childers, J.; Coan, A.L. (1996). U.S. South Pacific albacore fishery, 1986–1995. Sixth South Pacific albacore research (SPAR 6) workshop working paper No. 19. 22 p.
- Griggs, L.; Murray, T. (2000). Determination of size composition, sex ratio, and length:weight relationships of albacore tuna during the 1998/99 fishing year from samples collected in the fish sheds. Final Research Report for Ministry of Fisheries Research Project TUN9801 Objective 4. 16 p. (Unpublished report held by Ministry of Fisheries, Wellington).
- Griggs, L.; Murray, T. (2001a). Monitoring the length structure of commercial landings of albacore tuna during the 2000–01 fishing year. Final Research Report for Ministry of Fisheries Research Project TUN2000/01. August 2001. (Unpublished report held by Ministry of Fisheries, Wellington).
- Griggs, L.; Murray, T. (2001b). Monitoring the length structure of commercial landings of albacore tuna during the 2000–01 fishing year. SCTB14 Working Paper ALB–3, 14th Meeting of the Standing Committee on Tuna and Billfish, New Caledonia, 9–16 August 2001.
- Griggs, L. (2002a). Monitoring the length structure of commercial landings of albacore tuna during the 2001–02 fishing year. Final Research Report for Ministry of Fisheries Research Project TUN2001/02, Objective 1. December 2002. (Unpublished report held by Ministry of Fisheries, Wellington).
- Griggs, L. (2002b). Monitoring the length structure of commercial landings of albacore tuna during the 2001–02 fishing year. SCTB15 Working Paper ALB–5, 15th Meeting of the Standing Committee on Tuna and Billfish, Hawaii, 22–27 July 2002.
- Griggs, L. (2003a). Monitoring the length structure of commercial landings of albacore tuna during the 2002–03 fishing year. Final Research Report for Ministry of Fisheries Research Project TUN2001/02, Objective 2. October 2003. (Unpublished report held by Ministry of Fisheries, Wellington).
- Griggs, L. (2003b). Monitoring the length structure of commercial landings of albacore tuna during the 2002–03 fishing year. SCTB16 Working Paper ALB–8, 16th Meeting of the Standing Committee on Tuna and Billfish, Mooloolaba, Australia, 9–16 July 2003.

- Griggs, L. (2004a). Monitoring the length structure of commercial landings of albacore tuna during the 2003–04 fishing year. Final Research Report for Ministry of Fisheries Research Project ALB2003/01, Objective 1. October 2004. 17 p. (Unpublished report held by Ministry of Fisheries, Wellington).
- Griggs, L. (2004b). Monitoring the length structure of New Zealand commercial landings of albacore during the 2003–04 fishing year. SCTB17 Working Paper BIO–6, 17th Meeting of the Standing Committee on Tuna and Billfish, Majuro, Republic of the Marshall Islands, 9–18 August 2004.
- Griggs, L. (2005a). Catch monitoring of the New Zealand albacore troll fishery. WCPFC–SC1 information paper SA IP–1, 1st meeting of the Scientific Committee of the Western and Central Pacific Fisheries Commission, Noumea, New Caledonia, 8–19 August 2005.
- Griggs, L. (2005b). Monitoring the length structure of commercial landings of albacore (*Thunnus alalunga*) during the 2004–2005 fishing year. Final Research Report for Ministry of Fisheries Research Project ALB2003/01, Objective 2. November 2004. 21 p. (Unpublished report held by Ministry of Fisheries, Wellington).
- Fournier, D.A.; Hampton, J.; Sibert, J.R. (1998). MULTIFAN-CL: a length-based, age-structured model for fisheries stock assessment, with application to South Pacific albacore, *Thunnus alalunga*. *Canadian Journal of Fisheries and Aquatic Science* 55: 2105–2116.
- Hampton, J.; Fournier, D. (2000). Update of MULTIFAN-CL based assessment of South Pacific albacore tuna. SCTB13 Working Paper, 13th Meeting of the Standing Committee on Tuna and Billfish, New Caledonia, 5–12 July 2000.
- Ito, R.; Hamm, D.; Coan, A.L.; Childers, J. (2005). Summary of U.S. fisheries for highly migratory species in the Western-Central Pacific, 2000–2004. WCPFC–SC1 working paper FR WP–17, 1st meeting of the Scientific Committee of the Western and Central Pacific Fisheries Commission, Noumea, New Caledonia, 8–19 August 2005.
- Labelle, M. (1993). A review of the South Pacific albacore troll fishery 1985–1992. *South Pacific Commission Tuna and Billfish Assessment Programme Technical Report No. 32*.
- Labelle, M.; Hampton, J.; Bailey, K.; Murray, T.; Fournier, D.A.; Sibert, J.R. (1993). Determination of age and growth of South Pacific albacore (*Thunnus alalunga*) using three methodologies. *Fishery Bulletin* 91: 649–663.
- Langley, A.; Hampton, J. (2005). Stock assessment of albacore tuna in the south Pacific Ocean. WCPFC–SC1 working paper SA WP–3, 1st meeting of the Scientific Committee of the Western and Central Pacific Fisheries Commission, Noumea, New Caledonia, 8–19 August 2005.
- Murray, T. 1994: A review of the biology and fisheries for albacore *Thunnus alalunga*, in the South Pacific ocean. In *Interactions of Pacific tuna fisheries*. Edited by Shomura, S.; Majkowski, J.; Langi, S. (eds). *FAO Fisheries Technical Paper* 336/2. 188–206.
- Murray, T.; Richardson, K.; Dean, H.; Griggs, L. (1999). New Zealand tuna fisheries with reference to stock status and swordfish bycatch. Final Research Report for Ministry of Fisheries Research Project TUN9701. June 1999. 126 p. (Unpublished report held by Ministry of Fisheries, Wellington).
- Murray, T.; Richardson, K.; Dean, H.; Griggs, L. (2000). National Tuna Fishery Report 2000 – New Zealand. SCTB13 Working Paper, 13th Meeting of the Standing Committee on Tuna and Billfish, New Caledonia, 5–12 July 2000.

Ramon, D.; Bailey, K. (1996). Spawning seasonality in albacore *Thunnus alalunga*, in the South Pacific ocean. *Fishery Bulletin* 94: 725–733.

Stocker, M.; Shaw, W. (2005). Canadian albacore tuna fisheries in the north and south Pacific Ocean in 2004. WCPFC–SC1 working paper FR WP–4, 1st meeting of the Scientific Committee of the Western and Central Pacific Fisheries Commission, Noumea, New Caledonia, 8–19 August 2005.

Table 1: Summary of mean fork length, standard deviation, median, and percentiles for albacore sampled each month during the 2005–06 season.

	Auckland Jan 2006	Auckland Feb 2006	Auckland Mar 2006	Greymouth Jan 2006	Greymouth Feb 2006	Greymouth Mar 2006
n	1000	400	200	1000	1000	1070
mean	63.7	65.4	60.0	60.4	66.0	62.9
std.dev	7.6	5.8	9.1	5.9	7.4	7.9
min	45	46	45	46	49	48
1%	49	58	49	49	53	51
5%	56	59	49	51	56	52
median	62	64	61	61	65	63
95%	77	76	79	70	81	80
99%	81	79	83	78	84	85
max	86	84	84	82	89	92

Table 2: Summary of mean fork length, standard deviation, median, and percentiles for albacore sampled during the 2005–06 season, summarized by area.

	Auckland data combined	Greymouth data combined	All 2005- 06 data combined
n	1600	3070	4670
mean	64.2	63.2	63.3
std.dev	7.2	7.2	7.5
min	45	46	45
1%	50	51	50
5%	58	53	52
median	63	63	63
95%	77	78	78
99%	81	83	83
max	86	89	92

Table 3: Summary of length frequency statistics for albacore sampled during 10 years of troll sampling, and albacore caught by longline.

	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	Troll data 1997-2006	Longline data 1987-2005
n	4217	3978	3431	3962	5192	5170	7606	5485	5502	4670	49213	72241
mean	65.0	66.0	61.4	61.1	65.2	63.6	60.9	64.3	66.5	63.3	63.7	80.2
std.dev	6.9	6.7	8.7	5.6	8.5	8.6	6.4	5.1	7.1	7.5	7.4	11.6
min	40	45	38	39	40	42	42	40	45	45	38	37
1%	49	51	47	49	46	47	47	52	52	50	47	56
5%	51	59	48	55	49	51	50	58	55	52	50	63
median	66	64	62	60	68	62	61	63	68	63	63	79
95%	76	78	74	74	75	80	71	73	76	78	76	100
99%	81	81	81	81	78	83	76	76	80	83	81	105
max	92	91	91	94	99	89	92	94	94	92	99	135

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

		n	b_0	SE_{b_0}	b_1	SE_{b_1}	R^2
troll	1998-99	317	-10.61	0.13	2.95	0.03	0.97
troll	1999-2000	397	-9.46	0.16	2.67	0.04	0.93
troll	2000-01	599	-9.86	0.12	2.77	0.03	0.94
troll	2000-02	606	-9.69	0.10	2.73	0.02	0.95
troll	2002-03	709	-9.82	0.16	2.76	0.04	0.87
troll	2003-04	598	-10.33	0.14	2.89	0.03	0.92
troll	2004-05	400	-10.36	0.13	2.90	0.03	0.96
troll	2005-06	600	-10.47	0.10	2.92	0.02	0.96
troll	1999-2006	4226	-10.10	0.05	2.83	0.01	0.94
longline	1999-2005	32583	-10.23	0.02	2.86	0.00	0.92

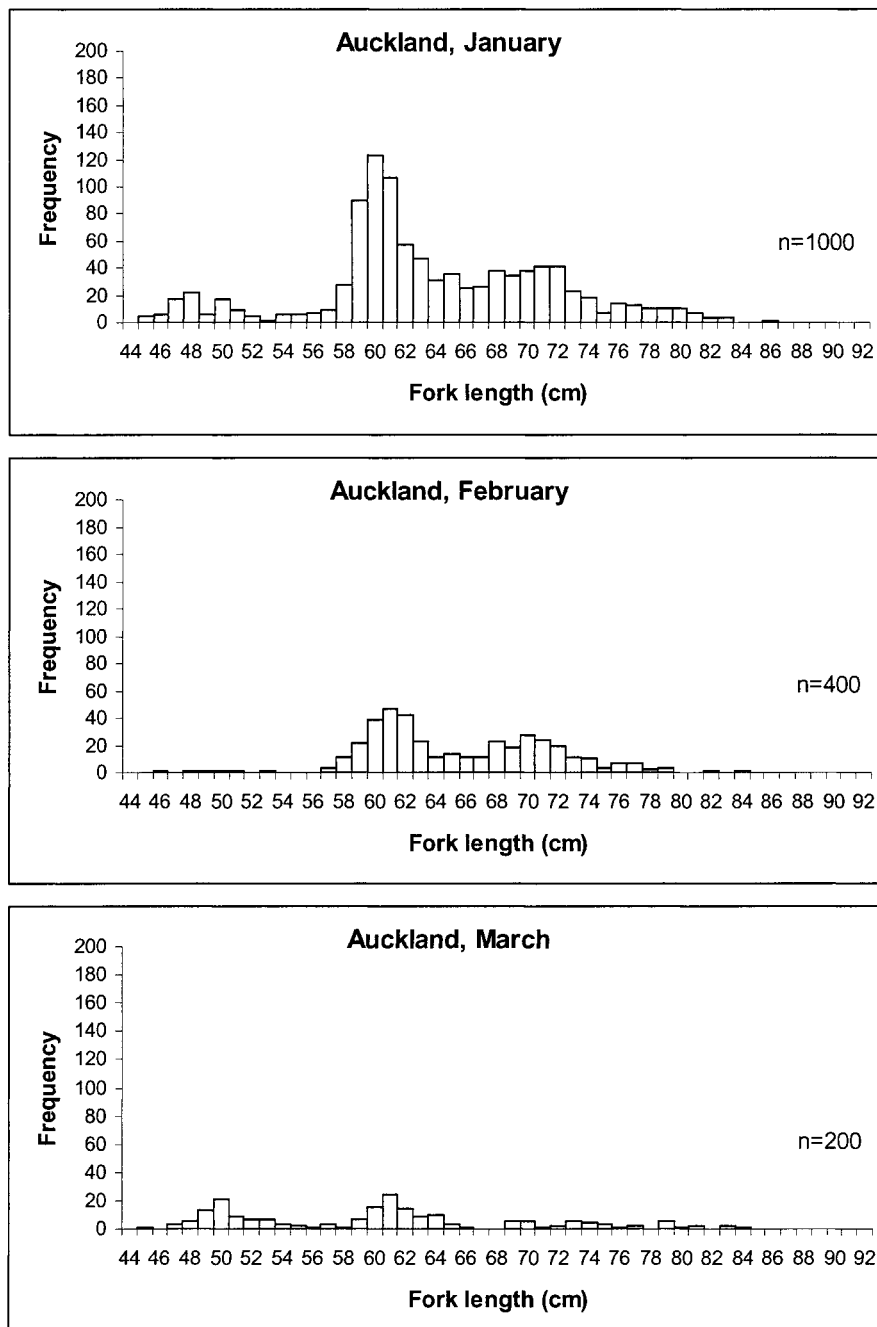


Figure 1: Albacore length frequency distributions, sampled from landings by troll vessels, Auckland, 2005–06.

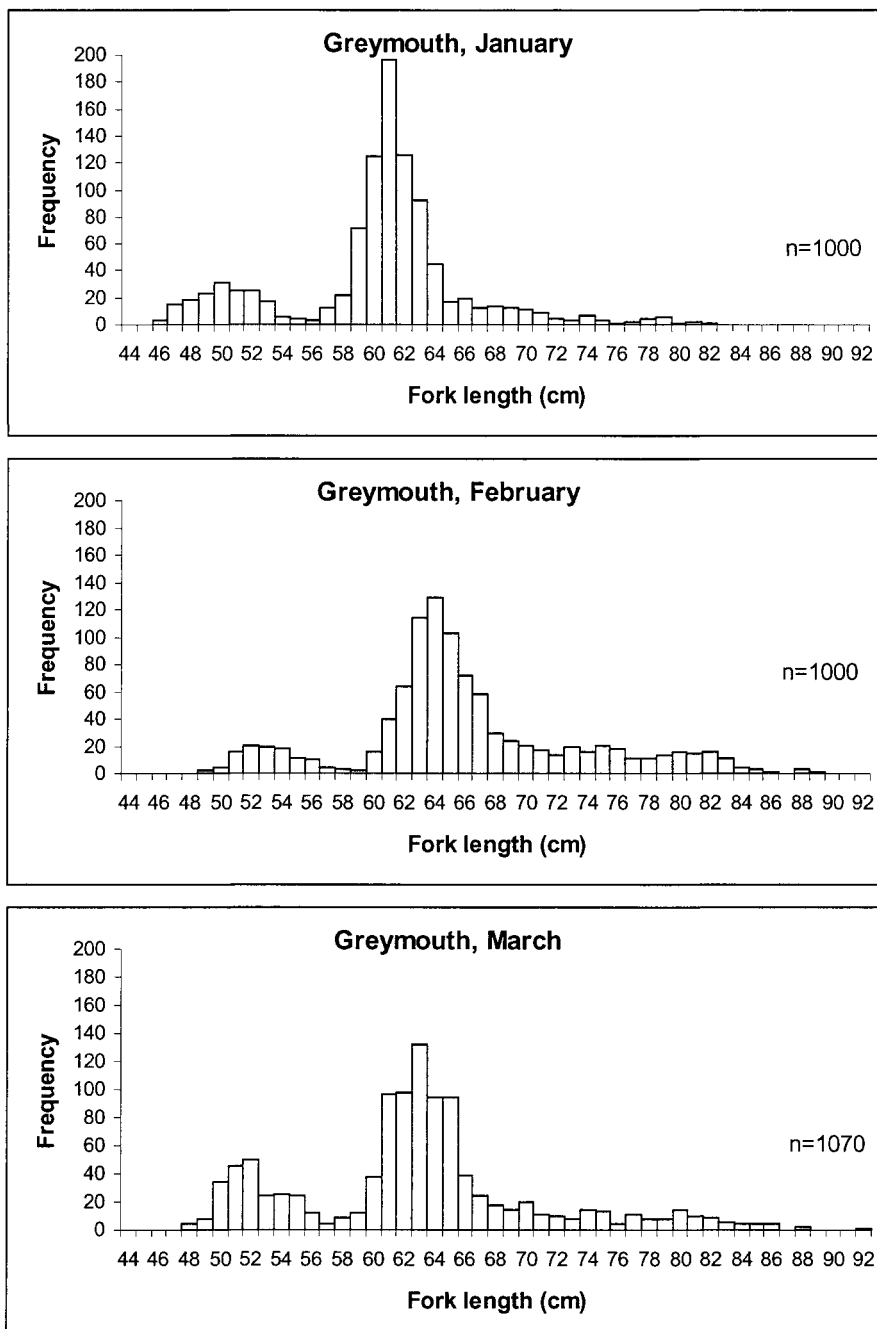


Figure 2: Albacore length frequency distributions, sampled from landings by troll vessels, Greymouth, 2005–06.

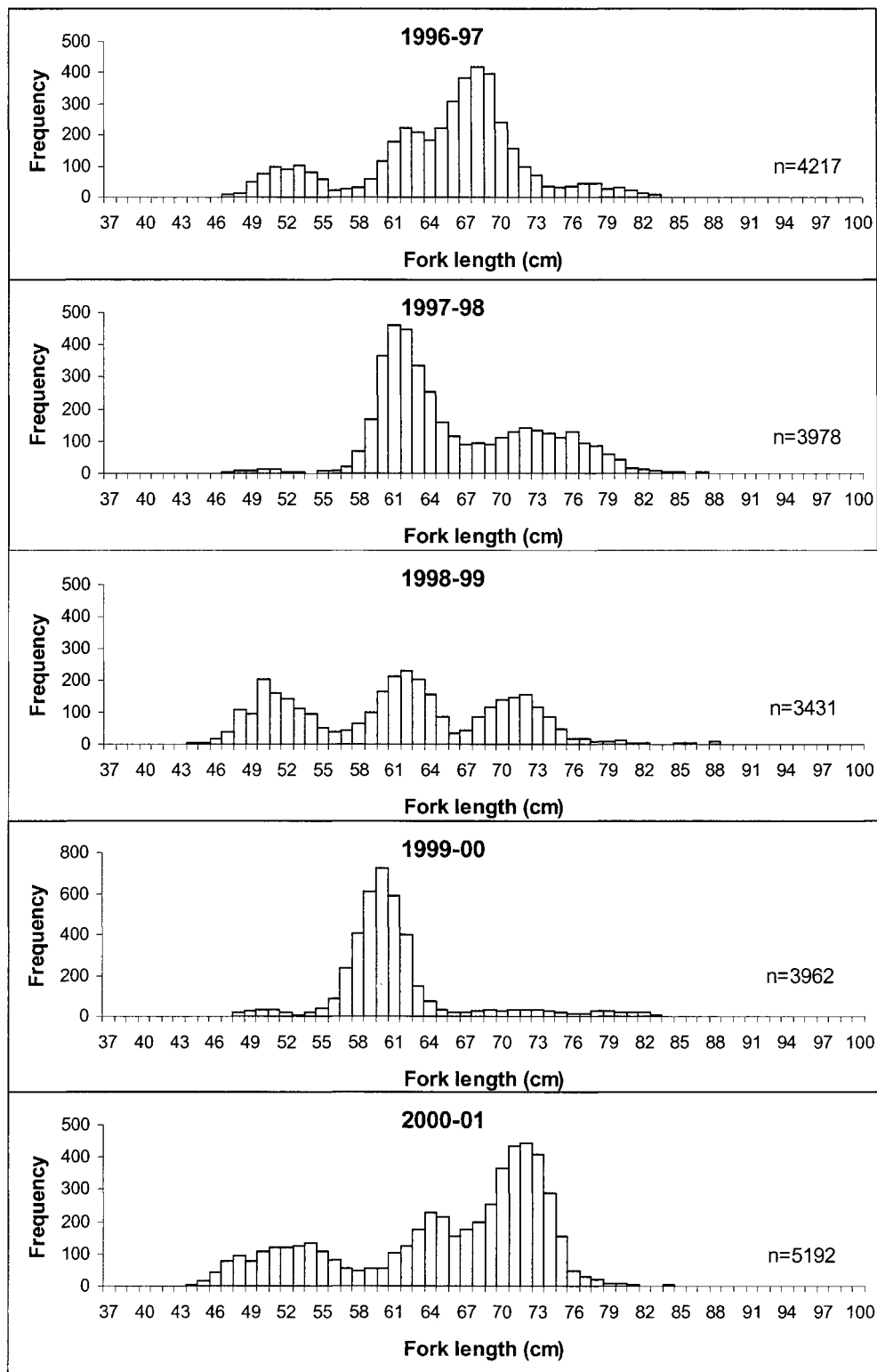


Figure 3: Albacore length frequency distributions for 10 years of sampling landings from troll vessels, 1996–97 to 2005–06.

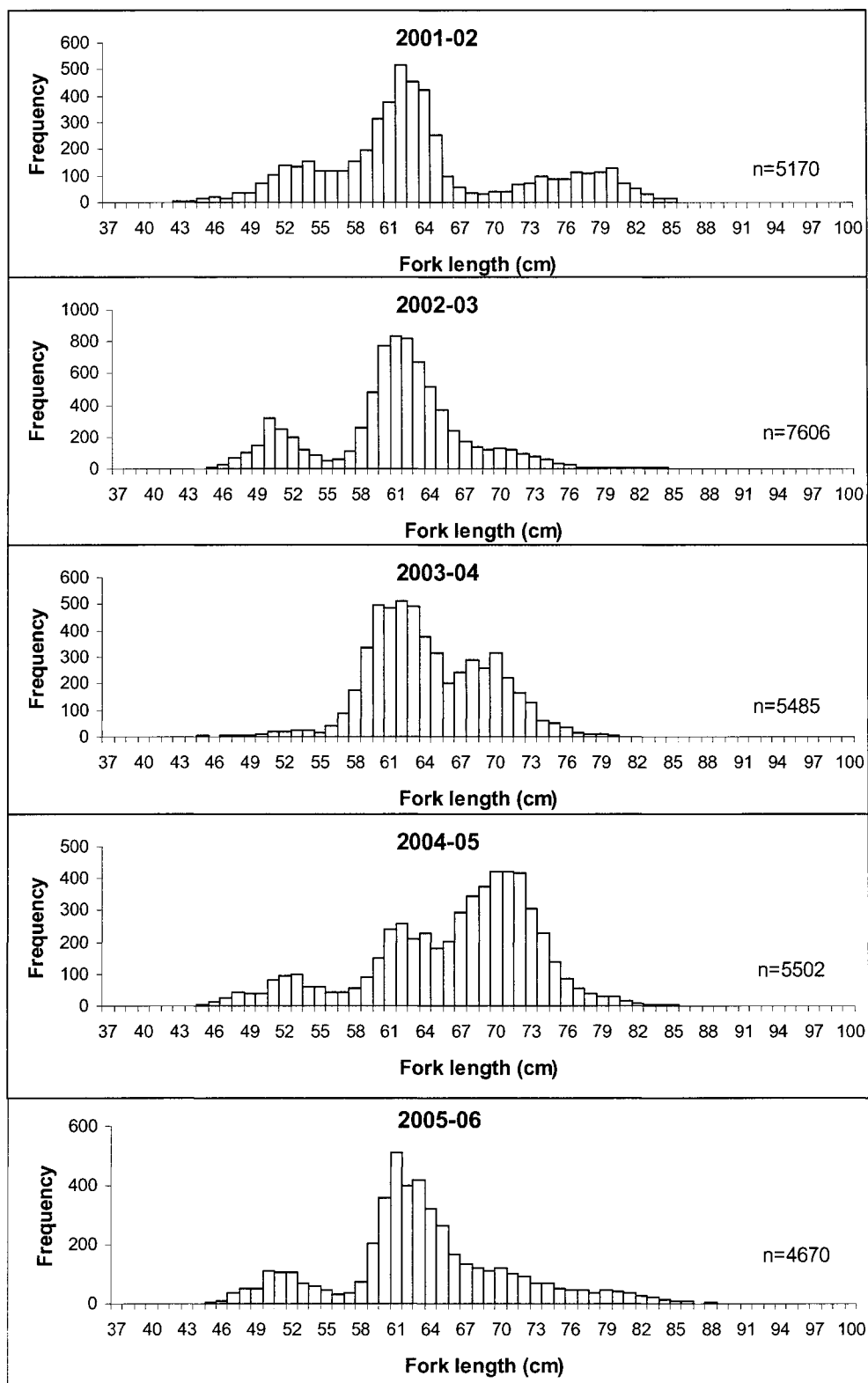


Figure 3 (continued): Albacore length frequency distributions for 10 years of sampling landings from troll vessels, 1996–97 to 2005–06.

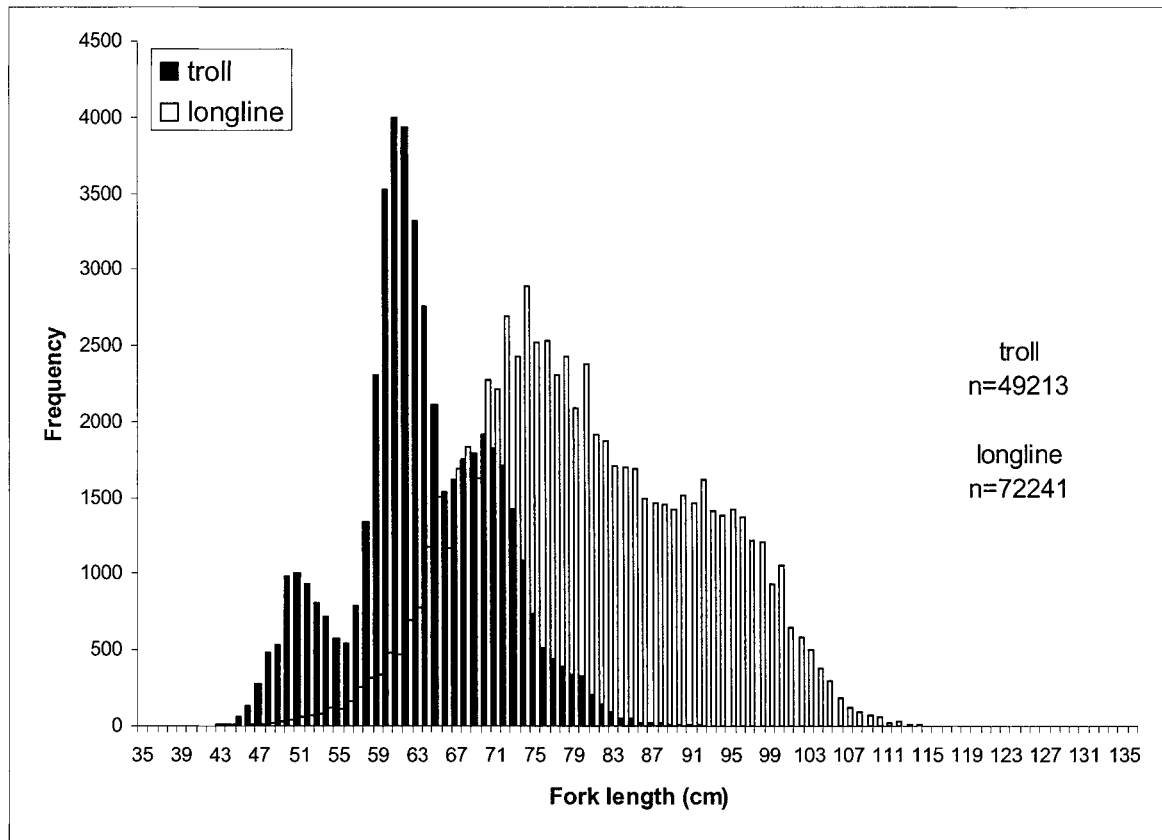


Figure 4: Length frequency distribution for troll- and longline-caught albacore. Troll data are from 10 years of sampling landings from troll vessels, 1996–97 to 2005–06. Longline data were recorded by observers from 1987 to 2005.

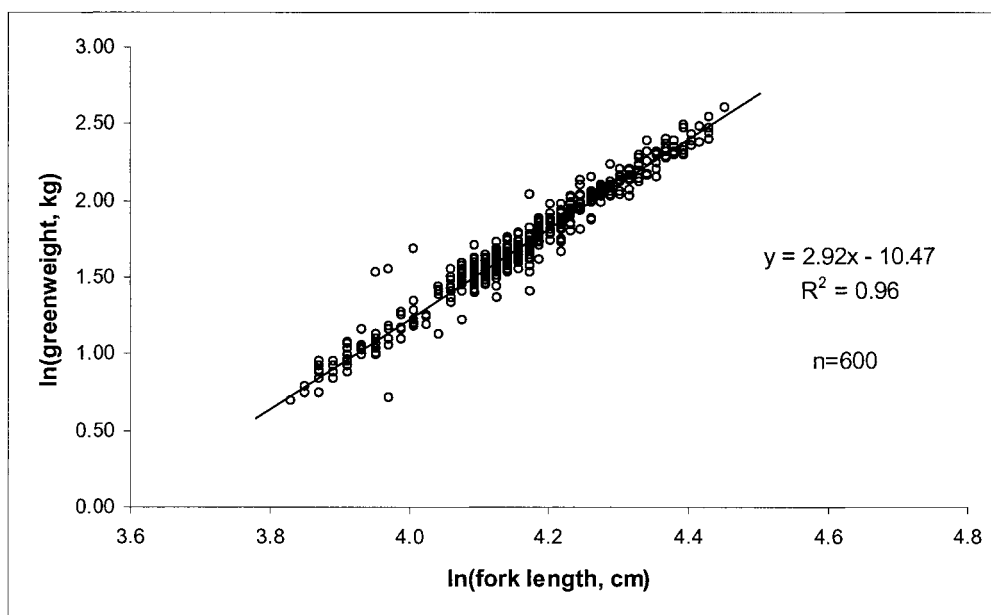


Figure 5: Length-weight relationship for troll caught albacore sampled from troll vessel landings during 2005–06.

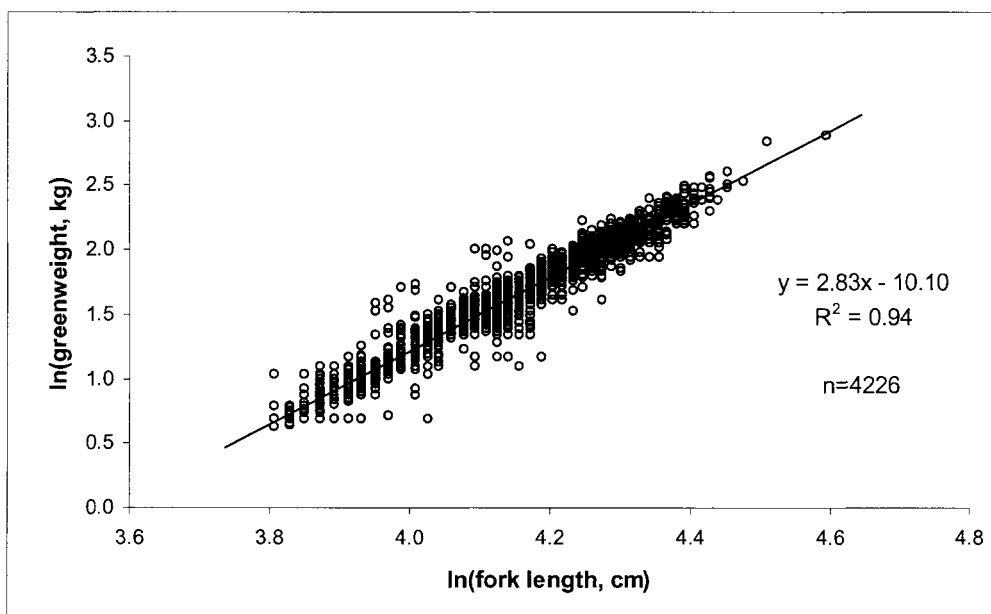


Figure 6: Length-weight relationship for troll caught albacore sampled from troll vessel landings from 1998–99 to 2005–06.

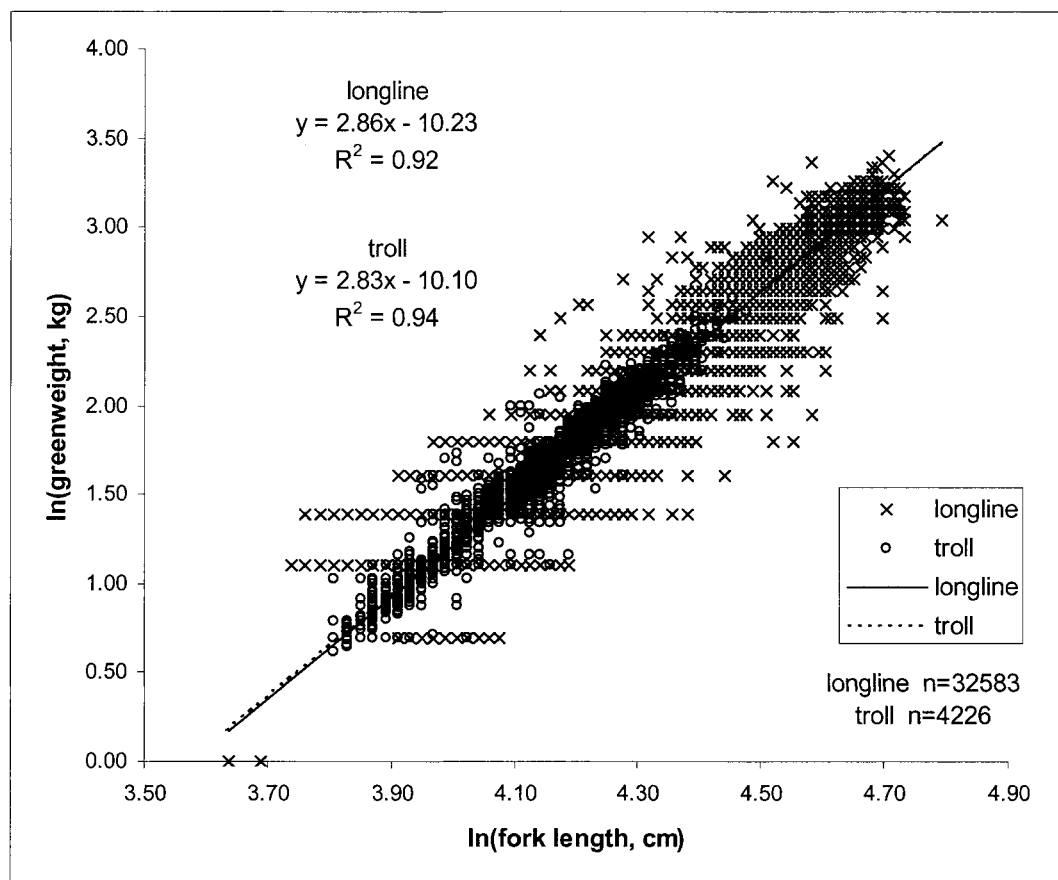


Figure 7: Length-weight relationship for troll and longline caught albacore. The troll data are from sampled vessels, 1996–97 to 2005–06. The longline data were recorded by observers, 1997–2005.