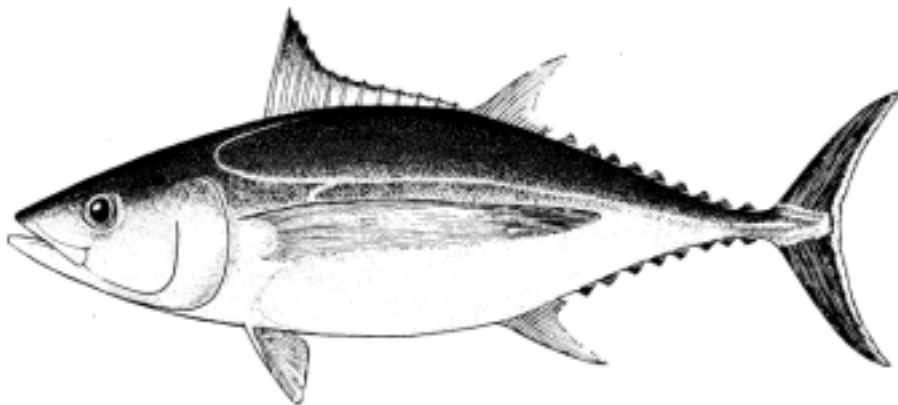




**Measuring the length structure of commercial landings of albacore tuna during the 2002–2003 fishing year**



**Lynda Griggs**

NIWA  
Wellington, New Zealand

July 2003

## **Monitoring the length structure of commercial landings of albacore tuna during the 2002–2003 fishing year.**

**Lynda Griggs**  
NIWA, Wellington, New Zealand

### **Abstract**

Albacore tuna caught by trolling in New Zealand waters during the 2002–03 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 2002–03 fishing year had a mean fork length of 60.9 cm, and ranged in size from 42–92 cm, with nearly all fish (99%) in the 47–76 cm range. Length:weight relationships are determined. Log of fork length plotted against log of green weight produced a significant linear relationship ( $R^2=0.87$ ).

Nearly all of the albacore sampled in the troll fishery over a seven year period from 1996–97 to 2002–03 are in the 47–81 cm size range (99%), with a mean fork length of 63.2 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 82.8 cm, and most fish (99%) in the 59–105 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, 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). Fish sampled in the 2001–02 season, mostly juveniles, ranged in size from 42–89 cm fork length, with nearly all of the fish in the 47–83 cm range, and a mean of 63.8 cm. 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 2002/2003 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 2001–02 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. Landings have recently increased in New Plymouth and this port was sampled for the first time this season. 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 collected from fish of fork length 50 cm or less.

## Results

During the 2002–03 fishing season, a total of 7606 fish were sampled, 2002 landed in Auckland, 3002 in New Plymouth, and 2602 in Greymouth. In Auckland, fish were sampled during January and February, from 5 boats each month. The season ended in the northern region by late February-early March. There were a few small landings in early March but were not sampled. New Plymouth sampling was carried out during January, February and March with 5 boats sampled each month. In Greymouth, fish were sampled from 5 boats in February, 7 boats in March, and one boat in April. The season started later than usual in the Greymouth region and ended in early April.

The area fished out of Greymouth extended from the Heaphy River (40°59' S, 172°05' E) to Jacksons Bay (43°57' S, 168°37' E) on the west coast of the South Island, while the area fished in the north extended from north of Kaipara Harbour (36°20' S, 173°30' E) to the South Taranaki Bight (39°58' S, 173°58' E) on the west coast of the North Island.

Weights were recorded for 709 fish, 202 from Auckland, 305 from New Plymouth and 202 from Greymouth. 64 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 2001–02 season, in Auckland, New Plymouth and Greymouth respectively. Fish sampled ranged in size from 42 cm to 92 cm, with almost all of the fish (99%) in the 47–76 cm range. The overall mean fork length was 60.9 cm. The distributions of the fish sampled in the three ports and their mean lengths were different: 61.4 cm in Auckland, 57.9 cm in New Plymouth and 64.1 cm in Greymouth. There were more small fish caught in New Plymouth than in the other ports and Figure 2 shows a particularly large mode of small fish (46–56 cm) caught in March, that is small in other months and in other ports.

Table 1 shows mean length, standard deviation, minimum and maximum lengths and percentiles for each month for each port sampled in the 2002–03 season, and Table 2 shows the data for each port combined and for 2002–03 combined.

Table 3 summarises the length frequency statistics for the fishing years sampled from 1996–97 to 2002–03, while Figure 4 shows length frequency distributions for each of these years. In this seven 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 63.2 cm (Table 2). 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, and there are few fish over 75 cm. There were more smaller fish (< 55 cm) in the 2002–03 season than in any of the other years, and the mean for this year (60.9 cm) is lower than in the previous 6 years.

Figure 5 shows length distributions of troll and longline caught albacore. Troll caught albacore are from 7 years sampling combined (1996–97 to 2002–03). 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 1987–2002. Albacore caught in New Zealand by longline are larger (mean fork length 82.8 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 2002–03 season.

	Auckland Jan 2003	Auckland Feb 2003	New Plym. Jan 2003	New Plym. Feb 2003	New Plym. Mar 2003	Greymouth Feb 2003	Greymouth Mar 2003	Greymouth Apr 2003
n	1002	1000	998	1004	1000	1000	1402	200
mean	60.9	61.9	59.4	59.3	54.9	62.6	64.9	65.5
std.dev.	6.1	4.4	6.2	5.5	5.9	3.7	6.2	7.1
min	44	47	42	46	47	50	47	50
1%	46	49	46	48	48	51	50	51
5%	49	57	47	49	49	54	52	54
median	60	61	60	61	52	63	65	63
95%	71	70	69	66	65	68	74	80
99%	81	73	73	73	71	71	78	86
max	89	85	89	83	85	83	92	87

Table 2: Summary of mean fork length, standard deviation, median and percentiles for albacore sampled during the 2002–03 season, summarized by area.

	Auckland data combined	New Plym. Data combined	Greymouth data combined	All 2003 data combined
n	2002	3002	2602	7606
mean	61.4	57.9	64.1	60.9
std.dev.	5.3	6.2	5.6	6.4
min	44	42	47	42
1%	47	47	50	47
5%	51	48	53	50
median	61	60	64	61
95%	71	67	74	71
99%	78	73	78	76
max	89	89	92	92

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

	1997 data combined	1998 data combined	1999 data combined	2000 data combined	2001 data combined	2002 data combined	2003 data combined	Troll data 1997-2003	Longline data 1987-2002
n	4217	3978	3431	3962	5192	5170	7606	33556	44155
mean	65.0	66.0	61.4	61.1	65.2	63.6	60.9	63.2	82.8
stdev	6.9	6.7	8.7	5.6	8.5	8.6	6.4	7.6	10.7
min	40	45	38	39	40	42	42	38	37
median	66	64	62	60	68	62	61	62	82
max	92	91	91	94	99	89	92	99	133

### Length:weight relationship

Figure 6 shows the length:weight relationship for albacore caught by troll during January-March 2003. Data are plotted as  $\ln(\text{greenweight})$  vs.  $\ln(\text{fork length})$ .

Figure 7 shows the length:weight relationship for albacore sampled over 5 fishing years, 1998–99 to 2002–03. 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:

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

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	320	-10.44	0.16	2.91	0.03	0.95
troll	1999-00	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	1999-2003	2631	-9.83	0.06	2.76	0.01	0.93
longline	1987-2002	31953	-10.29	0.02	2.87	0.00	0.91

### 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.

January	19.6%
February	20.1%
March	30.4%
April	36.6% (n=200 for this month)

The target CV for this port sampling project of 30 % as a mean weighted CV across all length classes was realised in each month except April where the sample size was substantially less than 1000 fish, and it was slightly above the target 30 % in March.

It appears the increased variability in size composition this year compared with previous years resulted in the target CV not being met. Future sampling should take this into account and slightly higher numbers of fish should be measured in all months in all ports.

## Discussion and Conclusions

Troll caught albacore sampled in the 2002–03 fishing year from the landings of New Zealand troll vessels ranged in size from 42–92 cm fork length, with nearly all of the fish in the 47–76 cm range, and the mean length was 60.9 cm. As albacore reach sexual maturity at about 85 cm (Bailey 1991), almost all of these fish are juveniles.

Albacore sampled over a 7 year period from 1996–97 to 2002–03 are mostly in the 47–81 cm size range, with an average fork length of 63.2 cm. The size distribution varies over the 7 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, and a greater proportion of large fish (68–78 cm) in 2000–01. In 2002–03, the peak of the largest mode is at 61 cm, and there are few fish over 75 cm. There were more smaller fish (< 55 cm) in the 2002–03 season than in any of the other years, and the mean for this year (60.9 cm) is lower than in the previous 6 years. This is largely due to catches off New Plymouth where smaller albacore have been reported previously in the commercial catch (Roberts 1972).

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 82.8 cm, mostly in the 59–105 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 (2002).

A significant linear relationship was found between albacore fork length and greenweight for troll caught fish sampled in 2002–03 ( $R^2=0.87$ ). The length:weight relationships showed similar slopes and intercepts for fish sampled over a four 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, Andrea Chadfield 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.

Thanks to Talbot Murray for helpful comments on the manuscript.

This work was funded by Ministry of Fisheries project TUN2001/02.

## **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. 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.

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. & 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. 16p.

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.

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.

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, 13<sup>th</sup> Meeting of the Standing Committee on Tuna and Billfish, New Caledonia, 5–12 July 2000.

Ito, R., Hamm, D., Coan, A.L. & Childers, J., 2002: Summary of U.S. fisheries statistics for highly migratory species in the central-western Pacific, 1997–2001. SCTB15 Working Paper NFR–24, 15th Meeting of the Standing Committee on Tuna and Billfish, Hawaii, 22–27 July 2002.

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.

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 S. Shomura, J. Majkowski, and S.Langi. FAO Fisheries Technical Paper 336/2. p188–206.

Murray, T., Richardson, K., Dean, H. & Griggs, L. 1999. New Zealand tuna fisheries with reference to stock status and swordfish bycatch (Report prepared for the New Zealand Ministry of Fisheries, June 1999.) 126 p.

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.

Roberts, P.E. 1972: Albacore off the north-west coast of New Zealand, February 1972. *New Zealand Journal of Marine and Freshwater Research* 8(3): 455–472.

Shaw, W. & Stocker, M., 2002: An update for Canadian tuna fisheries in the north and south Pacific Ocean for 2001. SCTB15 Working Paper NFR–3, 15th Meeting of the Standing Committee on Tuna and Billfish, Hawaii, 22–27 July 2002.

Figure 1: Albacore length frequency distributions, Auckland 2003

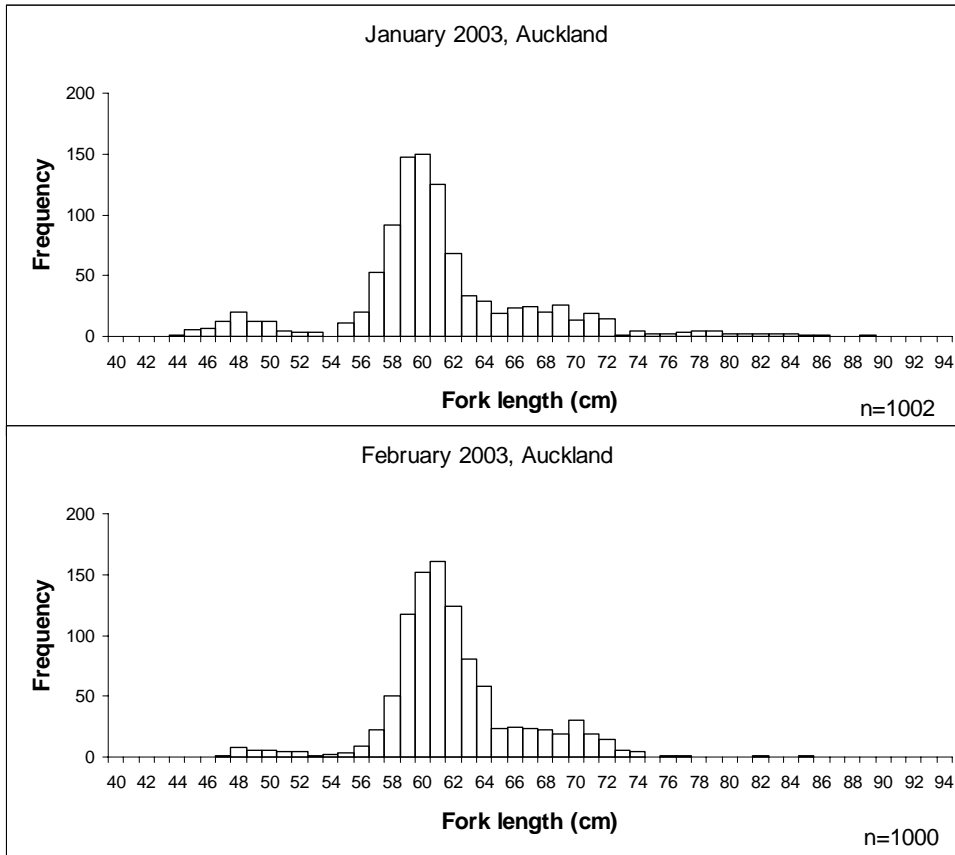


Figure 2: Albacore length frequency distributions, New Plymouth 2003

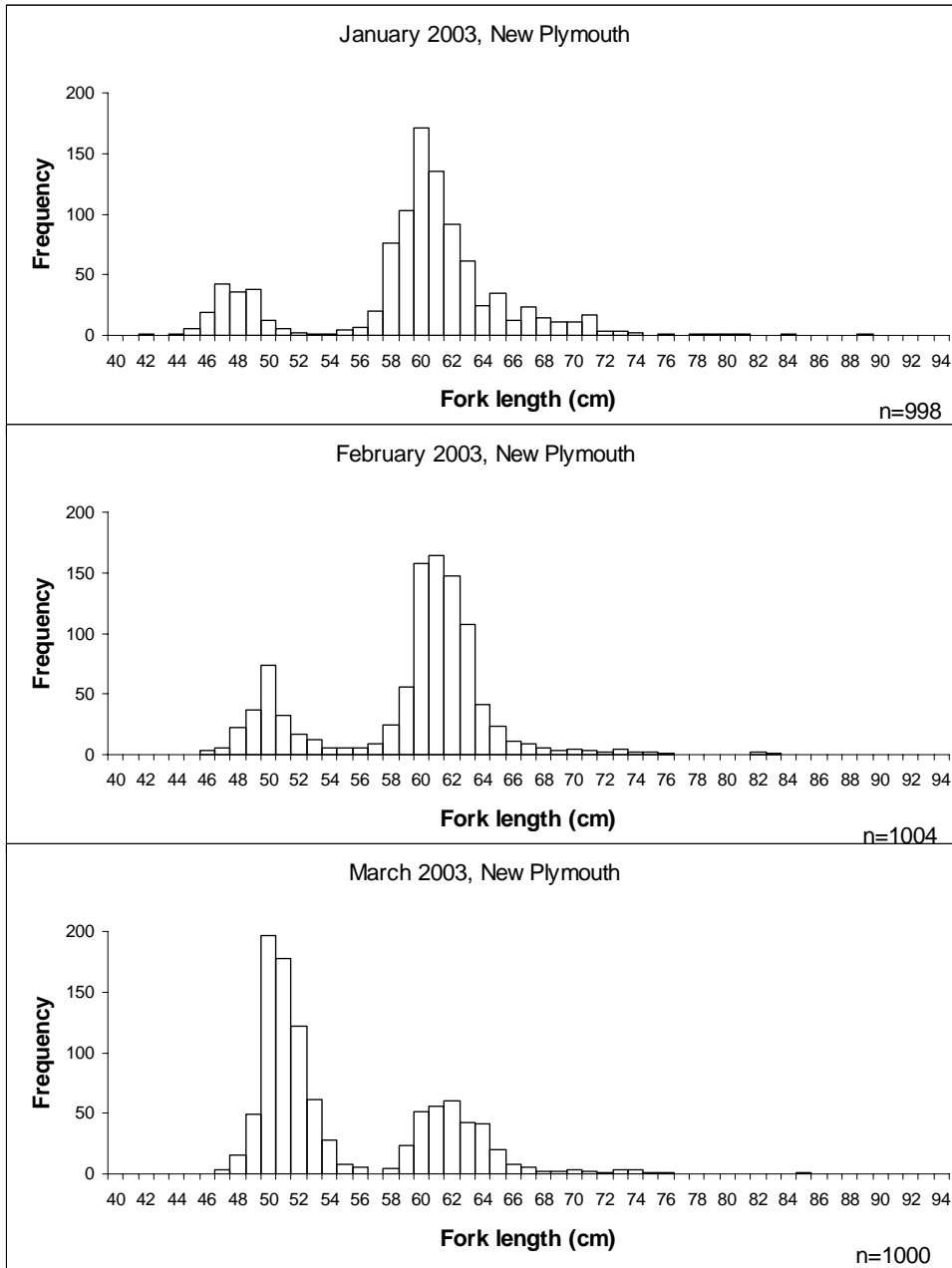


Figure 3: Albacore length frequency distributions, Greymouth 2003

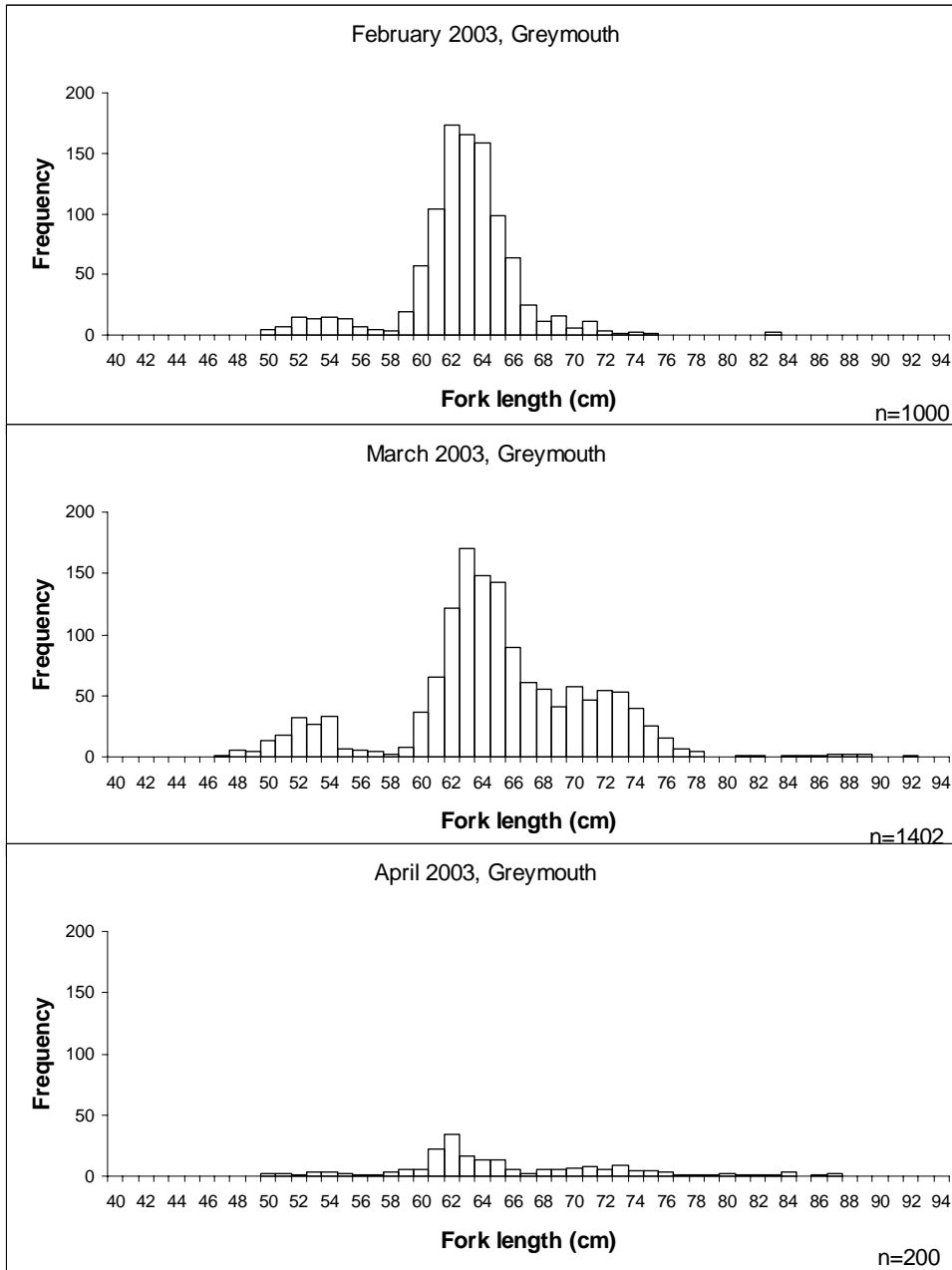


Figure 4: Length frequency distributions for six years of troll sampling from 1997 to 2002

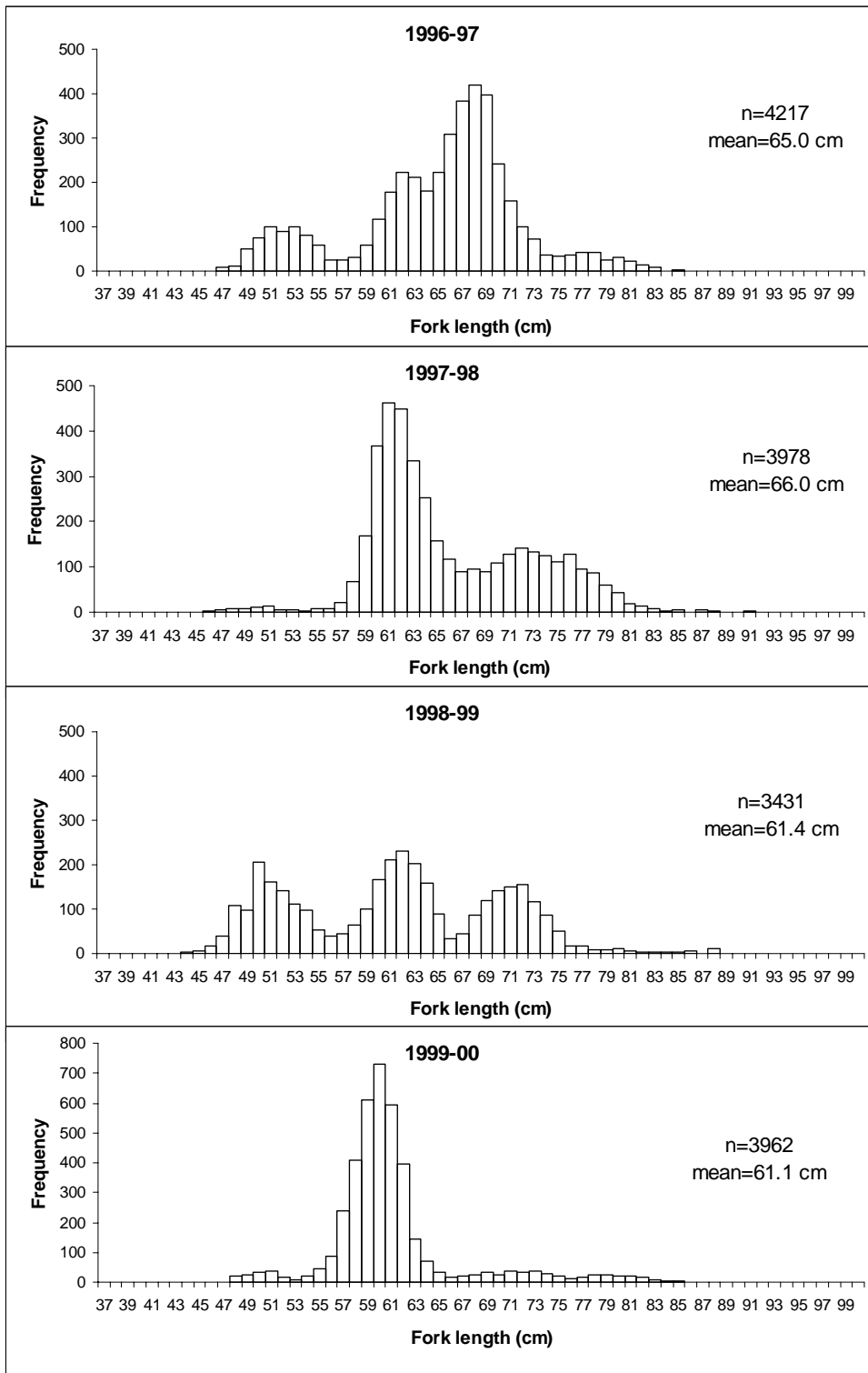


Figure 4 continued

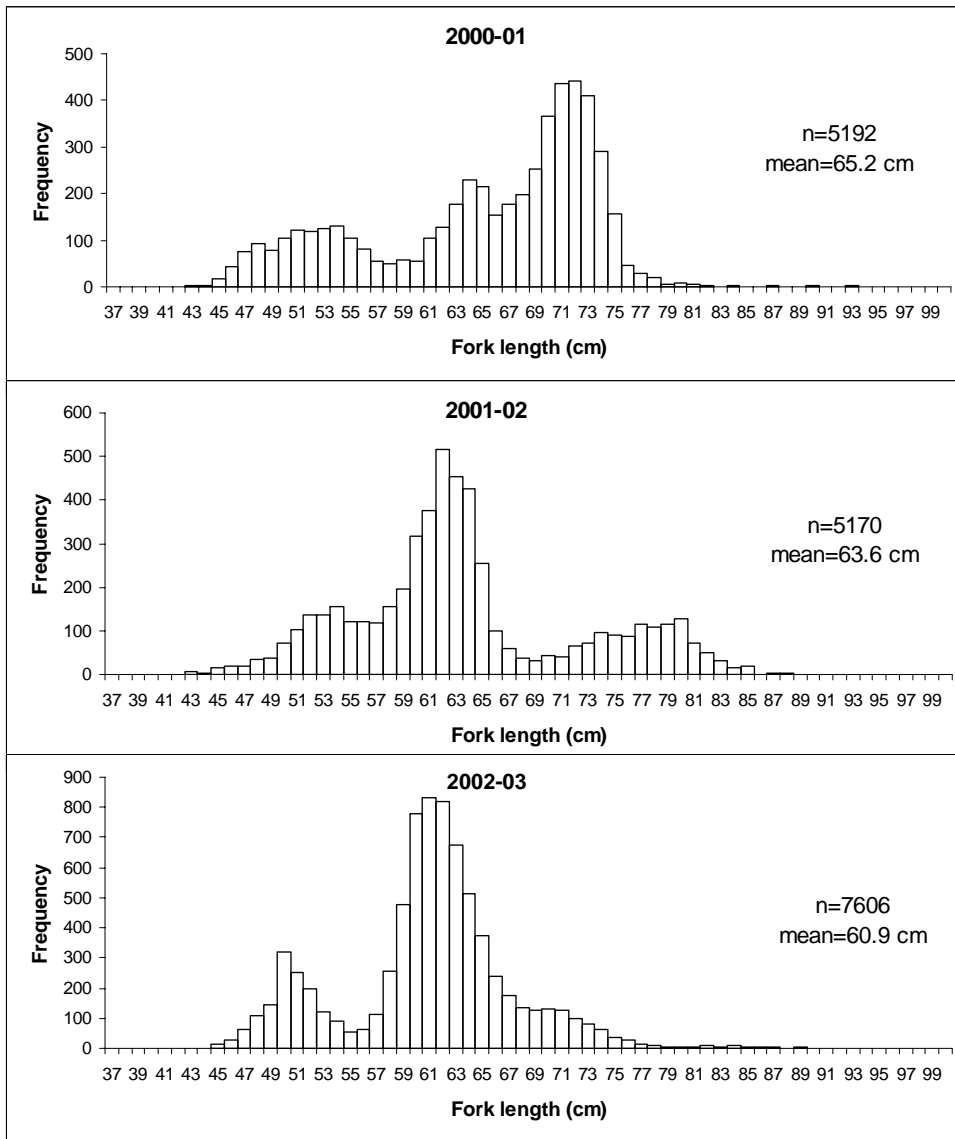


Figure 5: Length frequency distribution for troll and longline caught albacore

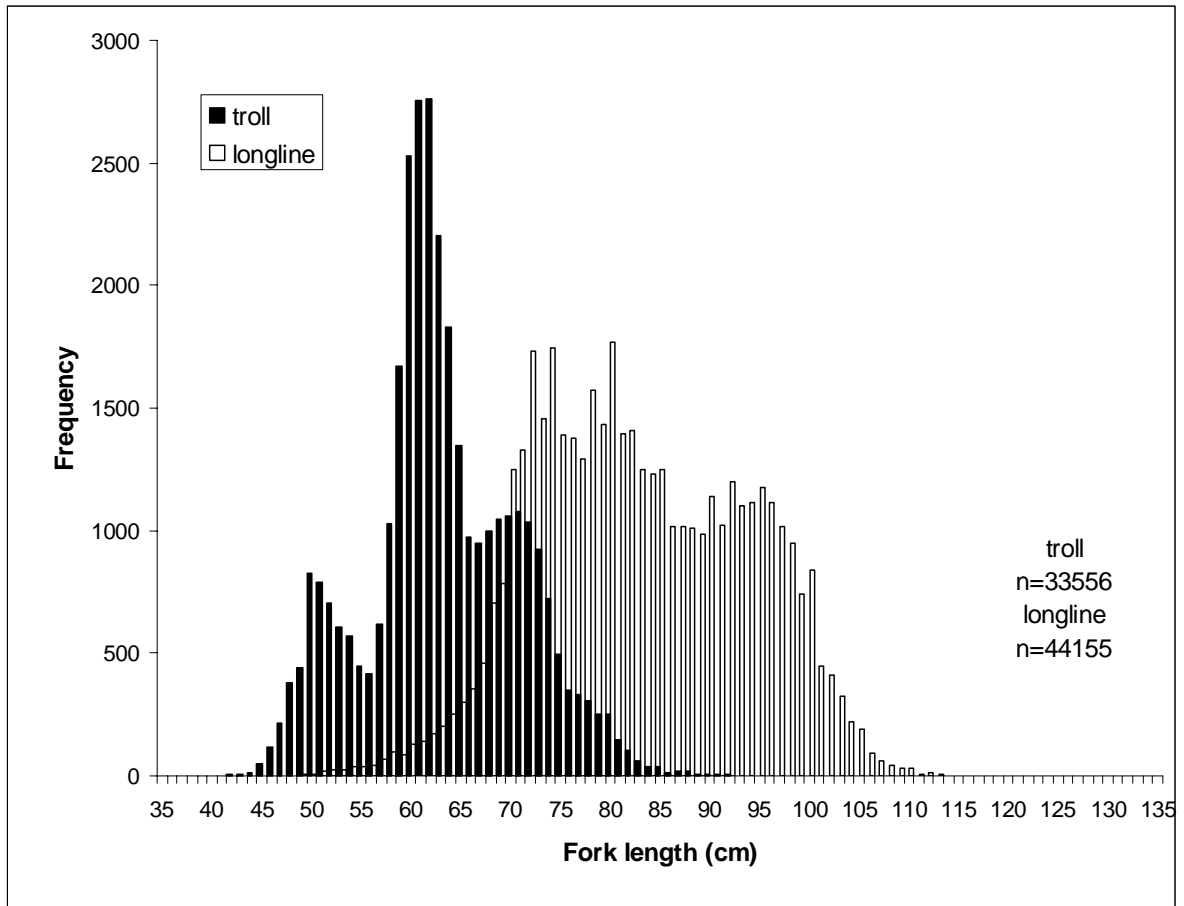




Figure 6: Length:weight relationship for troll caught albacore sampled in 2002–03

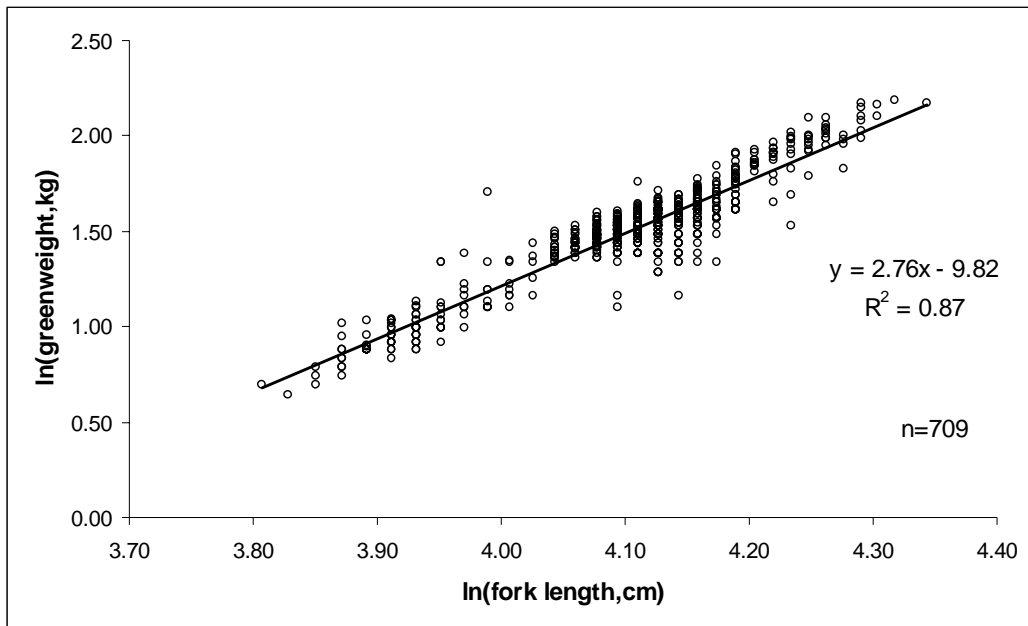


Figure 7: Length:weight relationship for troll caught albacore sampled in 1999–2003

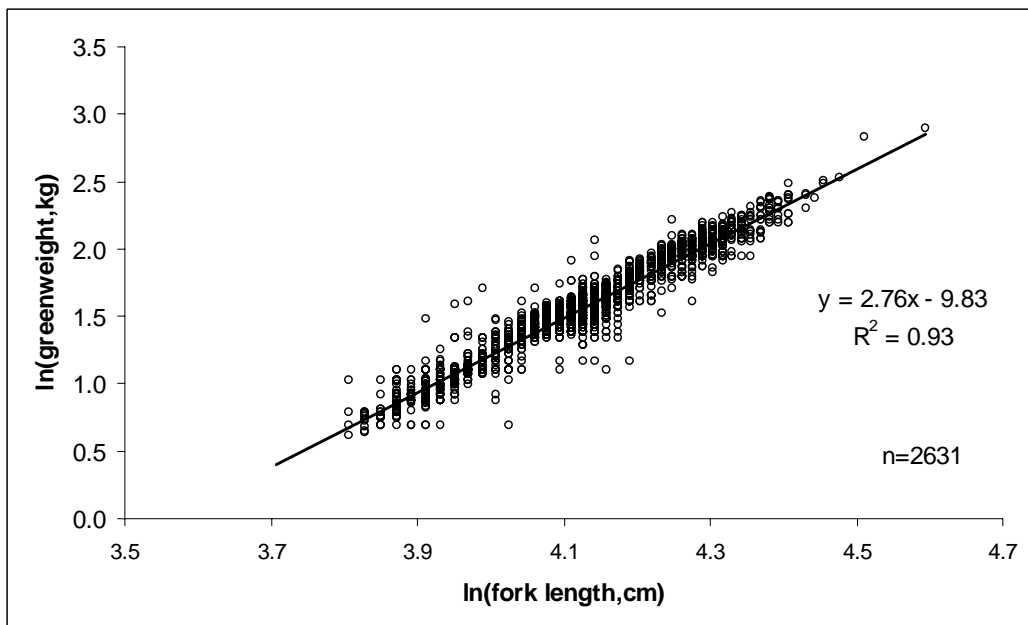


Figure 8: Length:weight relationship for troll and longline caught albacore

