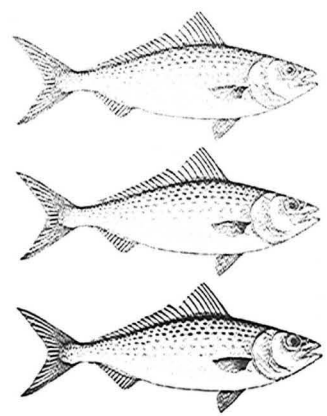


Size distribution of kahawai in commercial and recreational catches

E. Bradford



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Abstract

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Kahawai size distributions from commercial catch sampling, recreational surveys, and other sources are plotted in a uniform format.

The catch sampling size distributions (formed by combining weighted samples) from the purseseine fishery vary from year to year. In the Bay of Plenty, they are dependent upon whether the kahawai were caught in the kahawai target or bycatch fishery. The total purseseine catch in a year comes mainly from a few landings, each of which consists of the fish from a few schools. Hence, the purseseine catch is likely to be a highly variable sample of the kahawai population and the size distributions from the purseseine catch will represent the catch each year but not the population. Most, but not all, of the commercial catch comes from deeper water where juvenile kahawai are unlikely to occur.

Size distributions from the recreational fishery cover a wide length range. These size distributions come from the small catches of a large number of fishers and, as the fishers are sampled in a random way, are likely to form a random sample of the kahawai population available to recreational fishers. Most, but not all, of the recreational catch is taken from shore or close to shore. Although kahawai of all sizes inhabit the waters fished by recreational fishers, there has been speculation that the adult kahawai which are found in inshore waters may form a sub-population which is largely distinct from the adult kahawai in deeper waters. Hence, the recreational fishery may not have uniform access to the whole kahawai population.

Finding comparable size distributions of commercial and recreational catch, that is, ones collected at the same time in the same area, is difficult because of the timing of the catch sampling and recreational survey programmes and the different seasonal distributions of the commercial and recreational fisheries. However, those that have been chosen for comparison show that the recreational size distributions cover a wide size range and tend to have more small and more large kahawai than the more limited size range of the commercial distributions.

As the commercial and recreational size distributions are collected and constructed by quite different means they are not easily comparable statistically. However, they are so different that no formal tests are required.

Recreational fishers have an interest in catching large kahawai, say, those greater than 55 cm and would like large numbers of these fish available. All fishing reduces the numbers of fish which can grow to their maximum size. Changes from year to year in the proportions of large fish in the recreationally caught kahawai in the North region boat ramp surveys were investigated, and some were significant. Changes in the proportion of large fish do not tell us how many large fish were available, but serve as an indication of changes in the numbers of fish.

Comparing the recreational size distributions from the same area, but in different years, may be a useful tool for monitoring the kahawai population.

Introduction

Much kahawai size distribution data exist, mainly from sampling the commercial catch in 1990–93 (Jones *et al.* 1992, McKenzie *et al.* 1992, Drummond & Wilson 1993, Drummond 1995, Bradford 1998a), and from recreational boat ramp surveys in 1991, 1992–93, 1994, and 1996 (Sylvester 1993, 1994a, 1994b, 1995, Hartill *et al.* 1998) and the 1996 national diary survey of marine recreational fishing (Bradford *et al.* 1998). Other size distribution data come from the kahawai tagging programmes in the early 1980s (Wood *et al.* 1990) and in 1991 (Griggs *et al.* 1998), and a small amount from trawl surveys. These data are plotted and where practicable compared. The specified intention of these comparisons was to help determine the interactions between the recreational and commercial fisheries.

A statistical procedure to test the significance of the differences in the commercial and recreational size distributions is not readily available as they are sampled differently. The commercial size distributions are constructed from samples of the landings weighted by the catch size whereas the recreational size distributions are from individual fish.

Much of the recreational kahawai catch is taken from shore or close inshore and the commercial catch is mainly taken further out (in the 100–200 m depth zone, though some recreational fishers do fish for kahawai here). The recreational diary surveys run since 1991 gave information on how and where recreational fishers catch kahawai, though this information is not fully documented (Bradford 1995, 1996, 1998b). The distribution of kahawai size with depth suggests that while the juvenile kahawai are mainly inshore, the larger kahawai are found from close inshore to waters over 100 m in depth (Jones 1995). There are many past reports of large kahawai being present in large numbers close inshore, for example, the Motu River mouth (Rowe 1983).

Programme objective

1. To carry out a stock assessment of kahawai, including estimating biomass and sustainable yields

Objective for 1997–98

1. To compare the size structure of kahawai taken by recreational fishers as determined in past boat ramp surveys and the 1996 diary survey with the size structure taken by the commercial fleet as determined by past sampling of the commercial catch.

Methods

The commercial catch size distributions (frequency against length) were estimated as combinations of the weighted (by landed catch over sample weight) size distributions of the sampled fish. No further weighting was applied when data from different years were combined. The data were obtained from the market sampling database (*market*). Where possible, the data were grouped for consistency with the available recreational data. The estimated *c.v.s* for each length class were included on the plots and were estimated according to the procedure given by Davies & Walsh (1995).

The recreational kahawai size distributions (frequency against length) from the 1991, 1994, and 1996 North region boat ramp surveys, the 1992–93 Central region boat ramp survey, and the 1996 National diary survey were collated and plotted. These data are stored in the recreational survey database (*rec_data*). Kahawai size distributions from the 1980s tagging (from the *tag* database) and from trawl surveys (from the *trawl* database) were plotted where appropriate.

All these databases are maintained by NIWA for the Ministry of Fisheries.

The cumulative distribution functions (CDFs) of the above size distributions were plotted for appropriate pairs of CDFs (one commercial, one recreational). Different seasonal patterns in the recreational and commercial kahawai fisheries and different years of data collection could introduce a possible confounding of effects from temporal causes in any comparisons made.

The comparison of point statistics of the recreational and commercial size distributions, for example the distribution means, is not considered appropriate when the distributions have distinct modal peaks, nor is something like a simple t-test for the difference of means thought to be statistically viable. Though the commercial size distributions represent many thousands of fish, the actual degrees of freedom (effective number of points involved in calculating the standard deviation of mean, say) will be very much smaller. There is considerable within-sample correlation in the samples taken from the purseseine catch. However, the minimum, maximum, first and third quartiles, median, and mean were tabulated for the commercial and recreational size distributions.

The recreational and commercial size distributions are so obviously different that it was unnecessary to apply a statistical test.

Recreational fishers are concerned about the decrease in the numbers of large fish in their catch. The numbers of large kahawai available can not be estimated at present. However, the proportions of large fish (those greater than 55 cm) in the total number measured and in the adults were estimated for kahawai from the North region boat ramp surveys. These proportions were then tested for differences between years.

Results

Figure 1 shows the boundaries of the kahawai Fishstocks that adjoin the New Zealand coastline, coastal Quota Management Area (QMA) boundaries, and statistical areas used as subdivisions of KAH 3.

Commercial data

The 1990–93 catch sampling kahawai size distributions were published by Drummond & Wilson (1993), Drummond (1994, 1995), Jones *et al.* (1992), and McKenzie *et al.* (1992).

Figures 2–13 show the size distributions obtained during the 1990–93 kahawai catch sampling programmes in the North and Central regions. Some landings were stratified mainly into size classes. For this report, each stratum is treated as a separate landing. Effectively, that means that most of the within-landing variation is represented as between-landing variation. The length samples were weighted by the fraction of the landing that was sampled and summed. Each plot of the commercial size distributions includes the *c.v.* (Davis & Walsh 1995), the number of fish measured, *M*, and the number of “landings”, *K*. Plots are given by area, method, and fishing year and a combined (over all years sampled) plot by area and method. The areas used are defined in Table 1. The landings in KAH 3 have been divided into several areas based on statistical areas. The combined data from QMA 7 is also presented. The Kaikoura data (which were mainly larger, probably older, fish) are taken to represent kahawai from QMA 3. Summary statistics for the data plotted in Figures 2–13 are given in Table 2.

Table 1: Definitions of the areas for which commercial catch samples are given

Fishstock	Area	Definition
KAH 1	BPLE	Bay of Plenty
KAH 9	WCNI	West coast of the North Island
KAH 2	ECNI	East coast of the North Island
KAH 3	KAIK	Kaikoura (statistical area 18)
	Challenger	South west of the North Island (statistical areas 37, 39, and 40)
	Tasman/Golden Bay	Statistical area 38
	WCSI	West coast of the South Island (statistical area 36)
	Marlborough	Statistical area 17
	NCSI	North coast of the South Island (statistical areas 17, 18, 36, and 38 where the landing came from catches in more than one area)
	QMA 7	Combined KAH 3 data excluding data from Kaikoura

Table 3 gives summary statistics of the commercial data sets used in comparisons with the recreational data.

Except on the west coast of the North Island, the catch sampling came mainly from the purseseine fishery. In the Bay of Plenty, the kahawai target and kahawai bycatch purseseine fisheries were separated. Elsewhere, the number of kahawai bycatch landings sampled was too small to warrant separate treatment.

Table 2: Summary statistics for distributions from commercial catch sampling. Min., minimum; Max., maximum; Q1 and Q3, first and third quartile. The figure on which the data are plotted is indicated

	Min.	Q1	Median	Mean	Q3	Max.
Bay of Plenty						
Figure 2						
Target purseseine 90–91	35	42	44	45.53	48	61
Target purseseine 91–92	29	41	43	43.27	47	58
Target purseseine 92–93	31	36	38	42.19	50	60
Target purseseine All	29	40	43	43.43	48	61
Figure 3						
Other purseseine 90–91	31	38	44	43.76	49	60
Other purseseine 91–92	29	34	49	45.42	53	60
Other purseseine All	29	37	45	44.44	51	60
Figure 4						
Trawl bycatch 90–91	34	45	48	47.74	51	58
Trawl bycatch 91–92	39	48	50	49.69	52	59
Trawl bycatch 92–93	46	48	50	49.77	51	53
Trawl bycatch All	34	46	49	48.45	51	59
West coast North Island						
Figure 5						
Purseseine 90–91	32	42	47	46.58	51	60
Purseseine 91–92	40	46	49	48.49	51	59
Purseseine All	36	46	49	48.45	51	59
Figure 6						
Pair trawl bycatch 90–91	31	42	46	45.35	49	59
Pair trawl bycatch 91–92	40	47	49	48.94	51	59
Pair trawl bycatch 92–93	29	44	48	47.54	51	61
Pair trawl bycatch All	25	43	47	46.17	50	61
Figure 7						
Trawl bycatch 90–91	39	46	48	48.60	51	59
Trawl bycatch 91–92	37	44	47	46.65	49	56
Trawl bycatch 92–93	23	45	49	47.79	51	60
Trawl bycatch All	23	45	48	47.54	50	60
East coast North Island						
Figure 8						
Purseseine 90–91	42	49	50	49.96	51	56
Purseseine 91–92	40	48	49	49.55	51	56
Purseseine 92–93	32	47	49	48.75	51	57
Purseseine All	32	48	49	49.33	51	57

Table 2 — continued

	Min	Q1	Median	Mean	Q3	Max
Kaikoura						
Figure 9						
Purseseine 90–91	37	51	53	53.06	55	63
Purseseine 91–92	42	51	53	52.81	55	62
Purseseine 92–93	44	52	53	53.34	55	62
Purseseine All	38	51	53	53.02	55	63
Challenger						
Figure 10						
Purseseine 90–91	38	48	50	50.18	52	58
Purseseine 91–92	38	48	51	50.15	52	59
Purseseine 92–93	32	50	51	50.51	53	61
Purseseine All	32	49	51	50.42	53	61
Tasman and Golden Bays						
Figure 11						
Purseseine 90–91	30	35	37	40.66	48	57
Purseseine 91–92	26	30	32	34.09	39	52
Purseseine 92–93	28	34	35	34.53	35	38
Purseseine All	26	33	35	36.72	40	57
West coast South Island						
Figure 12						
Purseseine 90–91	39	48	50	49.97	52	59
Purseseine 91–92	28	32	33	35.58	35	55
Purseseine All	28	32	33	36.16	37	57
Marlborough						
Figure 12						
Purseseine 90–91	30	45	50	47.66	52	62
Purseseine 91–92	43	51	52	52.32	54	60
Purseseine All	30	47	50	48.32	52	62
North coast South Island						
Figure 13						
Purseseine 90–91	36	49	51	50.81	53	60
Purseseine 91–92	34	44	49	47.73	52	59
Purseseine All	34	48	51	50.08	53	60
QMA 7						
Figure 13						
Purseseine 90–91	30	36	48	45.04	51	62
Purseseine 91–92	26	31	33	36.11	40	60
Purseseine All	26	32	36	39.71	48	62

Table 3: Summary statistics by length group for commercial data used in comparisons with recreational data. *N*, number of measured lengths; Min., minimum; Max., maximum; Q1 and Q3, first and third quartile

	<i>N</i>	Min.	Q1	Median	Mean	Q3	Max.
Bay of Plenty purseseine 1990–91	12 764	31	42	44	45.03	48	61
Bay of Plenty trawl 1990–91	1 141	34	45	48	47.74	51	58
KAH 9 purseseine 1990–91	592	32	42	47	46.58	51	60
KAH 9 trawl & pair trawl 1990–91	3 929	25	42	46	45.54	49	61
KAH 2 purseseine 1992–93	2 183	32	47	49	48.75	51	57
QMA 7 purseseine 1992–93	15 223	26	32	36	39.71	48	62

Most of the kahawai sampled on the west coast of the North Island were from the pair trawl and trawl bycatch fisheries. Some kahawai were sampled from the trawl bycatch fishery in the Bay of Plenty and on the east coast of the North Island.

Examination of Figures 2–13 and Table 2 shows that the commercial fishery, particularly the purseseine fishery, takes fish from only a few schools. Hence, the length samples taken from commercial landings will be highly variable, poor estimates of the kahawai population, and contain little information about the year class strengths of younger fish.

Recreational data

Most recreational fishing occurs from or close to shore. Smaller kahawai are found only in shallower water (*see* Figure 38 that is an updated version of figure 2 in Jones 1995) and are caught by recreational fishers. Large kahawai are found at all depths out to about 200 m; they can be caught by surf casting from the shore. Thus the recreational kahawai size distributions extend from less than 20 cm fish to over 65 cm fish.

The kahawai size distributions measured during the 1991 and 1994 North region, 1992–93 Central region, and 1996 national boat ramp surveys are given in Figures 14–18. Summary statistics are given in Tables 4 and 5. Size distributions from KAH 1 are given by sub-region (East Northland, Hauraki Gulf, and Bay of Plenty) as well as for the whole of KAH 1. The kahawai size distributions measured by diarists during the 1996 national diary survey are given in Figures 19 and 20. The number of fish measured, *n*, is given on each plot.

The proportions of large kahawai in the total size distribution and in the adults are estimated for the fish caught in the North region boat ramp surveys (Table 6). Recreational fishers have an interest in catching large kahawai, say, those greater than 55 cm. Changes in the proportion of large fish do not tell us how many large fish were available, but serve as an indication of changes in the numbers of fish.

Bradford *et al.* (1998) gave comparisons between the 1996 boat ramp size distributions and those measured by diarists. The diarists gave adequate kahawai size distributions for most purposes, and thus diarist measurements provide a suitable way of obtaining kahawai size distributions in remote areas where recreational fishing effort is dispersed and adequate sampling from boat ramp surveys would be expensive.

Table 4: Summary statistics by length group, region, and year of survey for recreationally caught kahawai measured at boat ramps in the North region. *N*, number of measured lengths; Min., minimum; Max., maximum; Med., median; Q1 and Q3, first and third quartile. The size distributions are plotted in Figures 14–16

	<i>N</i>	Min.	Q1	Med.	Mean	Q3	Max.
Bay of Plenty							
1991	3 512	13	36	43	42.19	49	71
1994	950	15	37	45	44.12	52	65
1996	1 731	18	39	47	45.31	52	68
Hauraki Gulf							
1991	1 034	17	30	35	35.44	39	73
1994	896	15	32	38	39.92	50	73
1996	716	23	31	36	38.45	45	65
East Northland							
1991	475	20	34	44	41.73	49	66
1994	458	19	36	45	43.43	50	64
1996	1 094	23	42	48	46.27	51	66
KAH 1							
1991	5 021	13	34	41	40.75	48	73
1994	2 304	15	34	42	42.35	51	73
1996	3 541	18	37	46	44.22	51	68
West coast–KAH 9							
1991	2 329	17	36	41	40.76	47	77
1994	1 240	15	33	39	40.19	47	66
1996	1 744	10	30	37	37.97	46	70

Table 5: Summary statistics by length group, region, and year of survey for recreationally caught kahawai measured at boat ramps in the Central and South regions. *N*, number of measured lengths; Min., minimum; Max., maximum; Med., median; Q1 and Q3, first and third quartile. The size distributions are plotted in Figures 17–18

	<i>N</i>	Min.	Q1	Med.	Mean	Q3	Max.
KAH 2							
1992–93	1 504	19	37	46	44.28	52	80
KAH 3							
1992–93	672	18	30	33	33.90	38	69
1996	168	21	35	42	41.94	47	64

Other data

Some size distributions of kahawai tagged and released in the 1980s study (Wood *et al.* 1990) are shown in Figure 21. The examples are from areas where the number of measured fish released was large enough to give an adequately determined size distribution. The fish were captured by methods available to recreational fishers, but often they are of fish caught from one or a few schools and thus are not truly representative of the recreational catch at this time. Few of the kahawai caught by purse seine (before tagging and release) were measured in the 1980s tagging study. The size distributions of kahawai tagged during 1991 from Tasman Bay and the Bay of Plenty (Griggs *et al.* 1998) are shown in Figure 22.

Figure 22 also shows size distributions from trawl surveys where kahawai were caught in sufficient numbers to give an adequate size distribution. Mainly small kahawai are susceptible to the *Kaharoa* trawl gear and many kahawai are caught in a few trawls (kahawai can usually outswim the trawl).

Table 6: Numbers of juveniles (< 40 cm), 40–55 cm, and large (> 55 cm) kahawai and the total number measured in the recreational boat ramp survey in the area and year specified together with the proportions of large kahawai in the total and in the adults (all fish > 39 cm). The degrees of freedom (df), χ^2 -values, and *p*-values are given for a series of proportions tests

East Northland

Year	Juveniles	40–55 cm	Large	Total	Proportions of	
					large in total	large in adult
1991	168	292	15	475	0.032	0.049
1994	143	294	21	458	0.046	0.067
1996	183	846	65	1 094	0.059	0.071
Proportions tested		df	χ^2 -value	<i>p</i> -value		
Large in total, 3 years		2	5.62	0.060		
Large in adults, 3 years		2	1.89	0.389		
Large in adults, 1991 & 1994		1	0.62	0.436		
Large in adults, 1991 & 1996		1	1.54	0.214		
Large in adults, 1994 & 1996		1	0.02	0.879		

Hauraki Gulf

Year	Juveniles	40–55 cm	Large	Total	Proportions of	
					large in total	large in adult
1991	787	233	14	1 034	0.014	0.057
1994	469	374	53	896	0.059	0.124
1996	441	242	33	716	0.046	0.120
Proportions tested		df	χ^2 -value	<i>p</i> -value		
Large in total, 3 years		2	29.32	0.000		
Large in adults, 3 years		2	8.42	0.015		
Large in adults, 1991 & 1994		1	7.22	0.007		
Large in adults, 1991 & 1996		1	5.62	0.018		
Large in adults, 1994 & 1996		1	0.00	0.964		

Bay of Plenty

Year	Juveniles	40–55 cm	Large	Total	Proportions of	
					large in total	large in adult
1991	1 296	2 108	108	3 512	0.031	0.049
1994	322	546	82	950	0.086	0.131
1996	452	1 104	175	1 731	0.101	0.137
Proportions tested		df	χ^2 -value	<i>p</i> -value		
Large in total, 3 years		2	118.62	0.000		
Large in adults, 3 years		2	94.22	0.000		
Large in adults, 1991 & 1994		1	51.26	0.000		
Large in adults, 1991 & 1996		1	83.38	0.000		
Large in adults, 1994 & 1996		1	0.09	0.761		

Table 6— continued

KAH 1

Year	Juveniles	40–55 cm	Large	Total	Proportions of	
					large in total	large in adult
1991	2 251	2 633	137	5 021	0.027	0.049
1994	934	1 214	156	2 304	0.068	0.114
1996	1 076	2 192	273	3 541	0.077	0.111
Proportions tested		df	χ^2 -value	<i>p</i> -value		
Large in total, 3 years		2	118.80	0.000		
Large in adults, 3 years		2	80.05	0.000		
Large in adults, 1991 & 1994		1	56.85	0.000		
Large in adults, 1991 & 1996		1	67.03	0.000		
Large in adults, 1994 & 1996		1	0.06	0.810		

West coast North Island — KAH 9

Year	Juveniles	40–55 cm	Large	Total	Proportions of	
					large in total	large in adult
1991	923	1 364	42	2 329	0.018	0.030
1994	628	543	69	1 240	0.056	0.113
1996	977	737	30	1 744	0.017	0.039
Proportions tested		df	χ^2 -value	<i>p</i> -value		
Large in total, 3 years		2	53.07	0.000		
Large in adults, 3 years		2	63.85	0.000		
Large in adults, 1991 & 1994		1	54.76	0.000		
Large in adults, 1991 & 1996		1	1.05	0.305		
Large in adults, 1994 & 1996		1	26.60	0.000		

Comparisons of commercial and recreational size distributions

It is difficult to find comparable pairs of commercial and recreational size distributions that were collected in the same area at the same time. The seasonal distributions and locations of the fisheries are different.

KAH 1 – Bay of Plenty

The 1991 purse seine and trawl bycatch size distributions are compared with the 1991 boat ramp survey data from the Bay of Plenty (Figures 23 and 24). The distributions are obviously different without applying any test. The recreational size distributions contain both more smaller fish and more larger fish than the commercial size distributions. The summary statistics for the catch sampling data used in the comparisons are given in Table 3 and for the recreational data in Table 4.

The recreational boat ramp survey data from the Bay of Plenty in 1991, 1994, and 1996 provide interesting comparisons (Figures 25 and 26 and Table 4). More larger fish were

caught in 1996 than in 1991. Most of the change appears to have occurred between 1991 and 1994. The spatial and temporal distribution of sampling differed in the three surveys since the objectives changed from year to year, hence the data are not strictly comparable (Todd Sylvester, Ministry of Fisheries, Auckland, pers. comm.).

The results of testing the difference in proportions of large kahawai in the total sample from the recreational catch and in the adults in the sample are given in Table 6. This gives a rough indication of changes in the numbers of large fish (one of the concerns of the recreational fishery). Differences in the proportion of large kahawai in the total catch could be reflecting an increase in the proportion of juveniles, so restricting the testing to adult fish is somewhat better. The test for changes in the proportion of large adults was performed for the three boat ramp surveys together and for each pair of boat ramp surveys. These tests show no significant change in East Northland and that in the Hauraki Gulf, Bay of Plenty, and all KAH 1 the change (an increase) occurred between 1991 and 1994.

Kahawai over 70 cm have been measured occasionally in boat ramp surveys.

KAH 9 – west coast North Island

The 1991 purseseine and trawl and pair trawl size distributions are compared with the 1991 recreational boat ramp survey size distribution (Figures 27 and 28, and Tables 3 and 4). The same types of differences as observed in the Bay of Plenty occur in KAH 9.

The recreational size distributions from the 1991, 1994, and 1996 boat ramp surveys show a different pattern to that observed in the Bay of Plenty (Figures 29 and 30 and Table 4). Here there is evidence of a strong cohort of about 30 cm fish (probably 3 year olds) in 1996. However, slightly fewer larger fish were caught in 1996 than in 1991. Testing for the proportion of large fish in the adult population shows that this proportion was significantly higher in 1994 than either 1991 or 1996, which were not significantly different (*see* Table 6).

One can interpret the KAH 9 data by proposing that some of the kahawai population migrates through the area after being resident for a few years. Some inconsistencies in the catch sampling data can also be explained by such an hypothesis (Bradford 1998).

KAH 2 – east coast North Island

Data from the 1992–93 purseseine catch sampling in KAH 2 (collected in November 1992) and from the 1992–93 Central region boat ramp survey are compared (Figures 31 and 32, and Tables 3 and 5). These data were originally compared by Drummond (1995). The same pattern of more small and large fish in the recreational size distribution occurs.

KAH 3 – QMA 7

Size frequency data collected from the purseseine catch in 1990–91 and 1991–92 and the 1992–93 Central region boat ramp survey are compared (Figures 33 and 34 and Tables 3 and 5). Here both size distributions show strong modal peaks about 32 cm; more small fish and a few large fish are caught by recreational fishers. The commercial size distribution shows another modal peak around 50 cm. Most of the recreationally caught kahawai would have

come from the inshore waters of Tasman Bay, which is a nursery area for young kahawai (Drummond 1994).

Sample sizes of recreationally caught kahawai from QMA 3 (east coast of the South Island) are too small to be useful in comparisons and were collected in a different year from the commercial catch sampling data. The estimated number of kahawai caught in QMA 3 in the 1991–92 South region diary survey was 33 000 and in the 1996 national diary survey was 18 000 (Bradford, unpublished estimates). During the 1996 boat ramp survey, 33 kahawai were counted from the Kaikoura ramp compared with 317 blue cod, and 20 kahawai were counted from the Motanau ramp compared with 14 553 blue cod (from the database *rec_data*). These low catches are not consistent with the tagging effort along the east coast of the South Island in the early 1980s (Wood *et al.* 1990) and suggest kahawai numbers may have declined in this area.

Comparisons between 1996 recreational data and 1980s tagging data

The size distributions of kahawai caught in east Northland and the Bay of Plenty in the 1996 boat ramp survey are compared with those from fish tagged and released in the 1980s tagging study (Figures 35, 36, and 37). The 1980s Bay of Plenty fish were caught by line in and around the Motu River mouth. The fish from the tagging study were caught by methods available to recreational fishers, but would have been taken from a few schools and cannot be assumed to give a good representation of the recreational size distributions at the time. The fish caught in the 1980s tend to be larger than those caught in 1996, but the largest fish were caught in 1996 in both these areas.

Discussion

The commercial size distributions are weighted averages over samples from the landings made. Sampling the purse seine catch gives lengths from the small number of schools taken in the purse seine nets. The commercial size distributions represent the catch but as few landings are made these size distributions are poor estimates of the population size (or age) distribution (Bradford 1998a). The recreational size distributions come from the catches of individuals who have taken a small number of fish from a large number of schools. The commercial and recreational size distributions are so different that no statistical tests are required. The recreational size distributions have a higher proportion of small (< 40 cm) kahawai than most of the commercial size distributions and also tend to have more large kahawai than the commercial size distributions. Recreational fishers probably target the largest kahawai they can find.

The recreational diary survey results show that most of the kahawai catch is taken from or close to shore. The commercial catch is taken further from shore in general. Of course, some recreational fishers do fish in the deeper offshore waters. It is also known that juvenile kahawai live in the shallower (to about 50 m depth) inshore waters and it is only as adults that they may move into deeper waters. Adult kahawai are found at all depths out to about 200 m (Jones 1995). Thus the size distributions largely reflect where the fish are taken.

The kahawai tagging studies (Wood *et al.* 1990, Griggs *et al.* 1998) showed that some kahawai move throughout New Zealand waters. Experiments with loop-tagged kahawai show that they suffer from a fever reaction from the tag and the tag wounds do not heal properly (Griggs *et al.* 1998). Sick and injured kahawai are thought to move into sheltered warmer waters (discussions with Brent Wood, NIWA, Wellington and Clive Stanley, CSIRO,

Hobart). Many tagged kahawai were caught in set nets soon after the 1991 Tasman Bay tagging (Griggs *et al.* 1998), suggesting that they were seeking shelter. We can hypothesise that tagging causes a behaviour change in kahawai, reducing the probability of their moving long distances, and hence the large number of tag returns from close to the point of release does not imply that all kahawai are relatively sedentary. We can hypothesise that some adult kahawai remain in the same area, probably close to shore. This would mean that the recreational fishery tends to access a different adult population from the commercial fishery. Spawning kahawai may come inshore seeking shelter as they lose condition (become thinner) at that time (Bradford 1998a).

The commercial and recreational fisheries have different size selectivity patterns. This difference would need to be included in any population model. A better understanding of the on-shore, off-shore movement and migration would also be required if the interaction between commercial fishing is to be properly modelled.

Despite the problems associated with knowing how much of the kahawai stock the recreational fishery is accessing, using size and age distributions from the recreational fishery is a promising technique for monitoring the stock, particularly in the North region. Samples would have to be collected in the same fashion from year to year. The sampling effort required in KAH 2 and, particularly, KAH 3 to get sufficient data may be prohibitive. KAH 3 contains a long coastline and recreational kahawai catches are now low in some parts of this area. KAH 3 showed a significant decline in recreational harvest in 1997 in the comparisons made using the same diarists during 1996 and 1997 (Bradford *et al.* 1999). NIWA could not catch juvenile kahawai for the otolith microchemistry project in the Tasman Bay and Wellington areas for some months in the summer of 1996–97, suggesting a low juvenile kahawai availability in the area at that time.

Acknowledgments

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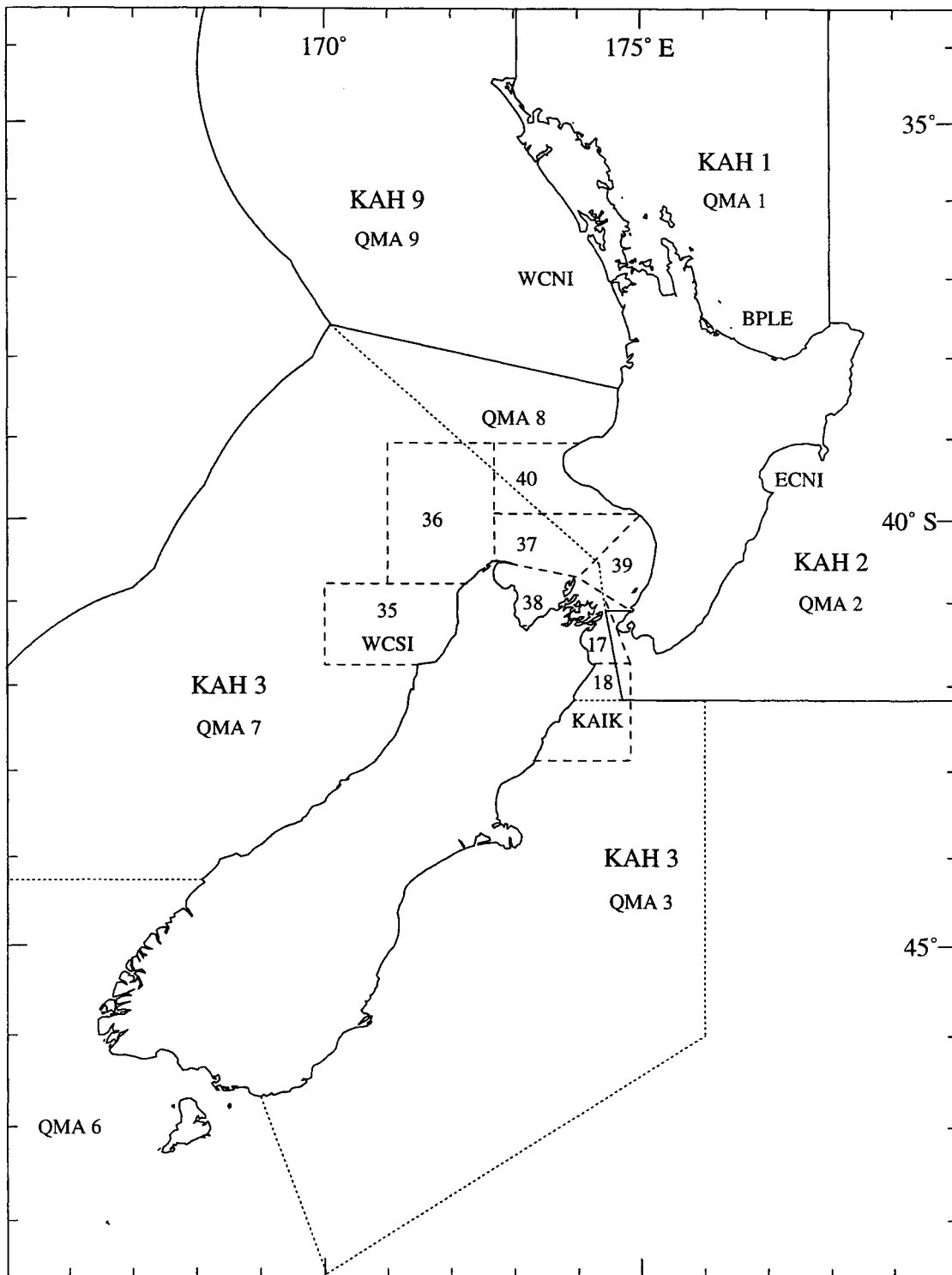


Figure 1: Map of New Zealand showing the kahawai Fishstocks and other areas referred to in this report. Fishstocks are drawn with solid line boundaries, the inshore QMAs with dotted line boundaries, and statistical areas with dashed boundaries.

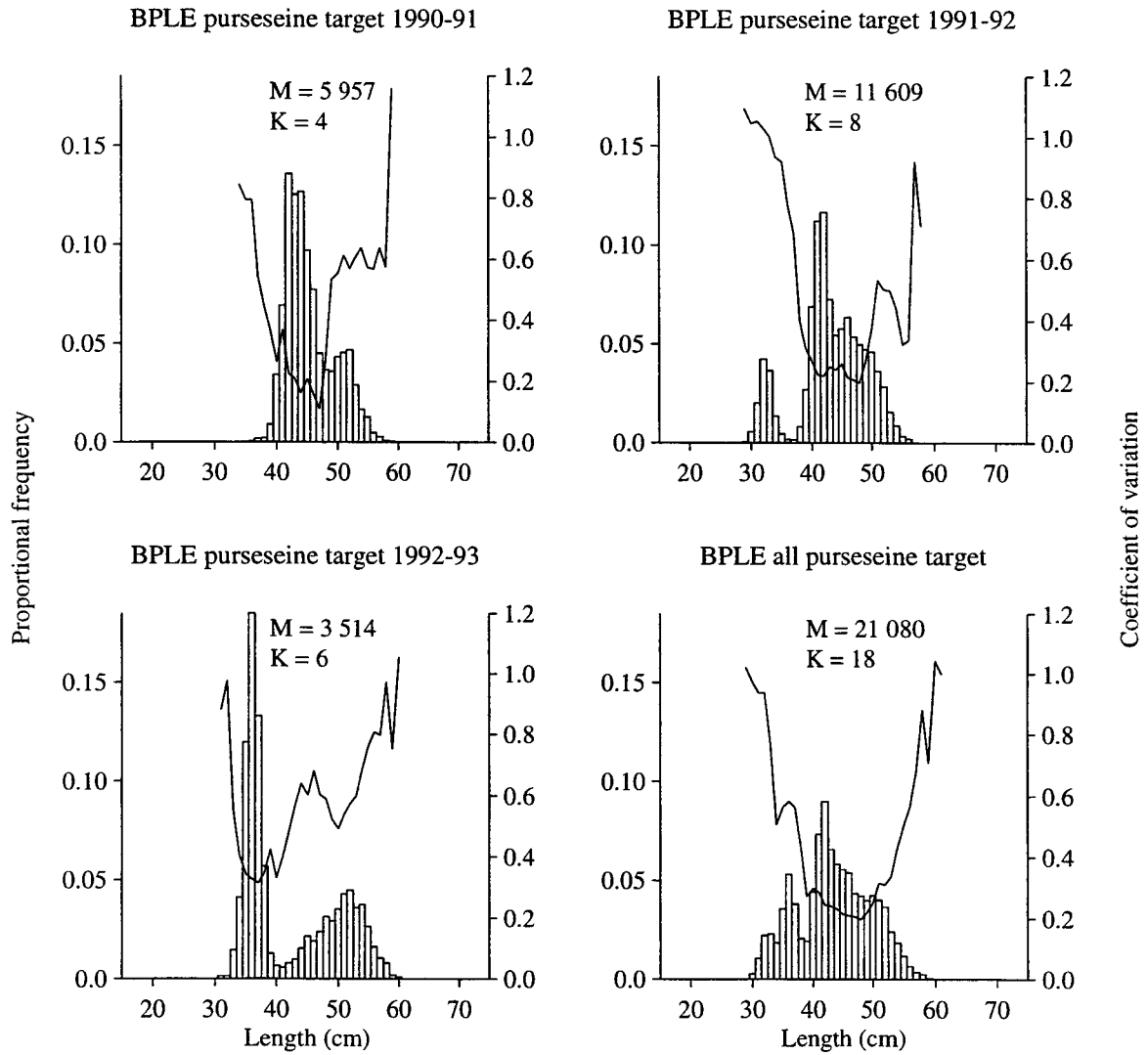


Figure 2: Kahawai size distributions from the catch sampling programme in the Bay of Plenty (BPLE) from 1990 to 1993. These data were sampled from kahawai caught as a target species of the purseseine fishery. M is the number of sampled fish and K is the number of landings.

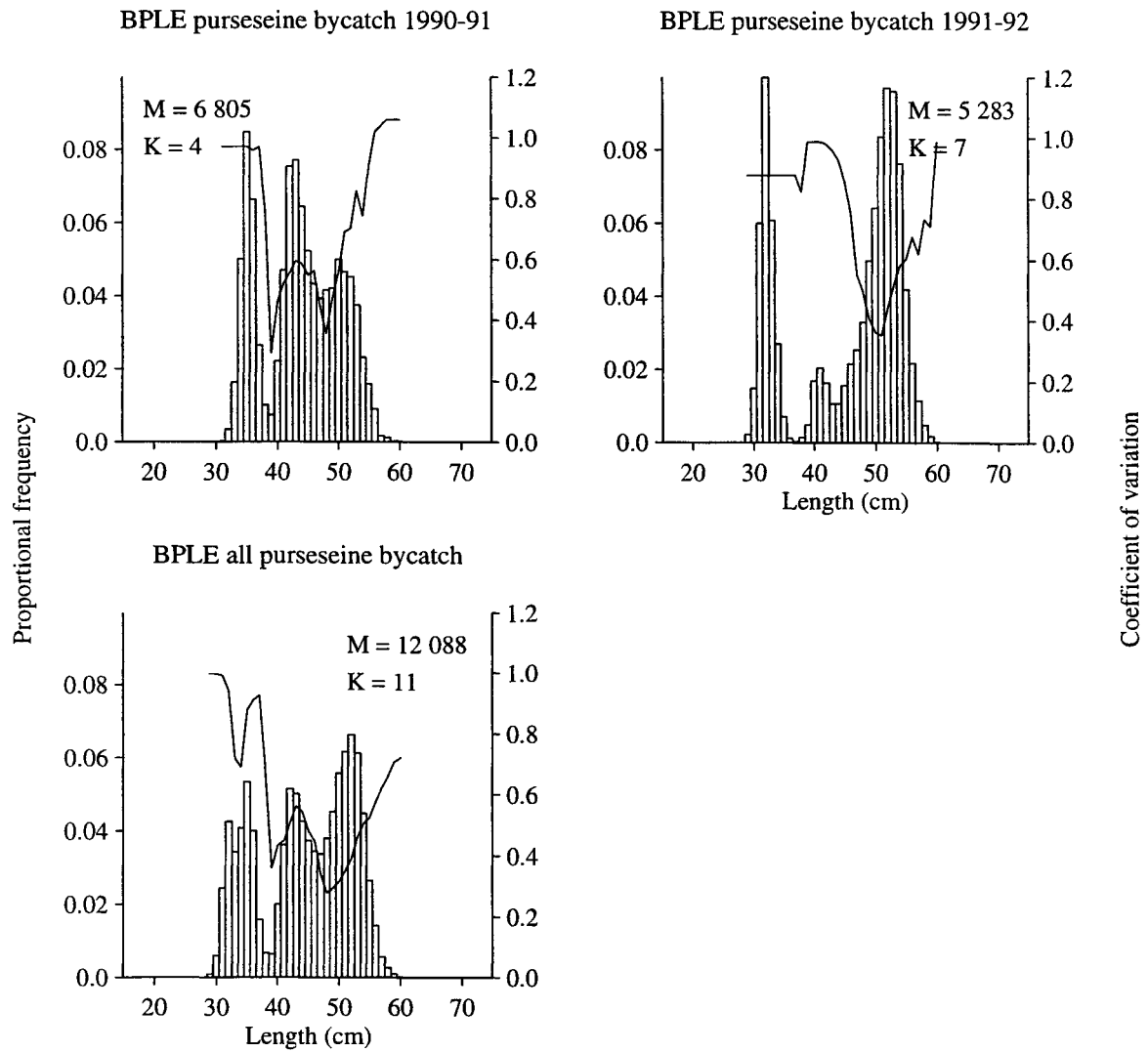


Figure 3: Kahawai size distributions from the catch sampling programme in the Bay of Plenty (BPLe) from 1990 to 1993. These data were sampled from kahawai caught as bycatch of other purseseine fisheries. M is the number of sampled fish and K is the number of landings.

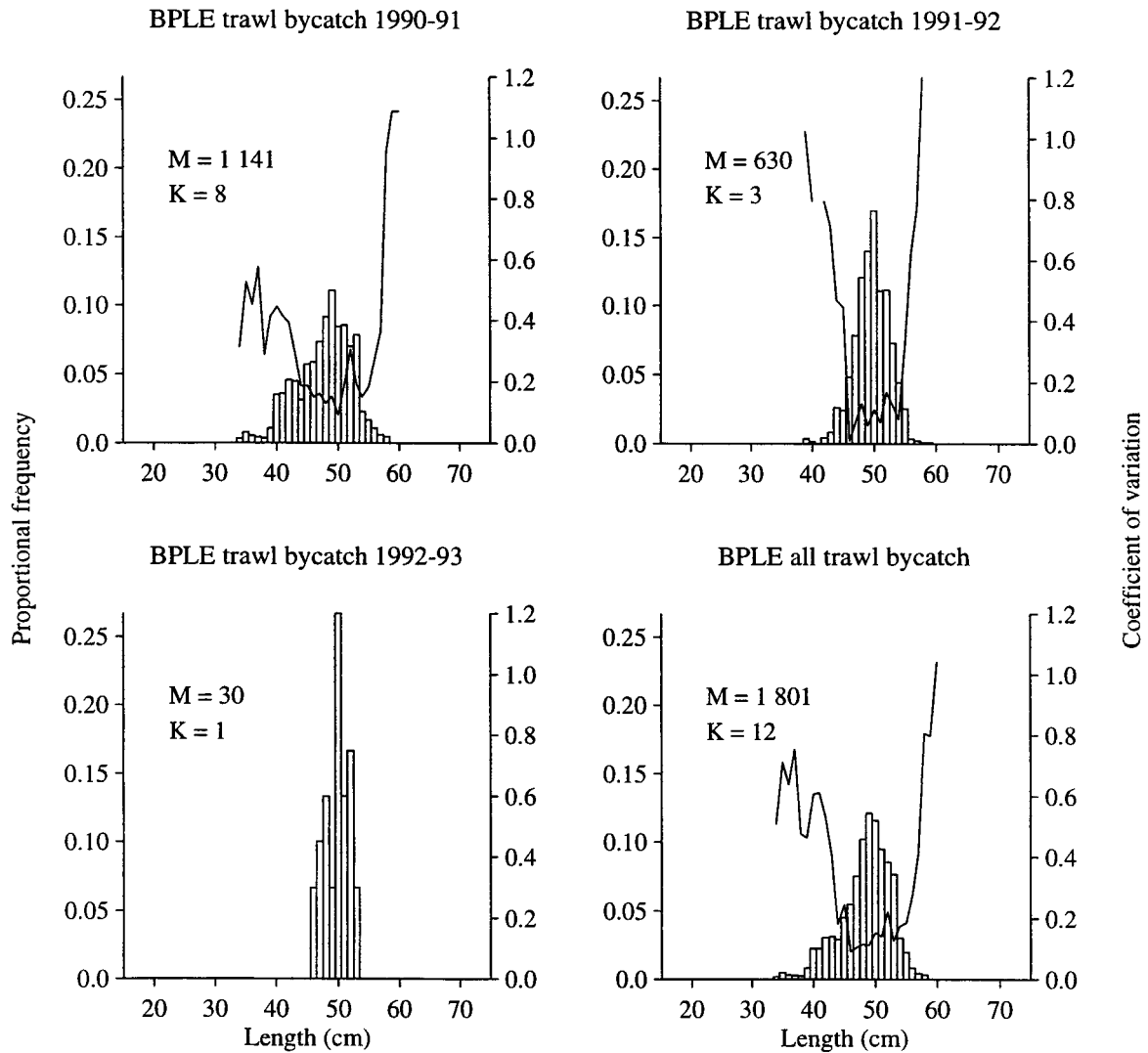


Figure 4: Kahawai size distributions from the catch sampling programme in the Bay of Plenty (BPLE) from 1990 to 1993. These data were sampled from kahawai caught as bycatch of the trawl fishery. M is the number of sampled fish and K is the number of landings.

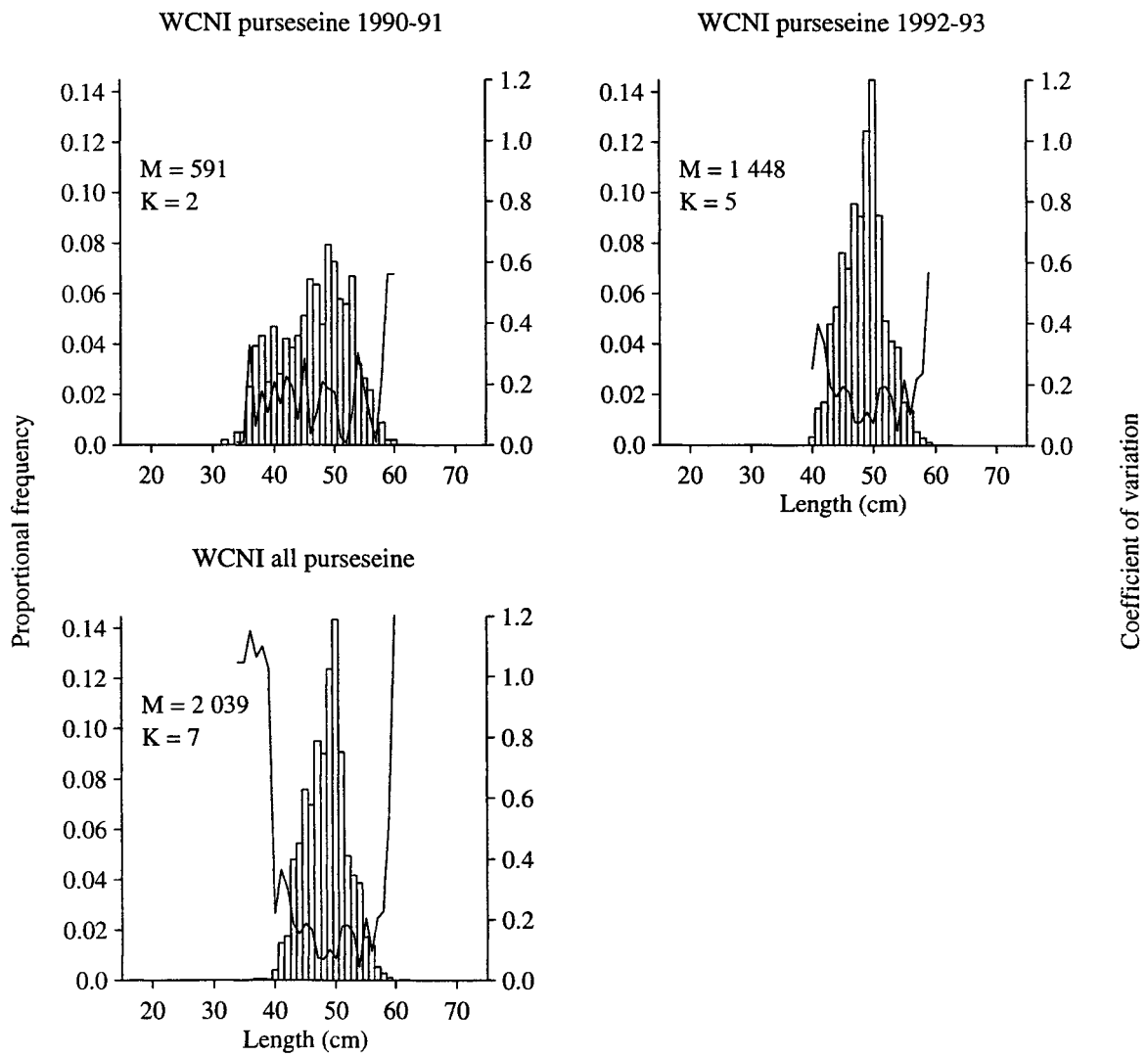


Figure 5: Kahawai size distributions from the catch sampling programme on the west coast of the North Island (WCNI) from 1990 to 1993. These data were sampled from the purseseine fishery. M is the number of sampled fish and K is the number of landings.

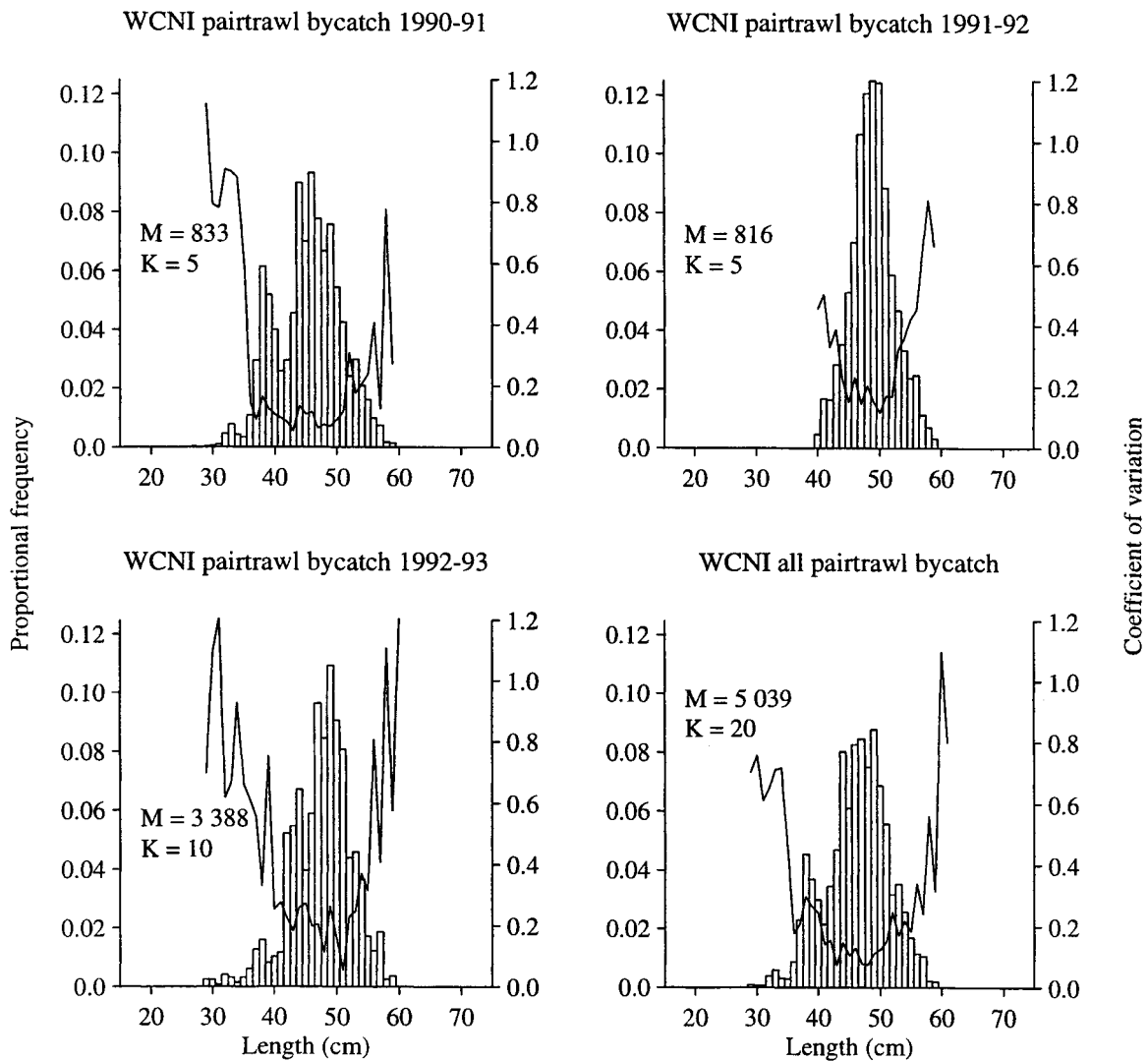


Figure 6: Kahawai size distributions from the catch sampling programme on the west coast of the North Island (WCNI) from 1990 to 1993. These data were sampled from kahawai caught as bycatch of the pair trawl fishery. M is the number of sampled fish and K is the number of landings.

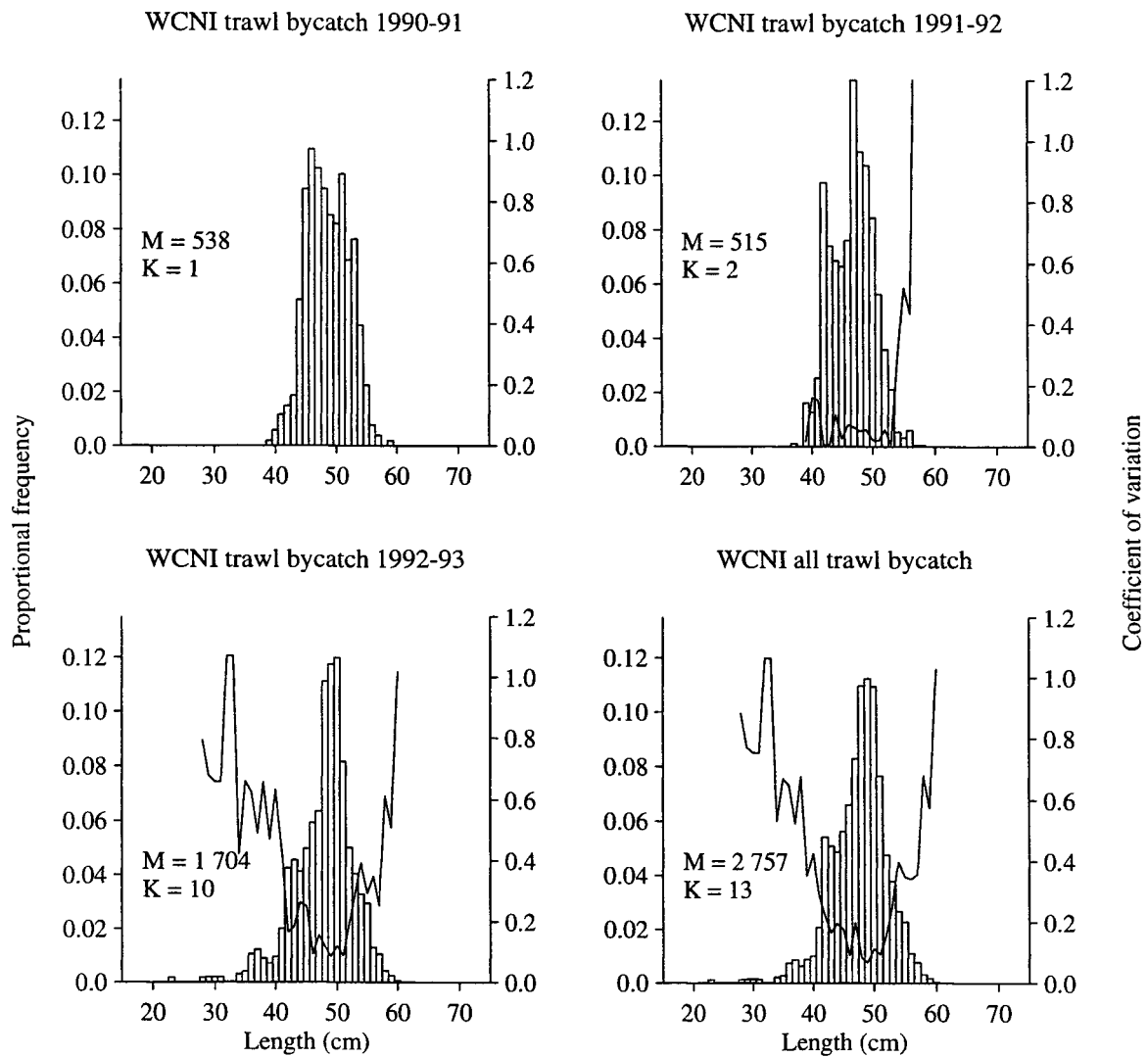


Figure 7: Kahawai size distributions from the catch sampling programme on the west coast of the North Island (WCNI) from 1990 to 1993. These data were sampled from kahawai caught as bycatch of the trawl fishery. M is the number of sampled fish and K is the number of landings.

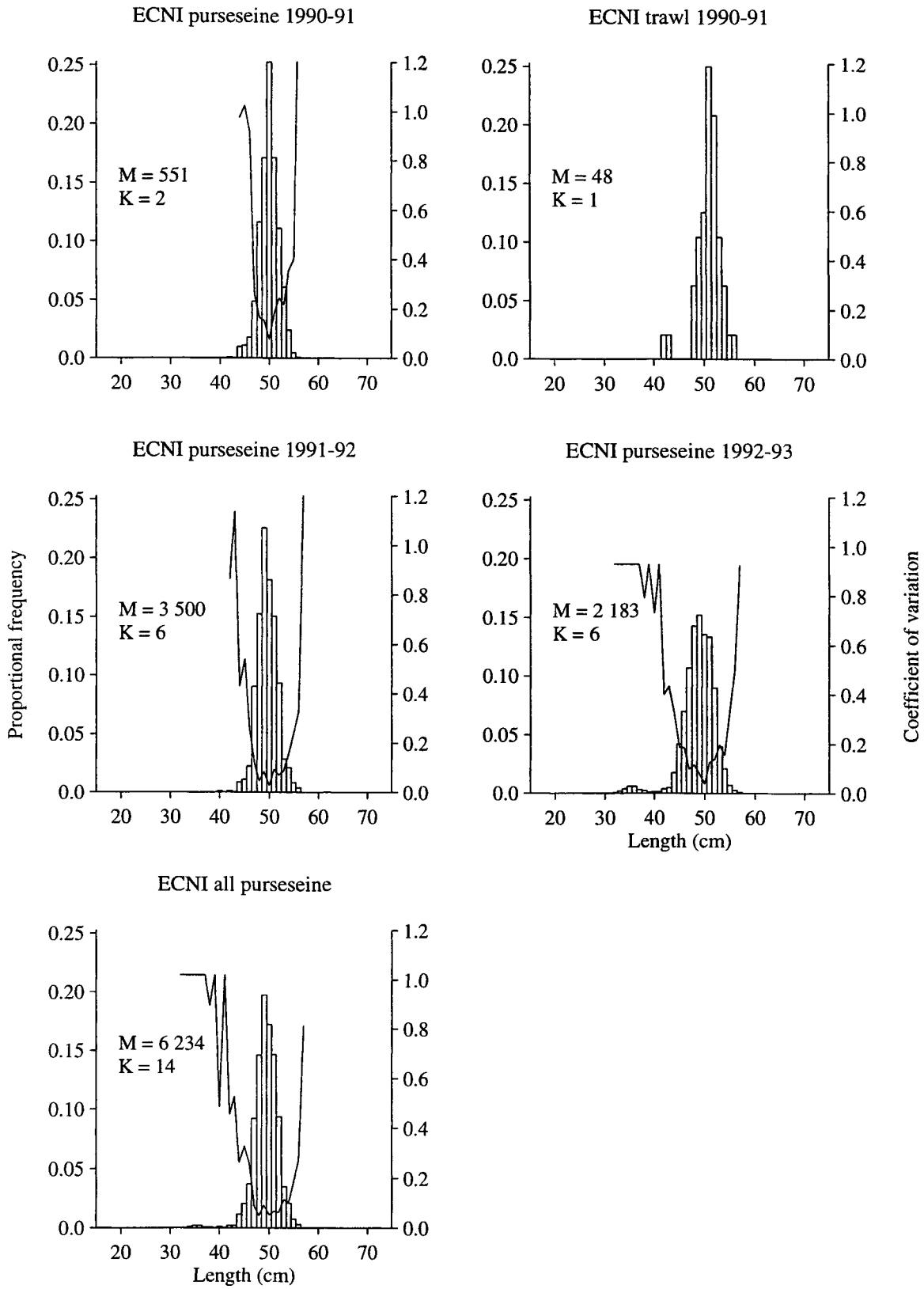


Figure 8: Kahawai size distributions from the catch sampling programme on the east coast of the North Island (ECNI) from 1990 to 1993. These data were sampled mainly from the purseseine fishery. M is the number of sampled fish and K is the number of landings.

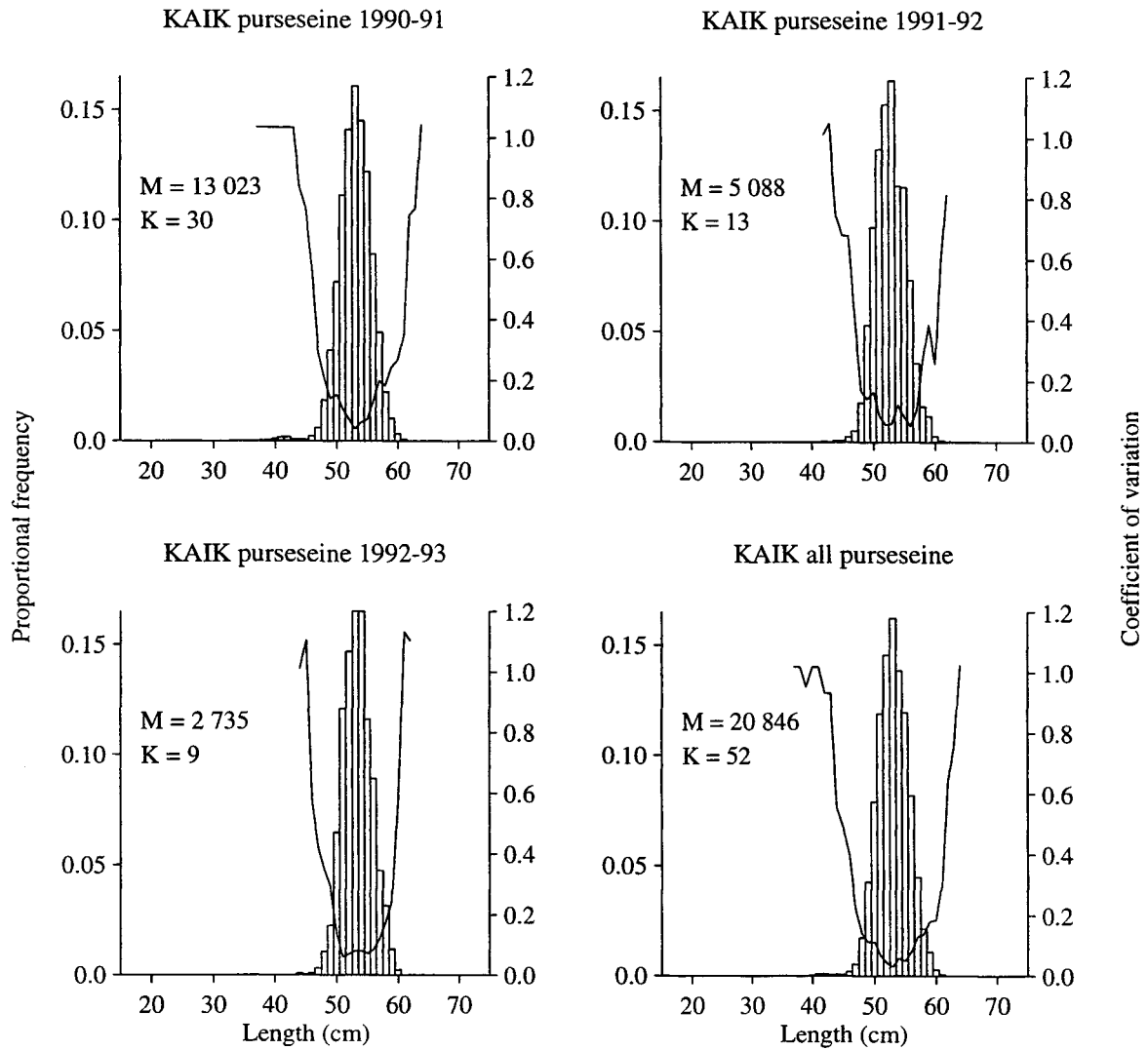


Figure 9: Kahawai size distributions from the catch sampling programme on the east coast of the South Island (KAIK, area 18) from 1990 to 1993. These data were sampled from the purseseine fishery. M is the number of sampled fish and K is the number of landings.

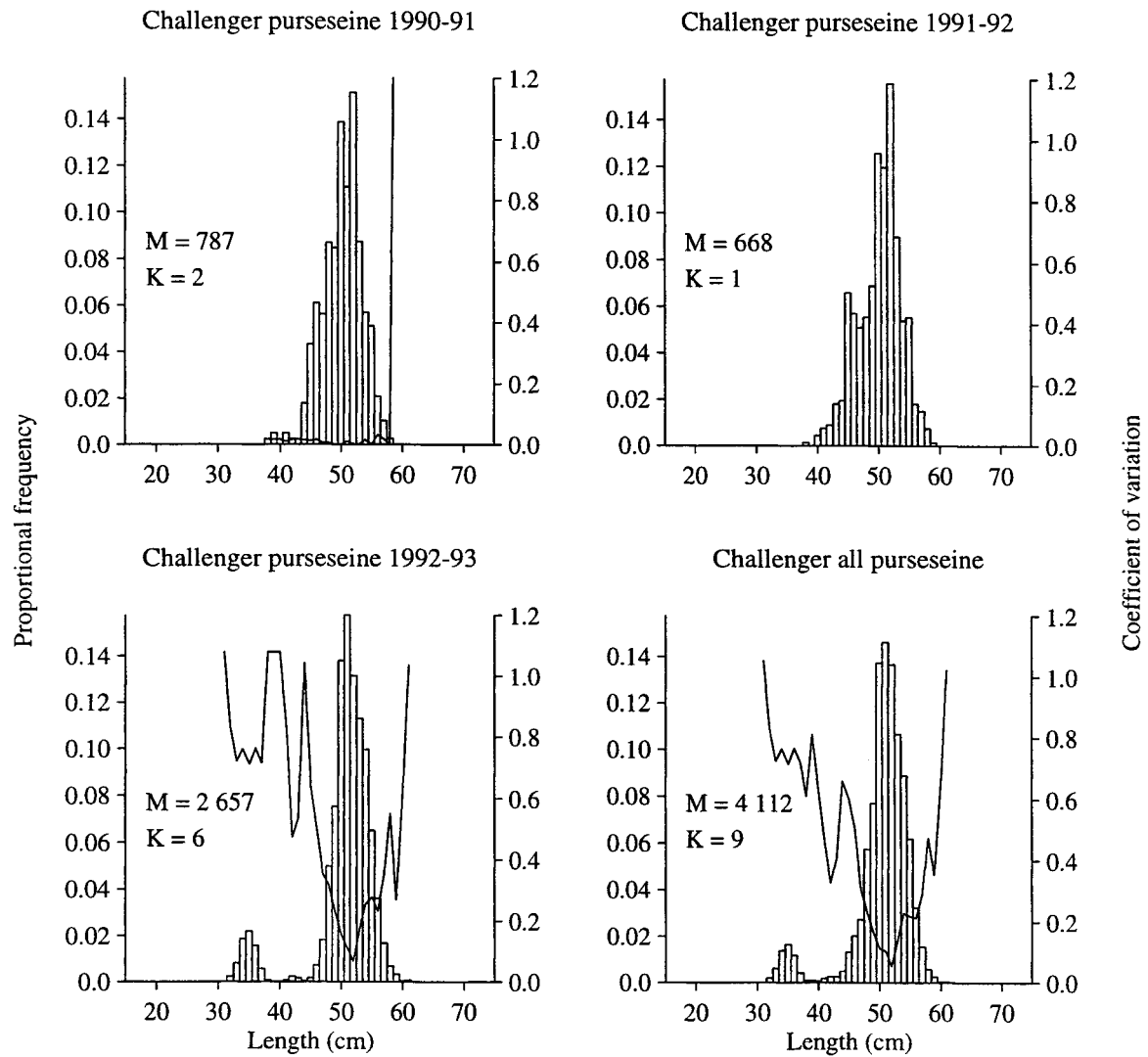


Figure 10: Kahawai size distributions from the catch sampling programme from the Challenger (areas 37, 39, and 40) from 1990 to 1993. These data were sampled from the purseseine fishery. M is the number of sampled fish and K is the number of landings.

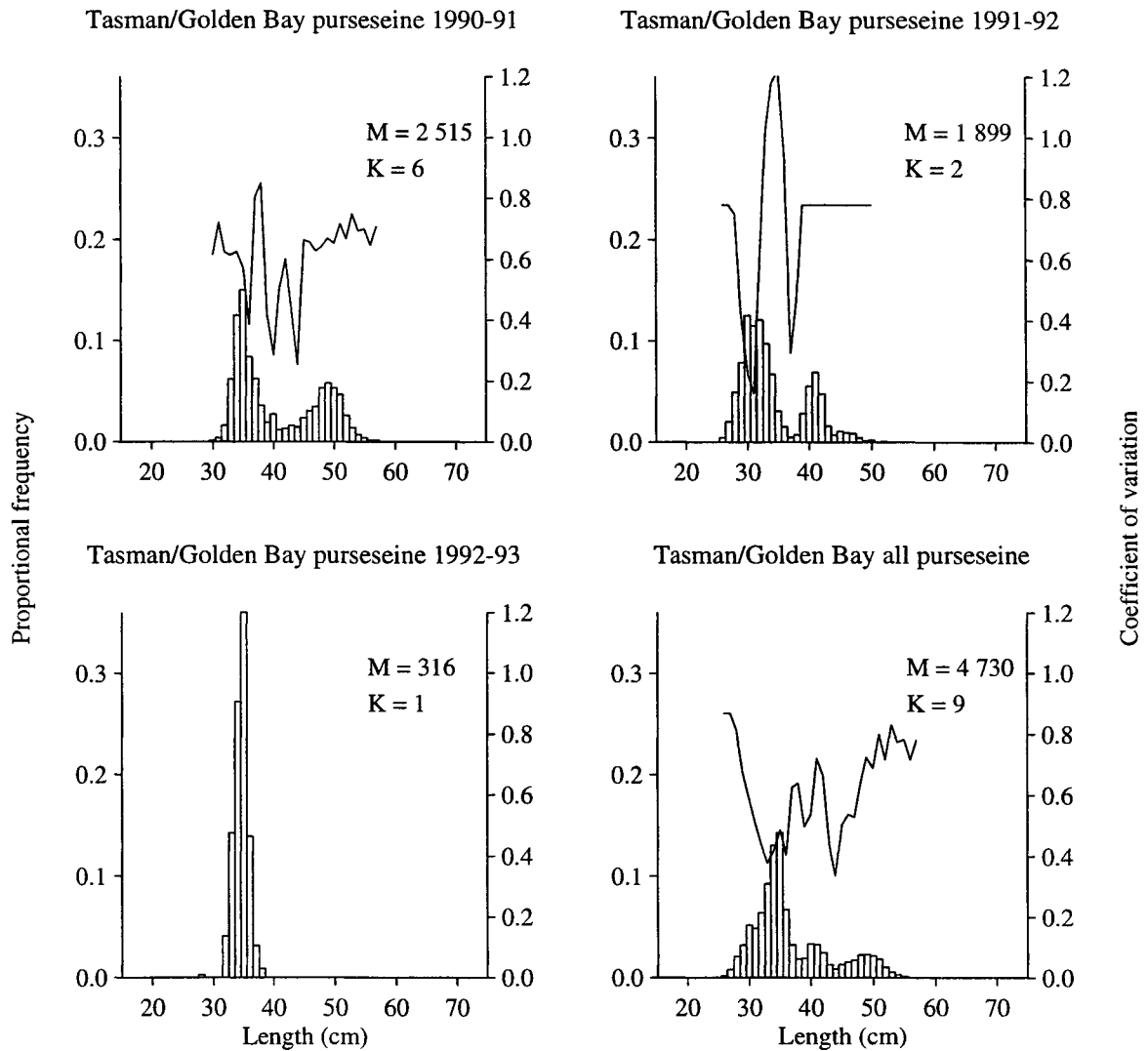


Figure 11: Kahawai size distributions from the catch sampling programme from Tasman and Golden Bays (TBGB, area 38) from 1990 to 1993. These data were sampled from the purseseine fishery. M is the number of sampled fish and K is the number of landings.

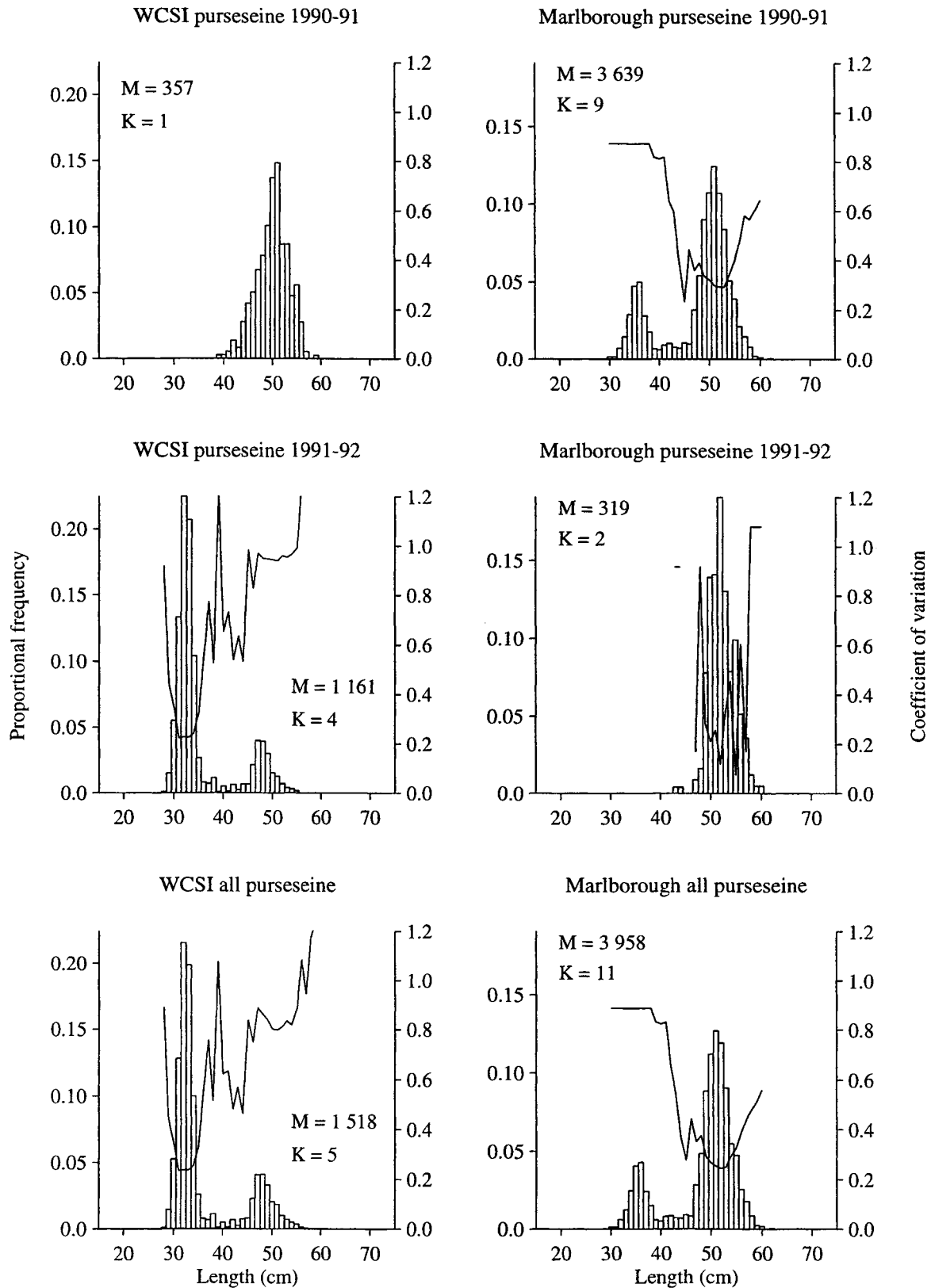


Figure 12: Kahawai size distributions from the catch sampling programme from the west coast South Island (WCSI, area 36) from 1990 to 1993 and Marlborough (area 17) from 1990 to 1993. These data were sampled from the purseseine fishery. M is the number of sampled fish and K is the number of landings.

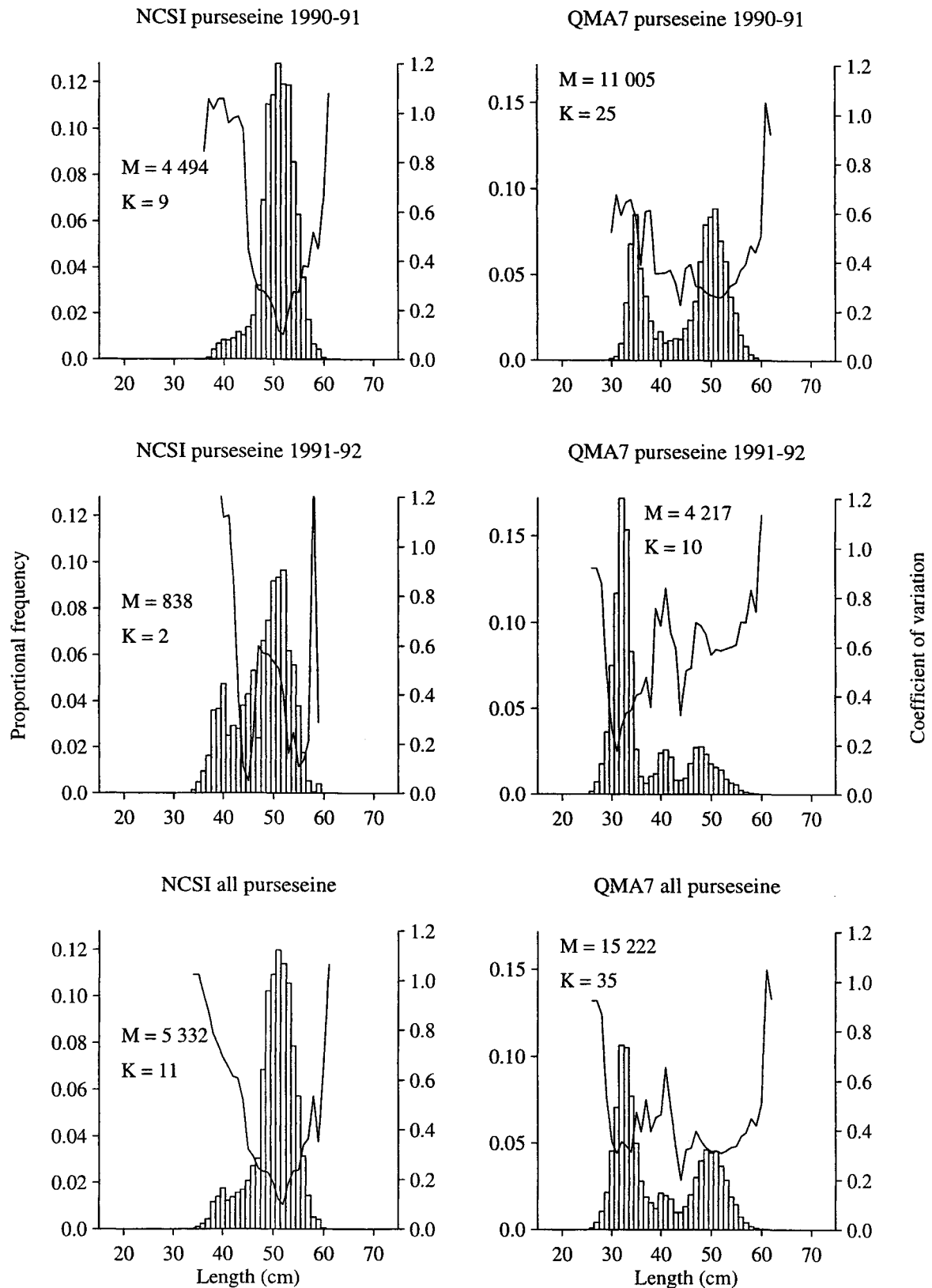


Figure 13: Kahawai size distributions from the catch sampling programme from the north coast of the South Island (NCSI, areas 17, 18, 37, and 38) from 1990 to 1993 (these data come from landings where the catch was taken in more than one area) and QMA 7 (combined results from WCSI, TBGB, NCSI, and MARL) from 1990 to 1993. Data in Figure 12 are not included. These data were sampled from the purseseine fishery. M is the number of sampled fish and K is the number of landings.

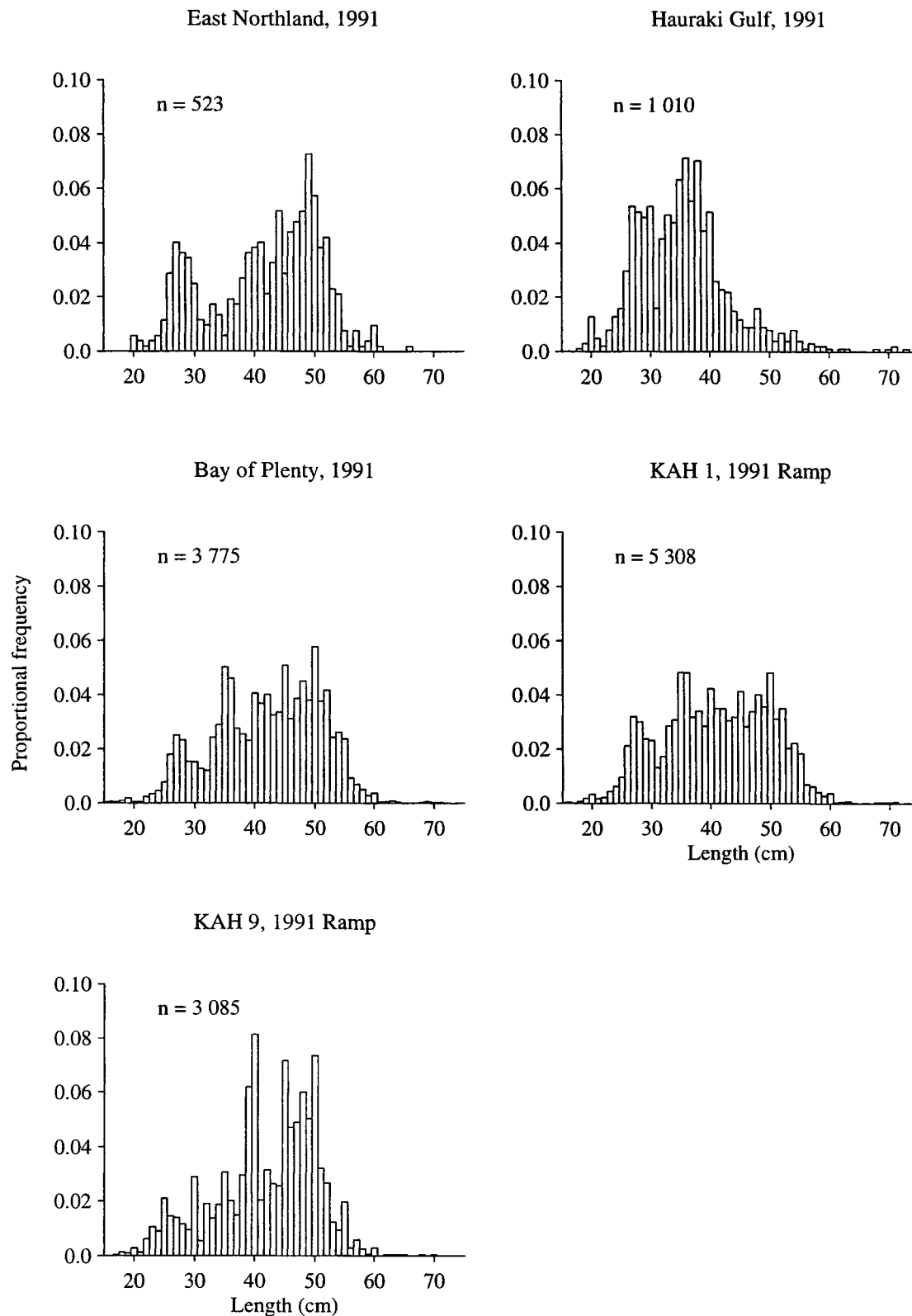


Figure 14: Kahawai size distributions from the North region boat ramp survey in 1991. n is the number of length measurements.

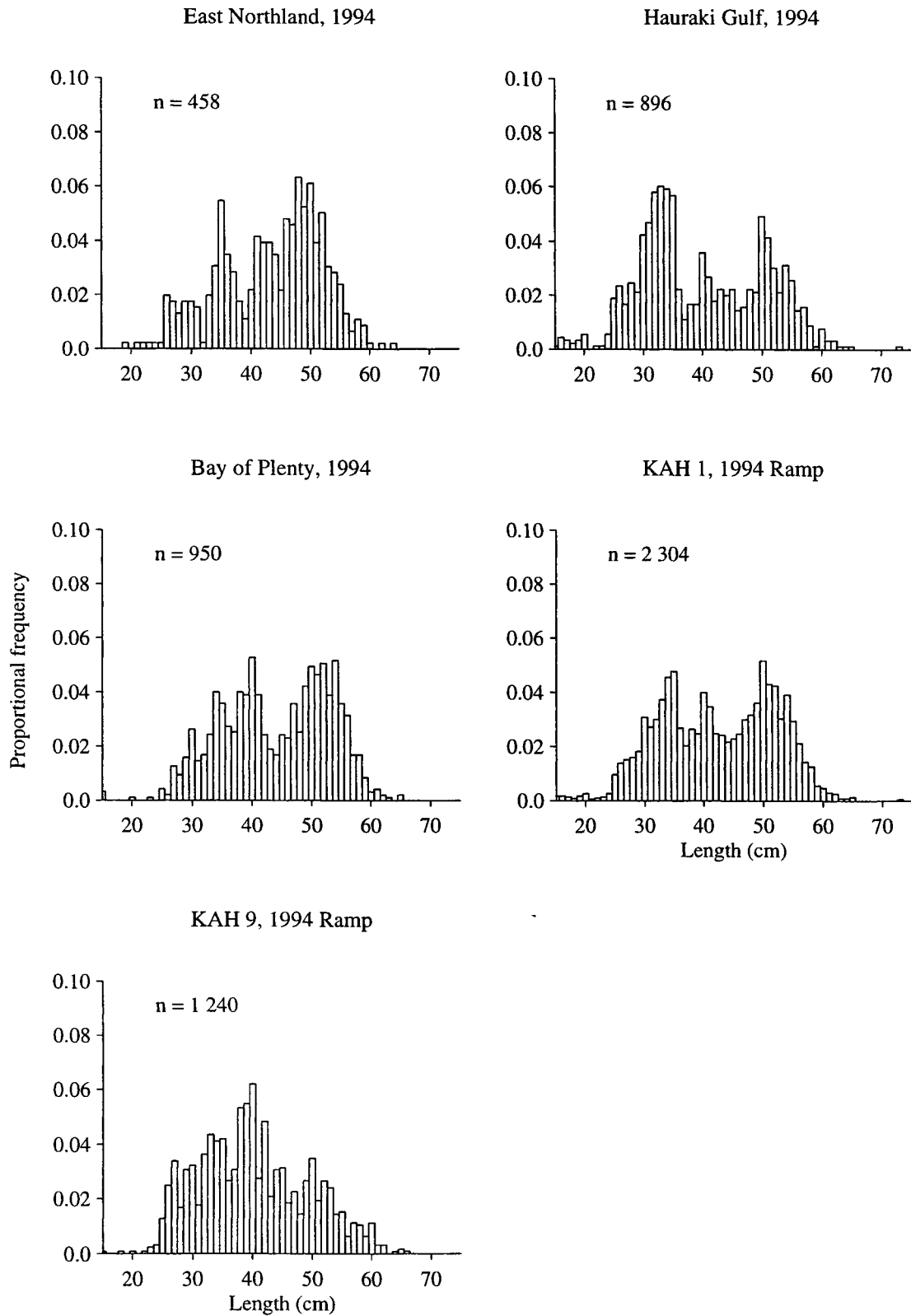


Figure 15: Kahawai size distributions from the North region boat ramp survey in 1994. n is the number of length measurements.

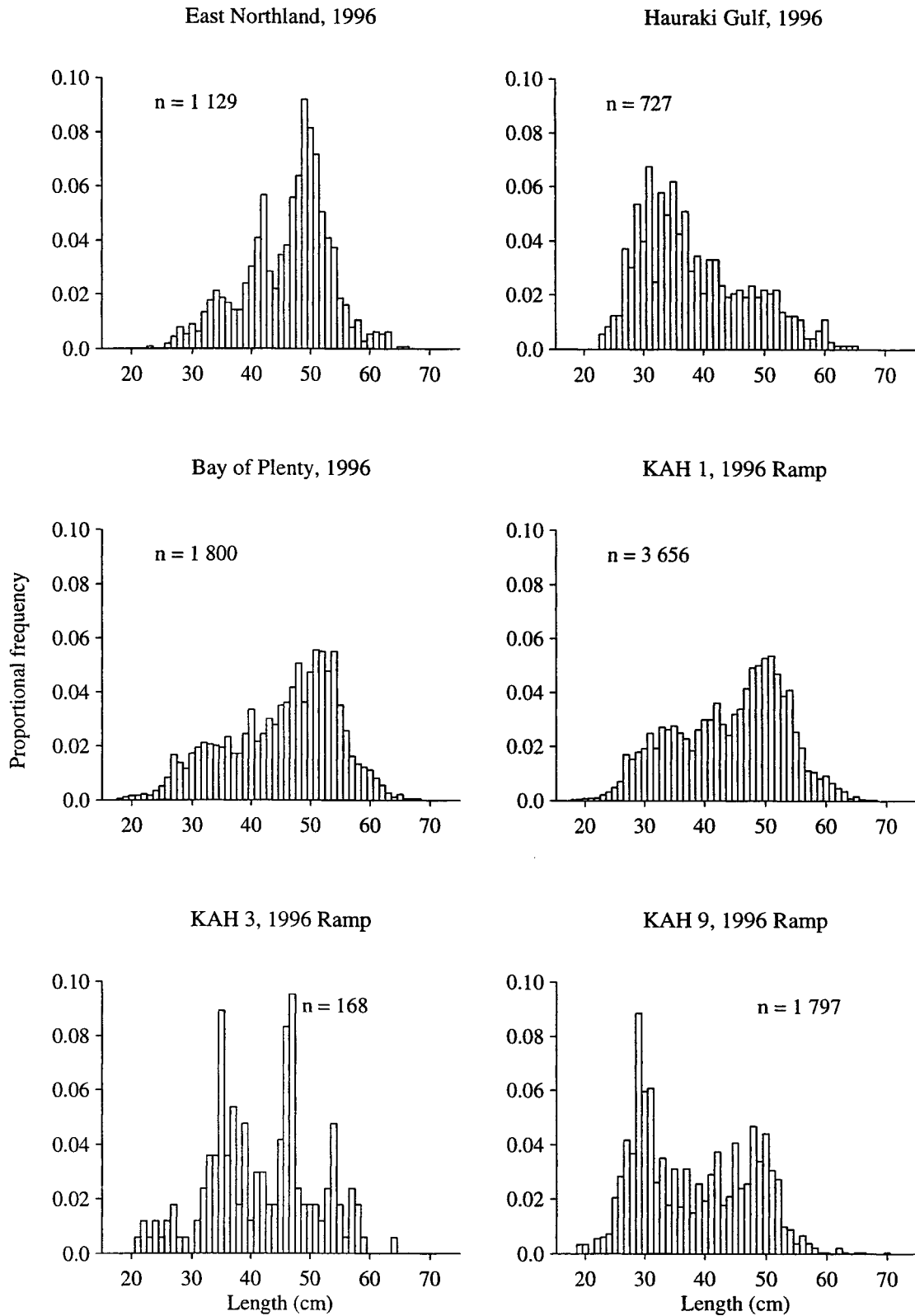


Figure 16: Kahawai size distributions from the 1996 national boat ramp survey. n is the number of length measurements.

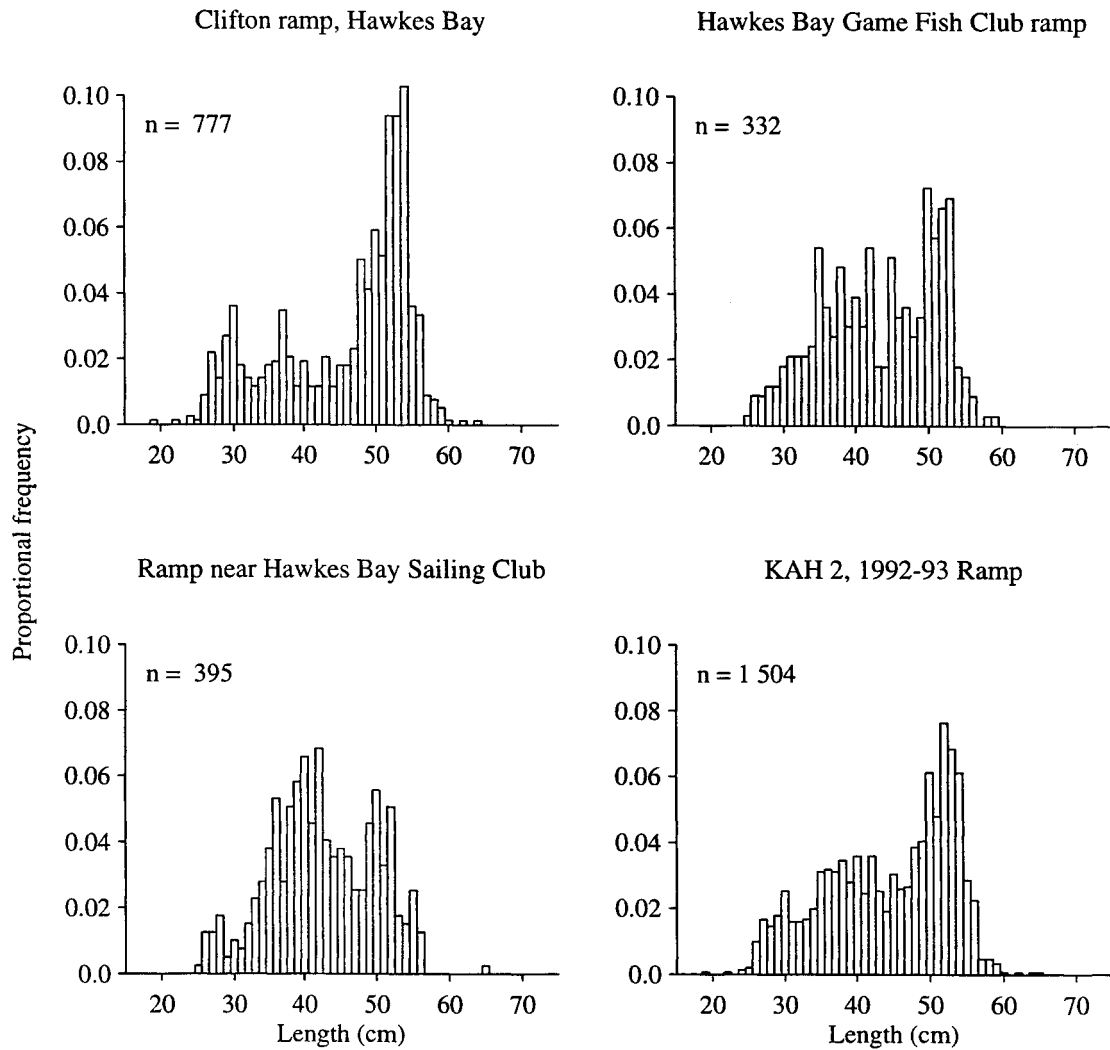


Figure 17: Kahawai size distributions in KAH 2 from the region from the 1992–93 Central region boat ramp survey. n is the number of length measurements.

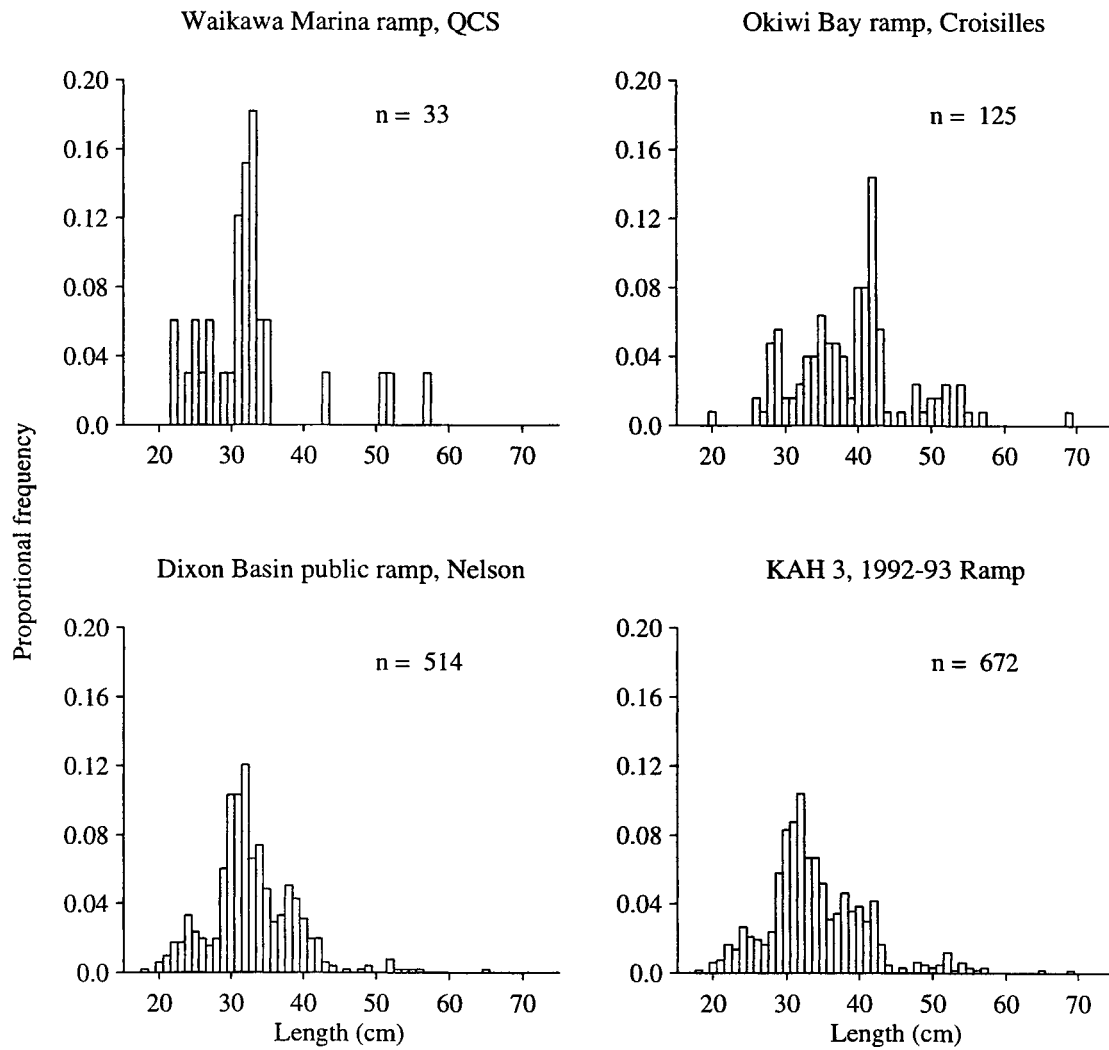


Figure 18: Kahawai size distributions in KAH 3 from the region from the 1992–93 Central region boat ramp survey. n is the number of length measurements.

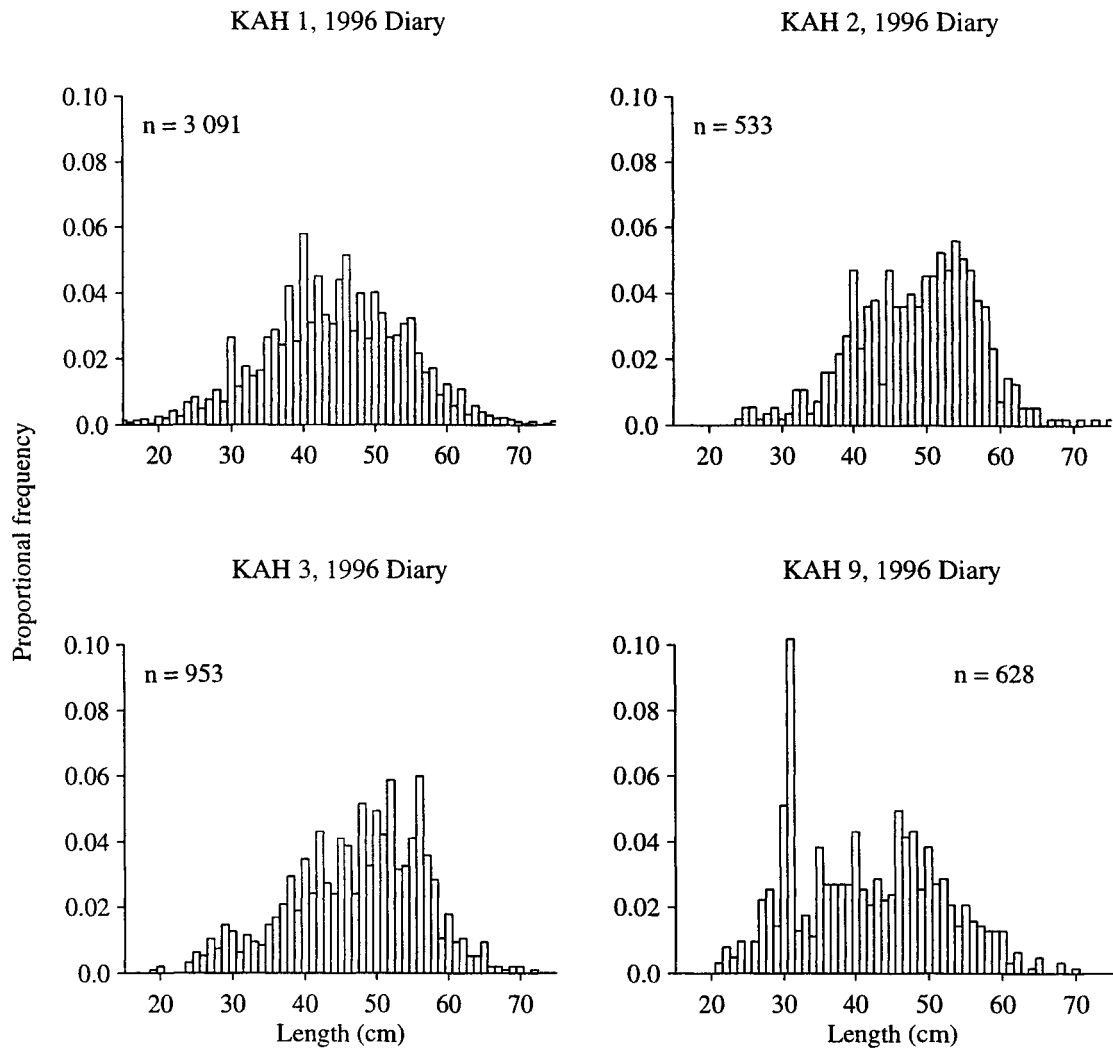


Figure 19: Kahawai size distributions measured by diarists during the 1996 national diary survey. Data are plotted by Fishstock. n is the number of length measurements.

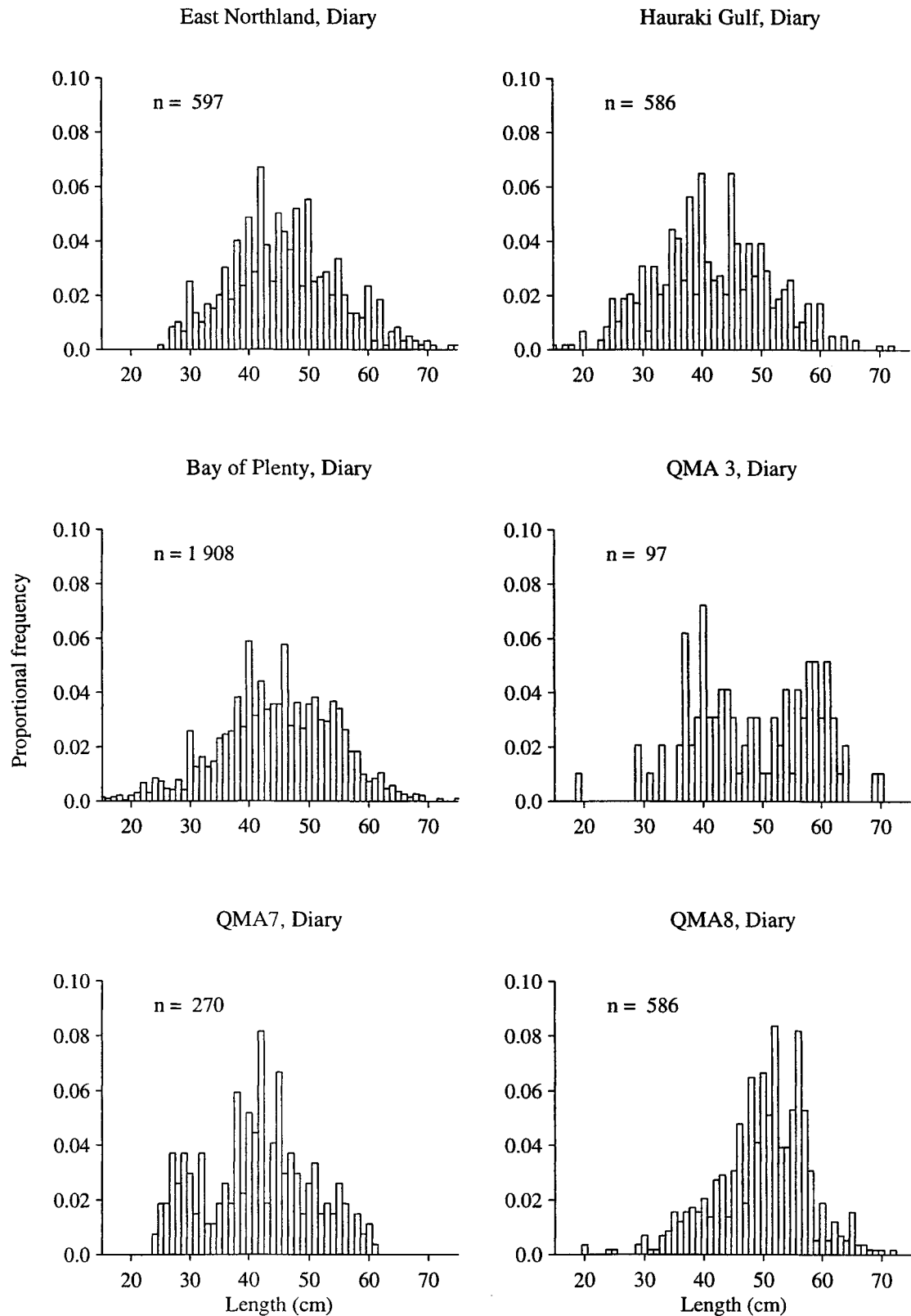


Figure 20: Kahawai size distributions measured by diarists during the 1996 national diary survey. Data are plotted by subregion. n is the number of length measurements.

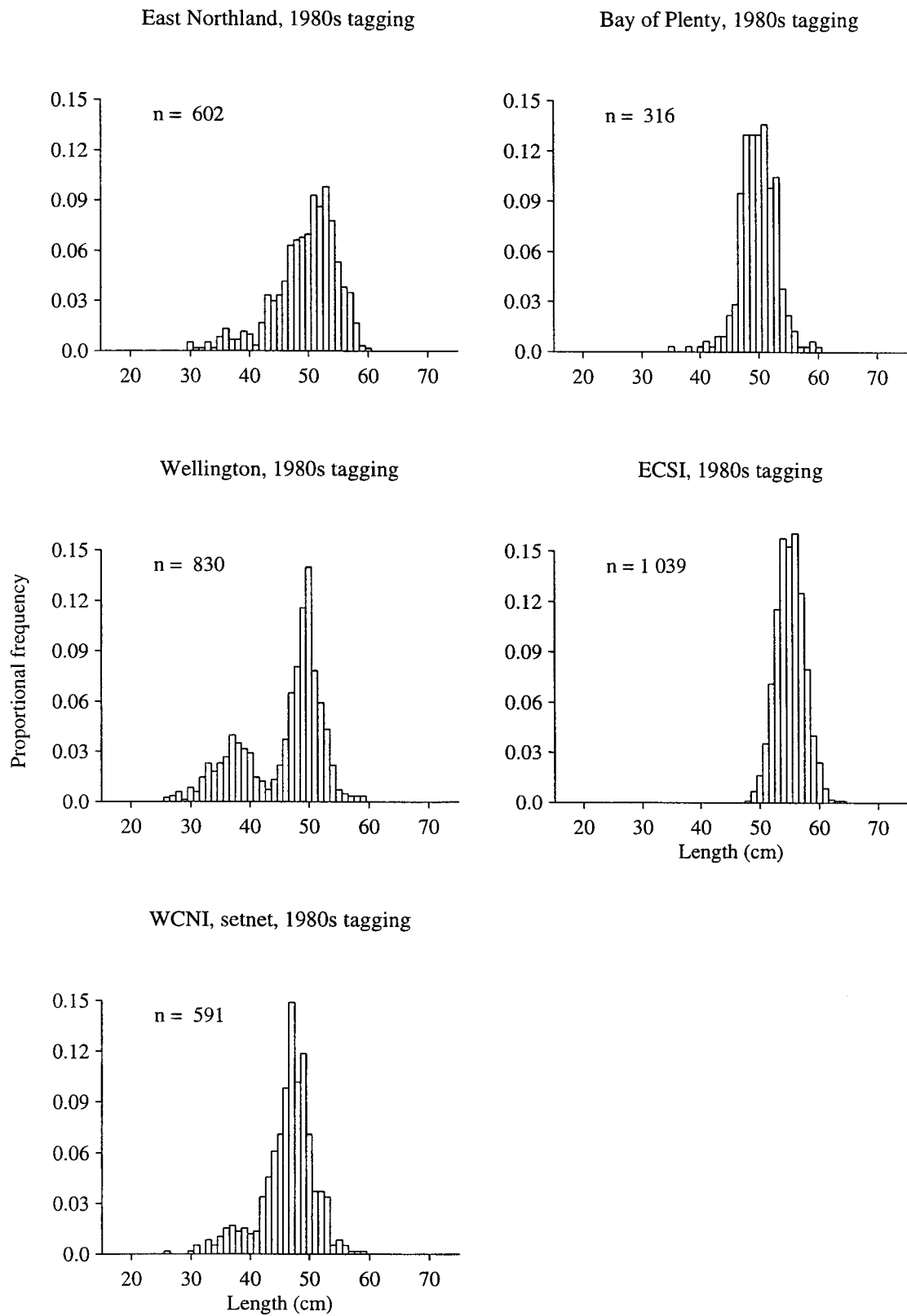


Figure 21: Kahawai size distributions of tagged fish released during the 1980s kahawai tagging programme. n is the number of length measurements.

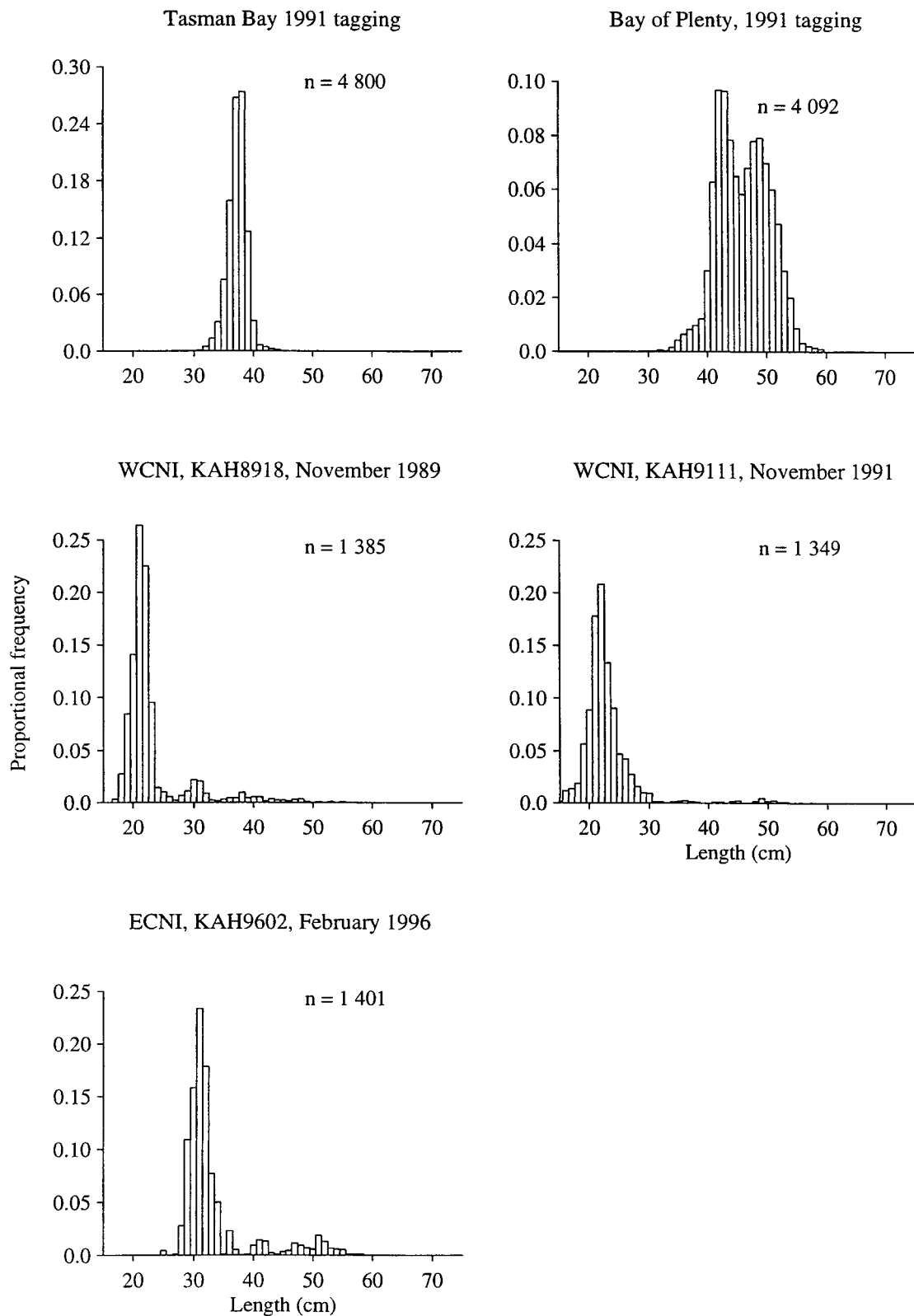
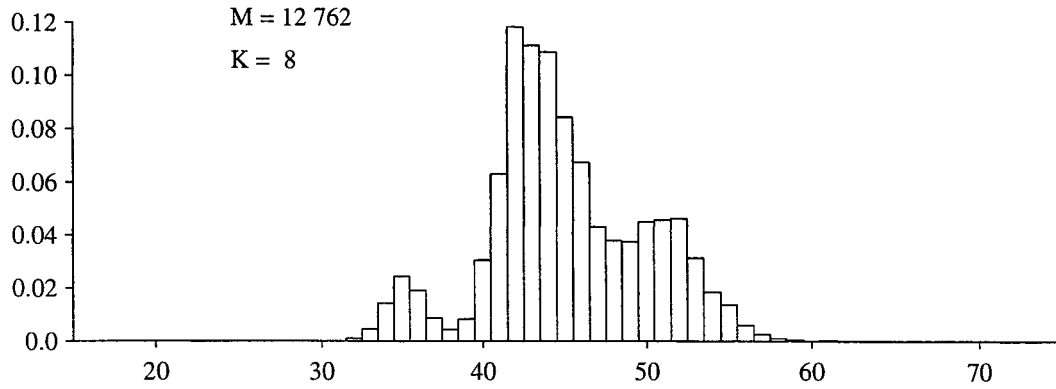
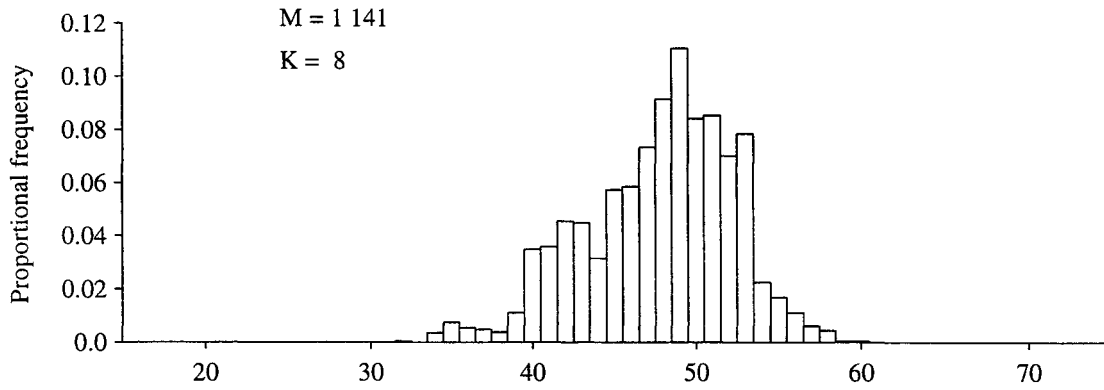


Figure 22: Kahawai size distributions of tagged fish released during the 1991 kahawai tagging programme and from the trawl database for those surveys where the kahawai catch was substantive (surveys KAH8919, KAH9111, and KAH9602). n is the number of length measurements.

Bay of Plenty, 1991 Purseseine



Bay of Plenty, 1991 Trawl



Bay of Plenty, 1991 Recreational

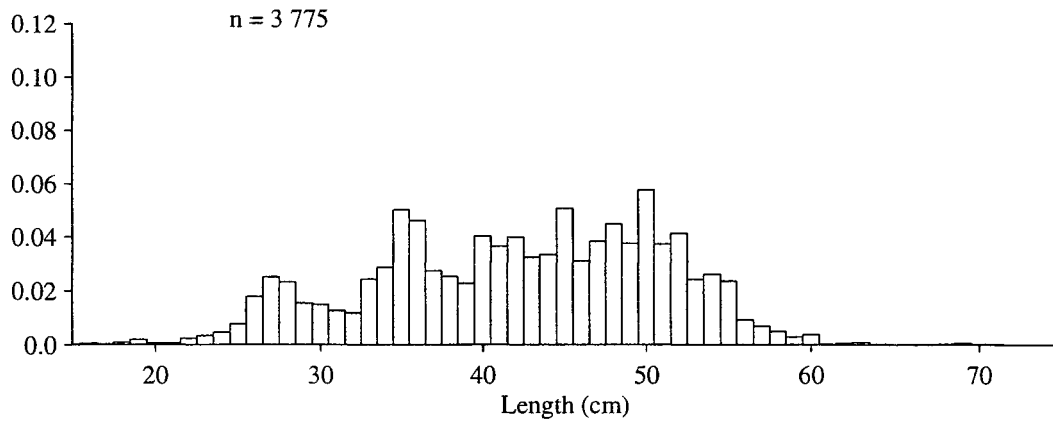
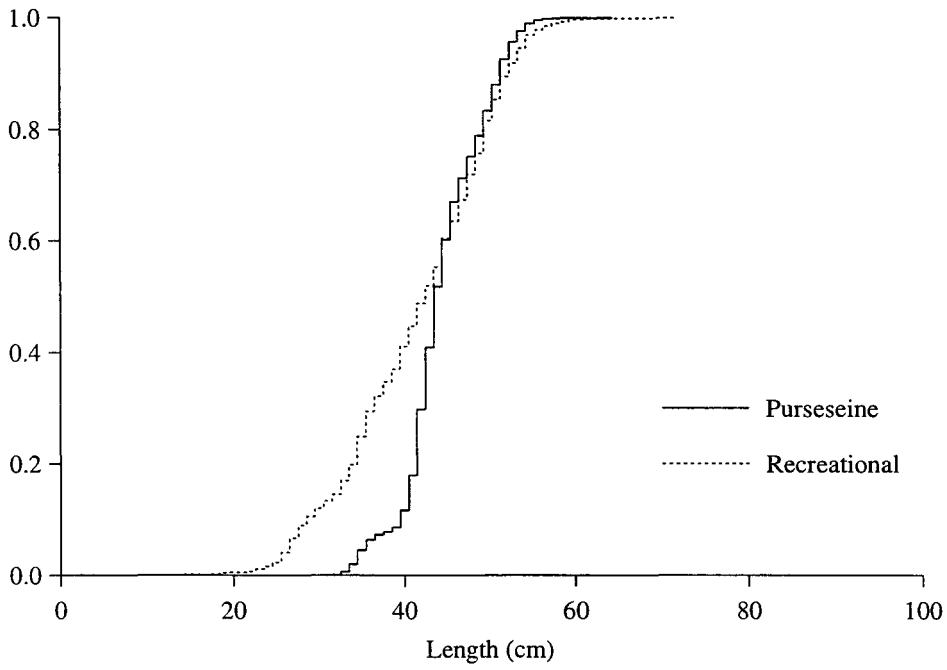


Figure 23: Kahawai size distributions from the Bay of Plenty from the 1990–91 purseseine and trawl catch samplings and 1991 recreational boat ramp survey. M is the number of fish sampled, K is the number of landings, and n is the number of fish measured.

Kahawai size distributions in the Bay of Plenty, 1991



Kahawai size distributions in the Bay of Plenty, 1991

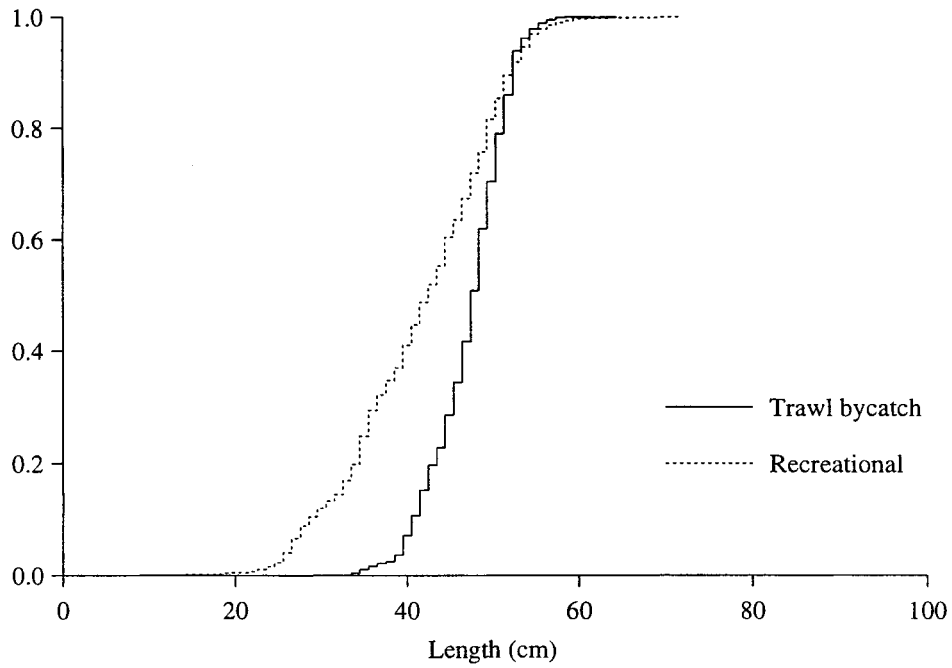
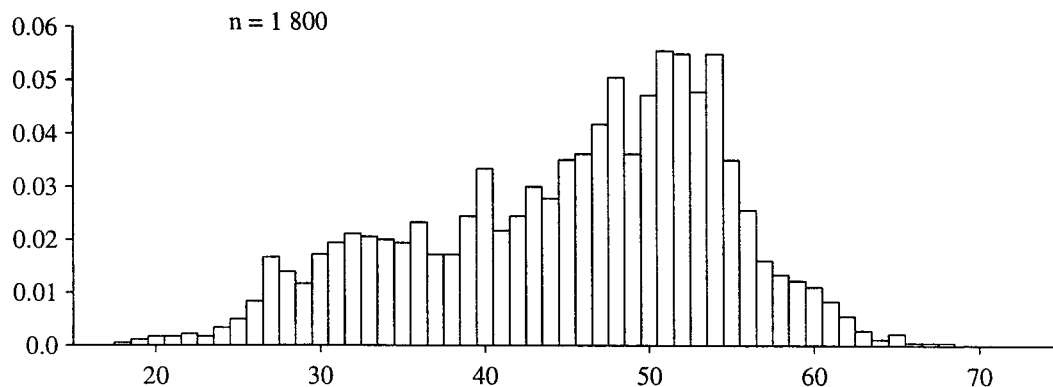
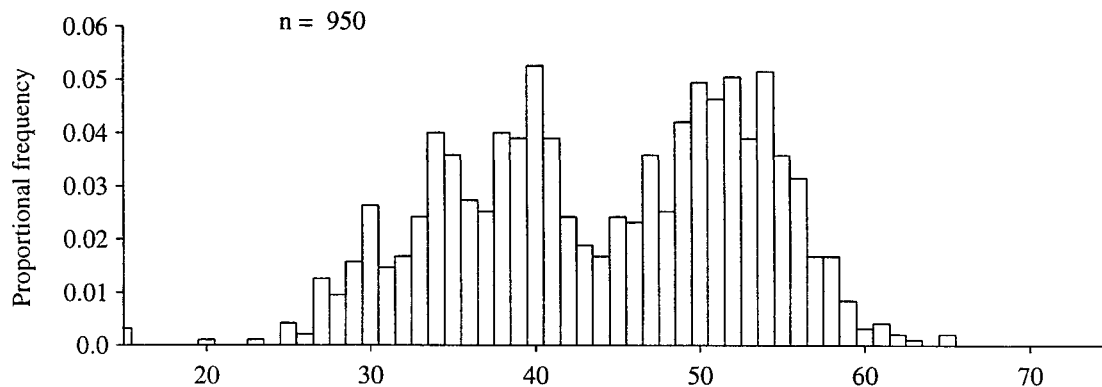


Figure 24: Kahawai cumulative size distributions comparing the 1991 purseseine and recreational and the 1991 trawl and recreational size distributions from the Bay of Plenty.

Bay of Plenty, 1996 Ramp



Bay of Plenty, 1994 Ramp



Bay of Plenty, 1991 Ramp

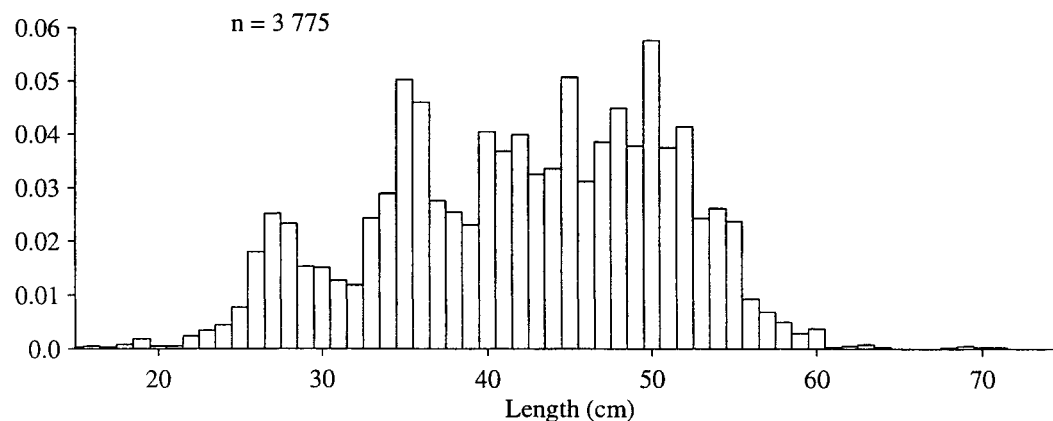
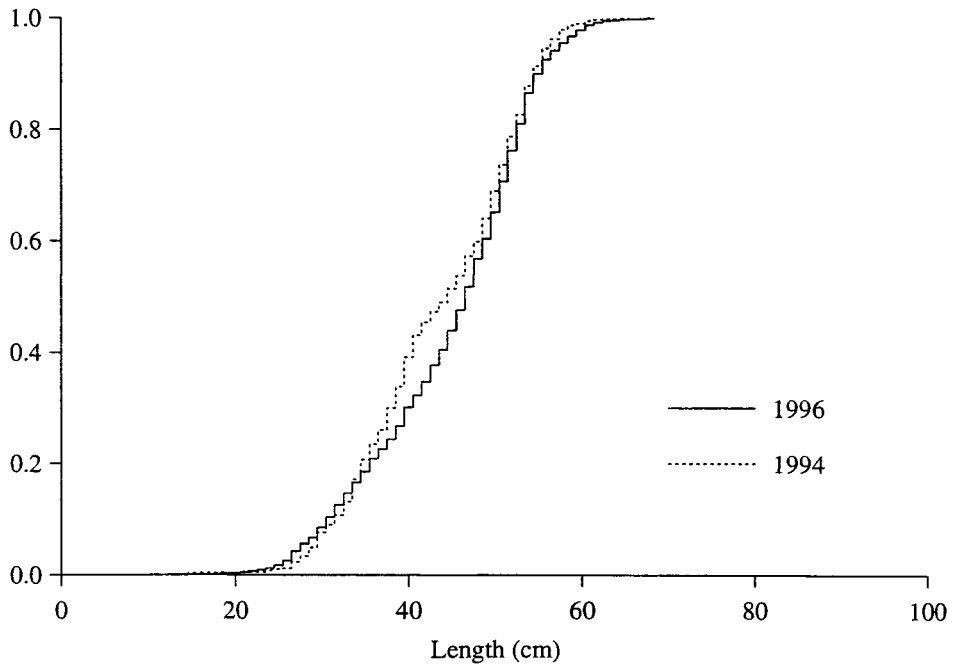


Figure 25: Kahawai size distributions from the Bay of Plenty from boat ramp surveys in 1991, 1994, and 1996. n is the number of fish measured.

Recreational kahawai size distributions in the Bay of Plenty



Recreational kahawai size distributions in the Bay of Plenty

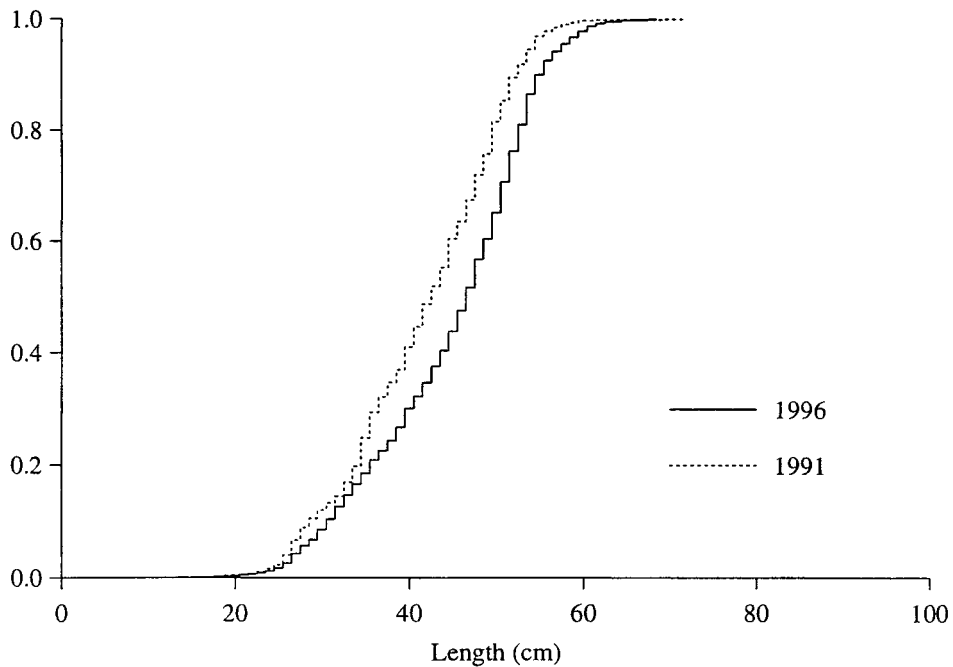
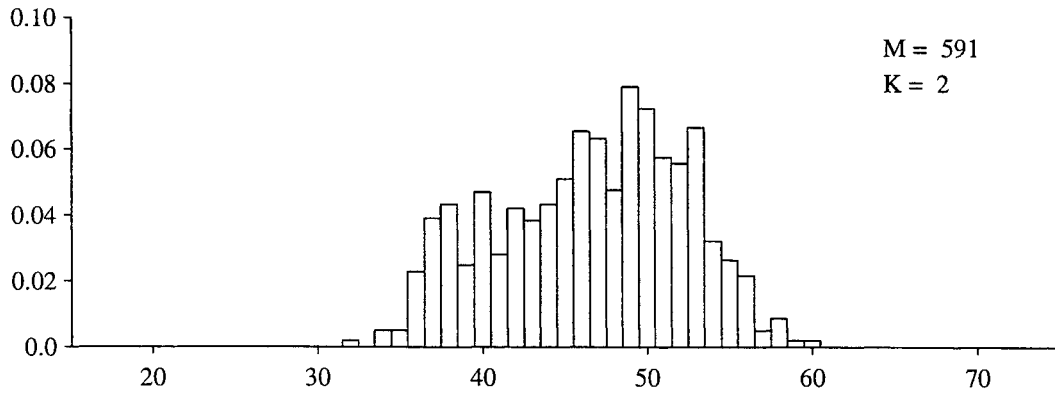
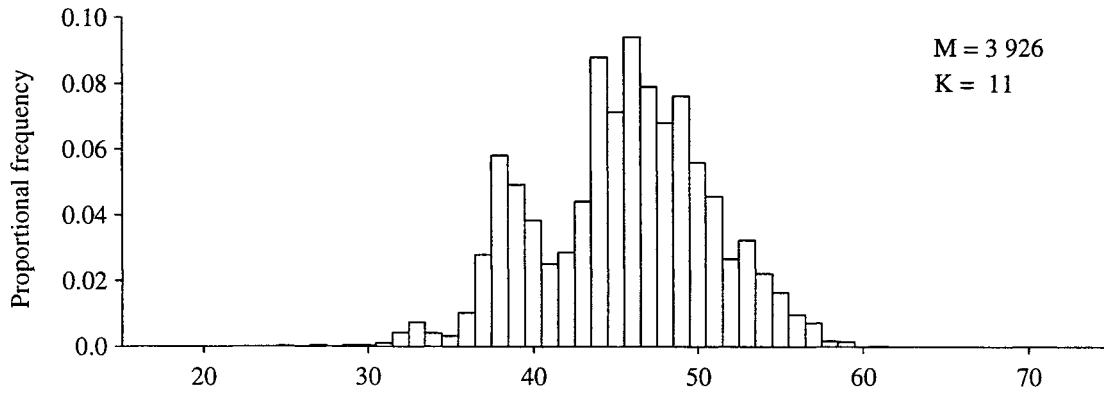


Figure 26: Kahawai cumulative size distributions comparing the 1994 and 1996 and the 1991 and 1996 recreational size distributions from the Bay of Plenty.

KAH 9, 1991 Purseseine



KAH 9, 1991 Trawl and pair trawl



KAH 9, 1991 Ramp

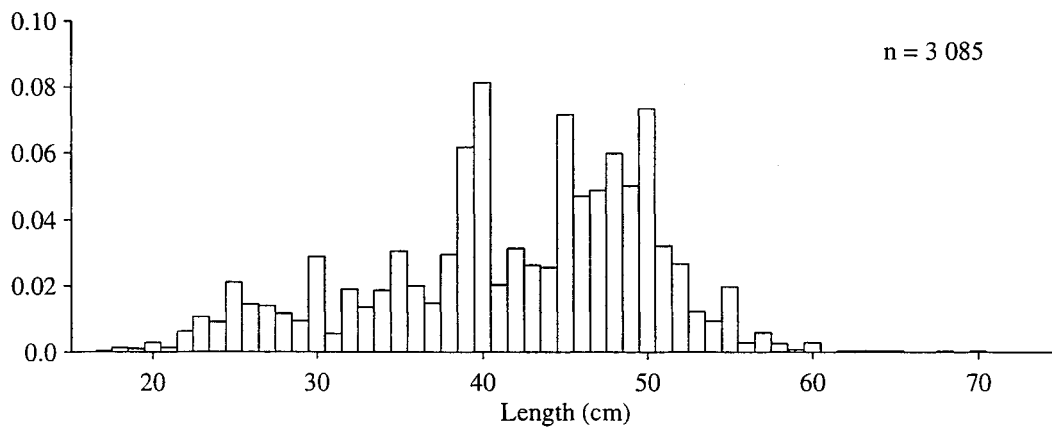
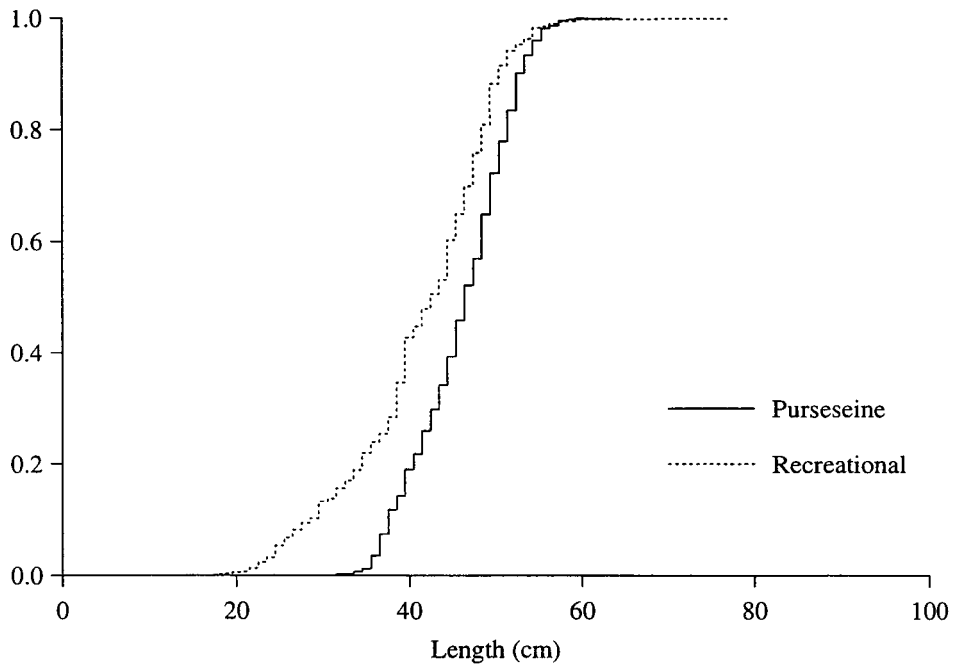


Figure 27: Kahawai size distributions from the trawl (including pair trawl) purseseine, and recreational fisheries in the KAH 9 in 1991. M is the number of fish sampled, K is the number of landings, and n is the number of fish measured.

Kahawai size distributions in KAH 9, 1991



Kahawai size distributions in KAH 9, 1991

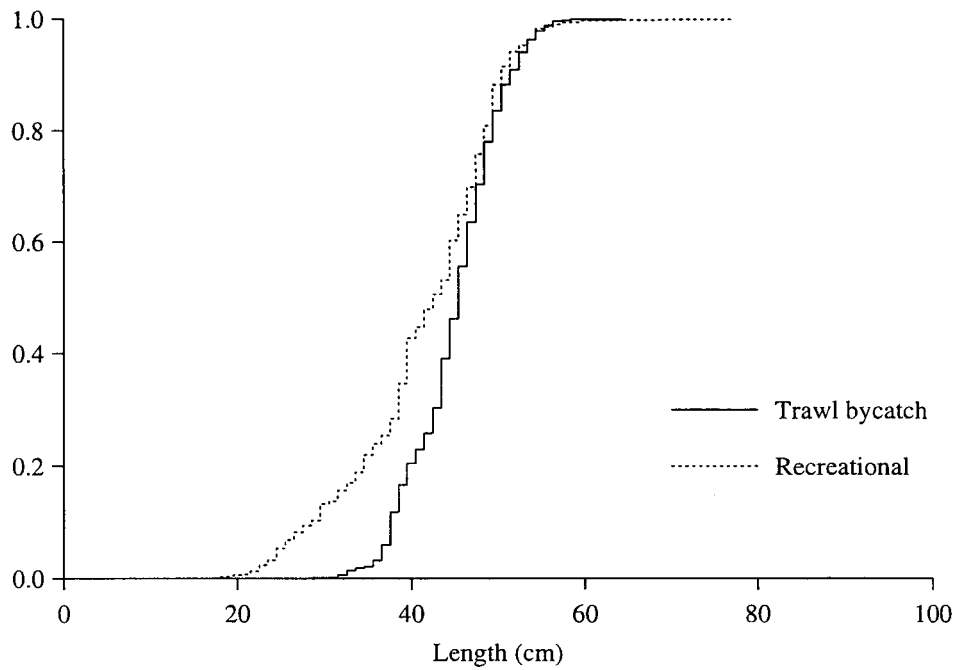


Figure 28: Kahawai cumulative size distributions comparing the 1991 purseseine and recreational and the 1991 trawl and recreational size distributions from KAH 9.

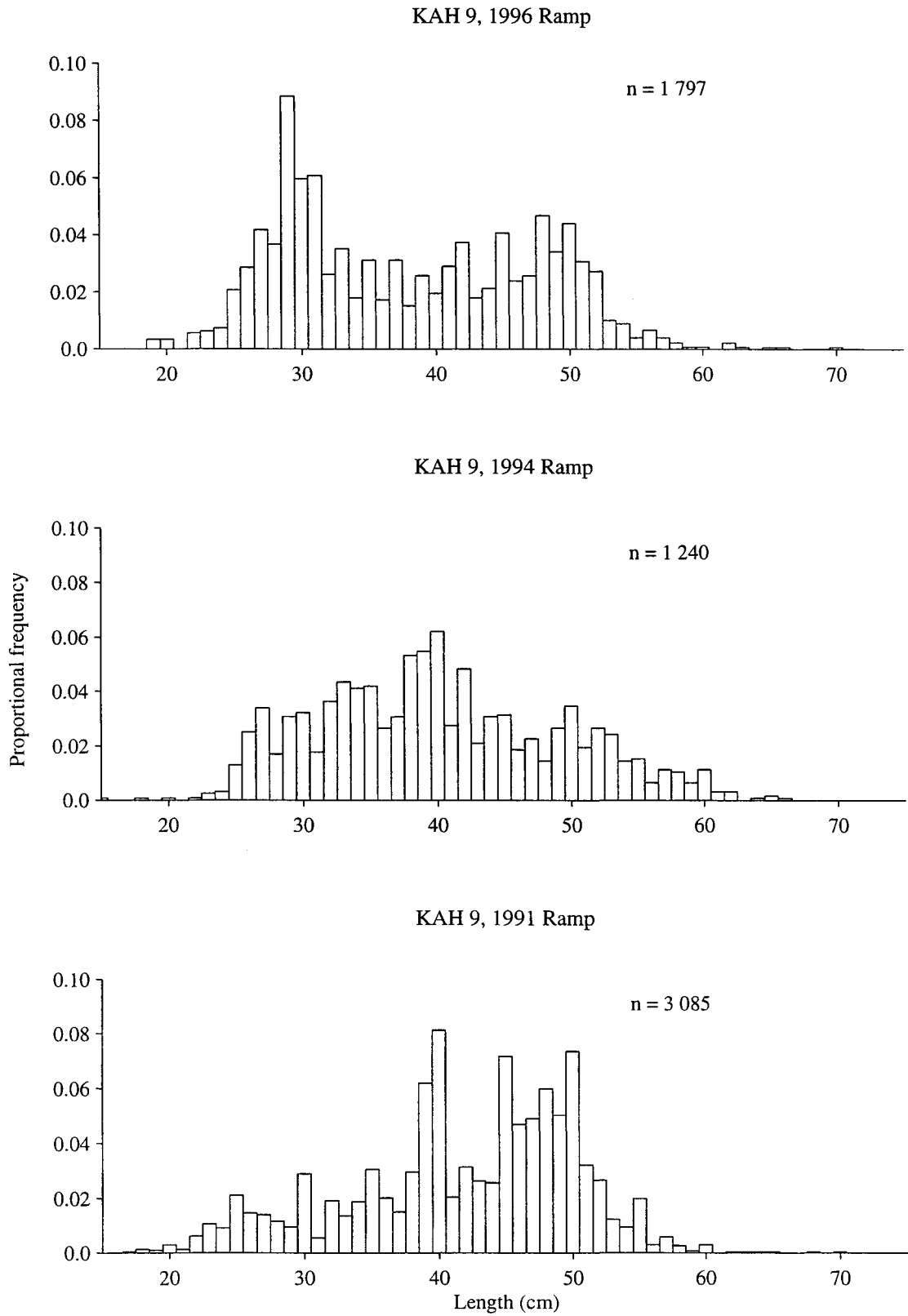
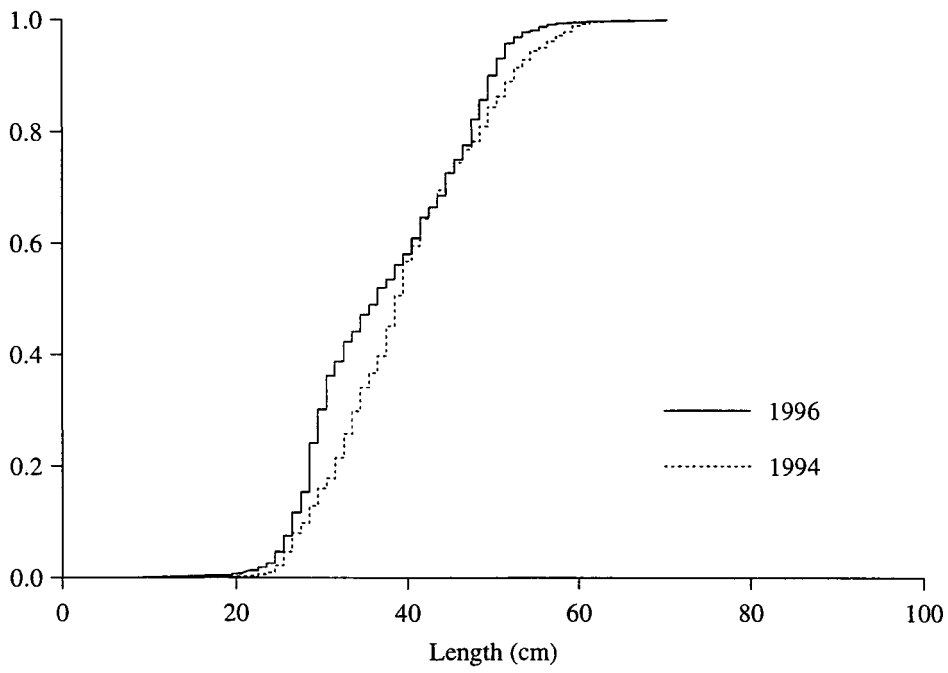


Figure 29: Kahawai size distributions from the KAH 9 from boat ramp surveys in 1991, 1994, and 1996. n is the number of fish measured.

Recreational kahawai size distributions in KAH 9



Recreational kahawai size distributions in KAH 9

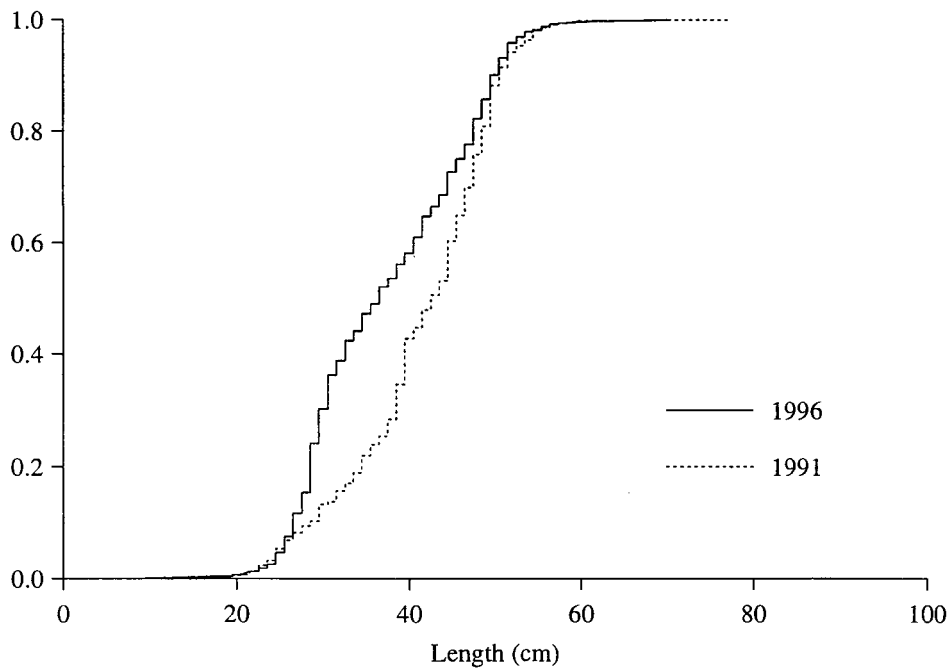


Figure 30: Kahawai cumulative size distributions comparing the 1994 and 1996 and the 1991 and 1996 recreational size distributions from KAH 9.

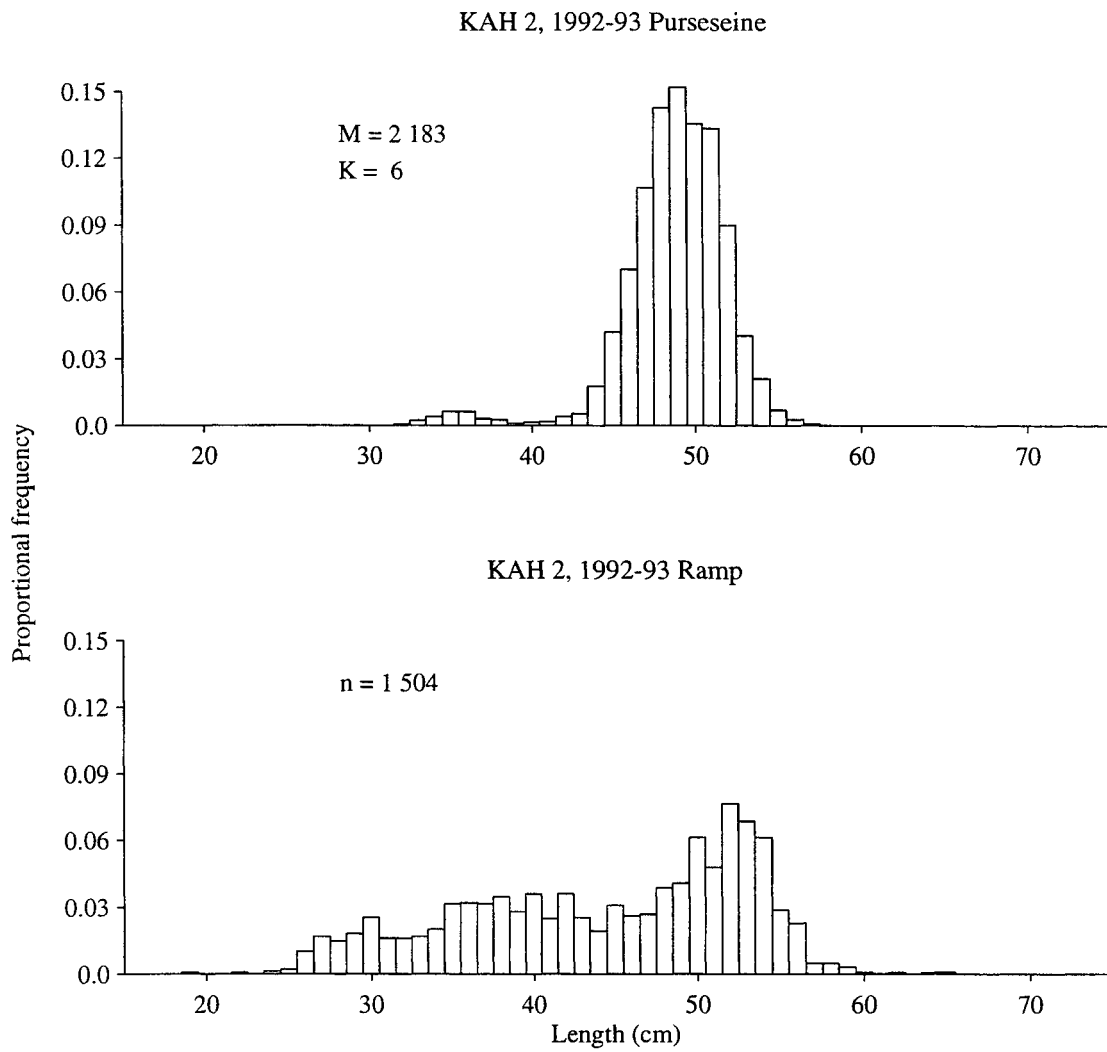


Figure 31: Kahawai size distributions from the purseseine and recreational fisheries in the KAH 2 in 1992–93. M is the number of fish sampled, K is the number of landings, and n is the number of fish measured.

Kahawai size distributions in the KAH 2, 1992-93

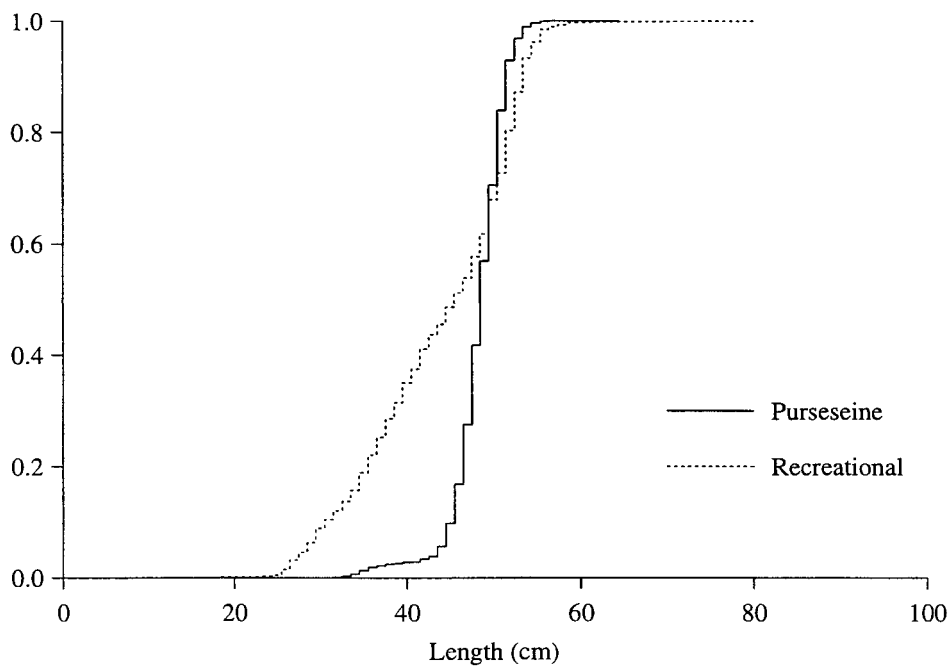


Figure 32: Kahawai cumulative size distributions comparing the 1992-93 purseseine and recreational size distributions from KAH 2.

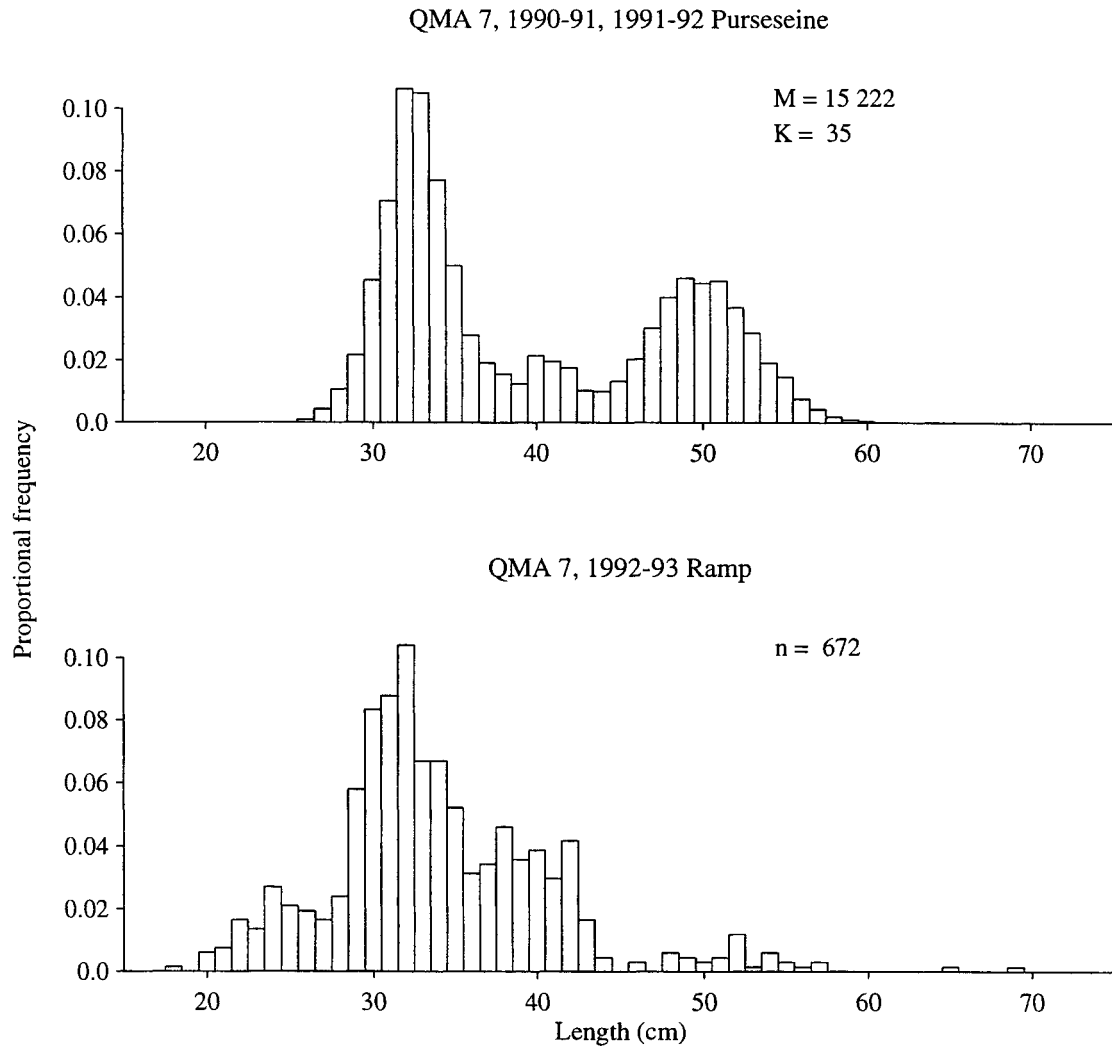


Figure 33: Kahawai size distributions from the purseseine and recreational fisheries in the QMA 7 in 1992-93. M is the number of fish sampled, K is the number of landings, and n is the number of fish measured.

Kahawai size distributions in the QMA 7, around 1992

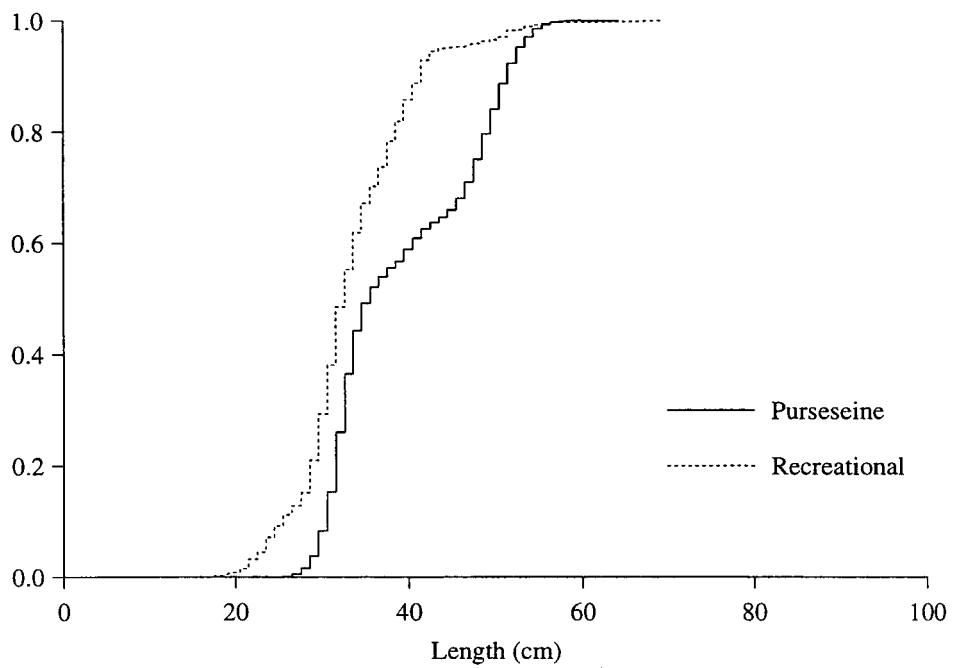


Figure 34: Kahawai cumulative size distributions comparing the 1992–93 purseseine and recreational size distributions from QMA 7.

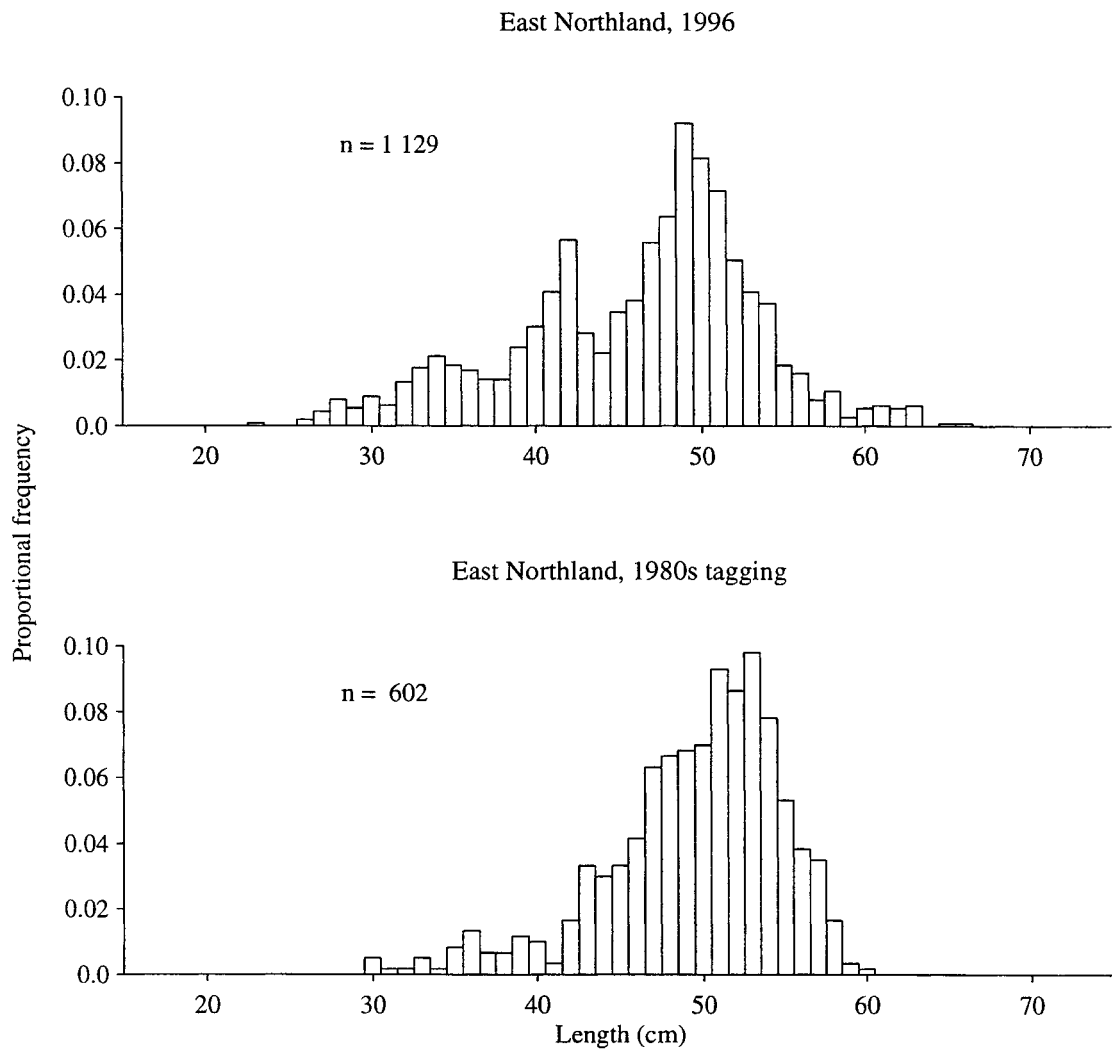


Figure 35: Kahawai size distributions in east Northland from the 1996 national boat ramp survey and the 1980s tagging. n is the number of fish measured.

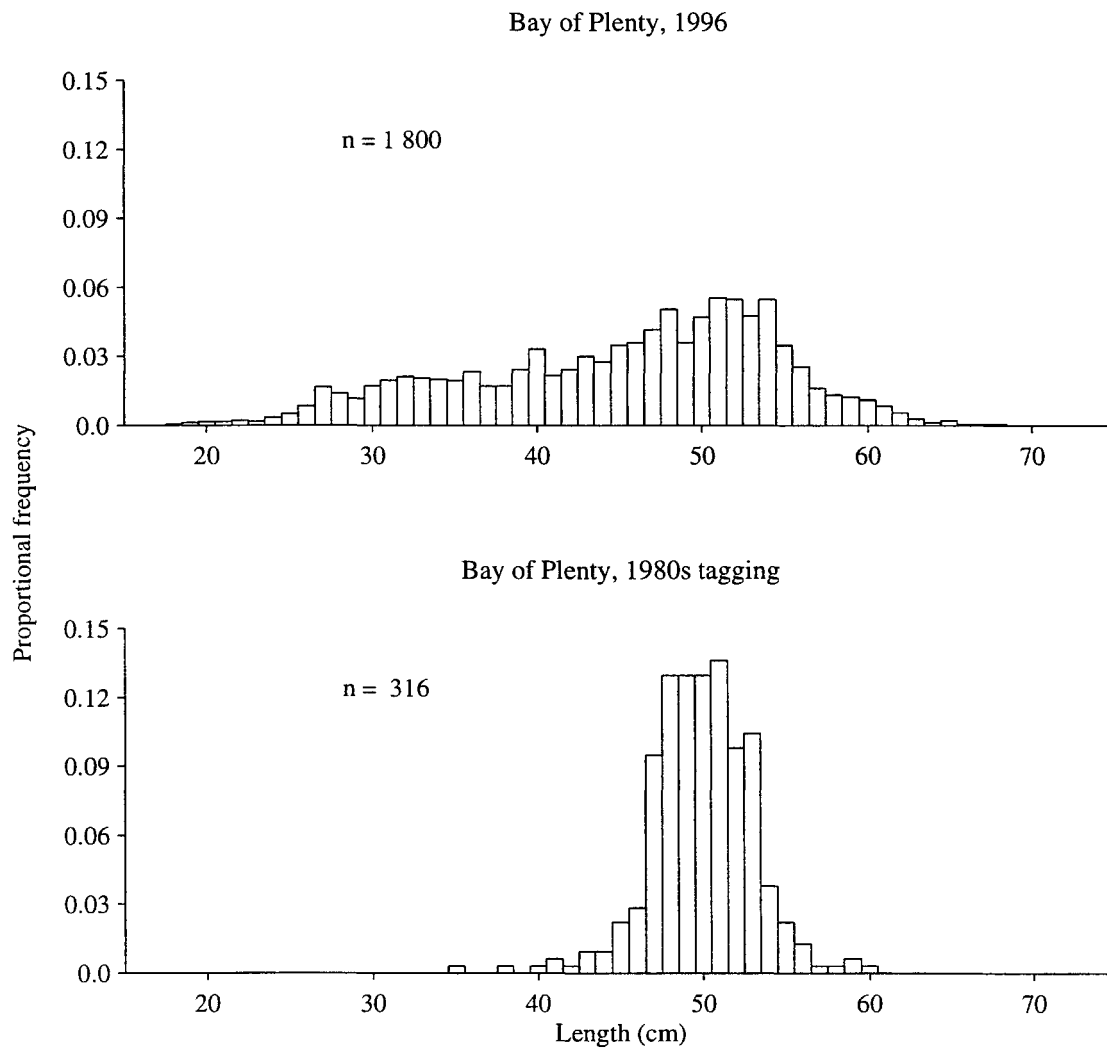
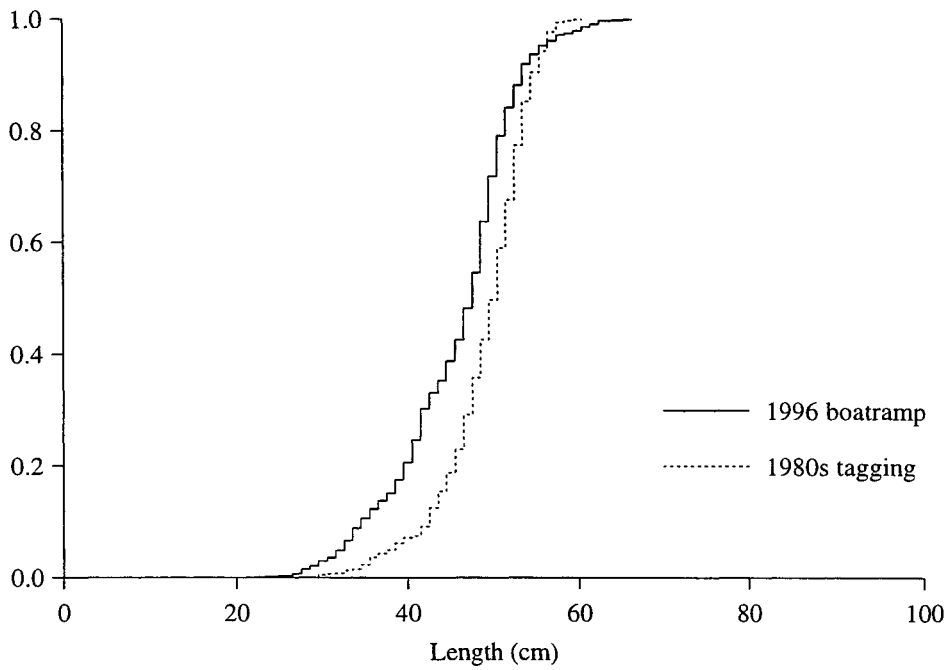


Figure 36: Kahawai size distributions in Bay of Plenty from the 1996 national boat ramp survey and the 1980s tagging. n is the number of fish measured.

Recreational kahawai size distributions in east Northland



Recreational kahawai size distributions in Bay of Plenty

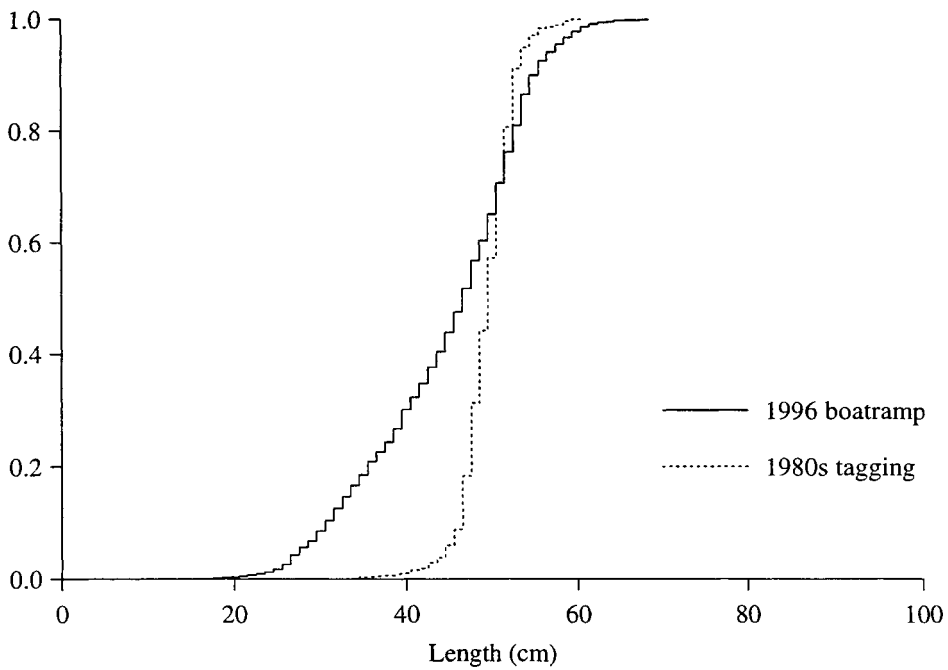


Figure 37: Kahawai cumulative size distributions from the 1996 national boat ramp survey and the 1980s tagging in east Northland and the Bay of Plenty.

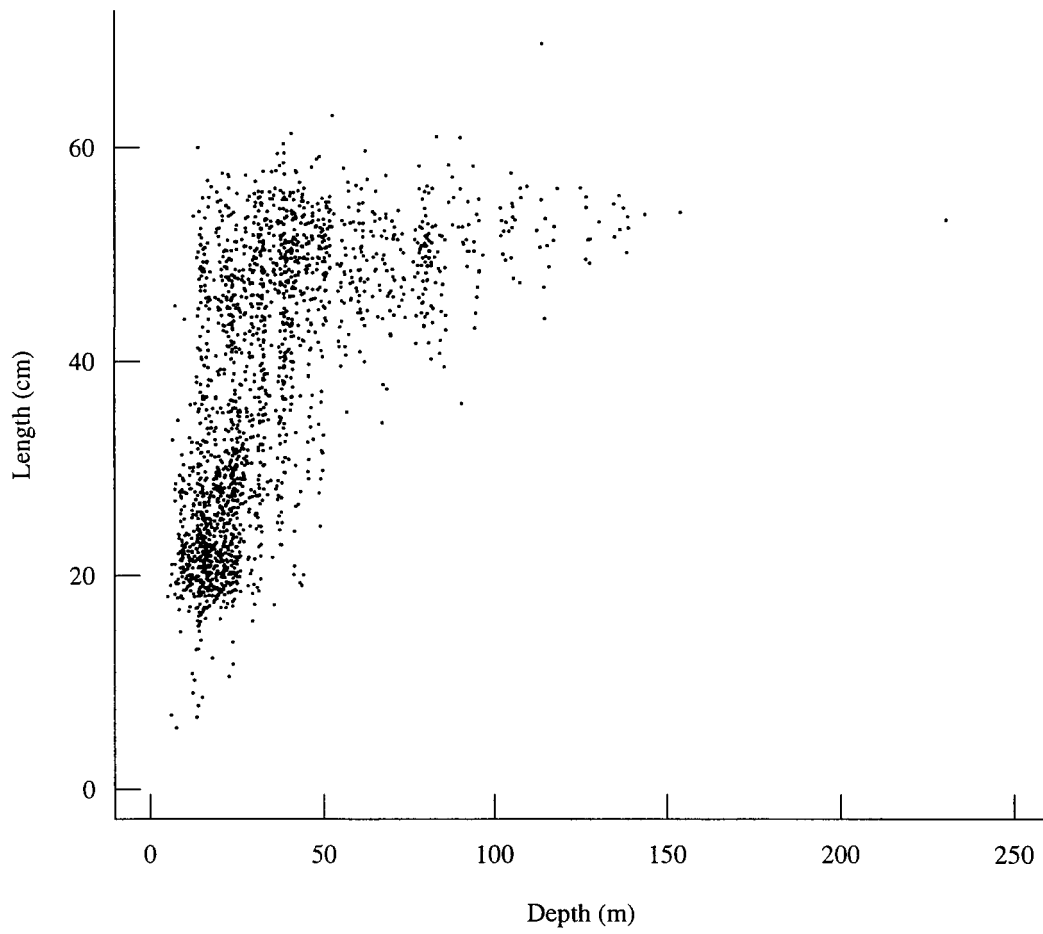


Figure 38: Kahawai lengths from the trawl database plotted against the depth at which they were caught. The points have been jittered.



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