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Kahawai: Information presented at the 1994 stock assessment

J. B. Jones
MAF Fisheries Greta Point
P O Box 297
Wellington
New Zealand

Current address
Western Australian Fisheries Department
c/- Department of Agriculture
3 Baron-Hay Court
South Perth 6151
Western Australia

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National Institute of Water and Atmospheric Research Ltd, Wellington

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1 Executive summary

Both the literature review and review of the kahawai fishery are updated since Jones *et al.* (1992). The 1992–93 catch table is revised to correct errors discovered subsequent to publication of Annala (1994).

Recent research information on kahawai is summarised. All available data support the hypothesis that there has been no measurable change in the average length of kahawai since the start of the purseseine fishery in the 1970s.

MCY cannot be estimated because of the uncertainty over changes in fishing effort and the development and state of the fishery. CAY cannot be estimated because of the lack of current biomass estimates.

Recent catch levels are thought to be sustainable for two reasons: (a) Values of Z, which include the effects of commercial and non commercial fishing, have been calculated for kahawai. Given a value of M of about 0.18, these estimates of Z suggest that the current values of F are $\leq M$. Levels of F near or below M are generally considered sustainable. (b) From the aerial sightings data for western and central Bay of Plenty there is no evidence of a decline in either the median number or median size of kahawai schools seen per month between 1976 and 1992–93.

2 Introduction

2.1 Overview

Kahawai are a popular recreational fish, especially in the north of the North Island. There is also a small but important commercial purseseine fishery. Concern by recreational interests at the state of the kahawai fishery and the effects of the commercial catch resulted in the establishment of a coordinated research programme between MAF Fisheries North, MAF Fisheries Central, and MAF Fisheries Greta Point in 1990. Research was based around a 5 year Strategic Plan first circulated to interested groups in 1991. Progress on the plan was documented by Murray (1994). Results of projects undertaken as part of the plan have been published separately.

This Fisheries Assessment Research Document (FARD) summarises the information on kahawai which has become available since the 1992 FARD for kahawai (Jones *et al.* 1992), and supplements the information provided in the 1994 Report from the Fishery Assessment Plenary (Annala 1994)

2.2 Description of the fishery

Commercial fishers take kahawai by a variety of methods, though the bulk of the catch is taken by purseseine vessels, mainly from the Bay of Plenty and around Cook Strait and Kaikoura. Significant quantities are also taken seasonally in setnet and trawl fisheries, usually as bycatch (Figure 1). In the 1992–93 fishing year just over 200 licensed Fish Receivers (LFRs) reported landings of kahawai, but 86% of the catch was accounted for by only four LFRs.

2.3 Literature review

Jones *et al.* (1992) reviewed the literature. Three papers have since been published on kahawai otolith chemistry, the first two based on Australian work with *Arripis trutta*. Kalish (1991) measured oxygen and carbon isotopes in otoliths of kahawai as a potential method for obtaining environmental temperature records from fish. A second paper described changes to isotope ratios in otoliths caused by subjecting fish to stress (Kalish 1992). Gauldie *et al.* (1993) compared the banding patterns from scales and otoliths of known age (14 year old, 66 cm fork length) kahawai from the Napier Aquarium and concluded that counts of otolith check rings provided an overestimate of true age but that otolith calcium density mapped by proton microprobe gave accurate age estimates. Paul (1992) reviewed age and growth studies of New Zealand marine fish, including kahawai.

The results of the market sampling programme in the MAF Fisheries North region during 1991–92 were reported by McKenzie *et al.* (1992) and those from the MAF Fisheries Central region by Drummond & Wilson (1993). The MAF Fisheries South recreational survey results were summarised in Teirney *et al.* (1992) and detailed by Bell *et al.* (1993). The tonnages they estimated for the recreational kahawai catch are included in Section 3.2 (page 4). Recreational fishing habits and perceptions from a non-random survey in the Central region were described by Kilner & Bell (1992). Their survey showed that kahawai are among the most popular finfish in the Central region.

Kingsford (1992) described the association of small juvenile kahawai with drifting seaweed. Paulin (1993) revised the taxonomy of the family Arripidae and described a new species of *Arripis* from New Zealand waters. A thesis (Hickford 1993) on the impact of setnets provided information on setnet mesh selection of kahawai and a length-weight relationship for kahawai at Kaikoura. A thesis by Drummond (1994) documented the existence of a juvenile nursery area for kahawai in inner Tasman Bay and the dispersal of the fish into open water to mature at age 5.

3 Review of the fishery

3.1 TACCs, catch, landings, and effort

3.1.1 Total landings

Historical landings for the commercial fishery were provided by Jones *et al.* (1992). Reported landings of kahawai by Fishstock from 1983–84 to 1992–93 are given in Table 1[1].

As kahawai are not included in the Quota Management System, the only sources of catch data are the Licensed Fish Receiver (LFR) database, the Catch Effort Landing Returns (CELR) database, and MAF Policy records for purseseine method only. Of the three, the LFR figures are considered to be reliable but do not have method or area information. The CELR forms are completed on the fishing vessel and from these the area and method statistics are derived. However, when kahawai are a minor component of the catch, the kahawai tonnage does not appear on the CELR forms and only the total catch of minor species (including kahawai) is given. In addition, an audit of the purseseine CELR forms by MAF Fisheries Research staff showed that about 25% of the forms had one or more data fields entered incorrectly on the database. Because of these errors, it is necessary to manually check the data forms against the database records. The catch figures in this FARD are derived from manually checked forms. Since the 1990–91 season purseseine vessels have also reported catch directly to MAF Policy which is able to provide an estimate of catch independent of the CELR.

3.1.2 Purseseine catches

The kahawai fishery is important to the domestic purseseine fleet. For about 5 months of the year (December to May) the northern fleet, based in Tauranga, targets skipjack tuna (*Katsuwonus pelamis*) with very little bycatch. Outside the skipjack season (or when skipjack are scarce) the fleet fishes for a mix of species including kahawai, jack mackerels (*Trachurus* spp.), and blue mackerel (*Scomber australasicus*). To reduce product storage costs, these are caught 'on demand' as export orders are received. The southern fleet, based in Nelson, fishes primarily for mackerels and kahawai except in midwinter when they stop fishing. In 1992–93, one Nelson-based vessel went north to target skipjack during the summer which reduced the overall KAH 3 catch.

1 After the May 1994 Plenary, it was discovered that one purseseine vessel had, between November 1992 and June 1993, been filling in both a Catch Effort Landing Return and Catch Landing Return form. This resulted in double-counting of the catch by 723 t. Table 1 has therefore been revised since Annala (1994).

3.1.3Other commercial methods

From the CELR database, setnets were the next most important method after purseseining and accounted for about 7–10% of the commercial kahawai catch over the 1990–91 to 1992–93 seasons. Trawling (both bottom and pair) accounted for just under 4%. Other methods were insignificant (less than 1.5% each). There is a difference in the relative importance of methods by Fishstock. Figure 1 shows the percentage of the apportioned[2] 1992–93 catch from each Fishstock by method.

3.2Recreational, Traditional, and Maori Fisheries

The MAF Fisheries South recreational catch and effort survey estimated that residents in the MAF Fisheries South region caught 81 t (c.v. 16%) of kahawai from KAH 3 during 1991–92 (Bell *et al.* 1993). The MAF Fisheries Central recreational catch and effort survey estimated the 1992–93 catch by Central region residents as 293 t (c.v. 16%) in KAH 2 and 132 t (c.v. 23%) from KAH 3 (MAF Fisheries preliminary data). Combining these two surveys (noting, however, that they represent different years) gives a best indication of recreational harvest of 213 t for KAH 3. The recreational catch of kahawai in the MAF Fisheries North region by resident recreational fishers was unknown at the May 1994 Fishery Assessment Plenary.

3.3Management controls

Until 1991 there was no control on the amount of kahawai that could be caught commercially by existing permit holders. A voluntary moratorium was placed on targeting kahawai by purseseine in the Bay of Plenty from 1 December 1990 to 31 March 1991. In March 1991, the Minister of Fisheries announced his decision on the management of kahawai for the 1990–91 fishing year. The total commercial catch limit for kahawai was set at 6500 t, with 10% reserved for Maori, and 4856 t allocated for purseseining. The competitive catch limits for purseseining were divided as follows: 1666 t from KAH 1; 851 t from KAH 2; and 2339 t from KAH 3. However, by March 1991 the 1990–91 KAH 3 purseseine landings had already exceeded 2339 t so a 1-year kahawai bycatch allowance of 500 t was granted in KAH 3 to allow fishing to continue on other target species.

The total commercial catch limit, the purseseine catch limit, and the moratorium were rolled over for the 1991–92 and 1992–93 fishing years. For the 1993–94 fishing year the competitive catch limits for purseseining in KAH 1 were further reduced to 1200 t and purseseine catches in KAH 9 were included in the KAH 1 quota. Extensive voluntary closed areas in the Bay of Plenty, Nelson Bays, Marlborough, and Kaikoura were also agreed to between the Minister, the recreational sector, and the industry. The voluntary moratorium on targeting kahawai by purseseine in KAH 1 was extended from 1 December to the Tuesday after Easter (5 April in 1994).

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2 Because not all fishers report kahawai landings by method, an apportioned catch figure was derived as follows. The total catch from the CELR database (C) was divided by the total catch reported by method (M) and the result multiplied by the reported catch for each method (m), that is, apportioned catch = mC/M.

As from 1 October 1993 the commercial setnet minimum mesh size of 85 mm was increased to 90 mm in the Auckland Fishery Management Area (FMA), South-East FMA, and Southland & Subantarctic FMA; and to 100 mm in the Central FMA and Challenger FMA. These size limits also apply to amateur nets. There is no minimum length or specific bag-limit for kahawai except in southern areas (15 fish per person): elsewhere it is included in the general bag limit provisions.

Though a total catch limit has been set for kahawai, there is no mechanism to control catches by methods other than purseseine and the 6500 t limit was exceeded in 1992–93 (*see* Table 1). An audit of the CELR forms carried out after the May 1994 plenary revealed that there had been a 550 t purseseine catch in QMA 9 (for which there was no catch limit allocated in 1992–93) and a purseseine catch overrun in QMA 2 of 185 t.

4 Research

4.1 Stock structure

Evidence from tag returns indicates that some kahawai move long distances around the North and South Islands. New Zealand kahawai are therefore likely to be a single stock. The evidence is suggestive, but not conclusive, since most tagged kahawai are recaptured within 70 n. miles of the release site (*see* Section 4.3.3, page 8) and spawning areas are not well understood.

Kahawai are managed as separate units: KAH 1 (QMA 1); KAH 2 (QMA 2); KAH 3 (QMAs 3–8); KAH 9 (QMA 9) and KAH 10 (QMA 10).

Paulin (1993) described a new species of kahawai (*Arripis xylabion*) from the Kermadec Islands (QMA 10) which also occurs off northern New Zealand (Worthington 1993). It can be distinguished from *A. trutta* in having a relatively larger upper lobe of the tail fin (> 30% compared to < 29% of standard length (SL) in *A. trutta*), and a larger maximum size than *A. trutta* (85 cm compared to 55 cm SL) (Paulin 1993). It should be noted that Paulin's measurements are based on a small sample size and that *A. trutta* grows larger than 55 cm, at least to 60 cm SL (MAF Fisheries unpublished records). The southern extent of *A. xylabion* is unknown.

4.2 Resource surveys

There have been no directed research surveys from which biomass estimates of kahawai can be derived.

4.2.1 Aerial sightings data

The aerial sightings database is the most comprehensive dataset on kahawai availability. Analysis of trends in the dataset have been reported separately (Bradford & Taylor 1995). From the western Bay of Plenty aerial sightings data there is no evidence of a long-term change in the median number or size of kahawai schools, or in surface abundance between 1976 and 1992–93.

4.3 Other studies

4.3.1 Biology

Kahawai are a schooling pelagic species belonging to the family Arripidae. There are four species, of which kahawai (*Arripis trutta*) occur around the eastern Australian, Victorian, Tasmanian, and New Zealand coasts (Paulin 1993). In New Zealand, kahawai are found around the North Island, the South Island, the Kermadec Islands and Chatham Islands. A related species, *Arripis xylabion* occurs around the Kermadec Islands and northern New Zealand (Paulin 1993, Worthington 1993, *see* Section 4.1, page 5).

Kahawai feed mainly on small fishes but also on pelagic crustaceans, especially krill (*Nyctiphanes australis*). Kahawai smaller than 100 mm fork length (FL) eat mainly copepods. Though kahawai are principally pelagic feeders they will take food from the sea bed (Baker 1971). Kahawai compete directly for food with mackerels (*Trachurus* spp. and scombrids (*Katsuwonus, Scomber, Thunnus*) (Bailey 1983, MAF Fisheries unpublished data).

Spawning female kahawai occurred in January and February 1993 in QMA 1 and QMA 9 trawl bycatch (MAF Fisheries unpublished data). Schools of running ripe female kahawai have been caught on the sea bed at 60–100 m depth in Hawke Bay, but have never been observed in or reported from purseseine landings in KAH 1, KAH 2 or KAH 3 (MAF Fisheries unpublished data). However, there are reliable reports of running ripe female kahawai occurring at the surface (D.A. Robertson, pers. comm.).

Kahawai eggs are pelagic (Robertson 1975). Eggs were collected in February from the outer Hauraki Gulf (Crossland 1982). Egg counts carried out in the 1970s (MAF Fisheries unpublished data) showed that kahawai produce 60 000–750 000 eggs. Larval kahawai have been found in open water associated with floating detritus and weed (Kingsford 1992).

Juvenile fish (0+ age class) recruit to sandy beaches in the surf zone and can also be found in shallow water over estuarine eel grass (*Zostera* sp.) meadows (Robertson 1982, Jones & Hadfield 1985, Drummond 1994). As with most fish species (Macpherson & Duarte 1991), there is a positive relationship between kahawai size and water depth (Figure 2). As they grow the fish move into deeper water in estuaries and harbours and then some move further offshore. This size-related movement behaviour has been observed among the fish tagged in Tasman Bay (Drummond 1994 and unpublished MAF Fisheries tagging data).

Behaviour described in previous paragraphs has important fishery implications. Firstly, as juvenile kahawai recruit to sea grass meadows, estuaries, and beaches they are vulnerable to the effects of environmental modification of estuarine 'nursery areas'. Such changes are effected by land use changes, runoff, pollution, and urban sprawl. The effects on kahawai have not been investigated. Secondly, it has been established from work on other schooling fishes that the density of fish within a school is directly related to the lengths of the fish (Serebrov 1976, Pitcher *et al.* 1985, Misund 1993). Thus for a given volume a school of small fish contains many more fish than a school of big fish. Since small kahawai school inshore, fishing techniques based on volume (such as trawling, purseseining, or ringnetting) will generate disproportionately greater mortality inshore than offshore (*see* Gordoa & Duarte (1991) for a discussion of this principle as applied to hake).

4.3.2 Length frequency data

Kahawai length frequency data are available from purseseine catch sampling carried out between 1973 and 1975 at Gisborne (12 samples from kahawai schools caught between East Cape and Gisborne, MAF Fisheries unpublished data); from purseseine catch sampling between 1981 and 1983 in the MAF Fisheries Central region (24 samples, MAF Fisheries unpublished data); and in 1983 in the Bay of Plenty (3 samples, Wood *et al.* 1990). Between 1990–91 and 1992–93 a catch sampling project was carried out in the Auckland FMA (McKenzie *et al.* 1992 (Figure 3) and MAF Fisheries unpublished data), and between 1990–91 and 1992–93 in the Central FMA (Drummond & Wilson 1993 and unpublished MAF Fisheries data).

Three non-random length frequency datasets are also available from non commercial catches. A length frequency histogram of 417 fish collected by setnet, trammel net, and 'some' lure caught fish was provided by Penlington (1988) from a study of the recreational fishery at the mouth of the Motu River in 1982. Length frequencies have also been collected from a boatramp survey carried out by MAF Fisheries North during 1991 and by MAF Fisheries Central in 1992. Data analysis has not been completed for either boatramp survey.

There is an extensive literature on schooling behaviour in fish and it has been established that within any school, length variation is quite small due to the operation of size sorting mechanisms and that the distribution of lengths conforms to a gaussian distribution (Gordoa & Duarte 1991, Misund 1993). There is no reason to believe that kahawai are an exception to this rule. Thus the length frequency of a single kahawai school, or several schools combined, provides no information about the length frequency of the total population.

However, it is possible to compare mean school lengths between purseseine landings when the landing consists of fish from one set. This has been done for the Bay of Plenty. The mean length of each of the 3 landings measured in 1983, the 8 landings measured in 1991, and the 21 landings measured in 1992 are provided in Table 2. Two of the 1992 landings had larger mean sizes than any of the 1983 samples. Ten (34%) of the combined 1991 and 1992 sampled landings had a mean size as large as, or larger than, those measured in 1983.

There were also 12 landings measured from East Cape to Gisborne in the 1970s (now area QMA 2) (Table 3). A randomisation test was carried out between the sample means from the these data and the 29 landings from 1991–92 from the Bay of Plenty (QMA 1). The test involves comparing the difference between the two observed groups with the difference obtained between two groups randomly selected from the pooled data (Manly 1991). If the two sets of samples came from the same population (and we know there is movement of tagged fish between the two areas), the mean difference should be close to zero. The choice of test statistic is not critical; in this case the difference between the two group means was used. The randomisation test was repeated 400 times: 32% of the differences between the groups selected at random were greater than or equal to the observed difference of 0.81 (Figure 4). Therefore the null hypothesis, that there is no significant difference in mean lengths between the 1970s and 1990s, cannot be rejected.

Discussion at the May 1994 Plenary highlighted the ability of the purseseine vessels to selectively target kahawai by size. A possible explanation for the absence of any demonstrable change in kahawai length between the 1970s and the 1990s is that the purseseiners are targeting the same size classes now as they did in 1983. It was concluded by the Plenary that historical comparison of purseseine catch did not provide reliable information on length frequency trends in the population. However, there are still large kahawai remaining for the fishery to target.

In the MAF Fisheries Central region, analysis of length frequency data suggests that sizes are consistent within areas, but not between areas (Drummond & Wilson 1993, Drummond 1994). Historical length frequency data were therefore compared with recent length frequency data by area. In the South Taranaki Bight during the period 1990–91 to 1992–93 there were only 3 days fishing on the Rolling Ground. This low level of fishing contrasts with the pattern in the 1980s when the Rolling Ground supported a significant kahawai fishery. The median length in February 1993 was 51 cm (one landing sampled), slightly larger than fish sampled from the same area during 1981–83 when schools had median lengths ranging between 46 and 50 cm (Wood *et al.* 1990; MAF Fisheries unpublished data).

The Farewell Spit area yields consistently large kahawai. Wood *et al.* (1990) recorded a median size of 47 cm in 1981–83 and Drummond & Wilson (1993) found median lengths of 49–50 cm during both the 1990 and 1991 summers. A catch sampled in December 1992 had a median length of 53 cm.

Sizes of kahawai caught at Kaikoura have been consistent over time, with a median length which varied between 52 and 54 cm over the period October 1990 to January 1993. The median size of fish sampled during October 1983, 1990, 1991, and 1992 has in each instance been 53 cm (Wood *et al.* 1990, Drummond & Wilson 1992, Drummond, pers. comm.)(Figure 5).

The 1991 MAF Fisheries North boatramp survey data reveal that recreational fishers catch a wider range of sizes and proportionally more smaller fish (15–30 cm) than the commercial fishery. There is also a difference in length frequency between areas in the recreational catch. Recreational fishers caught proportionally more smaller fish (20–40 cm) than larger fish (40–60 cm) in the Hauraki Gulf than in either the Coromandel or Bay of Plenty (Figure 6).

4.3.3 Tagging data

There have been two tagging studies on kahawai. The first was undertaken to study the movements of kahawai, and 13 911 tagged fish were released on 32 occasions between 1981 and 1984 at 27 sites around the North and South Islands (Wood *et al.* 1990). The recapture rate was about 10%. The second study was undertaken in 1991 when just under 10 000 kahawai were injected with oxytetracycline, tagged, and released at two sites as part of an age verification experiment (MAF Fisheries unpublished data). As at January 1994, 14% of these tags had been returned.

The tag returns show that some kahawai move long distances; however, most kahawai are recaptured within 70 n. miles of the release site. Returns from the 1981–84 tagging programme (all areas, excluding recaptures within 30 days of release) show that 48% were recaptured within 50 n. miles and 72% within 100 n. miles of the release site (Figure 7). In the Bay of Plenty only, 66% of recaptures occurred within 50 n. miles of the release site and 77% were recaptured within 100 n. miles of their release site. For kahawai tagged in the Bay of Plenty in 1991 (excluding recaptures within 30 days of release) 84% had moved less than 50 n. miles and 91% less than 100 n. miles (Figure 8).

In the 1991 tagging study release length and recapture length were measured by MAF Fisheries staff. For fish within the size range 30–60 cm, distance travelled was found to be unrelated to length at recapture (Figure 9). Days at liberty were also unrelated to distance travelled for the 1981–84 tagging data (excluding the first 30 days at liberty). There is some evidence to suggest age-related movement between juvenile and adult habitats (Drummond 1994), but no seasonal movement of adults has yet been substantiated. The oldest tag recapture, after 11 years at liberty, was at Kaikoura at the same point it was released.

4.3.4 Fishery parameters

Estimates of the fishery parameter Z are given in Table 4. The analysis of catch curves is difficult for schooling pelagic species for several reasons which include: (a) difficulties in obtaining an adequate representative sample of sufficient size when species school by size; (b) uncertainty in the value of M; and (c) lack of contrast in the data when the exploitation rate is low.

5 Management implications

There is a widely held perception, repeatedly reinforced by media articles, that kahawai, especially in KAH 1 (including Northland) and KAH 9, are becoming scarce and smaller in size due to excessive commercial catches. For the Bay of Plenty, where the bulk of the KAH 1 purseseine catch occurs, scientific evidence does not support this assertion.

(a) Recreational length frequencies collected by MAF Fisheries in a 1990–91 boatramp survey show that 20% of all kahawai measured (3 775 fish) exceeded 50 cm in length.

(b) From the aerial sightings data for the western and central Bay of Plenty, there is no evidence of a decline in the median number and size of kahawai schools seen per month between 1976 and 1993.

There has been no significant purseseine catch of kahawai in KAH 9, and purseseine catches in KAH 1 north of the Hauraki Gulf have been minimal. For the activities of the purseseiners to be responsible for any declines in abundance in these areas, large movements of kahawai around and between QMAs would be needed. Returns of tagged fish from the 1981–84 tagging programme (all areas, excluding recaptures within 30 days of release) show that while a few tagged kahawai travel long distances (up to 750 n. miles), 48% were recaptured within 50 n. miles and 72% within 100 n. miles of the release site.

Shore fishers will, on average, catch smaller kahawai than boat fishers. Fish 15–30 cm in length are found near the shore and are predominantly 2 or 3 years old. Recreational fishers would thus notice reduced catches resulting from a bad year class. Good and bad year classes would have an impact on recreational catches but would have less of an impact on commercial catches, which concentrate on larger fish representing 10–15 year classes (Drummond & Wilson 1993, MAF Fisheries unpublished data).

Values of Z, which include the effects of commercial and non-commercial fishing, have been calculated for kahawai. Given a value of M of around 0.18, these estimates of Z suggest that the current values of F are less than or equal to M. Levels of F at or below M are generally considered sustainable.

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Table 1: Reported landings (t) of kahawai by Fishstock from 1983–84 to 1992–93. Estimates of mis-labelled fish, dumped fish, or fish landed as bait are not included. Data for the distribution of catches among QMAs and Total Catch are from the FSU database through 1987–88 and from the CELR database after that date. Total LFRR values are the landings reported by Licensed Fish Receivers. This table was prepared after an audit of the purseseine CELR forms and tonnages have been adjusted from the preliminary data tabled in Annala (1994). –, no data available.

	Fishstock							
	KAH1	KAH2	KAH3	KAH9	KAH10			
QMA(s)	1	2	3–8	9	10	Unknown area	Total catch	Total LFRR
71983–84	1 941	919	813	547	0	46	4 266	–
1984–85	1 517	697	1 669	299	0	441	4 623	–
1985–86	1 597	280	1 589	329	0	621	4 416	–
1986–87	1 890	212	3 969	253	0	1 301	7 525	6 481
1987–88	4 292	1 655	2 947	135	0	581	9 610	9 218
1988–89	2 170	779	4 301	179	0	–	7 431	7 377
1989–90	2 049	534	5 711	156	0	16	8 466	8 696
1990–91	1 617	872	2 950	242	0	4	5 687	5 780
1991–92	2 190	807	1 900	199	<1	7	5 104	5 071
1992–93	2 738	1 132	1 930	832	2	0	6 639	6 966

Table 2: **Purseseine landings of kahawai sampled in the Bay of Plenty in 1983, 1991 and 1992 (n= number in sample, Mean = mean fork length, s.d = standard deviation).**

Date	n	Mean	s.d.
31/05/83	100	52.72	2.48
13/06/83	100	49.34	2.54
16/06/83	100	51.79	2.83
14/05/91	3 158	43.56	2.29
15/05/91	2 758	37.16	4.91
27/05/91	821	45.46	3.96
28/05/91	741	45.19	4.39
31/05/91	1 157	51.59	2.48
24/07/91	1 029	45.83	4.23
05/08/91	2 069	44.27	2.75
07/12/91	1 029	49.62	3.30
04/01/92	300	50.4	1.97
08/01/92	560	45.99	2.50
11/04/92	564	53.6	2.60
14/04/92	3 152	50.29	2.22
15/04/92	1 493	41.15	5.00
16/04/92	1 287	32.17	1.21
27/05/92	2 620	43.45	3.66
28/05/92	2 174	44.49	3.57
29/05/92	769	44.75	3.84
06/08/92	418	32.35	1.22
06/08/92	422	42.42	2.91
30/09/92	610	50.77	2.78
30/09/92	801	51.23	2.54
04/10/92	1 104	45.42	4.05
11/10/92	577	46.96	2.42
11/10/92	646	51.27	2.55
12/10/92	333	36.00	1.49
02/12/92	726	54.10	1.98
10/12/92	747	38.33	4.45
16/12/92	239	50.90	2.5
16/12/92	257	36.95	2.61

Table 3: **Purseseine landings of kahawai sampled in the East Cape-Gisborne area during the 1970s (abbreviations as for Table 2).**

Date	n	Mean	s.d.
10/12/73	55	51.84	3.31
10/12/73	55	51.64	2.44
17/01/74	100	49.64	3.35
16/12/74	99	48.64	2.99
19/09/75	123	36.65	2.81
25/09/75	212	43.84	3.29
01/09/75	46	35.22	3.16
22/10/75	83	46.25	3.10
24/10/75	107	45.11	2.83
28/10/75	86	45.86	2.54
03/11/75	59	47.07	2.93
19/11/75	100	48.39	2.32

Table 4: **Estimates of Z for kahawai**

Fishstock	Estimate	Source
KAH 2	0.24	MAF Fisheries unpubl. data
KAH 3 (Marlborough Sounds)	0.22-0.35	Drummond & Wilson 1993
KAH 3 (Cloudy/Clifford Bays)	0.19-0.27	Drummond & Wilson 1993
KAH 3 (Kaikoura)	0.23-0.30	Drummond & Wilson 1993
KAH 9	0.11	Jones *et al.* 1992

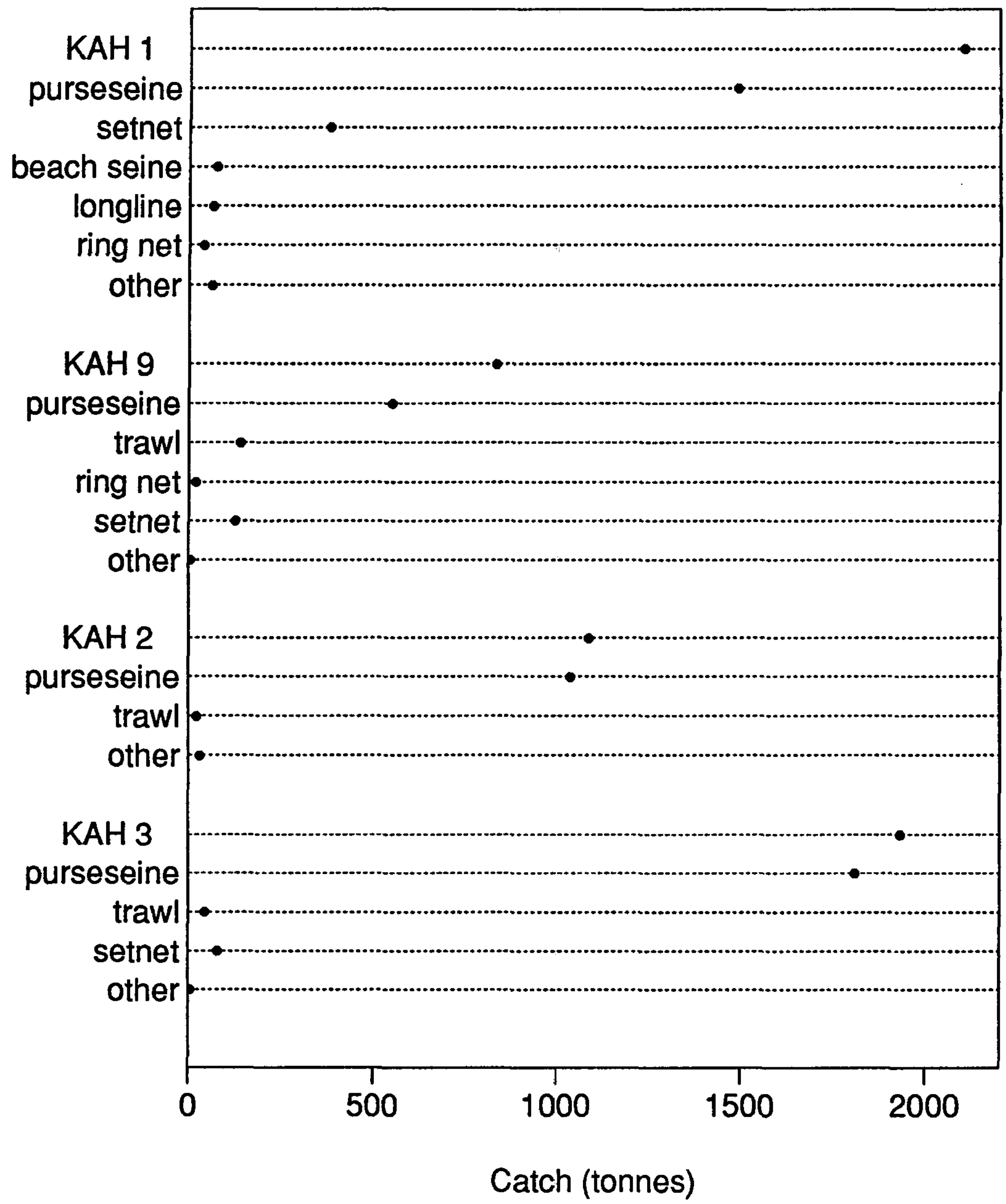


Figure 1: Commercial catch by main methods in each kahawai Fishstock for the 1992–93 fishing year. The catches are apportioned catches from the CELR database. Total catches by Fishstock are shown (KAH 1, KAH 9, KAH 2, and KAH 3).

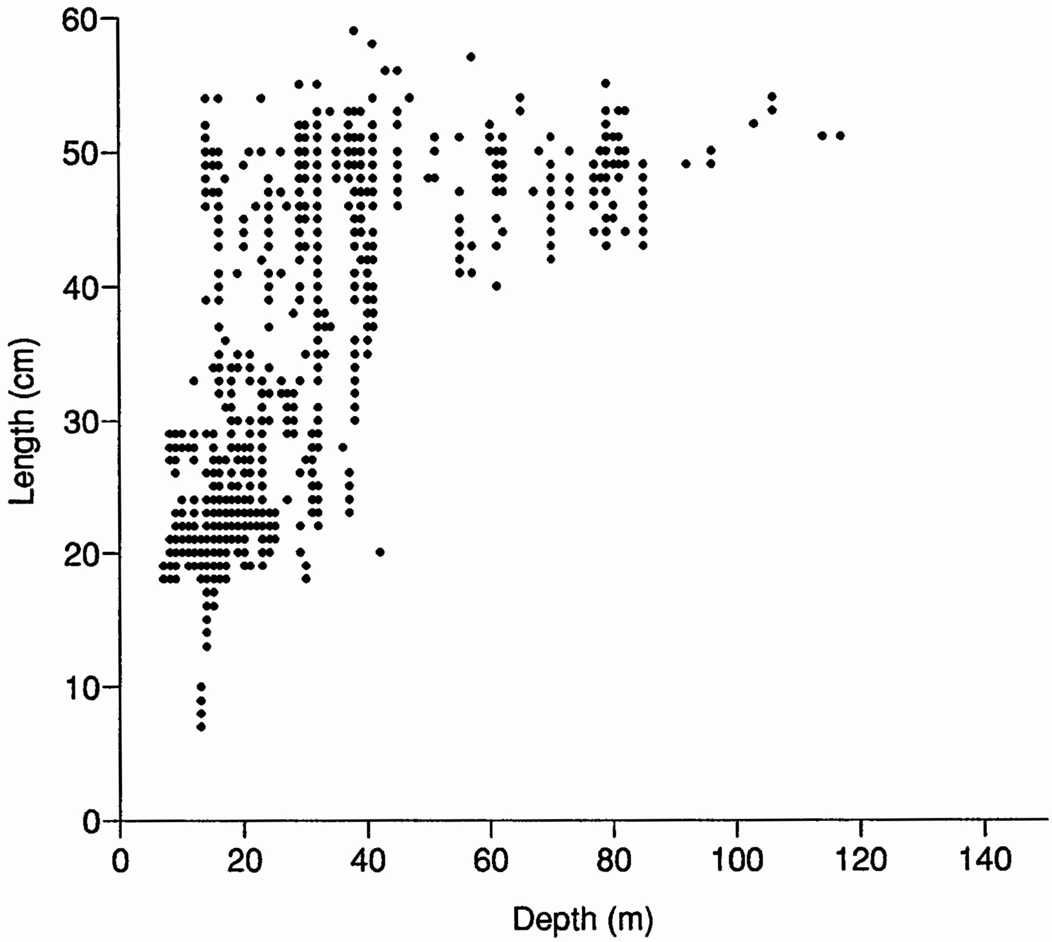


Figure 2: **The relationship between water depth and individual kahawai length. Data taken from the MAF Fisheries research trawl database, all years and areas combined.**

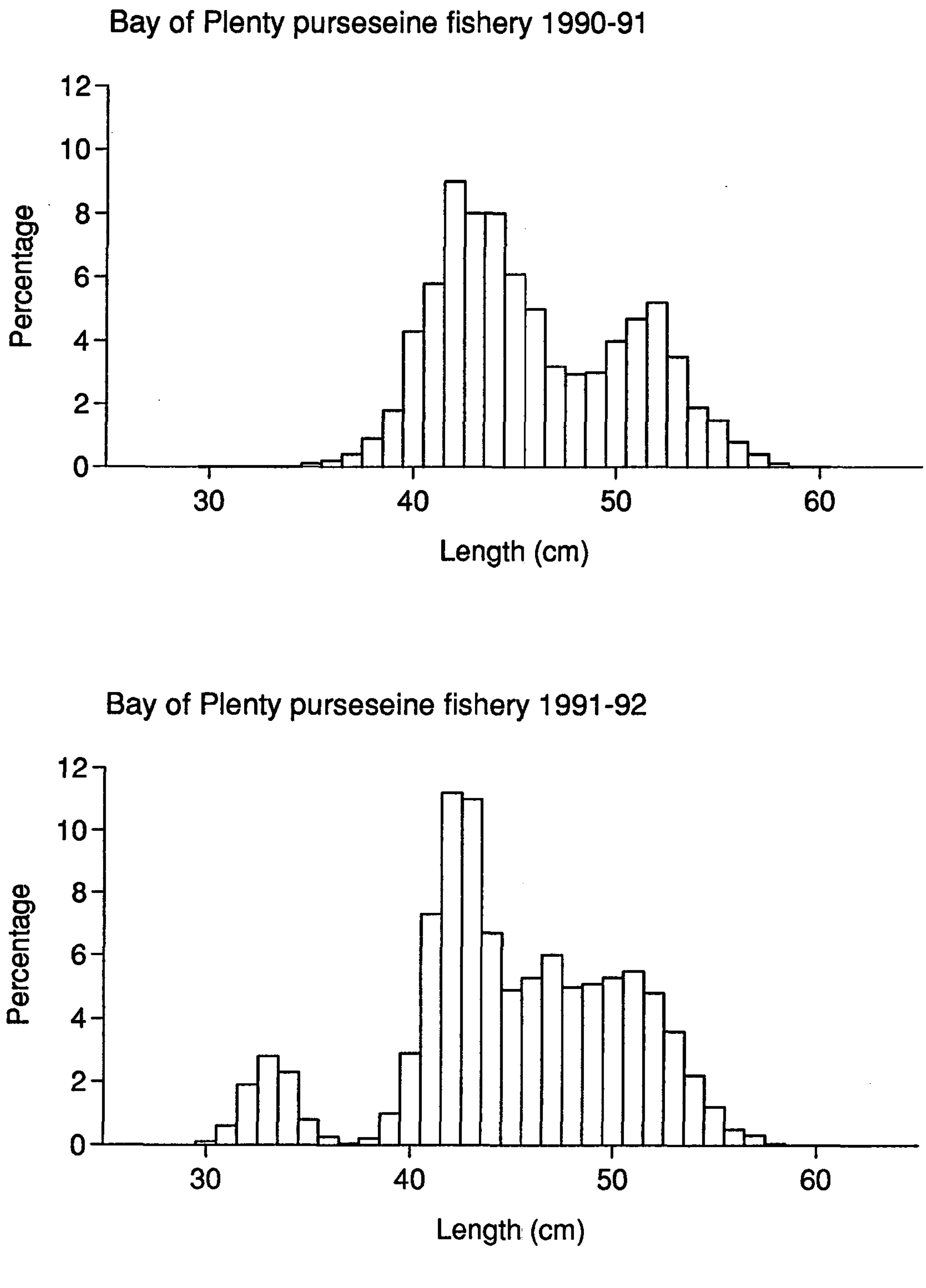


Figure 3: Length frequencies of kahawai measured during the catch sampling programmes of 1990–91 and 1991–92. Data taken from McKenzie *et al.* (1992).

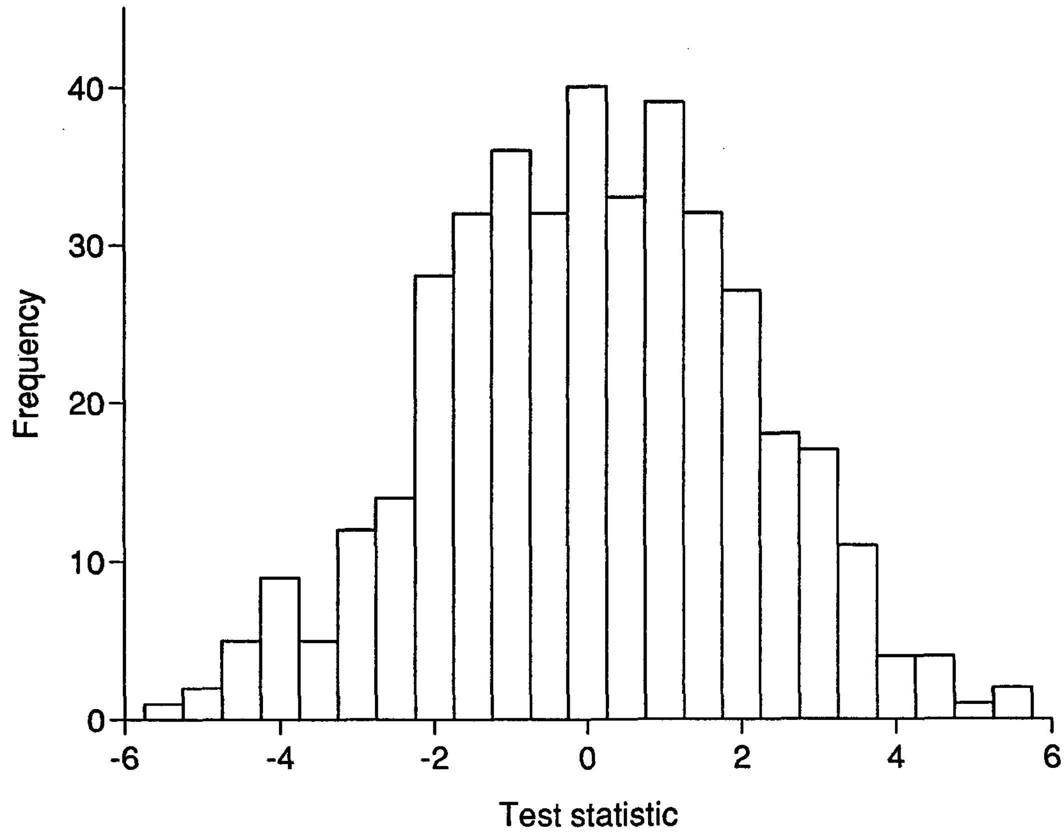
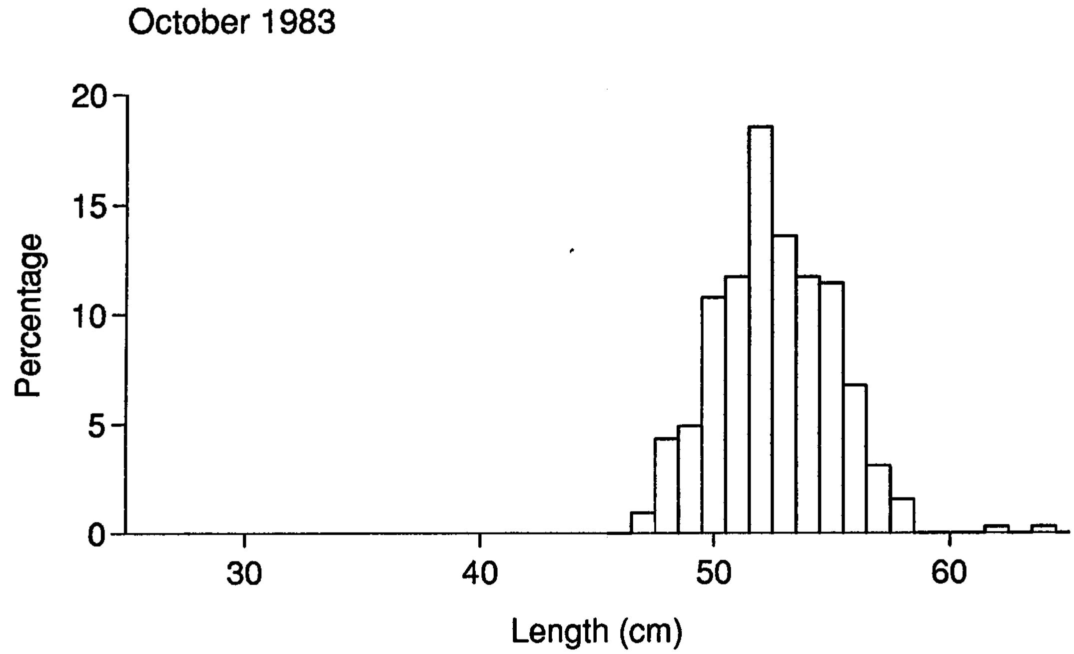


Figure 4: **Results of randomisation test for difference between the mean lengths of landings from the 1970s and 1990s. Histogram showing the distribution of the test statistic values obtained from 400 randomisations of the data. The value of the test statistic for the observed data was 0.81. There is no significant difference between the 1970s and 1990s mean lengths.**



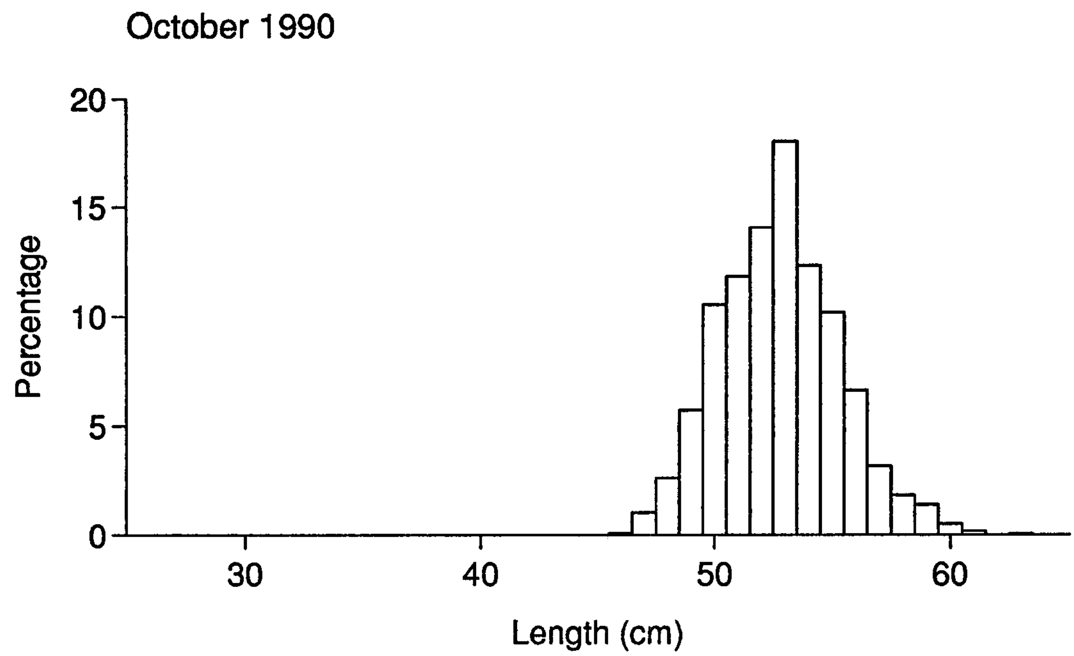


Figure 5: **Kaikoura fishery, length frequency distribution of kahawai landings in October 1983 and October 1990. Data for 1983 taken from Wood *et al.* (1990) (324 fish measured and expressed as a percentage). Data for 1990 taken from Drummond & Wilson (1993) (1306 fish measured and scaled up to represent the total catch (434 t) expressed as a percentage.**

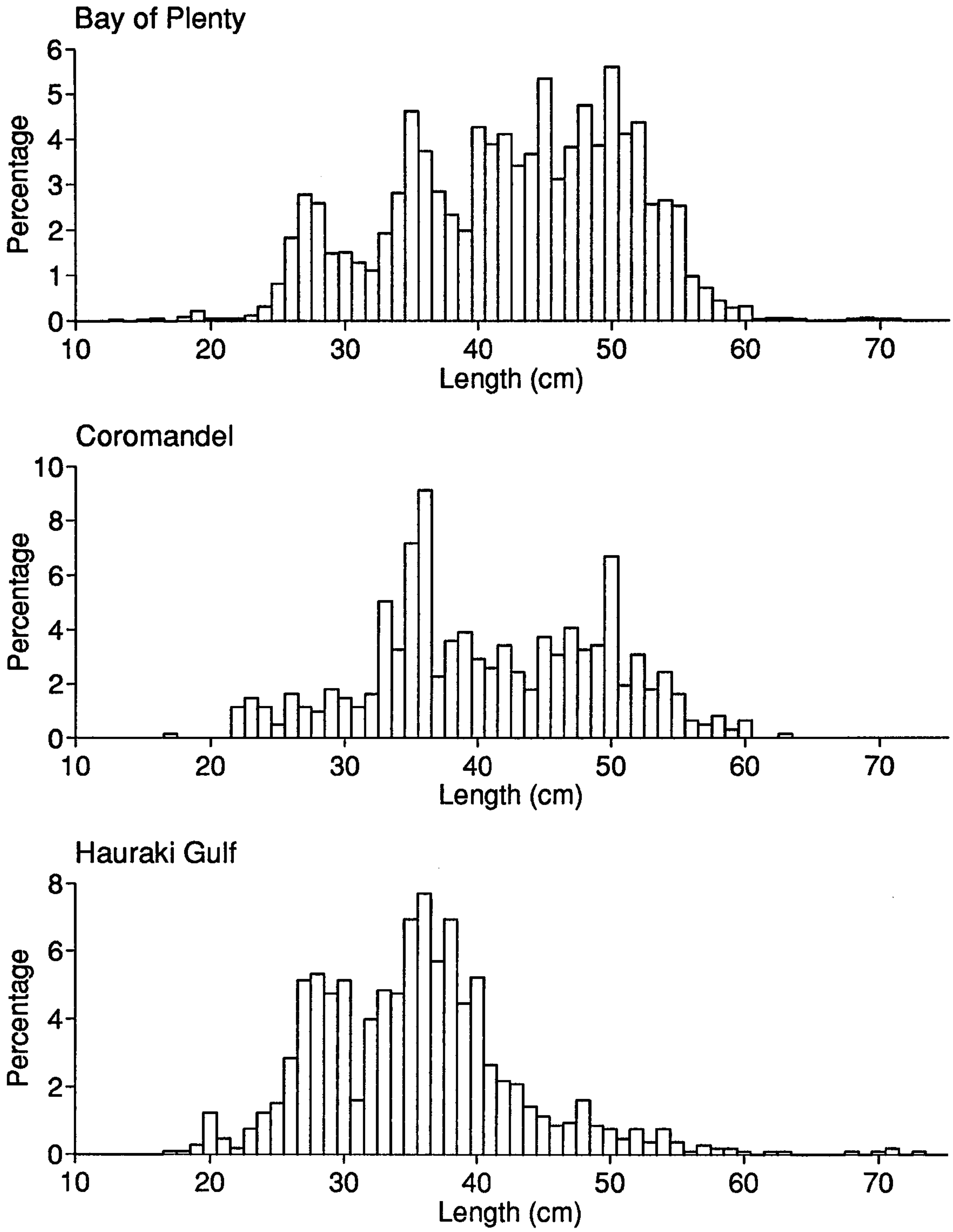


Figure 6: Length frequencies obtained from the Bay of Plenty, Coromandel and Hauraki Gulf recreational boatramp survey in 1991 (data from Todd Sylvester pers. comm.).

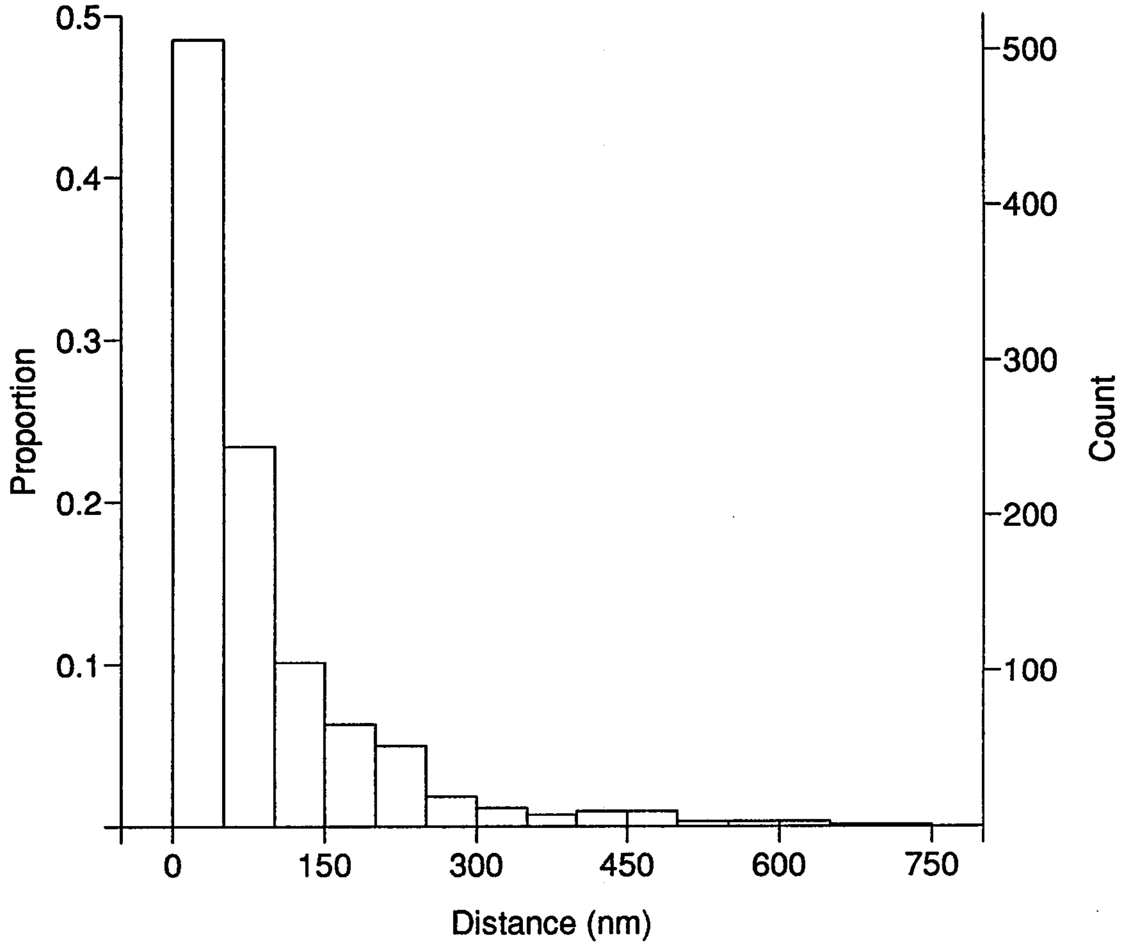


Figure 7: **Distance travelled by tagged kahawai released in all areas during 1981–84 and recaptured at least 30 days after release.**

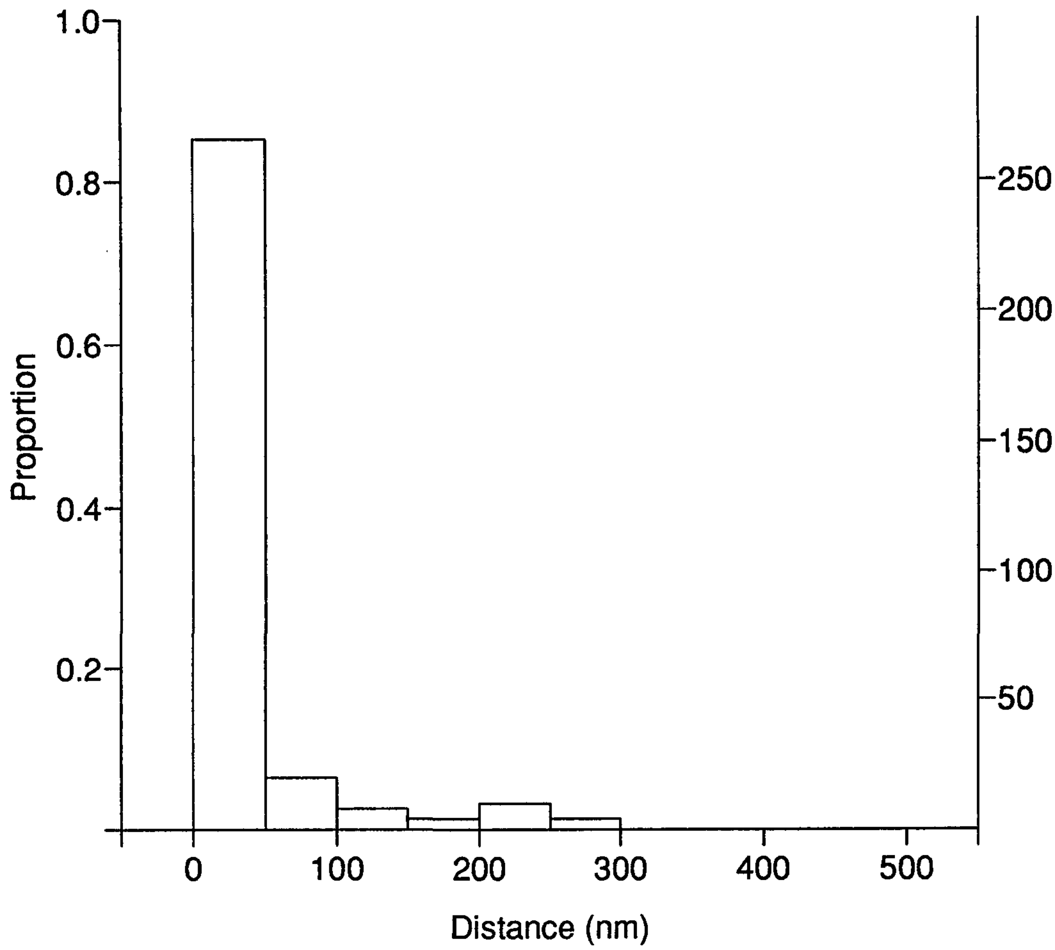


Figure 8: **Distance travelled by tagged kahawai released in the Bay of Plenty during 1991 and recaptured at least 30 days after release.**

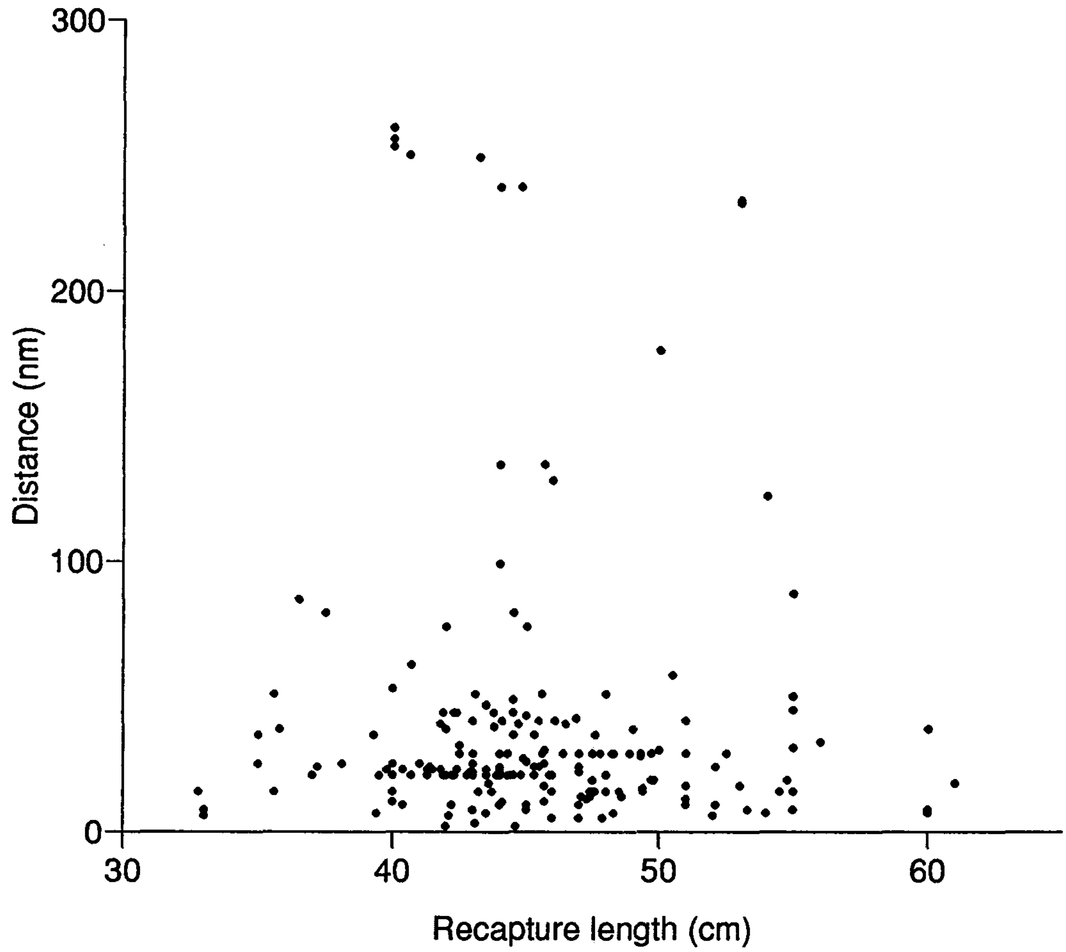


Figure 9: **Recapture length against distance travelled (excluding recaptures within 30 days of release) for kahawai tagged and released in the Bay of Plenty in 1991.**