CPUE from kahawai (*Arripis trutta*) setnet and trawl fisheries in Fishstocks KAH 1, 2, 3, and 8 between 1989 and 2005

J. R. McKenzie
J. Walker
B. Hartill

NIWA
P O Box 109695
Auckland

New Zealand Fisheries Assessment Report 2007/30
September 2007

Published by Ministry of Fisheries
Wellington
2007

ISSN 1175-1584

Citation:
McKenzie, J.R.; Walker, J.; Hartill, B. (2007).
CPUE from kahawai (*Arripis trutta*) setnet and trawl fisheries
in Fishstocks KAH 1, 2, 3, and 8 between 1989 and 2005.
New Zealand Fisheries Assessment Report 2007/30. 44 p.

This series continues the informal
New Zealand Fisheries Assessment Research Document series
which ceased at the end of 1999.

EXECUTIVE SUMMARY

McKenzie, J.R.; Walker, J.; Hartill, B. (2007) CPUE from kahawai (*Arripis trutta*) setnet and trawl fisheries in Fishstocks KAH 1, 2, 3, and 8 between 1989 and 2005.

New Zealand Fisheries Assessment Report 2007/ 30 44 p.

There is reasonable evidence from this study that the availability of kahawai to the setnet fishery in the last decade has declined over all stock areas except for east Northland and the Hauraki Gulf. With the exception of KAH 2, catch data from trawl do not show the same pattern. Confidence that setnet effort information reflect the landed kahawai catch comes from the fact that there is little discrepancy between the estimated at-sea catch weights and the 'true' landed values. The same cannot be said for the trawl data; at-sea catch information for trawl-caught kahawai is scant. Because it is difficult to classify kahawai trawl effort in a precise way much of the pattern seen in the trawl CPUE analyses could be due to mis-specified effort. In the absence of corroborating evidence (e.g., aerial overflight data) it is not advisable to assume the trawl indices reflect kahawai availability on trawl fishing grounds.

1 INTRODUCTION

Kahawai are a pelagic species found throughout New Zealand waters, but mostly around the North Island and the north of the South Island.

Up until the mid 1970s, most of the commercial kahawai catch was taken by setnetting and trawling, but the development of purse seine fisheries after 1975 saw a rapid escalation in landings, which increased from 300 to 500 tonnes to 9610 tonnes in 1987–88. Annual landings have since declined to less than 3000 tonnes p.a., and the commercial fishery is now constrained to 3035 tonnes, following its introduction to the Quota Management System in 2003–04.

The KAH 1 fishery (Figure 1) is the largest kahawai fishery in New Zealand, with over 70% of the annual catch taken by purse seine vessels. Most of this catch is taken while targeting kahawai in waters close to Tauranga in the second half of the fishing year. The largest KAH 1 fishery, in terms of the number of landings, is the setnet bycatch fishery, but in recent years ring netting has become increasingly popular and over half of the net-caught kahawai is now taken as a result of targeting at night by this method. The third largest source of kahawai landings is the single trawl fishery, which catches kahawai as a bycatch when targeting snapper, trevally, and other species.

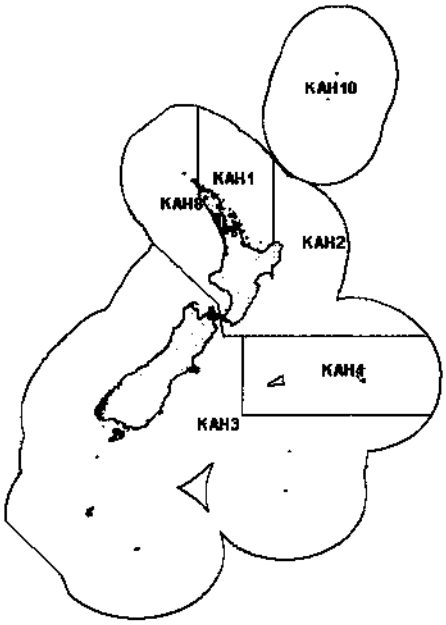


Figure 1: New Zealand kahawai quota management areas.

The KAH 2 fishery (Figure 1) is almost entirely a purse seine fishery, although small tonnages are also taken by trawlers and setnetters.

In the late 1980s, the KAH 3 fishery (Figure 1) was the largest in New Zealand, accounting for over half of the national commercial harvest, but in recent years there has been a significant decline in the harvest, at least partially due to a concentration of the purse seine fleet in KAH 1 at Tauranga. Almost all of the KAH 3 catch was taken north of Kaikoura on the east coast, and north of Kahurangi Point on the west coast of the South Island. Most of the remaining catch has been taken by trawlers in recent years.

The main method used to catch kahawai in KAH 9 (Figure 1) is single trawl, although these landings were almost entirely caught as a bycatch of other species, including snapper and trevally. Purse seining rarely took place off the northwestern coast of the North Island, as conditions are usually unsuitable when seining from vessels of the size used in New Zealand waters. The only exception to this was in 1992–93, when KAH 9 was the only QMA which was not subject to a competitive catch limit, and vessels ventured on to the west coast. In following years, the KAH 1 catch limit was collectively applied to KAH 9 as well, and purse seine vessels remained on the east coast. Kahawai are also taken by the QMA 9 setnet fishery, largely as a bycatch. Ring netting is becomingly increasingly popular on this coast, as in KAH 1.

A significant limitation to the assessment of New Zealand kahawai stocks is a lack of biomass information. Targeting of kahawai occurs only in the small net and purse seine fisheries. These fisheries provide the best hope for monitoring stock abundance using CPUE approaches. In the kahawai purse seine fishery, the measure of abundance is more likely to be discernable in search-time data from fleet spotter aircraft. Setnet effort being defined by net-length and soak-time is amenable to conventional log-linear modelling techniques.

Although significant quantities of kahawai are taken by trawl in some stocks, kahawai rarely makes the top five species caught by weight in a typical coastal trawl tow. This means, due to the limitations of the Ministry of Fisheries catch reporting system, that a large proportion of the trawl kahawai effort information is not recorded in Ministry databases.

The utility of setnet and trawl catch and effort data to provide abundance indices for the main kahawai fishing areas is investigated. The study was carried out as part of Ministry of Fisheries project KAH200501.

2 METHODS

Kahawai trawl and setnet Catch Per Unit Effort (CPUE) information was obtained from the Ministry of Fisheries. The spatial resolution of the data was statistical reporting area for setnet and latitude and longitude for trawl. The setnet effort information was net-length and set-duration whereas trawl effort was expressed in number of tows. Included with these data were a number of ancillary characters, e.g., fisher-ids and bycatch information. Ancillary characteristics were used as covariates in the analysis and as a data validation aid.

CPUE data were available for fishing years 1989–90 to 2004–05 (16 years).

Annual catch indices (assumed to represent kahawai availability) were derived using generalised linear modelling (GLM) procedures (Vignaux 1994, Francis 1999). The GLMs were conducted using the statistical software package R. The stepwise regression procedure (StepAIC) was used to select parameters (covariates) for inclusion in the final catch model. This procedure adds and removes parameters on the basis of improvement in Akaike's Information Criterion score (AIC: Sakamoto et al. 1986). The net improvement in the overall model R-square was calculated for each parameter added by the StepAIC process. Parameters resulting in less than a 3% improvement in model R-square were rejected. A set of Cook's distance scores (Cook & Weisberg 1982) were derived for the final model as a way of identifying datum observations with 'unacceptable' influence on the model fit. Observations with a Cook's scores greater than 0.05 were rejected and the models refitted.

The approach taken with all the GLMs was to enter the fishing 'effort' terms as a covariate (i.e., "right-hand" model term), thus the regressor variable was simply log-catch (kg); this is algebraically analogous to subtracting log effort from log catch. To understand what the GLM results may mean in stock abundance terms, it is important to understand what a significant 'effort' term would imply. Under a scenario in which there has been no change in abundance between years yet fishing effort has been variable, the GLM should identify 'effort' as explanatory whereas the 'fishing-year' term should

have very low explanatory power. Conversely, if fishing effort had been relatively constant between years yet catches have changed the GLM should find 'fishery-year' explanatory whereas 'effort' should be shown to have little or no explanatory power. The important point to realise is that although, logically, catch and effort should be correlated at some fundamental level, the failure of a GLM selection process to identify 'effort' as important does not necessarily diminish the relevance of the 'fishing year' index as a relative abundance measure. The critical thing is the 'effort' parameter **must** have been 'offered' in the GLM selection process.

3 DATA SELECTION

3.1 Setnet catch effort data

Setnet catch and effort information was included in the analysis under the criteria that kahawai appeared in the effort section of the reporting form either as one of the top five species caught in a set and/or was designated as the target species. The setnet fisheries report solely on Ministry Catch Effort Landing Return (CELR) forms. Because of the CELR form structure kahawai trip catch and effort information is aggregated at the daily level at the spatial resolution of Ministry statistical reporting areas. The basic observational unit (record) used in the GLM analysis was the total kahawai catch (kg) per day.

Because the catch weights recorded in the effort section of CELR forms are estimated, the total landed catch of kahawai from trips where kahawai was targeted or caught were also extracted as a means to validate the estimated catch totals. The full list of fields in the raw extract data tables are given in Appendix 1. The catch figures used in the GLM analyses were the landed green weight totals prorated by the estimated catches.

Data were divided spatially into the four kahawai management areas (KAH 1, KAH 2, KAH 3, KAH 8) with KAH 1 divided further into East Northland, Hauraki Gulf, and Bay of Plenty substock areas.

Ring-net fishing effort is distinct from setnet effort in that ring-netting involves an active searching component. Before October 1990, ring-net and setnet effort was recorded on Ministry forms under the one code "setnet"; because of this data from the 1989–90 fishing year was dropped from the analyses.

Important target species were identified on the basis of the total associated kahawai catch. Target species were grouped on the basis of similarity in catch location and degree of commonality in gear configurations. For example, kahawai was often taken in grey mullet and flounder target fisheries in harbours; however, it was considered that differences in gear configurations between these two target fisheries warranted their separation into distinct target classes. Data pertaining to the targeting of 'insignificant', 'unrelated', and 'ungroupable' target species were not included in the final GLMs.

Data from vessels recording fewer than 10 kahawai catching days in a given year were deleted for that year. The catch histories of all the vessels remaining in the reduced dataset were calculated; data pertaining to vessels with fewer than four years history in the fishery were deleted. The remaining vessels were sorted in descending order by total kahawai catch. The data cut-off was either the top 20 vessels or up to the number of vessels necessary to include 70% of the total kahawai catch.

The response dependant variable used in the GLM analyses was the log of the daily kahawai catch (kg). Covariates investigated in the setnet GLM models were:

Fishing year (15)	Categorical
Season (4)	Categorical
Vessel	Categorical
Target species	Categorical
Net length (m)	Continuous
Set duration (hours up to 24)	Continuous

Second order interaction parameters were also investigated being combinations of the above parameters excluding "fishing year" (8 additional parameters).

3.1.1 East Northland (KAH 1)

Before grooming, the initial dataset consisted of 11 132 records. On the basis of target-species three target fisheries were identified (Appendix 3): kahawai/grey mullet; trevally; snapper/rig/tarakihi/gurnard. Data from targeting species other than these groups were removed; the revised data set had 9166 records.

Data from vessels with a history of more than three years in the fishery where the number of days fishing in a year exceeded nine were sorted by total kahawai catch (Appendix 4). Eighteen vessels were included in the final dataset: 4764 records.

Thirteen zero catch records were removed from the final data set (0.3% reduction).

The estimated catches, although being slightly below the true landed values in most years, were reasonably well correlated in the final dataset (Figure 2).

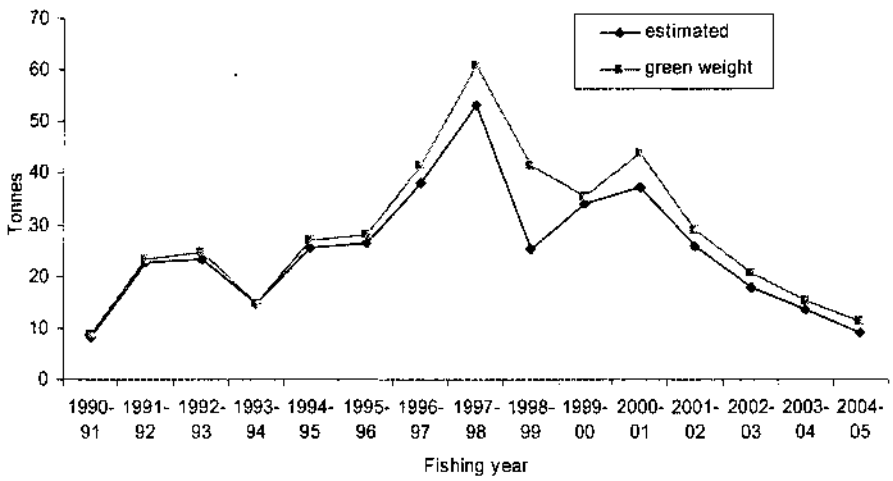


Figure 2: Estimated and landed kahawai green-weight totals from the east Northland setnet fishery.

3.1.2 Hauraki Gulf (KAH 1)

Before grooming, the initial dataset consisted of 12 789 records. On the basis of target-species three target fisheries were identified (Appendix 5): kahawai/snapper/grey mullet; trevally/rig/gurnard; flatfish. Data from targeting species other than these groups were removed; the new data set had 12 536 records.

Data from vessels with a history of more than three years in the fishery where the number of days fishing in a year exceeded nine were sorted by total kahawai catch (Appendix 6). Twenty vessels were included in the final dataset representing 80% of the kahawai catch: 4531 records.

Zero catch records were removed, reducing the final set by a further 114 records (1.9 % reduction).

Although the estimated catches were below the true landed values in most years they were reasonably well correlated in the final dataset (Figure 3).

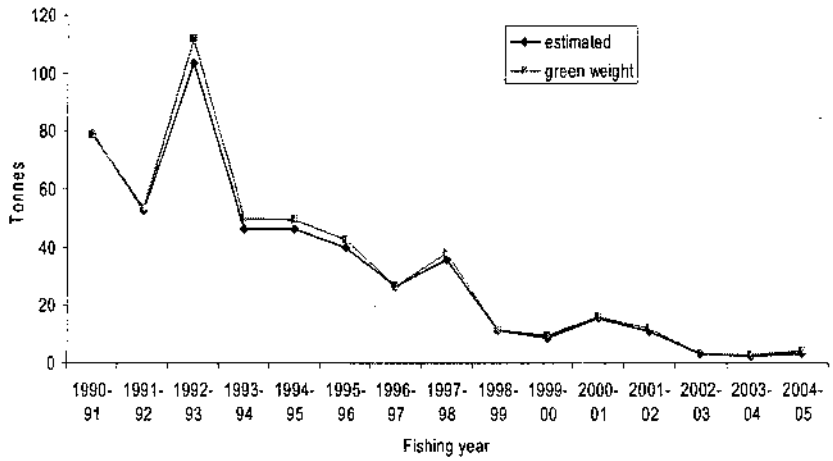


Figure 3: Estimated and landed landed kahawai green-weight totals from the Hauraki Gulf setnet fishery.

3.1.3 Bay of Plenty (KAH 1)

Before grooming, the initial dataset consisted of 6191 records. On the basis of target-species three target fisheries were identified (Appendix 7): trevally; kahawai/grey mullet; tarakihi/snapper/rig/gurnard/kingfish. Data from targeting species other than these groups were removed: the new data set had 4598 records.

Data from vessels with a history of more than three years in the fishery where the number of days fishing in a year exceeded nine were sorted by total kahawai catch (Appendix 8). All 11 vessels were included in the final dataset: 2353 records.

Zero catch records were removed, reducing the final set by a further seven records (0.25 % reduction).

The estimated catches, although consistently above the true landed values in most years, were reasonably well correlated in the final dataset (Figure 4).

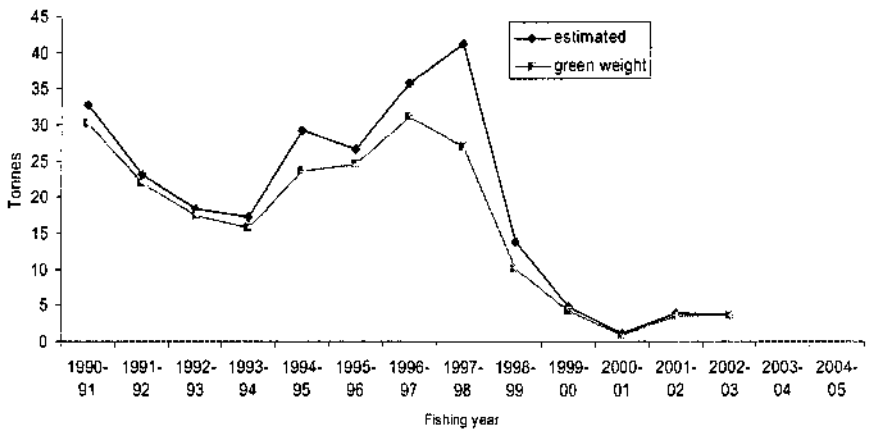


Figure 4: Estimated and landed kahawai green-weight totals from the Bay of Plenty setnet fishery.

Data for the 2003–04 and 2004–05 fishing years were insufficient for inclusion in the GLM analyses.

3.1.4 KAH 2

Before grooming, the initial dataset consisted of 3487 records. On the basis of target-species three target fisheries were identified (Appendix 9): kahawai; flatfish; butterfish/blue warehou/blue moki/tarakihi/rig/gurnard/kingfish. Data from targeting species other than these groups were removed; the revised data set had 3341 records.

Data from vessels with a history of more than three years in the fishery where the number of days fishing in a year exceeded nine were sorted by total kahawai catch (Appendix 10). The catch records of all nine vessels that met the history criteria were retained: 1651 records.

Zero catch records were removed, reducing the final set by a further four records (0.25 % reduction).

The estimated catches, although being consistently above the true landed values in most years, were reasonably well correlated in the final dataset (Figure 5).

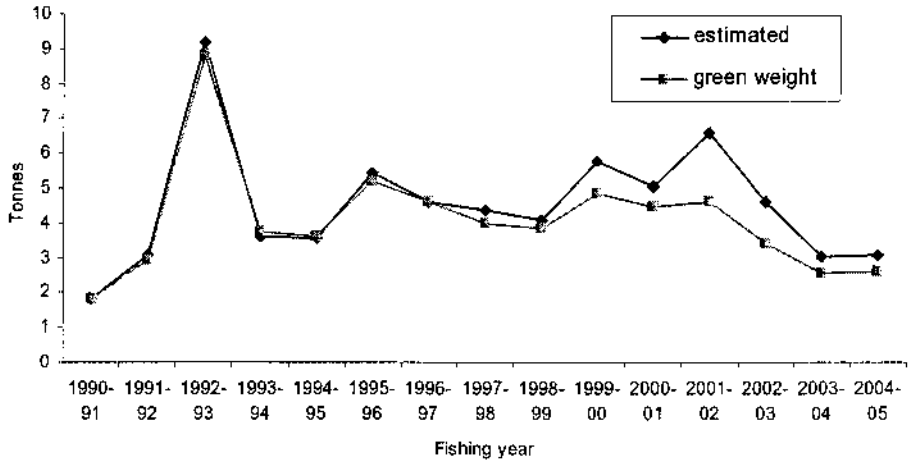


Figure 5: Estimated and landed kahawai green-weight totals from the KAH2 setnet fishery.

3.1.5 KAH 3

Before grooming, the initial dataset consisted of 3485 records. On the basis of target-species two target fisheries were identified (Appendix 11): kahawai/ grey mullet; rig/spiny dog fish/butterfish/tarakihi/blue moki/elephant fish/snapper/trevally/gurnard. Data from targeting species other than these groups were removed; the new data set had 2014 records.

Data from vessels with a history of more than three years in the fishery where the number of days fishing in a year exceeded nine were sorted by total kahawai catch (Appendix 12). The catch records of all five vessels that met the historv criteria were retained: 1069 records.

Zero catch records were removed, reducing the final set by a further 12 records (1.12 % reduction).

The estimated catches were consistent with the true landed values in most years (Figure 6).

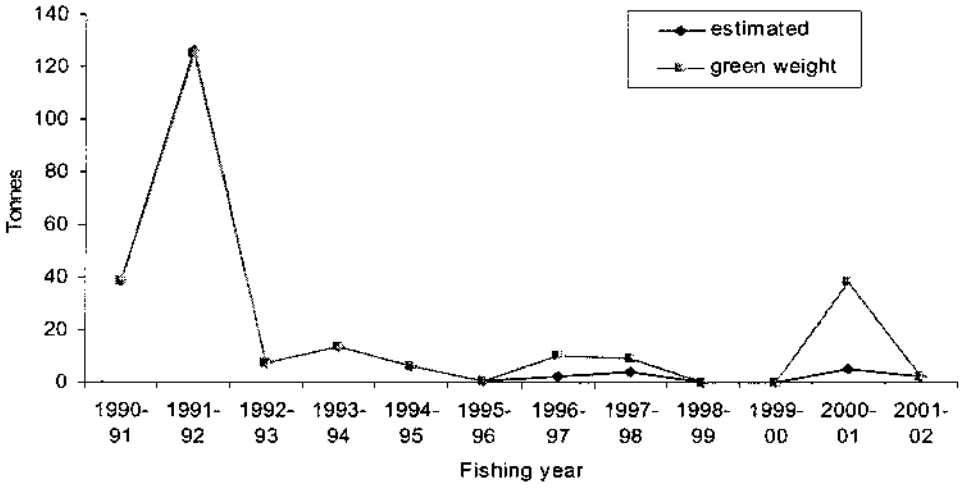


Figure 6: Estimated and landed kahawai green-weight totals from the KAH 3 setnet fishery.

Data for the 1995–96, 1998–99, 1999–2000, 2002–03, 2003–04, and 2004–05 fishing years were insufficient for inclusion in the GLM analyses.

3.1.6 KAH 8

Before grooming, the initial dataset consisted of 30 691 records. On the basis of target-species three target fisheries were identified (Appendix 13): kahawai/grey mullet/rig; snapper/gurnard/trevally; flatfish. Data from targeting species other than these groups were removed; the new data set had 24 608 records.

Data from vessels with a history of more than three years in the fishery where the number of days fishing in a year exceeded nine were sorted by total kahawai catch (Appendix 14). The top 30 vessels represented 73% of the cumulative kahawai catch. Two 4 year history vessels were replaced by the 40th and 42nd vessels as these had significantly longer catch histories (14 and 15 years): 9501 records.

Zero catch records were removed, reducing the final set by a further 11 records (0.11 % reduction).

The estimated catches, although being consistently above the true landed values in most years, were reasonably well correlated in the final dataset (Figure 7).

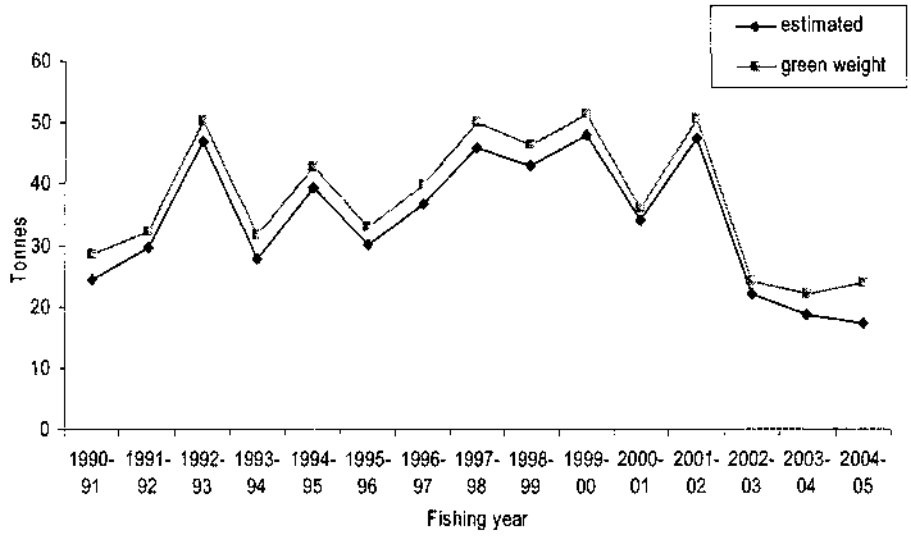


Figure 7: Estimated and landed kahawai green-weight totals from the KAH 8 setnet fishery.

3.2 Trawl catch effort data

Trawl catch effort information was extracted under the criterion that kahawai was recorded in the landed catch section of the trip reporting form. Where kahawai was reported in the landed trip form, all the catch and effort records pertaining to that trip were extracted. Data were extracted from the catch effort landing return (CELR) and trawl catch effort processing return (TCEPR) databases. The full list of fields in the raw extract data tables are given in Appendix 2.

Data were divided spatially into the four kahawai management areas (KAH 1, KAH 2, KAH 3, KAH 8) with KAH 1 divided further into East Northland, Hauraki Gulf, and Bay of Plenty substock areas. The total landed catch of kahawai from East Northland and the Hauraki Gulf between 1989 and 2005, being less than 30 tonnes, was insufficient to support a standardised CPUE analysis.

Data from vessels recording fewer than three kahawai catching trips in a given year were deleted for that year. The catch histories of all the vessels remaining in the reduced dataset were calculated; data for vessels with fewer than four years history in the fishery were deleted. The remaining vessels were sorted in descending order by their total kahawai catch. The arbitrary cut-off was either the top 20 vessels or up to the number of vessels necessary to include 70% of the total kahawai catch.

For most trawl trips landing kahawai there was no information reported in the effort section in relation to its catch, hence where the kahawai was caught and the associated fishing effort was usually unknown. This was due to kahawai rarely ranking in the top five species caught. The catch term was therefore limited to kilos per trip by stock. Trips recording fishing effort in more than one kahawai stock area were rejected. Tows targeting the following species were discounted on the grounds that the probability of kahawai bycatch was low: hoki, gemfish, orange roughy, squid, ling, cardinal fish, ruby fish, scampi, oreo dory, mirror dory. For each stock area it was possible to identify up to six common by-catch species. These species were offered to the GLM selection process expressed as a proportion of the total number of target-tows per trip. Total effort, expressed as the total number of tows per trip, this was offered to the GLM as a continuous variable.

The variable used in the GLM analyses was the log of the total trip kahawai catch (kg). Covariates investigated in the setnet GLM models were:

Fishing year	Categorical(16)
Season	Categorical (4)
Vessel	Categorical (n)
Number of trip-tows	Continuous
Target species (up to 6)	
proportion of trip-tows	Continuous

Second order interaction parameters were also investigated, being combinations of the above parameters, excluding "fishing year" (up 28 additional parameters).

3.2.1 Bay of Plenty (KAH 1)

Vessel data were sorted by total kahawai catch (Appendix 15). Sixteen vessels were selected on the basis of their total kahawai catch and fishing longevity: 3071 records.

On the basis of the number of targeted tows three significant target fisheries were identified: snapper; trevally; tarakihi (Appendix 16).

3.2.2 KAH 2

Vessel data were sorted by total kahawai catch (Appendix 17). Twenty vessels were selected on the basis of their total kahawai catch and fishing longevity: 4832 records.

On the basis of the number of targeted tows, three significant target fisheries were identified: tarakihi; gurnard; flatfish (Appendix 18).

3.2.3 KAH 3

Vessel data were sorted by total kahawai catch (Appendix 19). Twenty vessels were selected on the basis of their total kahawai catch and fishing longevity: 3096 records.

On the basis of the number of targeted tows two significant target fisheries were identified: barracuda; red cod (Appendix 20).

3.2.4 KAH 8

Vessel data were sorted by total kahawai catch (Appendix 21). Twenty vessels were selected on the basis of their total kahawai catch and fishing longevity: 5429 records.

On the basis of the number of targeted tows four significant target fisheries were identified: snapper; trevally; gurnard; tarakihi (Appendix 22).

4 RESULTS

4.1 East Northland (KAH 1)

4.1.1 Setnet

The GLM stepwise selection process did not result in 'fishing year' being in the terminating model. The regressions were rerun forcing 'fishing year' as the first selected parameter. Fourteen observations produced inference (Cook's distance) scores higher than 0.5 in the terminating model. These observations were removed from the dataset and the stepwise process repeated. Six parameters were selected for the final GLM model on the bases of the 3% R-square improvement criteria (Table 1).

Table 1: Stepwise regression results for East Northland setnet catches. Parameters chosen for the final GLM are shaded.

covariate	AIC	% improvement	R-square	% improvement
fyear	13157.14	-	0.0083	-
vessel	12747.24	3.12	0.1282	1435.51
season	12678.91	0.54	0.1473	14.90
vessel:season	12376.51	2.39	0.2278	22.78
duration	12362.53	0.11	0.2314	1.58
vessel:duration	12322.37	0.32	0.2423	4.71
season:duration	12307.46	0.12	0.2464	1.69
target	12297.69	0.08	0.2489	1.01
season:target	12284.20	0.11	0.2528	1.57

A lack of trend in the standardised residual and quantile-quantile plots indicates the final model provides an acceptable fit to the data (Figure 8).

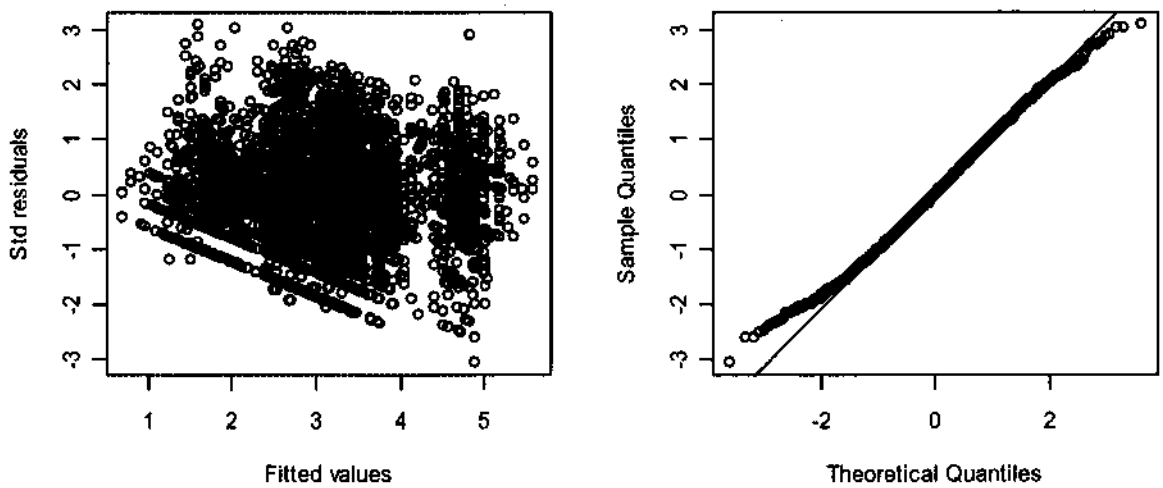


Figure 8: Standardised residual and quantile-quantile plots for the East Northland final model fit.

East Northland canonical year indices for the kahawai setnet fishery are given in Appendix 23 and Figure 9.

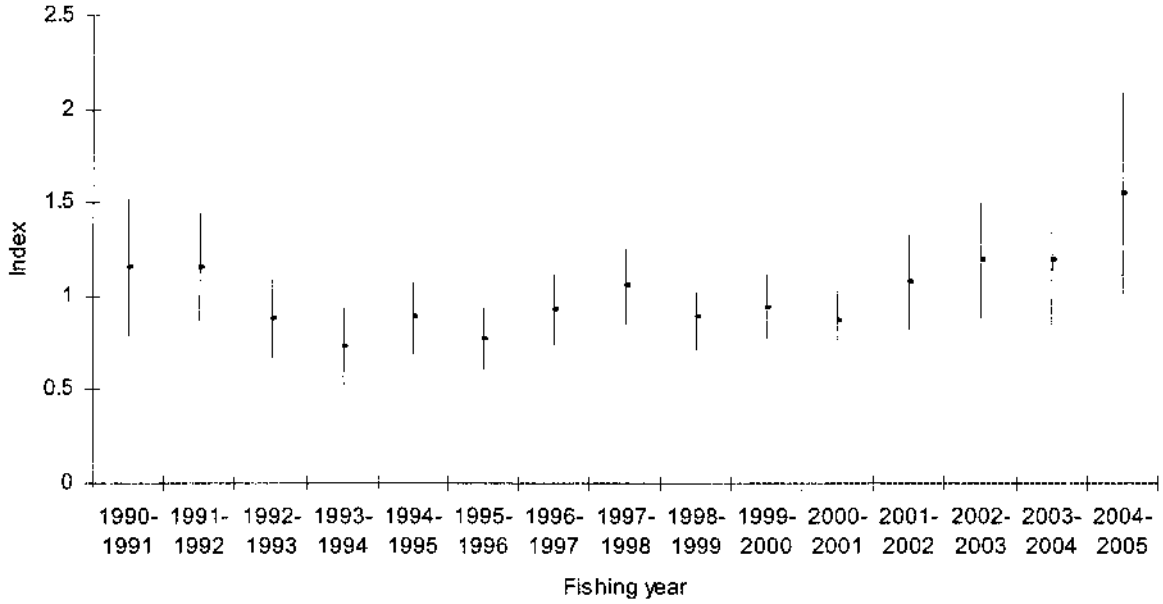


Figure 9: **Canonical year indices for East Northland with 95% confidence intervals (analytical).**

4.2 Hauraki Gulf (KAH 1)

4.2.1 Setnet

Seven observations produced inference (Cook's distance) scores higher than 0.5 in the terminating model. These observations were removed from the dataset and the stepwise process repeated. Six parameters were selected for the final GLM model based on the 3% R-square improvement criteria (Table 2).

Table 2: **Stepwise regression results for Hauraki Gulf setnet catches. Parameters chosen for the final GLM are shaded.**

covariate	AIC	% improvement	R square	% improvement
vessel	21512.55	-	0.2865	-
target	21316.86	0.91	0.3093	7.96
vessel:target	21152.40	0.77	0.3333	7.66
season	21072.07	0.38	0.3421	2.73
vessel:season	20865.95	0.98	0.3743	9.41
duration	20826.28	0.19	0.3784	1.10
fyear	20782.95	0.21	0.3842	1.53
vessel:duration	20752.11	0.15	0.3904	1.61
net	20726.60	0.12	0.3933	0.67
vessel:net	20662.42	0.31	0.4026	2.44

A lack of trend in the standardised residual and quantile-quantile plots indicates the final model provides an acceptable fit to the data (Figure 10).

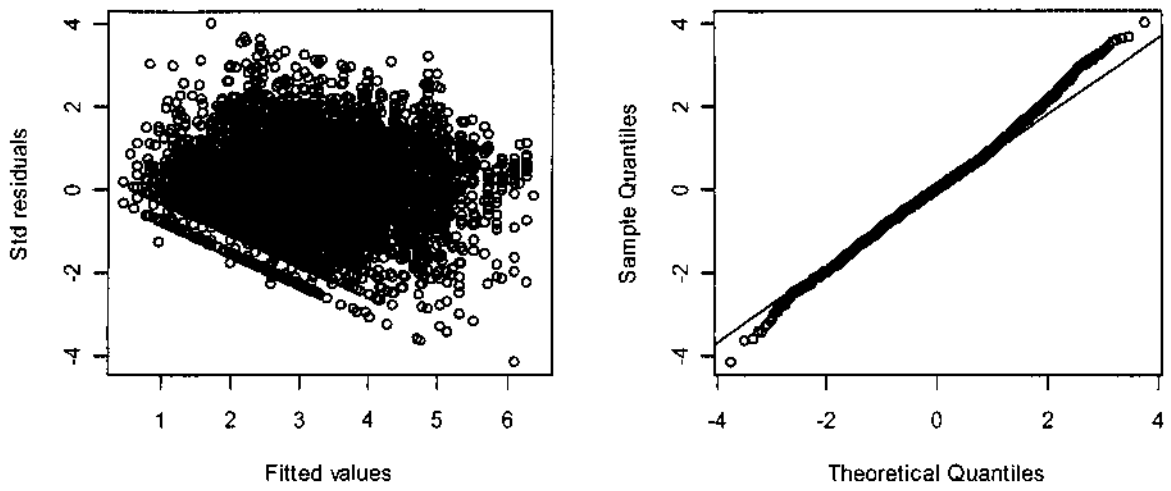


Figure 10: Standardise residual and quantile-quantile plots for the Hauraki Gulf final model fit.

Hauraki Gulf canonical year indices for the kahawai setnet fishery are given in Appendix 23 and Figure 11.

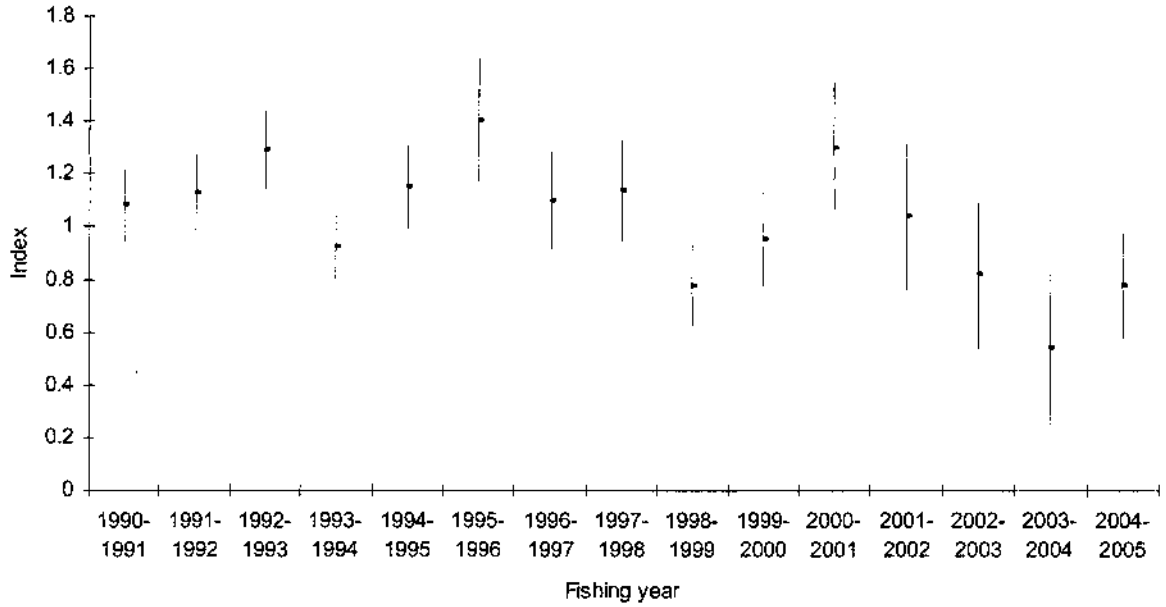


Figure 11: Canonical year indices for Hauraki Gulf with 95% confidence intervals (analytical).

4.3 Bay of Plenty (KAH 1)

4.3.1 Setnet

Three observations produced inference (Cook's distance) scores higher than 0.05 in the terminating model. These observations were removed from the dataset and the stepwise process repeated. Six parameters were selected for the final GLM model based on the 3% R-square improvement criteria (Table 3).

Table 3: Stepwise regression results for Bay of Plenty setnet catches. Parameters chosen for the final GLM are shaded.

covariate	AIC	% improvement	R square	% improvement
vessel	7831.73	5.85	0.1946	
season	7748.93	1.06	0.2242	15.21
fyear	7687.29	0.80	0.2486	10.88
vessel:season	7646.11	0.54	0.2711	9.05
target	7641.67	0.06	0.2731	0.74
vessel:target	7580.99	0.79	0.296	8.39
season:target	7561.65	0.26	0.3037	2.60
duration	7554.47	0.09	0.3061	0.79
vessel:duration	7506.71	0.63	0.323	5.52
target:duration	7499.51	0.10	0.3257	0.84
season:duration	7496.25	0.04	0.3275	0.55

A lack of trend in the standardised residual and quantile-quantile plots indicates the final model provides an acceptable fit to the data (Figure 12).

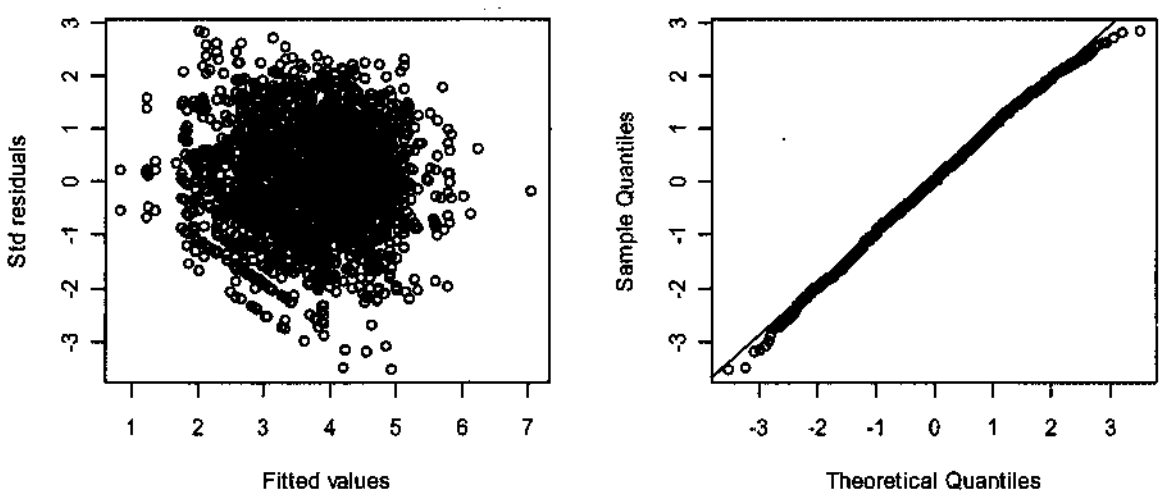


Figure 12: Standardised residual and quantile-quantile plots for the Bay of Plenty final model fit.

Bay of plenty canonical year indices for the kahawai setnet fishery are given in Appendix 23 and Figure 13.

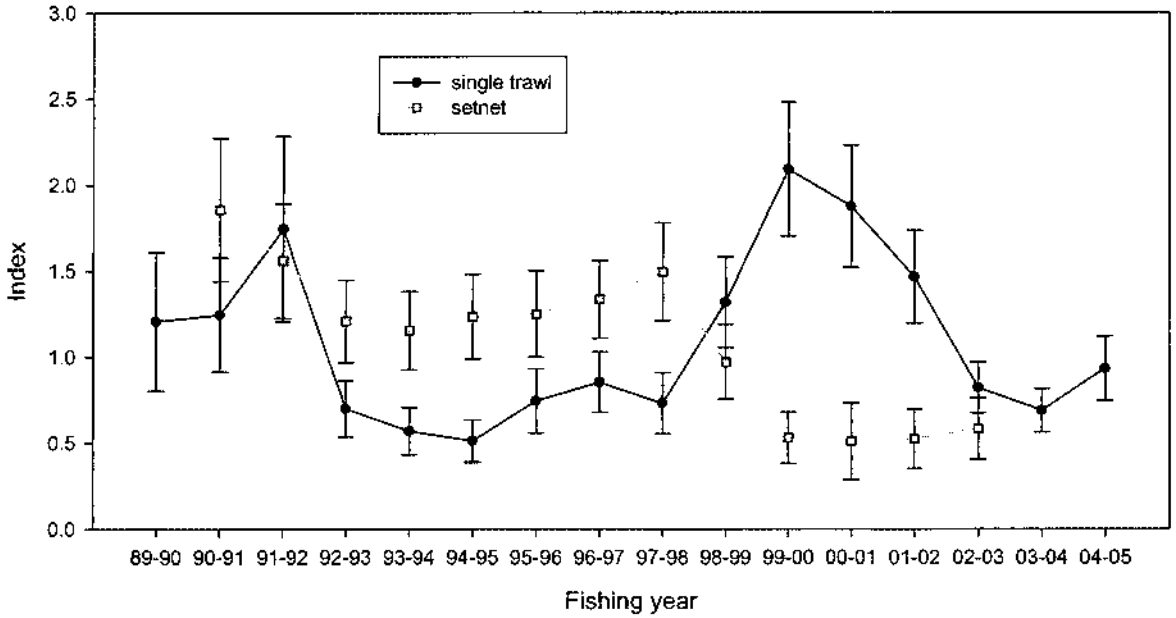


Figure 13: Canonical annual indices for Bay of Plenty with 95% confidence intervals (analytical).

4.3.2 Single trawl

Two observations produced inference (Cook's distance) scores higher than 0.05 in the terminating model. These observations were removed from the dataset and the stepwise process repeated. Six parameters were selected for the final GLM model based on the 3% R-square improvement criteria (Table 4).

Table 4: Stepwise regression results for Bay of Plenty trawl catches. Parameters chosen for the final GLM are shaded.

covariate	AIC	% improvement	R-square	% improvement
season	11712.25	-	0.1017	-
vessel	11284.38	3.65	0.2225	118.78
fyear	11084.68	1.77	0.2751	23.64
tows	10935.93	1.34	0.3096	12.54
vessel:tows	10896.65	0.36	0.3217	3.90
TAR	10884.45	0.11	0.3246	0.90
tows:TAR	10858.75	0.24	0.3305	1.81
season:vessel	10845.92	0.12	0.3427	3.69
vessel:TAR	10836.05	0.09	0.3479	1.51
TRE	10827.34	0.08	0.3500	0.60
vessel:TRE	10804.89	0.21	0.3576	2.17

A lack of trend in the standardised residual and quantile-quantile plots indicates the final model provides an acceptable fit to the data (Figure 14).

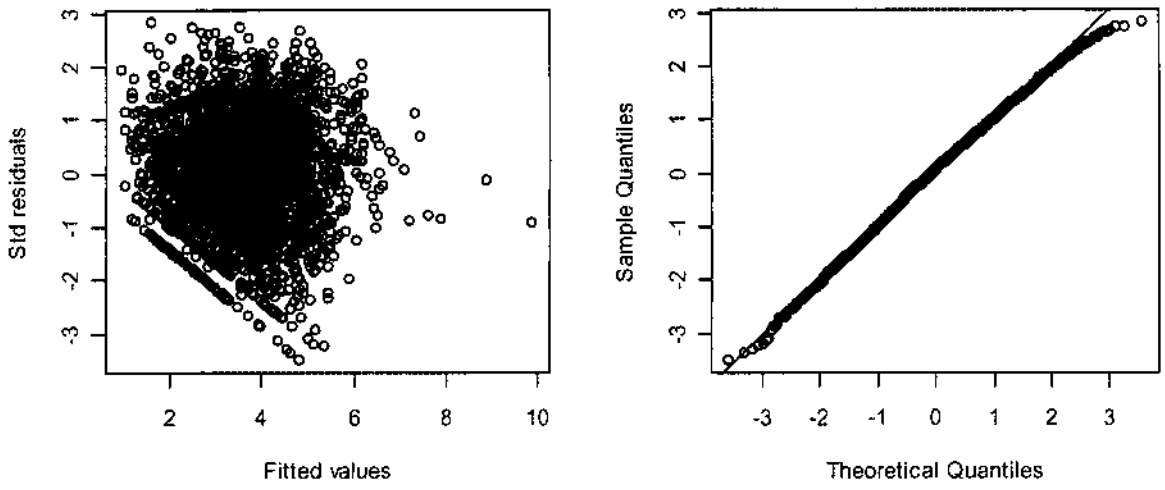


Figure 14: Standardised residual and quantile-quantile plots for the Bay of plenty trawl final model fit.

Bay of Plenty canonical year indices for the kahawai trawl fishery are given in Appendix 24 and Figure 13.

4.3.3 Bay of Plenty combined indices

There was little similarity in the final setnet and trawl indices (Figure 13); the Pearson correlation coefficient ($r = -0.4$) was not significant at the 5% level ($P < t = 0.08$).

4.4 KAH 2

4.4.1 Setnet

No observations had inference (Cook's distance) scores higher than 0.05 in the terminating model. Five parameters were selected for the final GLM model based on the 3% R-square improvement criteria (Table 5).

Table 5: Stepwise regression results for KAH 2 setnet catches. Parameters chosen for the final GLM are shaded.

covariate	AIC	% improvement	R-square	% improvement
vessel	5044.38	-	0.1504	-
season	5011.22	0.66	0.1691	12.43
target	4982.84	0.57	0.1846	9.17
fyear	4953.41	0.59	0.2060	11.59
vessel:season	4948.07	0.11	0.2200	6.80
vessel:target	4942.51	0.11	0.2250	2.27

A lack of trend in the standardised residual and quantile-quantile plots indicates the final model provides an acceptable fit to the data (Figure 15).

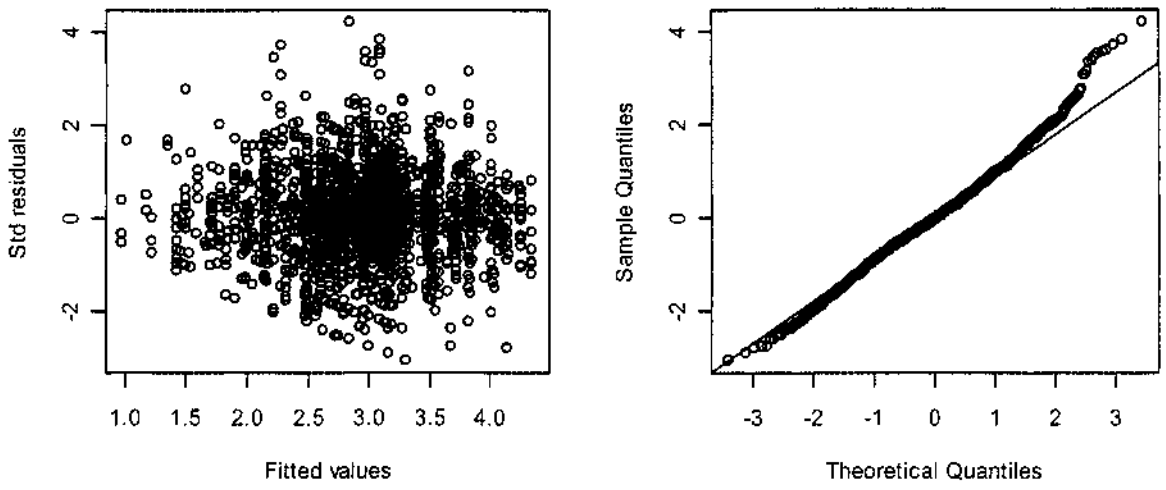


Figure 15: Standardised residual and quantile-quantile plots for the KAH 2 final model fit.

KAH 2 canonical year indices for the kahawai setnet fishery are given in Appendix 23 and Figure 16.

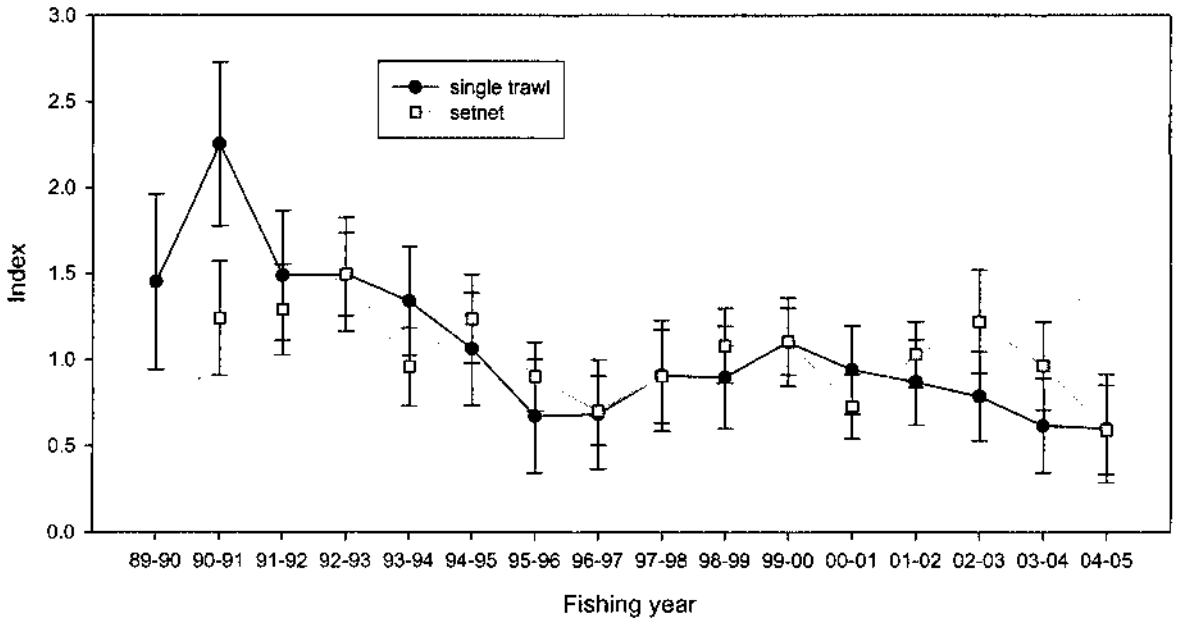


Figure 16: Canonical annual indices for KAH 2 with 95% confidence intervals (analytical).

4.4.2 Single trawl

Three observations produced inference (Cook's distance) scores higher than 0.05 in the terminating model. These observations were removed from the dataset and the stepwise process repeated. Six parameters were selected for the final GLM model based on the 3 % R-square improvement criteria (Table 6).

Table 6: **Stepwise regression results for KAH 2 trawl catches. Parameters chosen for the final GLM are shaded.**

covariate	AIC	% improvement	R-square	% improvement
vessel	16459.25	-	0.2216	-
fyear	16317.17	0.86	0.2465	11.23
tows	16174.28	0.88	0.2687	9.00
TAR	16089.25	0.53	0.2816	4.80
vessel:TAR	16043.04	0.29	0.2906	3.19
season	16011.87	0.19	0.2956	1.72
vessel:season	15734.71	1.73	0.3426	15.90
tows:TAR	15724.94	0.06	0.3441	0.43
vessel:tows	15714.57	0.07	0.348	1.13

A lack of trend in the standardised residual and quantile-quantile plots indicates the final model provides an acceptable fit to the data (Figure 17).

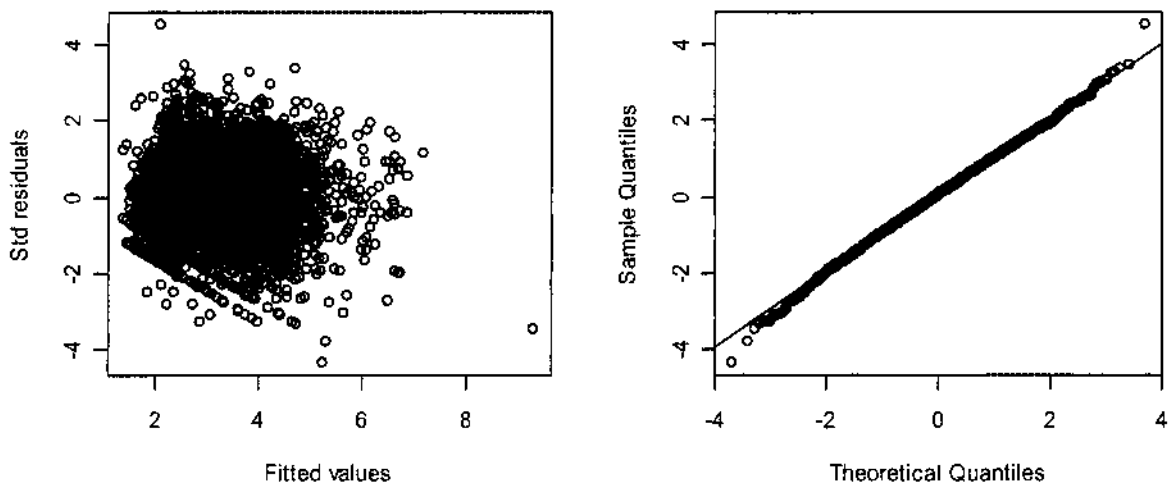


Figure 17: **Standardised residual and quantile-quantile plots for the KAH 2 trawl final model fit.**

Canonical year indices for the KAH 2 trawl fishery are given in Appendix 24 and Figure 16.

4.4.3 KAH 2 combined indices

There was reasonable similarity in the final setnet and trawl indices for KAH 2 (Figure 16) with the Pearson correlation coefficient ($r = 0.62$) significant at the 5% level ($P < t = 0.007$).

4.5 KAH 3

4.5.1 Setnet

Three observations produced inference (Cook's distance) scores higher than 0.05 in the terminating model. These observations were removed from the dataset and the stepwise process repeated. Four parameters were selected for the final GLM model based on the 3% R-square improvement criteria (Table 7).

Table 7: Stepwise regression results for KAH 3 setnet catches. Parameters chosen for the GLM model are shaded.

covariate	AIC	% improvement	R square	% improvement
vessel	3191.74	-	0.5253	-
fyear	2989.86	6.33	0.6245	18.88
net	2963.91	0.87	0.6357	1.79
vessel:net	2868.61	3.22	0.6739	6.01
season	2850.74	0.62	0.6814	1.11
vessel:season	2752.47	3.45	0.717	5.22
target	2750.66	0.07	0.7179	0.13

An indication of grouping in the standardised residual plots and the lack linearity in both tails of the quantile-quantile plots are indicative of a lack of normality in the data results from the final model should be interpreted with caution (Figure 18).

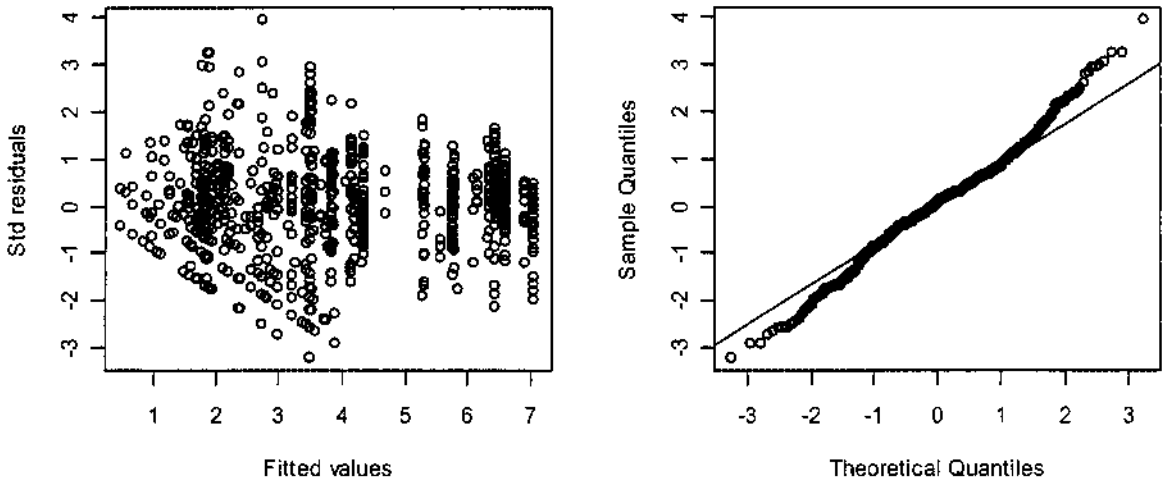


Figure 18: Standardised residual and quantile-quantile plots for the KAH 3 final model fit.

KAH 3 canonical year indices for the kahawai setnet fishery are given in Appendix 23 and Figure 19.

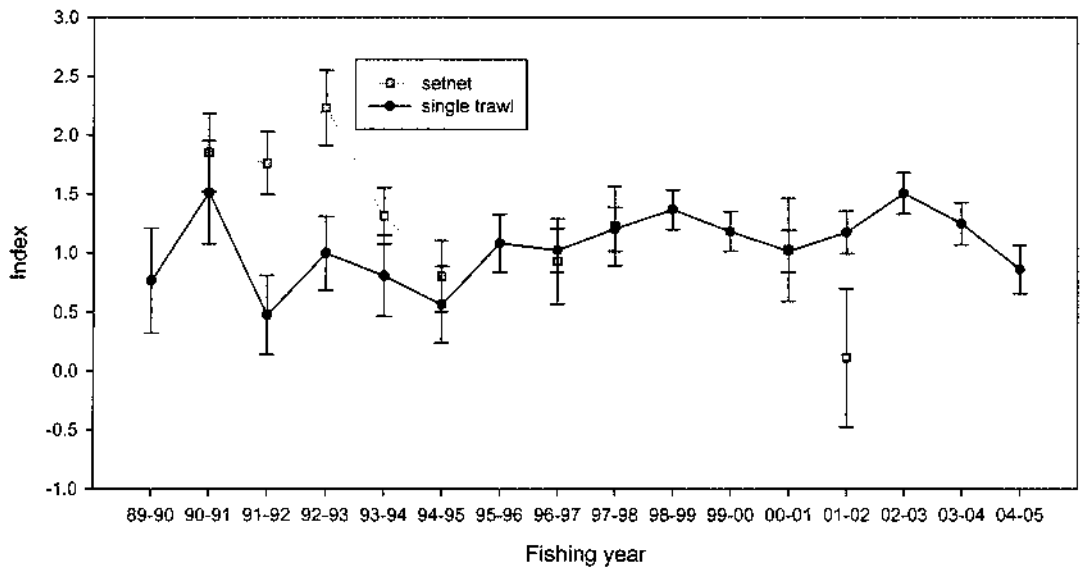


Figure 19: Canonical year indices for KAH 3 with 95% confidence intervals (analytical).

4.5.2 Single trawl

Two observations produced inference (Cook's distance) scores higher than 0.05 in the terminating model. These observations were removed from the dataset and the stepwise process repeated. Three parameters were selected for the final GLM model based on the 3% R-square improvement criteria (Table 8).

Table 8: Stepwise regression results for KAH 3 trawl catches. Parameters chosen for the final GLM are shaded.

covariate	AIC	% improvement	R-square	% improvement
vessel	11111.66	-	0.2346	-
fyear	11067.99	0.39	0.2489	6.09
season	11046.08	0.20	0.2549	2.41
vessel:season	11030.86	0.14	0.2716	6.55
BAR	11022.69	0.07	0.2738	0.81
vessel:BAR	11017.34	0.05	0.2793	2.00
tows	11012.48	0.04	0.2807	0.50
vessel:tows	11004.08	0.08	0.2868	2.17

A lack of trend in the standardised residual and quantile-quantile plots indicates the final model provides an acceptable fit to the data (Figure 20).

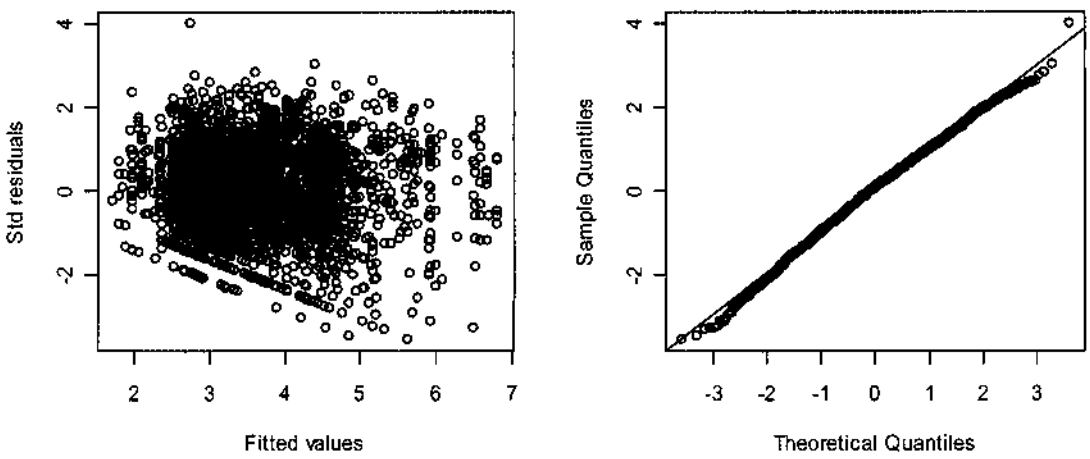


Figure 20: Standardised residual and quantile-quantile plots for the KAH 3 trawl final model fit.

Canonical year indices for the KAH 2 trawl fishery are given in Appendix 24 and Figure 19.

4.5.3 KAH 3 combined indices

There was very poor correspondence in the final setnet and trawl indices for KAH 3 (Figure 19); the Pearson correlation coefficient ($r = 0.006$) not significant at the 5% level ($P < t = 0.494$).

4.6 KAH 8

4.6.1 Setnet

Six observations produced inference (Cook's distance) scores higher than 0.05 in the terminating model. These observations were removed from the dataset and the stepwise process repeated. Eight parameters were selected for the final GLM model based on the 3% R-square improvement criteria (Table 9).

Table 9: Stepwise regression results for KAH 3 setnet catches. Parameters chosen for the final GLM are shaded.

covariate	AIC	% improvement	R square	% improvement
vessel	-	4.47	0.1510	-
target	32034.19	1.74	0.2005	32.78
vessel:target	31706.78	1.02	0.2308	15.11
season	31528.18	0.56	0.2454	6.33
vessel:season	31010.39	1.64	0.2919	18.95
fyear	30836.03	0.56	0.3059	4.80
duration	30811.04	0.08	0.3078	0.62
vessel:duration	30704.43	0.35	0.3176	3.18
target:season	30684.33	0.07	0.3194	0.57
net	30677.58	0.02	0.3200	0.19
vessel:net	30519.38	0.52	0.3332	4.13
duration:net	30493.01	0.09	0.3351	0.57

A lack of trend in the standardised residual and quantile-quantile plots indicates the final model provides an acceptable fit to the data (Figure 21).

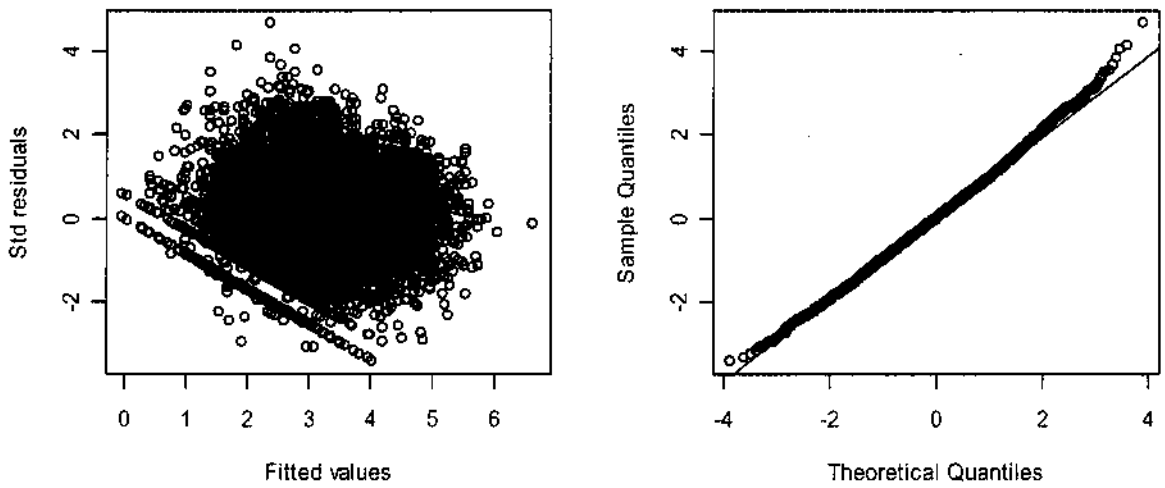


Figure 21: Standardised residual and quantile-quantile plots for the KAH 8 final model fit.

KAH 8 canonical year indices for the kahawai setnet fishery are given in Appendix 23 and Figure 22.

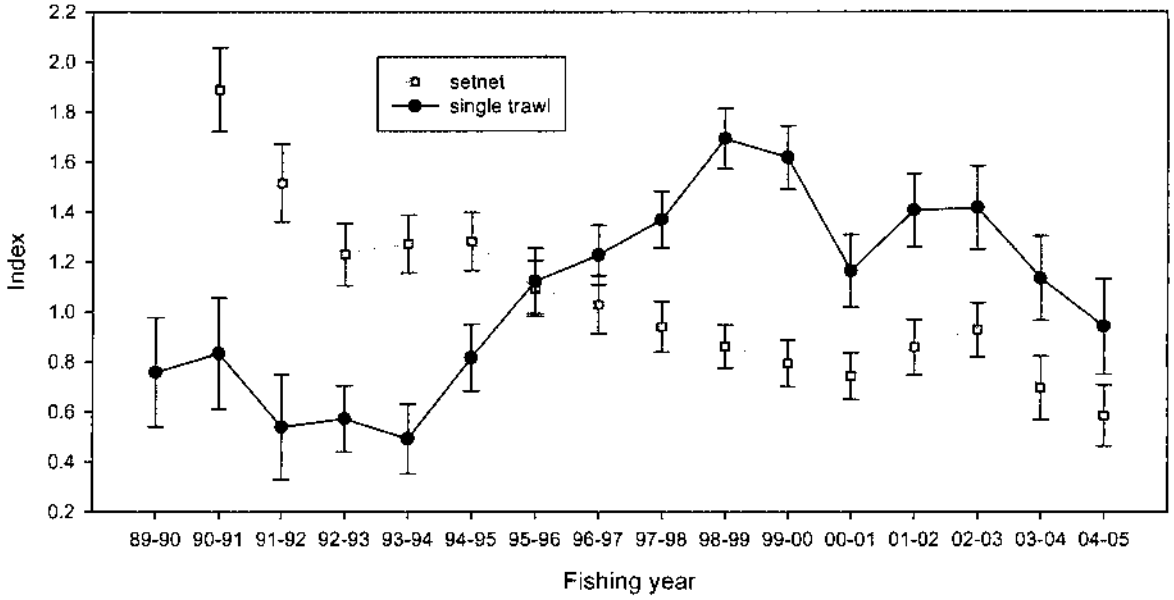


Figure 22: **Canonical year indices for KAH 8 with 95% confidence intervals (analytical).**

4.6.2 Single trawl

Six observations produced inference (Cook's distance) scores higher than 0.05 in the terminating model. These observations were removed from the dataset and the stepwise process repeated. Five parameters were selected for the final GLM model based on the 3% R-square improvement criteria (Table 10).

Table 10: **Stepwise regression results for KAH 8 trawl catches. Parameters chosen for the final GLM are shaded.**

covariate	AIC	% improvement	R-square	% improvement
vessel	20307.44	-	0.3937	-
season	19415.62	4.39	0.486	23.44
tows	19051.95	1.87	0.5195	6.89
fyear	18735.44	1.66	0.5481	5.50
vessel:season	18416.04	1.70	0.5781	5.47
TAR	18336.12	0.43	0.5844	1.09
TRE	18284.83	0.28	0.5884	0.68
season:tows	18234.37	0.28	0.5924	0.68

The lack of linearity in the left-hand tail of the quantile-quantile plots is indicative of a lack of normality in the data results from the final model which should be interpreted with caution (Figure 23).

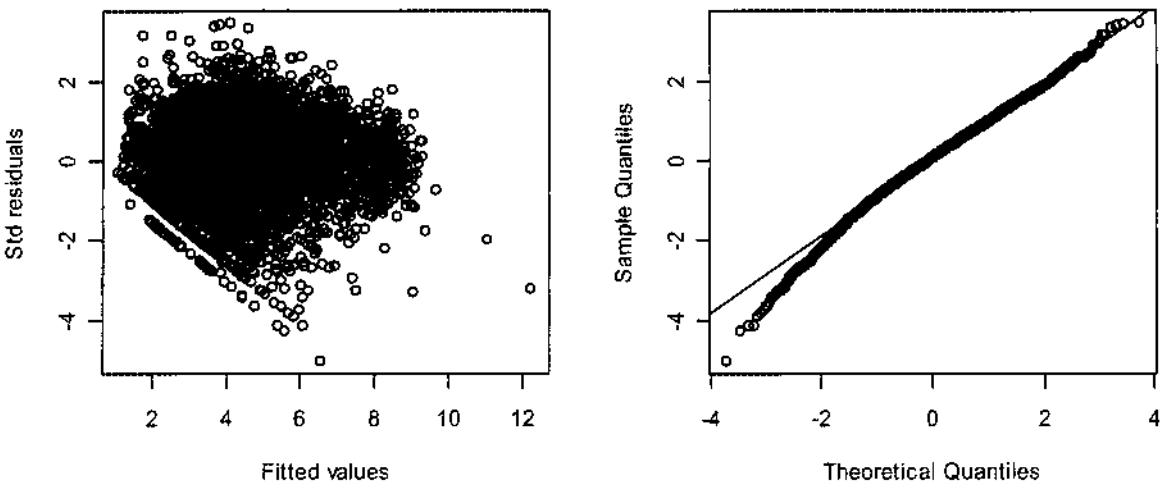


Figure 23: Standardised residual and quantile-quantile plots for the KAH 8 trawl final model fit.

Canonical year indices for the KAH 8 trawl fishery are given in Appendix 24 and Figure 22.

4.6.3 KAH 8 combined indices

There was very poor correspondence in the final setnet and trawl indices for KAH 3 (Figure 19); the Pearson correlation coefficient ($r = -0.60$) indicating significant **negative** correlation ($P < t = 0.008$).

5 DISCUSSION

There was very little similarity in single trawl and setnet annual indices from most of the kahawai stock areas. In part the explanation lies in spatial operational differences between the two methods; setnet fishers predominantly operate in harbours and enclosed waters, whereas trawlers predominantly work open coastal waters. Catch sampling has shown spatial differences in age composition with young fish and juveniles inhabiting predominately sheltered water areas like the Hauraki Gulf (Hartill & Walsh 2005).

We have confidence that setnet effort information reflects the landed kahawai catch because there is little discrepancy between the estimated at-sea catch weights and the 'true' landed values. The same cannot be said for the trawl data; at-sea catch information for trawl-caught kahawai is scant. Because it is difficult to classify kahawai trawl effort in a precise way, much of the pattern seen in the trawl CPUE analyses could be due to mis-specified effort.

Fishing-year was not significant in the GLM analyses of setnet catches from the East Northland and the Hauraki Gulf regions of KAH 1. This suggests that the availability of kahawai to the setnet fisheries in these regions was relatively stable between 1990 and 2005. GLM analyses of setnet and trawl catches in the Bay of Plenty region of KAH 1 produced significant but contradictory trends in the fishing year. The results indicate a major drop in the availability of kahawai to the Bay of Plenty setnet fishery occurred after 1998. The trend in trawl fishing year indices was increasing after 1998. Although it could be reasoned that the trawl fishery reflects kahawai availability in the more open coastal areas of the Bay of Plenty, we recommend (for the reasons above) this hypothesis is accorded minimal credence unless the index is later corroborated with school sightings data from aerial over-flights.

The GLM analyses suggest the availability of kahawai to KAH 2 trawl and setnet fisheries changed significantly between 1990 and 2005. Greater weight should be accorded to the setnet series, although the overall conclusion that the availability of kahawai in KAH 2 has declined is strengthened by the fact that the trawl and setnet fishing year indices are positively correlated.

Fishing year accounted for significant catch variation in KAH 3 trawl and setnet fisheries, the implication being that kahawai availability to the setnet fishery declined between 1990 and 2002. As with the Bay of Plenty, the KAH 3 setnet and trawl indices are not positively correlated. For similar reasons, we advise caution in interpreting the KAH 3 trawl results.

Fishing year was significant in the trawl and setnet CPUE series from KAH 8. A pronounced decline is seen in the KAH 8 setnet fishing year index between 1990 and 2005. The pattern in the trawl fishing year indices is not the same, being negatively correlated with the setnet index. There is sufficient spatial resolution in west coast fishing effort reporting data to have surety that most of the KAH 8 setnet catch came from the large west coast harbour systems (i.e., areas where trawl does not operate). It is plausible that the declining trend in kahawai availability in these harbours is due to local depletion or habitat degradation factors, a situation that may not necessarily imply overall stock decline.

There is reasonable evidence from this study that the availability of kahawai to the setnet fishery in the last decade has declined over all stock areas except for East Northland and the Hauraki Gulf. With the exception of KAH 2, CPUE data for trawl and setnet fisheries do not show the same trends. Because it is not possible to definitely assign catch to effort in the trawl data it is not advisable to assume the trawl indices reflect kahawai availability on the trawl fishing grounds.

6 REFERENCES

Cook, R. D.; Weisberg, S. (1982). Residuals and influence in regression. Chapman and Hall, London.

Francis, R.I.C.C. (1999). The impact of correlations in standardised CPUE indices. New Zealand Fisheries Assessment Research Document 99/42. 30 p (Unpublished report held in NIWA library, Wellington)

Hartill, B.; Walsh, C. (2005). Characterisation of the kahawai fisheries of New Zealand and review of biological knowledge Final Research Report for Ministry of Fisheries Research Project KAH2004/01 Objective 1 (Unpublished report held by MFish, Wellington.)

Sakamoto, Y.; Ishiguro, M.; Kitagawa, G. (1986). Akaike Information Criterion statistics. D. Reidel Publishing Company.

Vignaux, M. (1994). Catch per unit effort (CPUE) analysis of west coast South Island and Cook Strait spawning hoki fisheries, 1987–93. New Zealand Fisheries Assessment Research Document 94/11. 29 p (Unpublished report held in NIWA library, Wellington.)

7 APPENDICES

Appendix 1: List of CELR fields in raw setnet extract.

Effort and estimated catch:

Client_key
Vessel_key
DCF_key (linking key)
Rec Trip Start Date
Rec Trip End Date
Rec Landing Date
Trip Key
Fishing Date
Method Code = "SN"
Statistical Area
Mesh size
Total Net Length
Duration
Target Species
Total Catch Weight (kgs)
Top five Species
Top five Estimated Weight (kgs)

Landed catch

Client_key
DCF_key (linking key)
Trip Key
Form Number
Rec Trip Start Date
Rec Trip End Date
Rec Landing Date
Rec Landing Point
Trip Key
Fishstock
Greenweight (kgs)

Appendix 2: CELR/TCEPR fields in raw trawl data extract.

Effort and estimated catch:

CELR table:

Tripcode
DCF_key (linking key)
Vessel Key
Method = (BT)
Start Date
Start Stat Area
Start Latitude
Start Longitude
Number of Tows
Effort Height
Target Species
Target Species
Total Catch Weight (kgs)
Top five Species
Top five Estimated Weight (kgs)

TCEPR Table

Tripcode
Vessel Key
Pair Vessel Key
Method
Start Date
Start Time
End Date
End Time
Start Stat Area
Start Latitude
Start Longitude
Trawl Speed
Effort Depth
Effort Height
Target Species
Target Species
Total Catch Weight (kgs)
Top five Species
Top five Estimated Weight (kgs)

Appendix 2: CELR/TCEPR fields in raw trawl data extract cont.

Landed catch

CELR table:

Tripcode
vessel_key
landing_date
Fishstock
greenweight
DCF_key (linking key)

CLR Table

Tripcode
vessel_key
landing_date
Fishstock greenweight

Vessel details

vessel_key
overall_length_metres
draught_metres
beam_metres
built_year
engine_kilowatts
history_start_datetime
history_end_datetime

Appendix 3: Total kahawai catch (t) in relation to target species from the East Northland setnet fishery 1990 to 2005; data for shaded species included in CPUE analysis.

target	catch t	no records	%
TRE	406.253	3177	45.24
GMU	262.889	3989	74.52
KAH	63.808	395	81.63
SNA	62.586	1131	88.60
SCH	40.986	219	93.16
FLA	20.511	1248	95.45
SPO	13.825	351	96.99
YEM	7.852	162	97.86
TAR	4.126	76	98.32
PAR	3.913	73	98.76
GUR	2.338	47	99.02
POR	2.251	57	99.27
KIN	1.452	31	99.43
HAP	1.145	2	99.56
JDO	0.930	44	99.66
SPD	0.680	24	99.74
YBF	0.608	37	99.81
PAD	0.463	15	99.86
HPB	0.274	4	99.89
NULL	0.270	5	99.92
RMO	0.204	9	99.94
BUT	0.168	13	99.96
MOK	0.055	4	99.97
JMA	0.053	2	99.97
RSN	0.049	6	99.98
OSD	0.048	1	99.98
RCO	0.046	1	99.99
BCO	0.038	2	99.99
SFL	0.030	3	100.00
YFN	0.014	1	100.00
SSK	0.010	1	100.00
GAR	0.010	1	100.00
SCA	0.010	1	100.00
Totals	898	11132	

Appendix 4: Total kahawai catch (t) in relation to vessel from the East Northland setnet fishery 1990 to 2005; data from the shaded vessels were used in the final analysis.

rank order	vessel id	history yrs	catch t	%
1	Vs4730	9	100.640	22.67
2	Vs2615	14	76.402	39.88
3	Vs90	8	61.130	53.65
4	Vs8586	11	48.550	64.59
5	Vs2408	7	28.854	71.09
6	Vs2829	11	20.762	75.77
7	Vs2150	15	20.708	80.43
8	Vs2714	5	13.120	83.39
9	Vs2302	5	12.451	86.19
10	Vs2045	10	12.027	88.90
11	Vs2119	6	12.000	91.60
12	Vs5240	5	9.921	93.84
13	Vs2459	6	6.953	95.41
14	Vs2558	5	4.407	96.40
15	Vs2747	5	4.226	97.35
16	Vs15292	4	4.151	98.29
17	Vs2516	7	3.845	99.15
18	Vs91	5	3.766	100.00

Appendix 5: Total kahawai catch (t) in relation to target species from the Hauraki Gulf setnet fishery 1990 to 2005; data for shaded species included in CPUE analysis.

target	catch t	no records	%
KAH	474.974	1689	31.36
SNA	356.793	3131	54.92
GMU	277.365	1370	73.24
FLA	159.375	3640	83.76
TRE	122.732	829	91.86
SPO	93.712	1572	98.05
SFL	7.347	35	98.54
JDO	6.338	103	98.96
GUR	4.585	79	99.26
YBF	3.633	191	99.50
SCH	1.662	9	99.61
JMA	1.554	6	99.71
YEM	1.348	62	99.80
PAR	1.236	14	99.88
GFL	0.506	26	99.92
SDO	0.411	4	99.94
KIN	0.177	5	99.95
POR	0.135	1	99.96
TAR	0.130	3	99.97
OSD	0.085	2	99.98
SPZ	0.074	1	99.98
SWA	0.069	2	99.99
EMA	0.046	2	99.99
Totals	1514	12789	

Appendix 6: **Total kahawai catch (t) in relation to vessel from the Hauraki Gulf setnet fishery 1990 to 2005; only data from the shaded vessels were used in the final analysis.**

rank order	vessel id	history yrs	catch t	%
1	Vs1988	12	82.216	12.85
2	Vs570	6	53.693	21.25
3	Vs3696	8	51.669	29.33
4	Vs3420	5	47.143	36.70
5	Vs3640	8	38.643	42.74
6	Vs3706	12	33.339	47.95
7	Vs6921	4	27.526	52.26
8	Vs4088	9	27.436	56.55
9	Vs281	5	27.395	60.83
10	Vs1245	5	24.89	64.72
11	Vs3292	9	22.729	68.28
12	Vs15023	7	21.596	71.65
13	Vs3597	5	18.679	74.57
14	Vs4073	5	16.049	77.08
15	Vs3601	13	14.380	79.33
16	Vs3578	8	13.432	81.43
17	Vs15252	4	13.179	83.49
18	Vs4544	4	11.417	85.28
19	Vs1410	4	10.258	86.88
20	Vs3236	6	9.698	88.40
21	Vs3044	8	9.187	89.83
22	Vs4068	5	9.071	91.25
23	Vs3077	7	8.921	92.65
24	Vs2922	6	7.808	93.87
25	Vs3785	6	7.433	95.03
26	Vs2970	5	5.706	95.92
27	Vs3940	7	5.307	96.75
28	Vs4569	4	3.532	97.30
29	Vs1944	8	3.487	97.85
30	Vs3293	9	3.361	98.37
31	Vs4296	5	2.762	98.81
32	Vs3977	8	2.651	99.22
33	Vs4517	5	2.403	99.60
34	Vs4450	6	1.572	99.84
35	Vs3974	9	1.012	100.00

Appendix 7: Total kahawai catch (t) in relation to target species from the Bay of Plenty setnet fishery 1990 to 2005; data for shaded species included in CPUE analysis.

target	catch t	no records	%
TRE	208.981	1949	37.40
KAH	83.846	302	52.40
TAR	68.763	525	64.71
SNA	59.794	768	75.41
FLA	44.523	1224	83.37
SPO	33.186	470	89.31
GUR	19.690	375	92.84
KIN	12.522	91	95.08
GMU	11.432	118	97.12
WAR	3.497	38	97.75
HOK	1.716	14	98.06
YEM	1.287	60	98.29
PAD	1.217	75	98.50
SCA	1.159	3	98.71
MOK	1.150	42	98.92
HPB	1.009	6	99.10
ESO	0.719	10	99.23
SKI	0.716	19	99.35
BAR	0.654	18	99.47
YBF	0.523	31	99.57
BNS	0.468	3	99.65
SCH	0.347	11	99.71
POR	0.292	5	99.76
NULL	0.248	6	99.81
OSD	0.176	1	99.84
RSN	0.162	4	99.87
TRU	0.123	1	99.89
TRA	0.085	2	99.91
PAR	0.083	3	99.92
RCO	0.081	4	99.94
SWA	0.070	1	99.95
JMA	0.066	2	99.96
RMO	0.057	2	99.97
GAR	0.046	2	99.98
ALB	0.044	1	99.99
BUT	0.032	1	99.99
PMA	0.030	1	100.00
SUR	0.010	1	100.00
SDO	0.005	1	100.00
WWA	0.004	1	100.00
Totals	**559**	**6191**	

Appendix 8: Total kahawai catch (t) in relation to vessel from the Bay of Plenty setnet fishery 1990 to 2005; only data from the shaded vessels were used in the final analysis.

rank order	vessel id	history yrs	catch t	%
1	Vs488	7	43.424	16.99
2	Vs159	8	40.094	32.67
3	Vs1410	5	31.563	45.02
4	Vs515	10	27.961	55.96
5	Vs3894	7	27.128	66.57
6	Vs4023	10	23.771	75.87
7	Vs3871	4	23.621	85.11
8	Vs1537	4	15.811	91.29
9	Vs419	4	8.314	94.55
10	Vs4230	5	7.295	97.40
11	Vs441	13	6.649	100.00

Appendix 9: Total kahawai catch (t) in relation to target species from the KAH 2 setnet fishery 1990 to 2005; data for shaded species included in CPUE analysis.

target	catch t	no records	%
FLA	55.431	613	17.58
KAH	43.047	278	25.55
BUT	39.758	1300	62.83
WAR	16.942	447	75.65
MOK	13.048	199	81.36
KJN	12.328	159	85.92
FLO	12.132	81	88.24
GUR	8.698	146	92.43
TAR	5.112	44	93.69
SPO	4.509	74	95.81
SCH	1.614	28	96.62
RCO	1.513	46	97.94
TRE	0.640	22	98.57
TUR	0.624	1	98.59
SPD	0.356	11	98.91
GMU	0.297	8	99.14
ALB	0.292	2	99.20
NULL	0.177	1	99.23
YBF	0.168	2	99.28
BWH	0.164	3	99.37
SPE	0.111	4	99.48
POR	0.088	2	99.54
SKI	0.078	1	99.57
BAT	0.075	1	99.60
SFL	0.074	6	99.77
BFL	0.065	1	99.80
HPB	0.060	1	99.83
GFL	0.028	1	99.86
ELE	0.019	2	99.91
Total	217	3487	

Appendix 10: Total kahawai catch (t) in relation to vessel from the KAH 2 setnet fishery 1990 to 2005; only data from the shaded vessels were used in the final analysis.

rank order	vessel id	history yrs	catch t	%
1	Vs710	13	21.555	31.12
2	Vs643	10	2.813	35.18
3	Vs4825	8	9.267	48.56
4	Vs277	7	7.116	58.84
5	Vs11034	6	4.840	65.83
6	Vs5265	5	7.243	76.28
7	Vs5389	5	6.425	85.56
8	Vs4798	4	6.319	94.68
9	Vs5312	4	3.682	100.00

Appendix 11: Total kahawai catch (t) in relation to target species from the KAH 3 setnet fishery 1990 to 2005; data for shaded species included in CPUE analysis.

target	catch t	no records	%
KAH	544.780	1100	86.28
SPO	43.965	739	93.24
SPD	12.860	439	95.28
BUT	6.221	370	96.27
GMU	4.526	49	96.98
SCH	3.280	90	97.50
TAR	2.665	74	97.93
MOK	2.628	102	98.34
ELE	2.370	72	98.72
FLA	2.306	172	99.08
WAR	1.547	68	99.33
SNA	1.217	26	99.52
RCO	0.789	56	99.64
YEM	0.737	46	99.76
HPB	0.259	7	99.80
TRE	0.163	11	99.83
GTR	0.135	3	99.85
GUR	0.133	6	99.87
NULL	0.112	4	99.89
YBF	0.093	6	99.90
BNS	0.090	4	99.92
JMA	0.073	4	99.93
BAR	0.067	4	99.94
LIN	0.059	7	99.95
ESO	0.053	3	99.96
GFL	0.050	4	99.96
GSH	0.040	3	99.97
BFL	0.035	4	99.98
BWH	0.035	1	99.98
MIX	0.030	1	99.99

Appendix 12: Total kahawai catch (t) in relation to vessel from the KAH 3 setnet fishery 1990 to 2005; data from the shaded vessels were used in the final analysis.

rank order	vessel id	history yrs	catch t	%
1	Vs6342	5	255.403	75.00
2	Vs977	4	57.836	92.00
3	Vs6596	5	15.636	97.00
4	Vs34	7	7.073	99.00
5	Vs6595	8	2.332	100.00

Appendix 13: Total kahawai catch (t) in relation to target species from the KAH 8 setnet fishery 1990 to 2005; data for shaded species included in CPUE analysis.

target	catch t	no records	%
GMU	495.869	9168	34.91
KAH	252.649	1475	52.69
SPO	222.071	4863	68.33
TRE	123.315	2315	77.01
FLA	121.967	7998	85.60
GUR	109.603	2163	93.31
WAR	32.767	949	95.62
SCH	14.739	291	96.66
SNA	13.151	242	97.58
YEM	9.979	294	98.28
KIN	9.647	206	98.96
YBF	3.048	482	99.18
JMA	2.686	54	99.37
SPD	2.121	22	99.52
BNS	1.511	2	99.62
NULL	0.846	19	99.68
TAR	0.527	21	99.72
RCO	0.487	14	99.75
JDO	0.486	4	99.79
PAR	0.441	23	99.82
WWA	0.324	22	99.84
BAR	0.314	3	99.86
HPB	0.266	4	99.88
ALB	0.253	4	99.90
BUT	0.247	8	99.92
SWA	0.227	2	99.93
NSD	0.176	9	99.95
RMU	0.130	1	99.96
HAP	0.126	3	99.96
SPE	0.111	4	99.97
MUU	0.077	2	99.98
RMO	0.071	3	99.98
SOL	0.058	2	99.99
Totals	1420	30691	

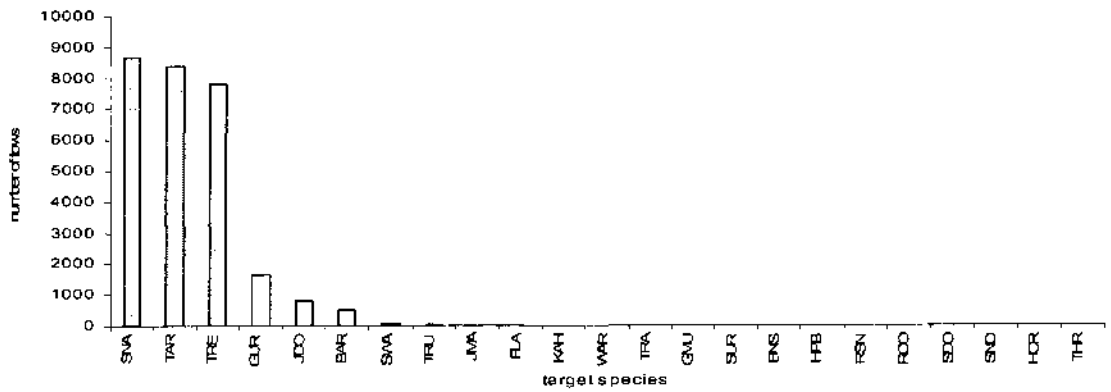
Appendix 14: Total kahawai catch (t) in relation to vessel from the KAH 8 setnet fishery 1990 to 2005; only data from the shaded vessels were used in the final analysis.

rank order	vessel id	history yrs	catch t	%
1	Vs15044	5	35.915	4.28
2	Vs3689	9	34.845	8.42
3	Vs4597	8	34.175	12.49
4	Vs2469	11	30.523	16.13
5	Vs3749	7	27.637	19.42
6	Vs10733	9	27.185	22.65
7	Vs8546	6	24.106	25.52
8	Vs159	6	23.807	28.36
9	Vs9241	8	22.761	31.07
10	Vs15058	8	22.427	33.74
11	Vs3640	8	22.352	36.40
12	Vs45	14	20.405	38.83
13	Vs4996	9	20.011	41.21
14	Vs3637	11	19.991	43.59
15	Vs3121	6	19.736	45.94
16	Vs15252	7	19.532	48.26
17	Vs15677	4	19.197	50.55
18	Vs4271	8	19.006	52.81
19	Vs3008	7	17.924	54.94
20	Vs3579	11	17.507	57.03
21	Vs20523	4	13.956	58.69
22	Vs5003	9	13.698	60.32
23	Vs3187	7	13.563	61.93
24	Vs2298	7	13.075	63.49
25	Vs5148	6	12.722	65.01
26	Vs3263	4	12.332	66.47
27	Vs5269	6	11.051	67.79
28	Vs3789	5	10.706	69.06
29	Vs3344	7	10.649	70.33
30	Vs3428	5	10.043	71.53
31	Vs4583	6	9.869	72.70
32	Vs765	6	9.714	73.86
33	Vs3206	5	9.674	75.01
34	Vs3582	6	9.613	76.15
35	Vs15330	4	9.543	77.29
36	Vs3612	5	8.752	78.33
37	Vs5537	5	8.381	79.33
38	Vs237	7	8.311	80.32
39	Vs15096	5	8.177	81.29
40	Vs3055	15	7.573	82.20
41	Vs2649	4	7.510	83.09
42	Vs3223	14	7.481	83.98
43	Vs15057	5	7.155	84.83
44	Vs3598	5	6.815	85.64
45	Vs3678	5	6.715	86.44
46	Vs3623	13	6.693	87.24
47	Vs3839	9	6.657	88.03
48	Vs20594	4	6.477	88.80
49	Vs3106	4	6.231	89.55

Appendix 15: Total kahawai catch (t) in relation to vessel from the Bay of Plenty trawl fishery 1990 to 2005; only data from the shaded vessels were used in the final analysis.

rank order	vessel id	history yrs	catch t	%
1	347	14	113.909	22.16
2	788	14	50.126	31.92
3	442	10	44.856	40.64
4	508	10	44.560	49.31
5	13207	9	39.412	56.98
6	336	11	28.089	62.45
7	5468	5	23.223	66.97
8	1856	16	20.911	71.03
9	316	6	20.246	74.97
10	327	8	19.029	78.68
11	359	5	18.714	82.32
12	435	8	15.595	85.35
13	794	10	14.265	88.13
14	324	6	14.210	90.89
15	357	7	8.893	92.62
16	3903	14	6.732	93.93
17	443	6	5.341	94.97
18	3788	5	4.305	95.81
19	5214	5	3.431	96.48
20	776	4	3.280	97.12
21	529	6	3.229	97.74
22	3006	6	2.864	98.30
23	3221	5	2.389	98.77
24	2089	8	1.544	99.07
25	3777	5	1.332	99.33
26	329	9	1.007	99.52
27	312	6	0.925	99.70
28	360	4	0.619	99.82
29	337	4	0.527	99.92
30	307	4	0.199	99.96
31	326	5	0.186	100.00

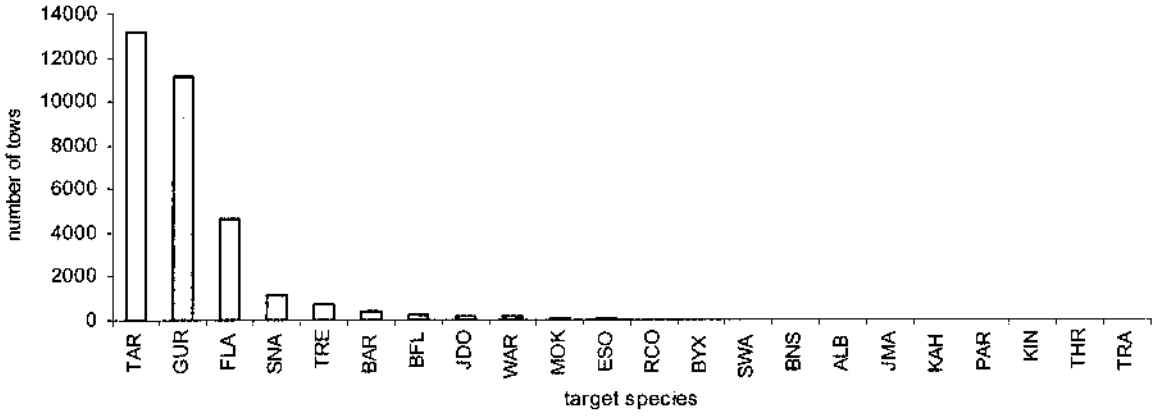
Appendix 16: Number of target tows by species from Bay of Plenty trawls catching kahawai.



Appendix 17: Total kahawai catch (t) in relation to vessel from the KAH 2 trawl fishery 1989 to 2005; only data from the shaded vessels were used in the final analysis.

rank order	vessel id	history yrs	catch t	%
1	347	7	51.590	10.66
2	508	9	33.019	17.48
3	5002	10	31.954	24.08
4	5468	8	24.940	29.23
5	539	15	23.556	34.10
6	788	5	23.062	38.86
7	1451	7	19.987	42.99
8	509	9	19.823	47.09
9	357	13	19.250	51.07
10	5514	9	18.508	54.89
11	504	11	16.269	58.25
12	333	5	15.548	61.46
13	8604	11	14.278	64.41
14	336	8	14.160	67.34
15	4662	16	12.963	70.02
16	828	4	12.708	72.64
17	2972	12	11.678	75.05
18	813	12	8.375	76.78
19	1031	6	7.355	78.30
20	4665	13	7.014	79.75
21	3036	6	6.683	81.13
22	353	4	6.406	82.46
23	729	10	5.713	83.64
24	3006	11	4.797	84.63
25	5214	6	4.790	85.62
26	560	10	4.576	86.56
27	6655	4	4.251	87.44
28	3059	5	4.237	88.32
29	5506	7	4.152	89.17
30	575	9	3.429	89.88
31	1795	8	3.346	90.57
32	8508	9	3.258	91.25
33	1102	6	3.117	91.89
34	648	12	2.842	92.48
35	1073	8	2.744	93.05
36	316	6	2.626	93.59
37	8590	5	2.547	94.11
38	821	6	2.367	94.60
39	317	4	2.358	95.09
40	528	5	2.189	95.54
41	507	5	2.159	95.99
42	1856	8	2.127	96.43
43	1057	4	2.062	96.85
44	558	16	1.830	97.23
45	794	4	1.725	97.59

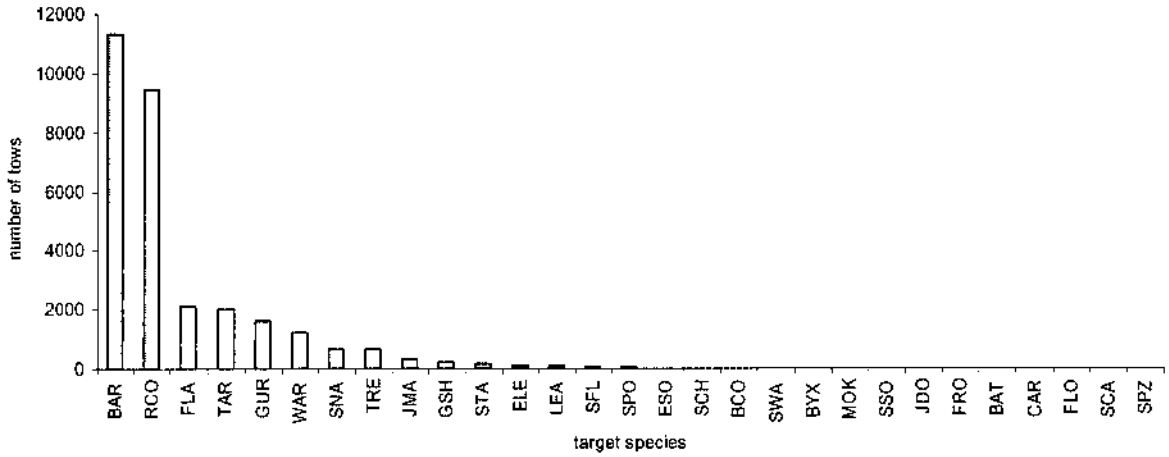
Appendix 18: Number of target tows by species from KAH 2 trawls catching kahawai.



Appendix 19: Total kahawai catch (t) in relation to vessel from the KAH 3 trawl fishery 1989 to 2005; only data from the shaded vessels were used in the final analysis.

rank order	vessel id	history yrs	catch t	%
1	1193	8	126.569	21.21
2	6129	10	62.231	31.65
3	5512	14	37.450	37.92
4	6663	6	34.094	43.64
5	566	15	25.108	47.85
6	289	9	20.124	51.22
7	333	5	19.426	54.47
8	7002	10	16.819	57.29
9	804	5	16.451	60.05
10	8609	10	11.504	61.98
11	322	16	10.688	63.77
12	5180	10	10.496	65.53
13	6142	8	10.299	67.26
14	3059	9	9.139	68.79
15	11742	9	8.971	70.29
16	504	6	8.956	71.79
17	1201	9	8.294	73.18
18	1035	15	7.993	74.52
19	1788	11	7.843	75.84
20	8684	9	7.664	77.12
21	321	4	6.946	78.29
22	5713	9	6.488	79.37
23	5296	12	6.269	80.42
24	4623	5	6.200	81.46
25	1960	10	6.168	82.50
26	1101	12	5.602	83.44
27	2022	4	5.187	84.31
28	1042	6	4.690	85.09
29	439	6	4.406	85.83
30	6285	12	4.218	86.54
31	1752	16	4.118	87.23

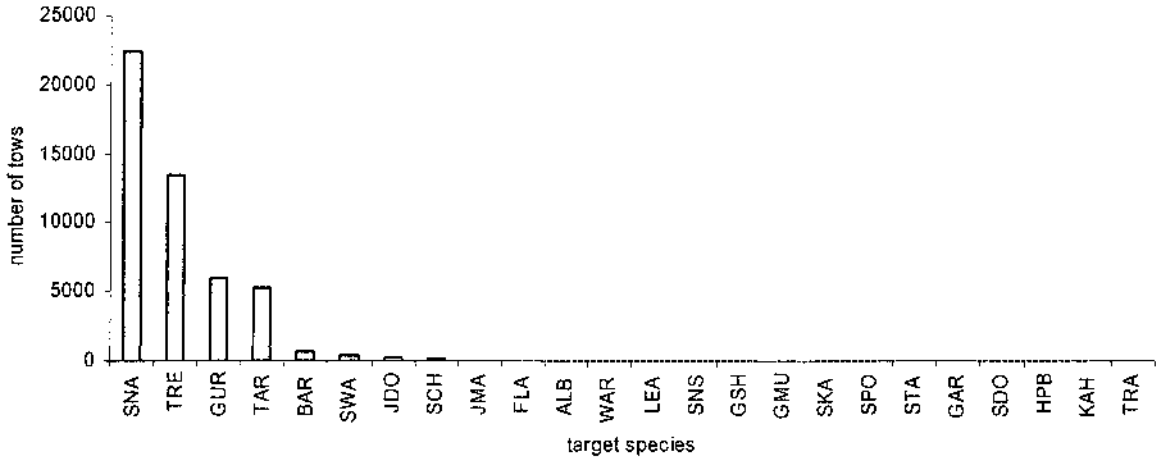
Appendix 20: Number of target tows by species from KAH 3 trawls catching kahawai.



Appendix 21: Total kahawai catch (t) in relation to vessel from the KAH 8 trawl fishery 1989 to 2005; only data from the shaded vessels were used in the final analysis.

rank order	vessel id	history yrs	catch t	%
1	12600	8	683.210	20.22
2	359	12	508.024	35.25
3	327	16	307.228	44.34
4	3036	12	244.919	51.59
5	360	12	184.833	57.06
6	3870	4	158.237	61.74
7	2048	16	155.624	66.34
8	1193	8	120.807	69.92
9	3735	13	78.902	72.25
10	5468	6	67.940	74.26
11	344	14	67.532	76.26
12	333	9	67.148	78.25
13	3221	14	66.522	80.22
14	5214	8	63.290	82.09
15	3788	4	59.950	83.86
16	4623	11	54.354	85.47
17	6129	10	51.604	87.00
18	4849	7	50.021	88.48
19	2089	7	36.191	89.55
20	312	14	34.815	90.58
21	529	8	33.506	91.57
22	581	7	30.193	92.46
23	1045	7	30.141	93.36
24	337	11	29.642	94.23
25	356	11	24.474	94.96
26	342	15	20.621	95.57
27	5512	8	15.964	96.04

Appendix 22: Number of target tows by species from KAH 8 trawls catching kahawai.



Appendix 23: Setnet annual canonical indices for the main kahawai stocks; bracketed numbers are c.v.s.

fishing year	east Northland	Hauraki Gulf	Bay of Plenty	KAH 2	KAH 3	KAH 8
1990-1991	1.1 (0.16)	1.08 (0.06)	1.86 (0.11)	1.24 (0.17)	1.85 (0.17)	1.89 (0.08)
1991-1992	1.29 (0.13)	1.13 (0.07)	1.56 (0.11)	1.29 (0.13)	1.76 (0.13)	1.52 (0.08)
1992-1993	0.93 (0.12)	1.29 (0.06)	1.21 (0.1)	1.49 (0.12)	2.23 (0.16)	1.23 (0.06)
1993-1994	0.81 (0.14)	0.92 (0.06)	1.15 (0.1)	0.96 (0.11)	1.31 (0.12)	1.27 (0.06)
1994-1995	0.88 (0.11)	1.15 (0.07)	1.23 (0.1)	1.24 (0.13)	0.8 (0.15)	1.28 (0.06)
1995-1996	0.85 (0.11)	1.4 (0.08)	1.25 (0.1)	0.9 (0.1)	-	1.09 (0.06)
1996-1997	0.94 (0.1)	1.1 (0.08)	1.34 (0.08)	0.7 (0.1)	0.93 (0.18)	1.03 (0.06)
1997-1998	1.02 (0.1)	1.13 (0.08)	1.5 (0.09)	0.9 (0.14)	1.23 (0.17)	0.94 (0.05)
1998-1999	0.78 (0.1)	0.78 (0.1)	0.97 (0.11)	1.08 (0.11)	-	0.86 (0.04)
1999-2000	0.87 (0.09)	0.95 (0.1)	0.53 (0.14)	1.1 (0.1)	-	0.79 (0.05)
2000-2001	0.97 (0.11)	1.3 (0.1)	0.51 (0.22)	0.73 (0.09)	1.03 (0.22)	0.74 (0.05)
2001-2002	0.98 (0.12)	1.04 (0.13)	0.52 (0.16)	1.03 (0.1)	0.11 (0.29)	0.86 (0.06)
2002-2003	1.28 (0.13)	0.82 (0.17)	0.58 (0.15)	1.22 (0.15)	-	0.93 (0.05)
2003-2004	1.24 (0.14)	0.54 (0.27)	-	0.96 (0.13)	-	0.7 (0.06)
2004-2005	1.29 (0.18)	0.77 (0.13)	-	0.59 (0.13)	-	0.59 (0.06)

Appendix 24: Trawl annual canonical indices for the main kahawai stocks; bracketed numbers are c.v.s.

fishing year	Bay of Plenty	KAH 2	KAH 3	KAH 8
1989-1990	1.21 (0.17)	1.45 (0.13)	0.76 (0.22)	0.76 (0.11)
1990-1991	1.25 (0.13)	2.25 (0.12)	1.51 (0.22)	0.83 (0.11)
1991-1992	1.74 (0.15)	1.49 (0.09)	0.47 (0.17)	0.54 (0.11)
1992-1993	0.7 (0.12)	1.49 (0.08)	1 (0.16)	0.57 (0.07)
1993-1994	0.57 (0.12)	1.34 (0.08)	0.81 (0.17)	0.49 (0.07)
1994-1995	0.51 (0.12)	1.06 (0.08)	0.56 (0.16)	0.82 (0.07)
1995-1996	0.75 (0.13)	0.67 (0.08)	1.08 (0.12)	1.12 (0.07)
1996-1997	0.85 (0.1)	0.68 (0.08)	1.02 (0.09)	1.23 (0.06)
1997-1998	0.73 (0.12)	0.91 (0.08)	1.2 (0.09)	1.37 (0.06)
1998-1999	1.32 (0.1)	0.9 (0.07)	1.37 (0.08)	1.69 (0.06)
1999-2000	2.09 (0.09)	1.1 (0.06)	1.18 (0.08)	1.62 (0.06)
2000-2001	1.87 (0.09)	0.94 (0.06)	1.01 (0.09)	1.16 (0.07)
2001-2002	1.47 (0.09)	0.87 (0.06)	1.17 (0.09)	1.41 (0.07)
2002-2003	0.82 (0.09)	0.79 (0.06)	1.5 (0.09)	1.42 (0.08)
2003-2004	0.69 (0.09)	0.62 (0.07)	1.24 (0.09)	1.14 (0.08)
2004-2005	0.93 (0.1)	0.6 (0.08)	0.86 (0.1)	0.94 (0.1)