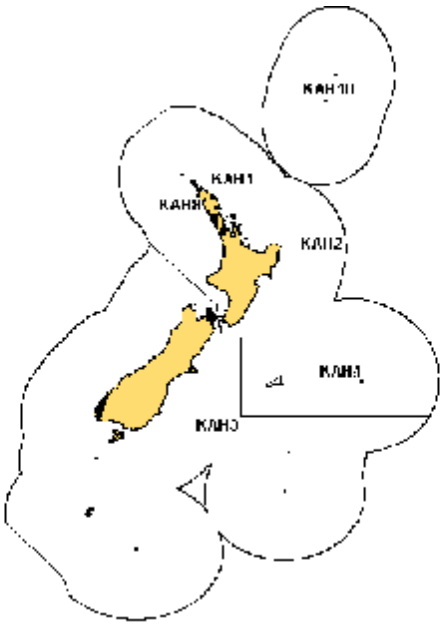
KAHAWAI (KAH)

(Arripis trutta and Arripis xylabion)



1. FISHERY SUMMARY

Kahawai (*Arripis trutta*) and Kermadec kahawai (*Arripis xylabion*) were introduced into the QMS on 1 October 2004 under a single species code, KAH. Kahawai were introduced into the QMS with six QMAs (KAH 1, KAH 2, KAH 3, KAH 4, KAH 8 and KAH 10), with allowances, TACC, and TAC as follows:

Table 1: KAH allowances, TACCs, and TACs on introduction to the QMS, 1 October 2004.

Fishstock	Recreational Allowance	Maori customary Allowance	Other mortality	TACC	TAC
KAH 1	1 865	550	75	1 195	3 685
KAH 2	680	205	35	785	1 705
KAH 3	435	125	20	455	1 035
KAH 4	5	1	0	10	16
KAH 8	425	125	25	580	1 155
KAH 10	5	1	0	10	16

These QMAs differ from the Management Areas used before kahawai were introduced into the QMS. The definitions of KAH 1, KAH 2 and KAH 10 remain unchanged, but KAH 4 was formerly part of KAH 3, as was that part of KAH 8 which is south of Tirua Point. The area of KAH 8 which is north of Tirua point was formerly called KAH 9.

The Minister agreed to review the TACs for kahawai for the 2005-06 fishing year. Subsequently, he decided to reduce TACs, TACCs and allowances by 10% as follows:

Table 2: KAH allowances, TACCs, and TACs, 1 October 2005.

Fishstock	Recreational Allowance	Maori customary Allowance	Other mortality	TACC	TAC
KAH 1	1 680	495	65	1 075	3 315
KAH 2	610	185	30	705	1 530
KAH 3	390	115	20	410	935
KAH 4	4	1	0	9	14
KAH 8	385	115	20	520	1 040
KAH 10	4	1	0	9	14

(a) Commercial fisheries

Commercial fishers take kahawai by a variety of methods. Purse seine vessels take most of the catch; however, substantial quantities are also taken seasonally in set net fisheries and as a bycatch in longline and trawl fisheries.

Kahawai is a pelagic schooling species and is mostly caught by the purse seine fishery. The kahawai purse seine fishery cannot be understood without taking into account the other species that the vessels target. The fleet, which is based in Tauranga, preferentially targets skipjack tuna (*Katsuwonus pelamis*) between December and May, with very little bycatch. When skipjack are not available, usually June through November, the fleet fishes for a mix of species including kahawai, jack mackerels (*Trachurus* spp.), trevally (*Pseudocaranx dentex*) and blue mackerel (*Scomber australasicus*). These are caught 'on demand' as export orders are received (to reduce product storage costs). However, since the mackerels and kahawai school together there is often a bycatch of kahawai resulting from targeting of mackerels. Reported landings, predominantly *A. trutta*, are shown for 1962 up to and including 1982 in Table 3 by calendar year for all areas combined, and from 1983-84 onwards by fishing year and by historic management areas in Table 4 and by QMAs in Table 5.

Table 3: Reported total landings (t) of kahawai from 1970 to 1982. Note that these data include estimates of kahawai from data where kahawai were reported within a general category of 'mixed fish' rather than separately as kahawai.

Year	Landings	Year	Landings	Year	Landings
1962	76	1969	234	1976	729
1963	81	1970	294	1977	1461
1964	86	1971	572	1978	2228
1965	102	1972	394	1979	3782
1966	254	1973	586	1980	5101
1967	457	1974	812	1981	3794
1968	305	1975	345	1982	5398

Source: 1962 to 1969 – Watkinson & Smith 1972; 1970 to 1982 – Sylvester 1989.

Before 1988 there were no restrictions in place for the purse seine fishery. During the period 1989 to 1991 kahawai were actively targeted to create catch history for future quota allocation.

Table 4: Reported landings (t) of kahawai by fishstock as defined prior to 2004 from 1983–84 to 2003–04. Estimates of fish landed as bait or as 'mixed fish' 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.

Fishstock	KAH 1	KAH 2	KAH 3	KAH 9	KAH 10	Unknown Area	Total Catch	Total LFRR
FMA(s)	1	2	3–8	9	10			
1983–84	1941	919	813	547	0	46	4266	–
1984–85	1517	697	1669	299	0	441	4623	–
1985–86	1597	280	1589	329	0	621	4416	–
1986–87	1890	212	3969	253	0	1301	7525	6481
1987–88	4292	1655	2947	135	0	581	9610	9218
1988–89	2170	779	4301	179	0	–	7431	7377
1989–90	2049	534	5711	156	0	16	8466	8696
1990–91	1617	872	2950	242	0	4	5687	5780
1991–92	2190	807	1900	199	<1	7	5104	5071
1992–93	2738	1132	1930	832	2	0	6639	6966
1993–94	2054	1136	1861	98	15	0	5164	4964
1994–95	1918	1079	1290	168	0	24	4479	4532
1995–96	1904	760	1548	237	7	46	4502	4648
1996–97	2214	808	938	194	1	3	4158	3763
1997–98	1601	291	525	264	0	19	2700	2823
1998–99	1833	922	1209	468	0	3	4435	4298
1999–00	1616	1138	718	440	0	<1	3912	3941
2000–01	1746	886	925	272	0	1	3829	3668
2001–02#	1354	816	377	271	0	<1	2819	2796
2002–03#	933	915	933	221	0	<1	3001	2964
2003-04#	1624	807	109	205	0	0	2745	2754

QMS Data.

Table 5: Prorated landings (t) of kahawai by the fishstocks defined in 2004 for the fishing years between 1998–99 and 2003-04. Distribution of data were derived by linking through the trip code, catch landing data (CLD), statistical areas and landing points and prorating to CLD totals. Landings for 2004-05 are from QMS MHR data.

Fishstock	KAH1	KAH2	KAH3	KAH4	KAH8	KAH10	Total
1998-99	1,652	975	697	0	1,120	0	4,444
1999-00	1,677	973	499	0	768	0	3,917
2000-01	1,678	922	425	0	581	0	3,606
2001-02	1,326	857	156	0	489	0	2,831
2002-03	869	855	650	0	542	0	2,916
2003-04	1,641	806	33	0	342	0	2,822
2004-05*	1,147	708	129	< 1	544	0	2,529

*QMS MHR data

For the 1990–91 fishing year, a total commercial catch limit for kahawai was set at 6500 t, with 4856 t set aside for those harvesting kahawai by purse seine (Table 6).

In KAH 1, a voluntary moratorium was placed on targeting kahawai by purse seine in the Bay of Plenty from 1 December 1990 to 31 March 1991, which was extended from 1 December to the Tuesday after Easter in subsequent years. While total landings decreased in 1991–92, landings in KAH 1 increased and in 1993–94 the competitive catch limit for purse seining in KAH 1 was reduced from 1666 tonnes to 1200 tonnes. Purse seine catches reported for KAH 9 were also included in this reduced catch limit, although seining for kahawai on the west coast of the North Island ceased after this reduction in the KAH1 purse seine limit. Purse seine catch limits were reached in KAH 1 between 1998–99 and 2000–01 and in 2003–04.

No change was made to the purse seine limit of 851 tonnes for KAH 2. The KAH 2 purse seine fishery was closed early due to the catch limit being reached before the end of the season in each year between 1991–92 and 1995–96 and between 2000–01 and 2001–02.

Within KAH 3, the kahawai purse seine fleet has voluntarily agreed, since 1991–92, not to fish in a number of near-shore areas around Tasman and Golden Bays, the Marlborough Sounds, Cloudy Bay, and Kaikoura. The main purpose of this agreement is to minimise local depletion of schools of kahawai found inshore, and the catches of juveniles. The purse seine catch limit for KAH 3 was reduced from 2339 to 1500 tonnes from 1995–96. Purse seine catch limits have never been reached in KAH 3.

Table 6: Reported catches (t) by purse seine method and competitive purse seine catch limit (t) from 1990–91 to 2003–04. All data are from weekly reports furnished by permit holders to the Ministry of Fisheries except those for 1993–94 which are from the CELR database. Fishstocks are as defined prior to 2004.

	KAH 1		KAH 2		KAH 3		KAH 9		KAH 10		Total	
Year	catch	catch limit	catch	catch limit	catch	catch limit	catch	catch limit	catch	catch limit	catch	catch limit
1990–91	1 422	1 666	493	851	n/a#	2839*	0	none	0	none	n/a	5 356
1991–92	1 613	1 666	735*	851	1 714	2339	0	none	0	none	4 080	4 856
1992–93	1 547	1 666	795*	851	1 808	2339	140	none	0	none	4 290	4 856
1993–94	1 262	1 200	1 101*	851	1 714	2339	15	§	0	none	4 092	4 390
1994–95	1 225	1 200	821*	851	1 644	2339	0	§	0	none	3 690	4 390
1995–96	1 077	1 200	805*	851	1 146	1500	0	§	0	none	3 028	3 551
1996–97	1 017	1 200	620	851	578	1500	0	§	0	none	2 784	3 551
1997–98	969	1 200	175	851	153	1500	0	§	0	none	1 297	3 551
1998–99	1 416*	1 200	134	851	463	1500	2	§	0	none	2 015	3 551
1999–00	1 371*	1 200	553	851	520	1500	0	§	0	none	2 444	3 551
2000–01	1 322*	1 200	954*	851	430	1500	0	§	0	none	2706	3551
2002-02	838	1 200	747*	851	221	1500	0	§	0	none	1806	3551
2002-03	514	1 200	819	851	816	1500	0	§	0	none	2149	3551
2003-04	1203*	1 200	714	851	1	1500	0	§	0	none	1918	3551

By March 1991 when the catch limit was imposed, the purse seine catch had already exceeded 2339 t and the fishery was immediately closed. As the catch already exceeded 2339 t before the Minister's decision was announced, an extra 500 t was allocated to cover kahawai bycatch only.
§ Combined landings from KAH 9 and KAH 1 were limited to 1200 t.
* Purse seine fishery for kahawai closed.

Kahawai entered the Quota Management System on 1 October 2004, and the TACs and TACCs were set for redefined kahawai fishstocks (Tables 1 and 2). Purse seine catch limits thus no longer applied after this introduction and landings, regardless of fishing method, are now restricted by quota availability and company fishing policies.

(b) Recreational fisheries

Kahawai are highly prized by some recreational fishers, who employ a range of shore and boat based fishing methods to target and/or catch the species. The only regulatory restrictions on recreational fishing for kahawai are a multi-species bag limit of 20 fish and a minimum set net mesh size of 90 mm, Kahawai is one of the fish species more frequently caught by recreational fishers and recreational groups continue to express concern about the state of kahawai stocks. In 1997 the Recreational Fishing Council carried out a survey of recreational fishers in major fishing magazines. There were 2002 respondents, of which 47% felt that kahawai stocks had 'declined significantly' and 32% felt they had 'declined a little' over the previous five years. Historical kahawai recreational catches are poorly known.

(i) Diary and survey based harvest estimates

Recreational harvest estimates by fish stock have been obtained from national telephone diary surveys undertaken in 1996 and 2000, with a follow up survey in 2001. Regional telephone diary surveys were undertaken in 1991/92 in the South Region, 1992/93 in the Central Region and in 1993/94 in the North Region.

The estimated numbers of kahawai harvested by recreational fishers from the available surveys are detailed in Table 7. There is uncertainty with the recreational harvest estimates for kahawai, as well as with the estimates of mean weight of recreationally captured kahawai, which varies substantially around the country.

The harvest estimates from the 2000 and 2001 surveys are available for the three KAH 1 regional strata used in the recreational catch sampling programme. The proportions of the KAH 1 harvest tonnage taken in each area, as estimated by the 2000 and 2001 surveys respectively, are: East Northland, 23 % and 21 %; Hauraki Gulf, 18 % and 17 %; and Bay of Plenty, 59 % and 62 % . It should be noted, however, that these results are not independent of each other as the diarist catch expansion factors, and many of the diarists, were common to both surveys.

Table 7: Estimated number of kahawai harvested by recreational fishers by Fishstock as defined prior to 2004. (Source: Tierney et al. 1997, Bradford 1997a, Bradford 1998, Boyd & Reilly 2002, and Boyd et al. 2004).

	Survey		KAH 1		KAH 2			
Year	Number	c.v. (%)	Range	Estimate (t)	Number	c.v. (%)	Range	Estimate (t)
1992/93	-	-	-	-	195000	-	245-350	297.5
1993/94	727000	-	920-1035	977.5	-	-	-	-
1996	666000	6	900-1020	960	142000	9	190-240	217
2000	1860000	13	915.6-2474.7	2195.1	1808000	74	769.1-5104.8	2937
2001	1905000	13	-	2248.3	492000	20	-	799.2

	Survey		KAH 3		KAH 9			
Year	Number	c.v. (%)	Range	Estimate (t)	Number	c.v. (%)	Range	Estimate (t)
1991/92	231000	-	160-260	210				
1993/94	6000	-	-	8.4#	254000	-	285-395	340
1996	226000	7	125-145	137	199000	9	195-225	204
2000	413000	16	563.5-771.3	667.4	337000	20	353.8-527.3	440.6
2001	353000	18	-	569.7	466000	24	-	608.5

#No harvest estimate available in the survey report, estimate presented is calculated as average fish weight for all years and areas by the number of fish estimated caught.

The national telephone diary surveys require three components from which to construct estimates of harvest in tonnes: i) it must estimate the population that fishes recreationally from which a group eligible to complete diaries is selected; ii) it requires this group to complete diaries of their recreational catch history from which a mean catch by species for the eligible population is generated; and, iii) it must estimate the mean weight of the recreational catch by species and area in order to convert the catch by number to a catch weight in tonnes. This latter component is best estimated from boat ramp surveys but has also been estimated as a component of the diaries. The Recreational Technical Working Group (RTWG) concluded that the framework used for the telephone interviews for the 1996 and previous surveys contained a methodological error, resulting in biased eligibility figures. Consequently the harvest estimates derived from these surveys are unreliable.

Comparisons between boat ramp and diary estimates of snapper landings per fisher-trip indicate that there are inconsistencies between the observational and diary information. These inconsistencies, suggest to the RTWG that the diary methodology used in all these surveys produces unreliable estimates of total harvest. In addition, there was concern expressed by the RTWG about very high harvest estimates from the 2000 survey in FMA 2 (e.g. KAH 2). Relative comparisons may be possible between stocks within these surveys.

Mean weight, the third component of the diary survey, introduces uncertainty in the estimates of total weight of recreational landings. However, it is possible to bypass this problem by using the estimated harvest in numbers.

The RTWG recommends that the harvest estimates from the diary surveys should be used only with the following qualifications: a) they may be very inaccurate; b) the 1996 and earlier surveys contain a methodological error; and, c) the 2000 and 2001 harvest estimates are implausibly high for many important fisheries.

Kahawai entered the Quota Management System on 1 October 2004, and recreational and Maori customary allowances are given in section 1. The lower of the point estimates of recreational catch of either 2000 or 2001 was used as a basis for setting non-commercial allowances. To account for boundary changes, 50 tonnes were taken from KAH3 and added to KAH8.

(ii) Aerial survey and boat ramp survey combined harvest estimates

Recently, a recreational harvest survey employing a methodology which combines aerial overflights with boat ramp interviews has been implemented to estimate recreational harvest of the most commonly caught finfish species in FMA 1. The design of this survey requires counting recreational fishing effort from overflights according to a design which is stratified by day of week (weekend or weekday), area of fishing and month of capture. These counts of effort are matched with estimates of mean catch by species by vessel using the same stratification. Total recreational catch by species is then estimated by multiplying the mean catch per unit of effort by the total effort. This methodology for estimating recreational marine catch has been employed in many overseas jurisdictions.

Maps delineating coastal areas of most the North Island have been used since the first marine recreational fishing survey was conducted in 1990–91. The same spatial definitions were used in this survey, although for analytical purposes, some areas were combined into four larger subdivisions of the Hauraki Gulf. This was necessary because very little fishing occurs in some parts of the Gulf, and the amount of information on the diurnal profile of fishing effort and catch rates was considered too limited to derive usefully precise harvest estimates over smaller spatial scales. However, the aerial overflight survey did not include catch or vessels in the outer Hauraki Gulf. These areas outside a line from Cape Rodney to Cape Colville are included in previous estimates of recreational catch for the Hauraki Gulf based on diary surveys.

Preliminary estimates of kahawai harvest for the summer months (1 December 2003 to 30 April 2004) from the Hauraki Gulf only have been calculated from this new method. The resulting estimate of 39.7 t (90% CI 31.0-50.4) (Table 8) is considerably lower than previous telephone diary based harvest estimates for the Hauraki Gulf (e.g. the diary survey harvest estimate range in 2000, including the outer Hauraki Gulf, was 164-445 t). The significance of this difference cannot be evaluated at this time because the harvest estimates have been obtained using different methodologies and boat ramp interview catch rates in 2004 were the lowest since the first survey in 1991 (Figure 1).

Table 8: Kahawai harvest estimate summary statistics for the summer of 2004 (1 December 2003 to 30 April 2004). Average daily tonnage estimates are given for each area/day-type combination and temporally weighted estimates are given for the Hauraki Gulf. Days from unused Furuno competition strata have been reallocated to the appropriate day-type strata (two midweek days and one weekend day). Overflight survey estimates are adjusted in the second half of the table to account for harvests by vessel based fishing methods which were not estimated by the overflight approach, harvests by shore based fishers, and the landed catch of fishers participating in the 2004 Furuno Fishing Tournament.

Area	Day-type	Number of days	Estimate	Mean of bootstraps	Median of bootstraps	5th percentile	95th percentile
1	Weekend/PH	52	0.158	0.159	0.158	0.118	0.201
	Midweek	100	0.072	0.070	0.070	0.043	0.098
2	Weekend/PH	52	0.055	0.052	0.049	0.025	0.086
	Midweek	100	0.025	0.034	0.029	0.001	0.081
3	Weekend/PH	52	0.008	0.006	0.006	0.003	0.011
	Midweek	100	0.039	0.037	0.032	0.009	0.078
4	Weekend/PH	52	0.025	0.022	0.021	0.009	0.039
	Midweek	100	0.000	0.000	0.000	0.000	0.000
Weighted summer total			26.3	26.5	26.1	20.4	33.6
Scaled to account for 13.1 % of catch by unassessed vessel based methods[1]			30.3	30.5	30.1	23.5	38.7
Scaled to account for 21.9 % of catch[2] by shore based methods			38.8	39.1	38.5	30.1	49.6
Including weighed in catch from Furuno Fishing Tournament (865 kg)			39.7	39.9	39.4	31.0	50.4

1 - Derived from concurrent boat ramp interview data.

2 - Derived from telphone diary survey estimates for the Hauraki Gulf.

The aerial overflight methodology directly accounts for boat based harvests of kahawai, including those used for bait and caught by trolling and longline methods, although the latter are assessed in a simplistic manner. The harvest by shore-based methods is assessed indirectly via historical diarist data. It is likely the catch from the Furuno Fishing Tournament is an overestimate, as it probably includes fish caught north of the area surveyed by the aerial overflight method. The released catch of kahawai is not assessed, and there are no estimates of the associated release mortality.

The Hauraki Gulf kahawai harvest is thought to be lower than that in East Northland and the Bay of Plenty.

(iii) CPUE

Boat ramp surveys have been conducted in KAH 1 since 1991, and these data have been used to generate both unstandardised and standardised CPUE indices for three regional fisheries: East Northland, Hauraki Gulf and Bay of Plenty (Hartill & Walsh 2005). Catch rates in East Northland increased in the early 1990s, and then declined in recent years, although coverage in the first ten years was patchy (Figure 1). The Hauraki Gulf is less variable, but there is some evidence of a decline in fisher success since 2001. The most stable index is that for the Bay of Plenty, where there has also been a small decline in recent years.

Boat ramp surveys conducted intermittently in KAH 1 since 1991 suggest that approximately 80% of the recreational catch is landed and that only a small proportion of the unlanded catch has been used for bait (Hartill & Walsh 2005). The indices of harvest rate given in Figure 1 are based on total catch rates, and include reports of kahawai returned to the sea.

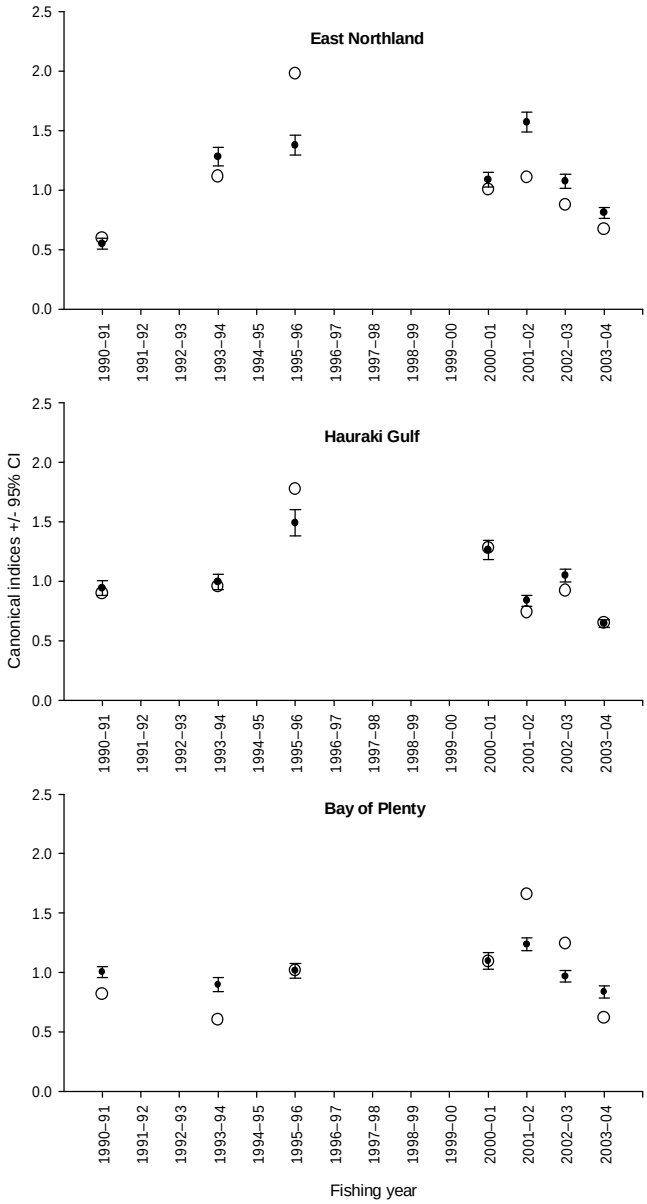


Figure 1: Kahawai catch rate indices for recreational fishers using baited hooks and/or jigs in East Northland, Hauraki Gulf and the Bay of Plenty, by fishing year since 1990–91. Closed circles are standardised indices with 95% canonical confidence intervals, and open circles are indices based on unstandardised catch rates, which have been scaled up to the average magnitude of the standardised indices (Hartill & Walsh 2005).

(c) Maori customary fisheries

Kahawai is an important traditional and customary food fish for Maori. The level of customary catch has not been quantified and an estimate of the current customary catch is not available. Some Maori have expressed concern over the state of their traditional fisheries for kahawai, especially around the river mouths in the eastern Bay of Plenty.

(d) Illegal catch

There is no known illegal catch of kahawai. Estimates of illegal catch are not available, but are probably insignificant.

(e) Other sources of mortality

There is no information on other sources of mortality. Juvenile kahawai may suffer from habitat degradation in estuarine areas.

2. BIOLOGY

Kahawai are a schooling pelagic species belonging to the family Arripididae. Kahawai are found around the North Island, the South Island, the Kermadec and Chatham Islands. They occur mainly in coastal seas, harbours and estuaries and will enter the saltwater sections of rivers. A second species, *A. xylabion*, is described (Paulin 1993). It is known to occur in the northern EEZ, at the Kermadec Islands and seasonally around Northland.

Kahawai feed mainly on fishes but also on pelagic crustaceans, especially krill (*Nyctiphanes australis*). Kahawai smaller than 100 mm eat mainly copepods. Although kahawai are principally pelagic feeders, they will take food from the seabed.

The spawning habitat of kahawai is unknown but is thought to be associated with the seabed in open water. Schools of females with running ripe ovaries have been caught by bottom trawl in 60–100 m in Hawke Bay (Jones et al. 1992). Other females with running ripe ovaries have been observed in east coast purse seine landings sampled in March and April 1992, and between January and April in 1993 (McKenzie, NIWA, unpublished data). Length-maturation data collected from thousands of samples in early 1990s suggests the onset of sexual maturity in males occurs at around 39 cm and in females at 40 cm (McKenzie, NIWA, unpublished data) which closely matches an estimate of 39 cm used for Australian *A. trutta* (Morton et al. 2005). This length roughly corresponds to fish of four years of age in both countries. Eggs have been found in February in the outer Hauraki Gulf. Juvenile fish (0+ year class) can be found in shallow water over eelgrass meadows (*Zostera* spp.) and in estuaries.

Kahawai are usually aged using otoliths, following an aging technique that has been validated. Kahawai grow rapidly, attaining a length of around 15 cm at the end of their first year, and maturing after 3–5 years at about 35–40 cm, after which their growth rate slows. The largest recorded *A. trutta* had a fork length of 79 cm and was caught by a recreational fisher in the Waitangi Estuary, in Hawke Bay in August 1997 (Duffy and Petherick 1999). Northern kahawai, *Arripis xylabion*, grow considerably bigger than kahawai and attain a maximum length of 94 cm, but beyond this, little is known about the biology of this species. Male and female von Bertalanffy growth curves appear to be broadly similar, with females attaining a slightly higher value for L_∞, although statistical comparison of sex specific curves using a Likelihood ratio test (Kimura 1980) suggests that they are statistically different (Hartill & Walsh 2005). Combined sex growth curves are probably adequate for modelling purposes, however, and are given for some areas in Table 9. Sex specific growth parameters given for KAH 1 in previous plenary documents (see Sullivan et al. 2005) have higher estimates for L_∞ (56.93 for males and 55.61 for females).

The maximum-recorded age of kahawai is 26 years. The instantaneous rate of natural mortality (M) was estimated from the equation $M=\log_e 100/\text{maximum age}$, where maximum age is the age to which 1% of the population survives in an unexploited stock. Based on a maximum age of 26 years, M was estimated to equal 0.18. A range of 0.15–0.25 is assumed to reflect the lack of precision in the estimate.

Table 9: Estimates of biological parameters.

Fishstock	Estimate	Source
1. Natural mortality (M)		
All	0.18	Jones et al. 1992

2. Weight = a(length)^b (weight in g, length in cm fork length)

	a	b	
KAH 1 (resting)	0.0306	2.82	Hartill & Walsh 2005
KAH 1 (mature)	0.0103	3.14	Hartill & Walsh 2005

3. von Bertalanffy growth parameters

		K		t_0	L_∞	
KAH 1	0.33	-0.10	54.3			Hartill et al. 2004
KAH 2	0.34	+0.60	53.5			Drummond 1995
KAH 3	0.30	+0.25	54.2			Drummond & Wilson 1993
KAH 9	0.23	-0.26	55.9			McKenzie, NIWA, unpubl. data

3. STOCKS AND AREAS

Tagging returns suggest that kahawai (*A. trutta*) remain in, or return to the same area for several years, but some move throughout the kahawai habitat. The pattern of kahawai movement around New Zealand is poorly understood and there are regional differences in age structure and abundance which are consistent with limited mixing between regions, however kahawai (*A. trutta*) are assumed to be a single biological stock. There is no information about any stock structuring for *A. xylabion*.

Kahawai are presently considered to form one New Zealand wide biological stock but defined as separate units for the purpose of fisheries management: KAH 1 (FMA 1); KAH 2 (FMA 2); KAH 3 (FMAs 3, 5, 6 & 7); KAH 4 (QMA 4); KAH 8 (FMAs 8 & 9) and KAH 10 (FMA 10). There are no new data that would alter these areas.

4. STOCK ASSESSMENT

The last assessment for kahawai was undertaken in 1997 which used a stock reduction model to obtain estimates of B_0, B_{1996} and MCY for a single nationwide kahawai stock. More recently, the recreational catch in KAH 1 has been sampled annually to determine the size and age composition of the recreational catch. In 2005 a preliminary relative index of abundance based on aerial sightings data was developed.

(a) Catch sampling

A five-year time series of size and age composition data for recreational catches taken in KAH 1 is available (2001 to 2005). Sampling was stratified into three areas: east Northland, the Hauraki Gulf; and, the Bay of Plenty.

In the Hauraki Gulf the number of kahawai encountered by boat ramp interviewers has declined in the last two years despite increased levels of sampling. The majority of fish landed in the Hauraki Gulf are juveniles. The age distribution of fish landed in East Northland has broadened over the last four years, with a higher proportion of older fish being caught. There has been less change in the Bay of Plenty, where catch rates are higher and the average age of those fish landed is greatest.

The catch sampling also shows that small kahawai are caught almost exclusively inshore. Larger kahawai may be taken inshore, or offshore.

Some sampling of commercial catches from KAH 1, KAH3 and KAH 9 also took place in the early 1990s, mainly from purse seine fisheries.

(b) Aerial sightings

A preliminary relative index of abundance for kahawai has been developed based on aerial sighting data. Spatio-temporal tabulation of kahawai sightings by QMA showed that the most extensive and consistent sightings occur in KAH 1. Sightings in KAH 2 were considerably fewer and more variable, and those in KAH 3 were consistent and of good numbers between 1978–79. Kahawai sightings in KAH 9 have been low in most years.

Trends in the analysis are variable depending on the assumptions made in standardising the index and assumptions about pilot learning. The preliminary combined model incorporated a model of tonnes sighted per hour flown and a model of presence with implied absence of sightings within a flight. The presence/absence data add more information to the indices, but they require additional work to investigate the most appropriate selection of implied absence data before being usable in a stock assessment model. Additional work on the incorporation of environmental variables, expansion of the index to other areas and further standardisation are also underway.

It is important to note that these analyses are preliminary and the relationship between sightings and stock size are unknown.

(c) Estimates of fishery parameters and abundance

Historic estimates of total mortality (Z) derived from the age composition of commercial catch data collected in the early 1990s are given in Table 10. Recent estimates of total mortality (Z) derived from recreational landings sampled in East Northland and the Bay of Plenty (KAH 1), and calculated using a Chapman Robson estimator are given in Table 11 (Armiger et al. 2006). The estimates given in Table 11 were calculated using a range of assumed ages for full recruitment to demonstrate the sensitivity of the analysis to this assumption.

Table 10: Estimates of Z derived from commercial fisheries catch sampling data.

Fishstock	Estimate	Time sampled	Source
KAH 2	0.24	Nov 92	Drummond (1995)
KAH 3 (Marlborough Sounds)	0.22–0.35	Nov 90 - Mar 91	Drummond & Wilson (1993)
KAH 3 (Cloudy/Clifford Bays)	0.19–0.27	Nov 90 - Jun 91	Drummond & Wilson (1993)
KAH 3 (Kaikoura)	0.23–0.30	Nov 90 - May 91	Drummond & Wilson (1993)
KAH 9	0.11	Feb 91 - Mar 91	Jones et al. (1992)

Table 11: Estimates of Z derived from recreational catch sampling in KAH 1, by survey year by assumed age at recruitment.

East Northland					
	2001	2002	2003	2004	2005
3	0.33	0.33	0.32	0.28	0.24
4	0.34	0.38	0.35	0.31	0.28
5	0.30	0.37	0.39	0.33	0.33
6	0.30	0.40	0.41	0.38	0.36
Bay of Plenty					
	2001	2002	2003	2004	2005
3	0.23	0.25	0.28	0.20	0.27
4	0.26	0.30	0.32	0.23	0.29
5	0.28	0.33	0.34	0.26	0.30
6	0.30	0.36	0.38	0.32	0.30

The interpretation of catch curve analyses is difficult for schooling pelagic species for several reasons which include: (a) difficulties in obtaining a representative sample of sufficient size to describe the age distribution of the population because of the schooling behaviour of kahawai; (b) uncertainty in the value of M; and (c) lack of contrast in the data if exploitation rates are not changing. The estimates of Z, which contain both natural and fishing mortality, are broadly similar across the two data sets (EN and BoP in Table 11).

(d) Biomass estimates

In 1997 a stock reduction model was used to obtain estimates of B_0, B_{1996} and MCY for a single nationwide kahawai stock. A single stock was assumed.

The base case values of biological parameters used in the model are shown in Table 12. A single sex model with a plus group from age 15 was used. The recruitment ogive was chosen to allow for the non-commercial catch of juvenile kahawai and occasional commercial catches of kahawai from age 3 onwards. The weight-length relationship was changed to the KAH 3 purse seine summer relationship shown in Table 10. The simulations used commercial catch data from 1970 through to 1994 from Tables 3 and 4. Uncertainties about the commercial catch prior to about 1988 have been documented in Sylvester (1989).

For the purposes of modelling, a base case was used where the non-commercial catch was assumed to be 700 t in 1970, increased annually by 100 t to a level of 2000 t in 1983, and then remained constant at 2000 t to be consistent with the 1990s recreational catch estimates (Table 7).

Recreational fishers believed that historical recreational catches were higher than previous estimates. A sensitivity analysis was undertaken where the non-commercial catch (including traditional catch) was taken as rising from 375 t to 4000 t in steps of 125 t for 1945 to 1974; constant at 4000 t from 1975 to 1984; then 3600 t (1985), 3200 t (1986), dropping in steps of 200 t to 2000 t in 1992 and then remaining constant at 2000 t. Using the higher historical recreational catch levels, for each value of M, the estimates of virgin biomass, B_{1996} / B_{MSY} and MCY increased. B_{1996} / B_{MSY} estimates increased

to 550%, 350% and 200% (compared to values in Table 13) and MCY increased to 14 200 t, 8200 t and 5700 t (compared to values in Table 14) for M = 0.25, 0.20 and 0.15, respectively.

Table 12: Biological parameters used in the model.

Parameter	Symbol	Value
Natural mortality	M	0.2 yr^{-1}
Age of recruitment	A_r	4 yr
Gradual recruitment	S_r	3 yr
Age at maturity	A_m	5 yr
Gradual maturity	S_m	0 yr
von Bertalanffy parameters	L_∞	60 cm
	K	0.3 yr^{-1}
	t_0	0 yr
Length-weight parameters	a	0.024
	b	2.91
Recruitment steepness	h	0.95
Recruitment variability (biomass cal'n)	σ_R	0
Recruitment variability (yield cal'n)	σ_R	0.6

The estimates were made by adjusting the maximum fishing mortality (F_{UB}) in any year (usually the year of maximum catch) to be such that Z (F_{AV} + M) was about 0.31 (the maximum likely value from Table 10). The average fishing mortality (F_{AV}) was calculated over the years 1980–92 (Table 14).

Table 13: Estimates of minimum virgin (B_0) and current (B_{1996}) biomasses compared with B_{MSY}. F_{AV} is the average fishing mortality between 1980 and 1992. Estimates are calculated for different values of natural mortality (M), such that Z_{UB} (M + F_{AV}) = 0.31. The value of F_{UB} was found by trial and error.

M	F_{AV}	B_0	B_{MSY}/B_0	B_{1996}/B_0	B_{1996}/B_{MSY}	F_{UB}
0.25	0.063	152 000	13.9%	71.7%	520%	0.10
0.20	0.112	106 000	16.1%	50.0%	310%	0.19
0.15	0.162	93 000	17.8%	28.0%	160%	0.30

The biomass estimates in Table 14 are uncertain and depend on the model assumptions (a single stock, deterministic recruitment, and the constraints on fishing mortality imposed) and input data. They may be regarded as conservative estimates as they are based on the upper end of the Z estimates in Table 10. The catch history is uncertain due to uncertainties in the commercial catch records, and the non-commercial catch history is based on an assumed pattern leading to a single estimate in the 1990s provided by the recreational surveys. The upper limit of Z is uncertain and comes from data in a limited part of the kahawai range. The modelling approach is quite sensitive to some of the key assumptions and no biomass indices were available.

(e) Estimation of Maximum Constant Yield (MCY)

The results of the stock assessment model were used to estimate MCY for a single national Fishstock. MCY = pB_0 where p is determined using a simulation method with the constraint that the biomass does not go below 20% B_0 more than 10% of the time. The estimates are presented in Table 14 for the range of M values used in Table 13. The productivity parameters are those used for biomass estimation.

Table 14: Natural mortality (M), formulae for estimating MCY, and MCY estimates (t) for kahawai.

M	Formulae	MCY
0.25	8.32%B_0	12 600
0.20	7.13%B_0	7 600
0.15	5.47%B_0	5 100

(f) Estimation of Current Annual Yield (CAY)

CAY has not been estimated because of the lack of reliable current biomass estimates.

(g) Other yield estimates and stock assessment results

There are no other yield estimates or stock assessment results.

(h) Other factors

The combined recreational and commercial catch levels during the last two years are less than the MCY estimates for values of M = 0.20 or greater.

The uncertainty about stock structure for kahawai means that stock status should also be considered for smaller areas. Values of Z, which include the effects of commercial and non-commercial fishing, were calculated for kahawai for KAH 2, 3 and 9 in 1990–91 and more recently, for KAH 1.

5. STATUS OF THE STOCKS

Estimates of B_{1996} and reference biomasses were made in 1997 assuming a single nationwide stock for kahawai. These estimates are unreliable and sensitive to some key assumptions, but thought to be conservative. The model estimated that, while there had been some decline in biomass, the estimated 1996 biomass level was still above the size that would support the maximum sustainable yield.

Recent estimates of current and reference biomass are not available.

It is not known if the current catches, allowances or TACCs are sustainable, or at a level that will allow the stock to move towards a size that will support the MSY.

Table 15: Summary of yield estimates (t) and reported commercial landings (t) for the most recent fishing year.

Fishstock		FMA	MCY	2004-05 Actual TACC	2004-05 landings
KAH 1	Auckland	1		1 075	1 147
KAH 2	Central (East)	2		705	708
KAH 3	South-East (Coast) Southland, Sub-Antarctic, and Challenger	3, 5, 6, 7		410	129
KAH 4	South-East (Chatham)	4		9	< 1
KAH 8	Central (West) and Auckland (West)	8, 9		520	544
KAH 10	Kermadec	10		9	0
Total			5 100 -12 600	2 728	2 529

6. FOR FURTHER INFORMATION

Armiger, H.; Hartill, B.; Tasker, R.; Smith, M. 2006. Length and age compositions of recreational landings of kahawai in KAH 1 in January to April 2003–04 and 2004–05. Final Research Report for Ministry of Fisheries Research Project KAH2003/01 Objectives 1 & 2. 33 pp.

Bradford, E.; Taylor, P.R. (1995). Trends in pelagic fish abundance from aerial sightings data. *N.Z. Fisheries Assessment Research Document 95/8.* 60 p.

Bradford, E. (1997a). Estimated recreational catches from Ministry of Fisheries North region marine recreational fishing surveys, 1993-94. *New Zealand Fisheries Assessment Research Document* 97/7. 16p.

Bradford, E. (1997b). Update of kahawai simulation model for the 1997 assessment and sensitivity analysis. *N.Z. Fisheries Assessment Research Document 97/20*. 12 p.

Bradford, E. (1998). Harvest estimates from the 1996 national recreational fishing surveys. *N.Z. Fisheries Assessment Research Document. 98/16*. 27 p.

Boyd, R. O., Reilly, J. L. (2002). 1999/2000 National marine recreational fishing survey: harvest estimates. *Draft New Zealand Fisheries Assessment Report* 2002/xx.

Boyd, R. O., Gowing, L., Reilly, J. L. (2004). 2000-2001 National marine recreational fishing survey: diary results and harvest estimates. *Draft New Zealand Fisheries Assessment Report* 2004/xx.

Drummond, K.L. (1994). Growth and life history of juvenile kahawai (*Arripis trutta* Bloch and Schneider) from Central New Zealand. (Unpublished MAppSc thesis, Australian Maritime College, Launceston, Tasmania.)

Drummond, K.L. (1995). Report on investigations into the Central New Zealand kahawai purse seine fishery over the 1992/93 summer. Central Fisheries Region Internal Report 25. 33 p.

Drummond, K.L.; Wilson, A.L. (1993). The biology and purse-seine fishery of kahawai (*Arripis trutta* Bloch and Schneider) from central New Zealand, during 1990/91–1991/92. *Central Fisheries Region Internal Report 22*. 42 p.

Duffy, C. A. J.; Petherick, C. (1999). A new size record for kahawai (Arripis trutta) from New Zealand. New Zealand Journal of Marine and Freshwater Research 33: p 565–569.

Hartill, B.; Cadenhead, H.; Tasker.; R.; Middleton, C.; Fisher, D.(2004). Monitoring the length and age composition of recreational landings of kahawai in KAH 1 in 2000–2001, 2001–02 and 2002–03. Final Research Report for Ministry of Fisheries Research Project KAH2000/1: Objective 1. 36 p.

Hartill, B.; Walsh, C. (2005). Characterisation of kahawai fisheries of New Zealand and a review of biological knowledge. Final Research Report for Ministry of Fisheries Research Project KAH200401. 160 p.

Jones, J.B.; Cresswell, P.; Drummond, K.; McKenzie, J. (1992). Kahawai. *N.Z. Fisheries Assessment Research Document 92/2*. 27 p.

Kilner, A.R. (1988). Kahawai (*Arripis trutta*). *N.Z. Fisheries Assessment Research Document 88/42*. 21 p.

Morton, A.; Lyle, J.; Welsford, D. (2005). Biology and status of key recreational finfish species in Tasmania. Tasmanian Aquaculture and Fisheries Institute Technical Report Series 25. 52 p.

Paulin, C. (1993). Review of Australasian fish family Arripididae (Percomorpha), with the description of a new species. *Australian journal of marine and freshwater research 44*: 459–471.
Sylvester, C.T.A. (1989). Kahawai fishery assessment 1989. *N.Z. Fisheries Assessment Research Document 89/10*. 17 p.
Teirney, L.D.; Kilner, A.R.; Millar, R.E.; Bradford, E.; Bell, J.D. (1997). Estimation of recreational catch from 1991/92 to 1993/94. *N.Z. Fisheries Assessment Research Document 97/15*. 43 p.
Watkinson, J.G.; Smith, R. (1972). New Zealand Fisheries. New Zealand Government Print. 91 p.