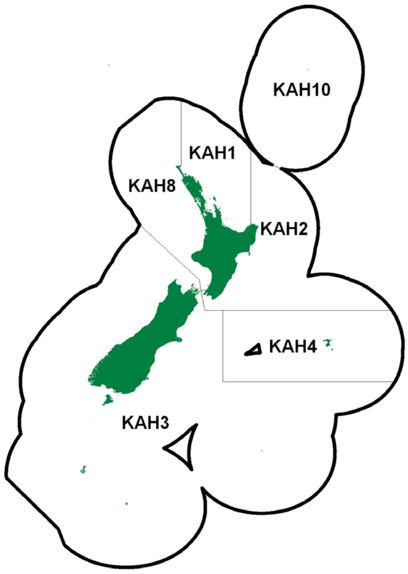
KAHAWAI (KAH)

(Arripis trutta and Arripis xylabion)
Kahawai



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. Within the QMS, kahawai management is based on six QMAs (KAH 1, KAH 2, KAH 3, KAH 4, KAH 8, and KAH 10).

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 the part of KAH 8 south of Tirua Point. The area of KAH 8 north of Tirua point was formerly called KAH 9.

TACs totalling 7612 t were set on introduction into the QMS. These TACs were based on a 15% reduction from both the level of commercial catch and assumed recreational use prior to introducing kahawai into the QMS. The Minister reviewed the TACs for kahawai for the 2005–06 fishing year. Subsequently, he decided to reduce TACs, TACCs, and allowances by a further 10% as shown in Table 1.

Table 1: KAH allowances, TACCs, and TACs, from 1 October 2010 to present.

Fishstock	Recreational Allowance	Customary Non-Commercial Allowance	Other mortality	TACC	TAC
KAH 1	900	200	45	1 075	2 200
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

1.1 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 surface longline and trawl fisheries.

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 from June to 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. Historical estimated kahawai landings are shown in Table 2, from 1931 to 1982. Reported landings, predominantly of *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. The historical landings and TACC for the main KAH stocks are depicted in Figure 1.

Table 2: Reported landings (t) for the main QMAs from 1931 to 1982.

Year	KAH 1	KAH 2	KAH 3	KAH 4	KAH 8
1931–32	1	0	0	0	0
1932–33	1	0	0	0	0
1933–34	0	0	1	0	0
1934–35	0	0	0	0	3
1935–36	0	0	0	0	0
1936–37	0	0	0	0	0
1937–38	2	1	1	0	0
1938–39	2	2	1	0	0
1939–40	1	1	1	0	0
1940–41	1	4	2	0	1
1941–42	2	1	1	0	0
1942–43	21	1	2	0	0
1943–44	58	3	4	0	3
1944	90	7	4	0	6
1945	102	2	3	0	1
1946	94	0	4	0	9
1947	54	0	4	0	1
1948	58	2	1	0	1
1949	23	3	0	0	1
1950	34	2	1	0	1
1951	22	1	0	0	2
1952	27	2	0	0	3
1953	14	1	0	0	4
1954	18	2	0	0	2
1955	19	6	0	0	7
1956	16	3	0	0	7
1957	25	6	0	0	13
1958	33	13	0	0	12
1959	31	2	0	0	14
1960	40	1	0	0	10
1961	40	0	0	0	12
1962	54	7	0	0	16
1963	60	11	0	0	11
1964	75	4	1	0	7
1965	85	13	0	0	4
1966	143	106	0	0	5
1967	147	303	0	0	5
1968	107	159	29	0	7
1969	163	29	12	0	33
1970	141	59	22	0	74
1971	185	258	10	0	119
1972	168	151	22	0	53
1973	295	132	13	0	147
1974	357	206	17	0	226
1975	140	28	18	0	154
1976	401	108	30	0	186
1977	631	385	218	0	224
1978	1 237	487	279	0	217
1979	1 642	552	608	0	267
1980	1 213	885	810	0	350
1981	659	625	1301	0	498
1982	1 133	639	980	0	484

Notes:
The 1931–1943 years are April–March but from 1944 onwards are calendar years.
Data up to 1985 are from fishing returns: data from 1986 to 1990 are from Quota Management Reports.Data for the period 1931 to 1982 are based on reported landings by harbour and are likely to be underestimated as a result of under-reporting.

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	1 461
1964	86	1971	572	1978	2 228
1965	102	1972	394	1979	3 782
1966	254	1973	586	1980	5 101
1967	457	1974	812	1981	3 794
1968	305	1975	345	1982	5 398

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.

Table 4: Reported landings (t) of kahawai by management areas 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 management areas and total catch are from the FSU database up to 1987–88 and from the CELR database after that date. Total LFRR or MHR values are the landings reported by Licensed Fish Receivers (to 2000–01) or on Monthly Harvest returns (to 2003–04).

Fishstock	KAH 1	KAH 2	KAH 3	KAH 9	KAH 10	Unknown Area	Total Catch	Total LFRR/MHR
FMA(s)	1	2	3–8	9	10			
1983–84	1 941	919	813	547	0	46	4 266	–
1984–85	1 517	697	1 669	299	0	441	4 623	–
1985–86	1 597	280	1 589	329	0	621	4 416	–
1986–87	1 890	212	3 969	253	0	1 301	7 525	6 481
1987–88	4 292	1 655	2 947	135	0	581	9 610	9 218
1988–89	2 170	779	4 301	179	0	–	7431	7 377
1989–90	2 049	534	5 711	156	0	16	8 466	8 696
1990–91	1 617	872	2 950	242	0	4	5 687	5 780
1991–92	2 190	807	1 900	199	< 1	7	5 104	5 071
1992–93	2 738	1 132	1 930	832	2	0	6 639	6 966
1993–94	2 054	1 136	1 861	98	15	0	5 164	4 964
1994–95	1 918	1 079	1 290	168	0	24	4479	4 532
1995–96	1 904	760	1 548	237	7	46	4 502	4 648
1996–97	2 214	808	938	194	1	3	4 158	3 763
1997–98	1 601	291	525	264	0	19	2 700	2 823
1998–99	1 833	922	1 209	468	0	3	4 435	4 298
1999–00	1 616	1 138	718	440	0	< 1	3 912	3 941
2000–01	1 746	886	925	272	0	1	3 829	3 668
2001–02	1 354	816	377	271	0	< 1	2 819	2 796
2002–03	933	915	933	221	0	< 1	3 001	2 964
2003–04	1 624	807	109	205	0	0	2 745	2 754

A total commercial catch limit for kahawai was set at 6500 t for the 1990–91 fishing year, with 4856 t set aside for those harvesting kahawai by purse seine (Table 6). Before the 2002–03 fishing year a high proportion of the purse seine catch was targeted, but in recent years approximately half of the landed catch has been reported as bycatch while targeting other species with purse seine gear.

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; this was extended from 1 December to the Tuesday after Easter in subsequent years. Although 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 t to 1200 t. Purse seine catches reported for KAH 9 were also included in this reduced catch limit, although seining for kahawai off the west coast of the North Island ceased after the reduction in the KAH 1 purse seine limit. Purse seine catch limits were reached in KAH 1 between 1998–99 and 2000–01 and in 2003–04.

Prior to the introduction to the QMS, no change was made to the purse seine limit of 851 t 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 in 2000–01 and 2001–02.

Table 5: Prorated landings (t) of kahawai by the Fishstocks (and FMA) defined in 2004 for the fishing years from 1998–99 to the present. 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 since 2004–05 are from QMS MHR data. The TACC is provided for those years since the introduction to the QMS.

Fishing	KAH 1		KAH 2		KAH 3		KAH 4		KAH 8		KAH 10		Total	
	1		2		3, 5, 7		4		8, 9		10			
year	Catch	TACC	Catch	TACC	Catch	TACC	Catch	TACC	Catch	TACC	Catch	TACC	Catch	TACC
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	1 195	708	785	129	455	< 1	10	544	580	0	10	2 529	3 025
2005–06	903	1 075	530	705	233	410	0	9	346	520	0	9	2 013	2 728
2006–07	1 046	1 075	672	705	382	410	< 1	9	407	520	0	9	2 507	2 728
2007–08	1 002	1 075	564	705	152	410	0	9	570	520	0	9	2 288	2 728
2008–09	945	1 075	823	705	157	410	0	9	381	520	0	9	2 306	2 728
2009–10	988	1 075	518	705	38	410	< 1	9	451	520	0	9	1 995	2 728
2010–11	1 002	1 075	719	705	46	410	0	9	454	520	0	9	2 221	2 728
2011–12	1 004	1 075	498	705	310	410	0	9	514	520	0	9	2 326	2 728
2012–13	1 095	1 075	502	705	195	410	0	9	468	520	0	9	2 260	2 728
2013–14	1 062	1 075	196	705	372	410	<1	9	472	520	0	9	2 102	2 728
2014–15	992	1 075	523	705	59	410	0	9	607	520	0	9	2 181	2 728
2015–16	1 086	1 075	611	705	44	410	<1	9	481	520	0	9	2 222	2 728
2016–17	1 021	1 075	399	705	58	410	0	9	316	520	0	9	1 794	2 728
2017–18	983	1 075	752	705	59	410	0	9	346	520	0	9	2 139	2 728
2018–19	1 045	1 075	635	705	41	410	0	9	321	520	0	9	2 042	2 728
2019–20	996	1 075	128	705	150	410	0	9	361	520	0	9	1 635	2 728

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 Bay and Golden Bay, the Marlborough Sounds, Cloudy Bay, and Kaikoura. The main purpose of this agreement is to minimise local depletion of schools of kahawai found in areas where recreational fisheries occur, and to minimise 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#	2 839*	0	none	0	none	n/a	5 356
1991–92	1 613	1 666	735*	851	1 714	2 339	0	none	0	none	4 080	4 856
1992–93	1 547	1 666	795*	851	1 808	2 339	140	none	0	none	4 290	4 856
1993–94	1 262	1 200	1 101*	851	1 714	2 339	15	§	0	none	4 092	4 390
1994–95	1 225	1 200	821*	851	1 644	2 339	0	§	0	none	3 690	4 390
1995–96	1 077	1 200	805*	851	1 146	1 500	0	§	0	none	3 028	3 551
1996–97	1 017	1 200	620	851	578	1 500	0	§	0	none	2 784	3 551
1997–98	969	1 200	175	851	153	1 500	0	§	0	none	1 297	3 551
1998–99	1 416*	1 200	134	851	463	1 500	2	§	0	none	2 015	3 551
1999–00	1 371*	1 200	553	851	520	1 500	0	§	0	none	2 444	3 551
2000–01	1 322*	1 200	954*	851	430	1 500	0	§	0	none	2 706	3 551
2001–02	838	1 200	747*	851	221	1 500	0	§	0	none	1 806	3 551
2002–03	514	1 200	819	851	816	1 500	0	§	0	none	2 149	3 551
2003–04	1 203*	1 200	714	851	1	1 500	0	§	0	none	1 918	3 551

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

Since kahawai entered the Quota Management System on 1 October 2004, the purse seine catch limits no longer apply, and landings (regardless of fishing method) are now restricted by quota availability and fishing company policies. KAH 1 landings have ranged between 903 t and 1095 t since the introduction of the current TACC of 1075 t in 2005 (Figure 1). Landings in KAH 2 have been more variable, falling to just 399 t in 2016–17 and 128 t in 2019–20, but exceeding the TACC of 705 t in 2008–09, 2010–11, and 2017–18. KAH 3 landings have been well below the TACC since 2014–15, with just 41 t landed in

2018–19, but increasing to 150 t in 2019–20. KAH 8 landings exceeded the TACC of 520 t in 2007–08 and 2014–15, but have recently declined, ranging between 316 t and 361 t in 2016–17 to 2019–20.

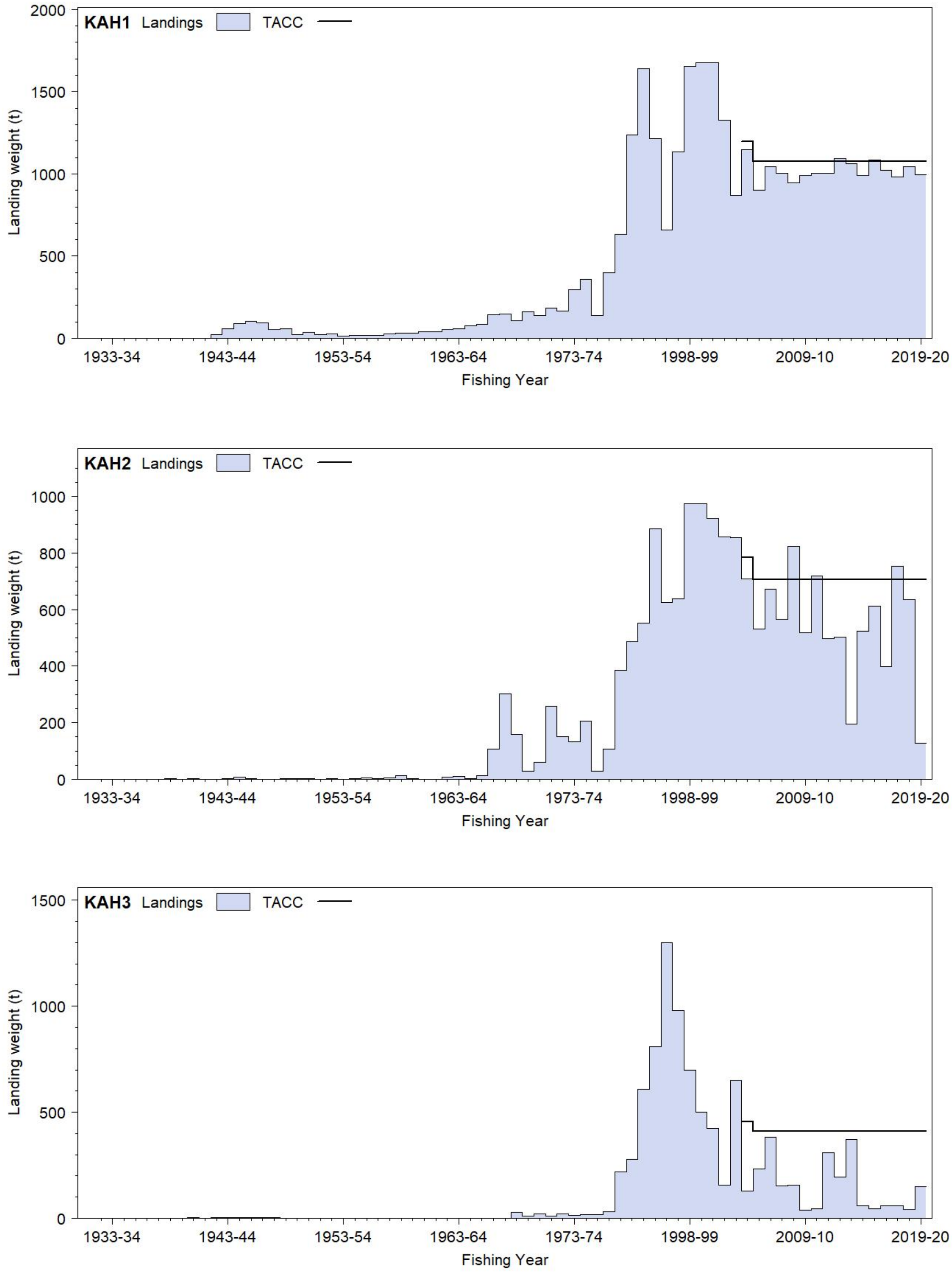


Figure 1: Total commercial landings and TACC for the four main KAH stocks. From top left to bottom right: KAH 1 (Auckland East), KAH 2 (Central East), KAH 3 (South East Coast, South East Chatham Rise, Sub-Antarctic, Southland, Challenger). **[Continued on next page]**

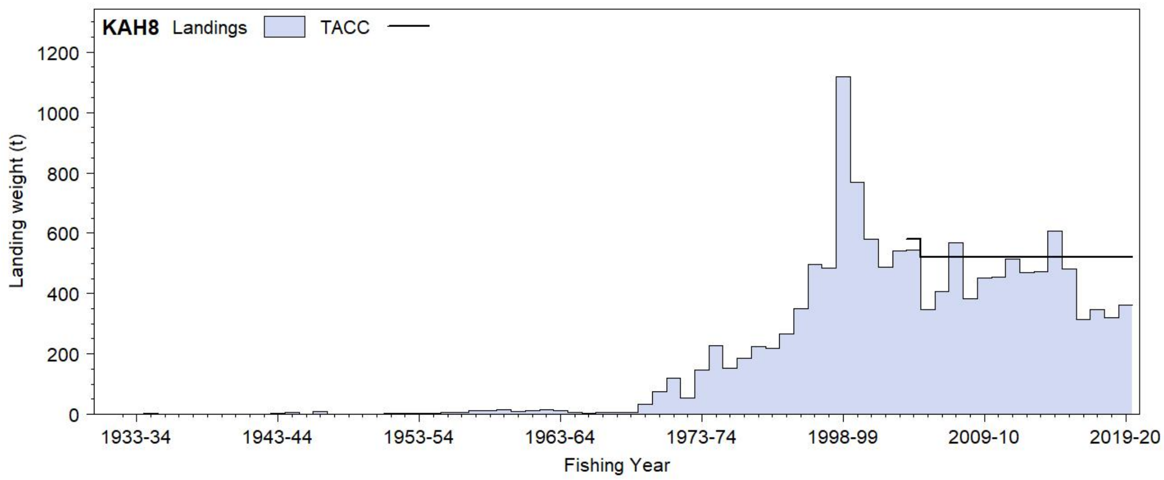


Figure 1: [Continued] Total commercial landings and TACC for the four main KAH stocks: KAH 8 (Central Egmont, Auckland West).

1.2 Recreational fisheries

Kahawai is the second most important recreational species in FMA 1 (after snapper). Kahawai are highly prized by many recreational fishers, who employ a range of shore and boat-based fishing methods to target and/or catch the species. 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 some areas. Historical kahawai recreational catches are poorly known. The current allowances within the TAC for each fishstock are shown in Table 1.

Information from the 2011–12 national panel survey (Wynne-Jones et al 2014) show that kahawai were mainly caught by rod or line (93.7%), with just over half of the landed catch taken from trailer boats (54.4%), and a third were taken off land, with very similar percentages seen in 2017–18 (Wynne-Jones et al 2019).

1.2.1 Management controls

The main method used to manage recreational harvests of kahawai is the daily bag limit. The current limits for kahawai are: up to 20 kahawai within a multi-species bag limit of 20 fish in the Auckland, Kermadec, Central, and Challenger management areas; up to 15 kahawai within a multi-species bag limit of 30 fish in the South-East, Southland, and Fiordland management areas; and up to 10 kahawai within a multi-species bag limit of 30 fish in the Kaikoura management area. A minimum net mesh size applies in all areas (the mesh sizes do vary by management area and net type).

1.2.2 Harvest estimates

There are two broad approaches to estimating recreational fisheries harvest: the use of onsite or access point methods, where fishers are surveyed or counted at their fishing location, or at an access point when they return to land after their fishing trip; and offsite methods, where some form of post-event interview and/or diary is used to collect data from fishers.

The first estimates of recreational harvest for kahawai were generated using an offsite regional telephone and diary survey approach in: MAF Fisheries South (1991–92), Central (1992–93), and North (1993–94) regions (Teirney et al 1997). Estimates for 1996 came from a national telephone and diary survey (Bradford 1998). Another national telephone and diary survey was carried out in 2000 (Boyd & Reilly 2002) and a rolling replacement of diarists in 2001 (Boyd et al 2004) provided estimates for a further year (mean weights were not re-estimated in 2001). Other than for the 1991–92 MAF Fisheries South survey, the diary method used mean weights of kahawai obtained from fish measured at boat ramps.

The harvest estimates provided by telephone-diary surveys between 1993 and 2001 are no longer considered reliable for various reasons. A Recreational Technical Working Group concluded that these harvest estimates 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 estimates are implausibly high for many important fisheries. This led to the development of an alternative maximum count aerial-access onsite method that provides a more direct means of estimating recreational harvests for boat-based fisheries. The maximum count aerial-access approach combines data collected concurrently from two sources: a creel survey of recreational fishers returning to a subsample of ramps throughout the day; and an aerial survey count of vessels observed to be fishing at the approximate time of peak fishing effort on the same day. The ratio of the aerial count in a particular area relative to the number of interviewed parties who claimed to have fished in that area at the time of the overflight was used to scale up harvests observed at surveyed ramps, to estimate harvest taken by all fishers returning to all ramps (Hartill et al 2007b).

This aerial-access method was first use to estimate the recreational snapper harvest in the Hauraki Gulf in 2003–04 (Hartill et al 2007b), which was subsequently extended to survey the wider SNA 1 fishery in 2004–05 (Hartill et al 2007c). One benefit of this method is that it also provides harvest estimates for other key species, in particular kahawai (Table 7). The Marine Amateur Fisheries Working Group has concluded that this approach generally provides broadly reliable estimates of recreational harvest for KAH 1. It is not, however, possible to reliably quantify shore-based fishing from the air and it is necessary to derive scalars from recent offsite surveys to account for the shore-based kahawai catch. Aerial-access surveys, focusing on snapper, provided kahawai harvest estimates for the Hauraki Gulf in 2003–04 and for all of FMA 1 in 2004–05, 2011–12, and 2017–18. Aerial-access surveys in FMA 1 in 2011–12 and 2017–18 (Hartill et al 2013, 2019) provided independent harvest estimates for comparison with those generated from national panel surveys in those years.

In response to problems with previous telephone-diary surveys and the cost and scale challenges associated with onsite methods, a National Panel Survey was conducted for the first time throughout the 2011–12 fishing year. The panel survey used face-to-face interviews of a random sample of 30 390 New Zealand households to recruit a panel of fishers and non-fishers for a full year. The panel members were contacted regularly about their fishing activities and harvest information collected in standardised phone interviews. The two 2011–12 surveys appear to provide plausible results that corroborate each other for KAH 1 and are therefore considered to be broadly reliable (Hartill et al 2013). The panel survey and corroborating aerial-access survey were repeated over the 2017–18 fishing year.

Recreational harvest estimates from offsite surveys up to and including 2017–18 are given in Table 8 (from Wynne-Jones et al 2014, 2019, and Hartill & Davey 2015 and Hartill et al 2019), noting that the QMAs do not all match up with the strata used for the older harvest estimates (in particular for KAH 3 and 8).

Table 7: Summary of kahawai harvest estimates (t) derived from an aerial overflight survey of the Hauraki Gulf in 2003–04 (1 December 2003 to 30 November 2004, Hartill et al 2007b) and a similar KAH 1 wide survey conducted in 2004–05 (1 December 2004 to 30 November 2005, Hartill et al 2007c) and in 2011–12 and 2017–18 (1 October to 30 October, Hartill et al 2013, 2019). Values in brackets denote CVs associated with each estimate.

Year	East Northland	Hauraki Gulf	Bay of Plenty	KAH 1
2003–04	–	56 (0.15)	–	–
2004–05	129 (0.14)	98 (0.18)	303 (0.14)	530 (0.09)
2011–12	191 (0.16)	483 (0.13)	268 (0.12)	942 (0.08)
2017–18	312 (0.13)	517 (0.09)	390 (0.11)	1 219 (0.06)

1.2.3 Monitoring harvest

In addition to estimating absolute harvests, a system to provide relative estimates of harvest over time for key fishstocks has been designed and implemented for some key recreational fisheries. The system uses web cameras to continuously monitor trends in trailer boat traffic at key boat ramps complemented by creel surveys that provide estimates of the proportion of observed boats that were used for fishing and the average harvest of snapper and kahawai per boat trip. These data are combined to provide relative harvest estimates for KAH 1, that have been scaled by concurrent region wide aerial-access harvest estimates, to estimate annual harvest tonnages landed by recreational fishers by substock (Table 9).

Table 8: Recreational catch estimates for kahawai stocks. The surveys ran from October or December to September or November but are denoted by the January calendar year. Mean fish weights were obtained from boat ramp surveys (for the telephone/diary and panel survey catch estimates). Totals are given in bold.

Stock	Year	Method	Number of fish (thousands)	Mean weight (g) (summer/winter)	Total weight (t)	CV
KAH 1	1994	Telephone/diary	727	[1]	978	–
	1996	Telephone/diary	666		960	0.06
	2000	Telephone/diary	1 860		2 195	0.13
	2001	Telephone/diary	1 905	[2]	2 248	0.13
Hauraki Gulf only	2004	Aerial-access			56	0.15
East Northland	2005	Aerial-access			129	0.14
Hauraki Gulf	2005	Aerial-access			98	0.18
Bay of Plenty	2005	Aerial-access			303	0.14
Total	2005	Aerial-access			530	0.09
East Northland	2012	Aerial-access		1 473/1 220[3]	191	0.16
Hauraki Gulf	2012	Aerial-access		1 565/1 475[3]	483	0.13
Bay of Plenty	2012	Aerial-access		1 477/1 628[3,4]	268	0.12
Total	2012	Aerial-access		[3,4,5]	942	0.08
East Northland	2012	Panel survey	139	1 473/1 220[3]	198	0.14
Hauraki Gulf	2012	Panel survey	245	1 565/1 475[3]	377	0.09
Bay of Plenty	2012	Panel survey	238	1 477/1 628[3,4]	238	0.11
Total	2012	Panel survey	638	[3,4,5]	958	0.07
East Northland	2018	Aerial-access			312	0.13
Hauraki Gulf	2018	Aerial-access			517	0.09
Bay of Plenty	2018	Aerial-access			390	0.11
Total	2018	Aerial-access			1 219	0.06
East Northland	2018	Panel survey	130	1 717	224	
Hauraki Gulf	2018	Panel survey	219	1 702/1 794	378	
Bay of Plenty	2018	Panel survey	215	1 693	364	
Total	2018	Panel survey	565		966	0.07
KAH 2	1993	Telephone/diary	195		298	-
	1996	Telephone/diary	142		217	0.09
	2000	Telephone/diary	1 808		2 937	0.74
	2001	Telephone/diary	492	[2]	799	0.20
	2012	Panel survey	146	1 583/1 449[3]	228	0.12
	2018	Panel survey	132	1 698	224	0.14
KAH 3	1992	Telephone/diary	231		210	-
	1994	Telephone/diary	6	[6]	8.4	-
	1996	Telephone/diary	226		137	0.07
	2000	Telephone/diary	413		667	0.16
	2001	Telephone/diary	353	[2]	570	0.18
	2012	Panel survey	105	1 279/2 340[3]	147	0.18
	2018	Panel survey	68	1 056	72	0.15
KAH 8	1994	Telephone/diary	254	[1]	340	-
	1996	Telephone/diary	199		204	0.09
	2000	Telephone/diary	337		441	0.20
	2001	Telephone/diary	466	[2]	609	0.24
	2012	Panel survey	282	1 664/1 318[3]	452	0.11
	2018	Panel survey	245	1 872/1 505	439	0.11

[1] Mean weight obtained from 1992–93 boat ramp sampling.
[2] The 2000 mean weights were used in the 2001 estimates.
[3] Separate mean weight estimates were used for summer (1 October 2011 to 30 April 2012) and for winter (1 May to 30 September 2012).
[4] Separate mean weight estimates were used for the eastern and western Bay of Plenty.
[5] Temporally and spatially separate mean weight estimates used as per notes 3 and 4.
[6] 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.

Trends inferred from this monitoring programme were initially very similar to that inferred from aerial-access harvest estimates in the Hauraki Gulf in 2004–05, 2006–07, and 2011–12, but the camera/creel kahawai harvest estimate for the Hauraki Gulf in 2017–18 is substantially lower than concurrent aerial-access and national panel surveys estimates for the same year (Table 9 c.f. Table 8). This difference appears to be due to a recent substantial increase in recreational fishing effort and catch around expanding mussel farms in the Firth of Thames, coinciding with a lesser increase in effort in the north-western gulf. Additional creel survey monitoring has been initiated to monitor changes in the recreational fishery in these areas, which had not been adequately monitored from boat ramps in the Auckland metropolitan area up until 2019–20. There is, however, a good correspondence between trends inferred from camera/creel survey based indices and aerial-access survey and/or national panel survey harvest estimates, for recreational harvesting of kahawai for East Northland and the Bay of Plenty. In East Northland, the kahawai catch landed at the two monitored ramps has gone through similar fluctuations, with no apparent long-term trend evident. In the Bay of Plenty the recreational kahawai halved immediately after 2011–12 and remained at this level before spiking up to the highest estimated harvest tonnage in 2017–18, before declining back to the level seen in the years immediately after 2011–12. These estimates show the variability of recreational harvests between years and, in particular, that harvest levels can be driven not only by stock abundance but also by changes in localised availability.

Table 9: Recreational catch estimates (t) for kahawai in different parts of the KAH 1 stock area calculated from web camera and creel monitoring at key ramps combined with aerial-access estimates for each area in 2004–05 and 2006–07 (Hauraki Gulf only) and 2011–12 and 2017–18 (all areas within KAH 1). Recent estimates, especially for the Hauraki Gulf, are lower than expected but the reasons for this are still being investigated.

Year	East Northland	CV	Hauraki Gulf	CV	Bay of Plenty	CV	Total KAH 1	CV
2004–05	149	0.20	88	0.26	229	0.15	465	0.11
2006–07	–	–	69	0.30	–	–	–	–
2011–12	217	0.18	541	0.19	259	0.21	1017	0.12
2012–13	207	0.22	212	0.20	139	0.21	558	0.12
2013–14	175	0.19	229	0.18	167	0.24	571	0.12
2014–15	86	0.20	191	0.19	107	0.26	384	0.13
2015–16	241	0.17	298	0.18	184	0.17	723	0.10
2016–17	158	0.22	181	0.19	170	0.24	509	0.13
2017–18	275	0.15	260	0.16	404	0.15	938	0.09
2018–19	227	0.16	245	0.17	174	0.16	646	0.10

Web camera and creel monitoring has commenced in other kahawai QMAs but the results have not yet been used to infer trends in those fisheries, although levels of recreational harvesting from these stocks are relatively low.

1.3 Customary non-commercial 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 non-commercial 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.

1.4 Illegal catch

Estimates of illegal catch are not available, but are probably insignificant.

1.5 Other sources of mortality

There is no information on other sources of mortality. Juvenile kahawai may suffer from habitat degradation due to run-off, situation and loss of shelter in estuarine areas.

2. BIOLOGY

Kahawai (*Arripis trutta*) are a schooling pelagic species belonging to the family Arripididae. Kahawai are found around the North Island, the South Island, the Kermadec Islands and Chatham Islands. They occur mainly in coastal seas, harbours, and estuaries and will enter the brackish water sections of rivers. A second species, *A. xylabion*, has been 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 mainly eat 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 offshore. 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 the early 1990s suggest that the onset of sexual maturity in males occurs at around 39 cm (fork length) and in females at 40 cm (McKenzie, NIWA, unpublished data). This 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 ageing technique that has been validated (Stevens & Kalish 1998). Kahawai grow rapidly, attaining a length of around 15 cm at the end of their first year, and mature after 3–5 years at about 35–40 cm, after which their growth rate slows. The longest 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 & Petherick 1999). Northern kahawai, *Arripis xylabion*, grow considerably bigger than kahawai and attain a maximum length of at least 94 cm, but beyond this, little is known about the biology of *A. xylabion*. 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 and are provided for some areas in Table 10. Sex specific growth parameters given for KAH 1 in previous plenary documents have higher estimates for L_∞ (56.93 for males and 55.61 for females).

The maximum recorded age of kahawai is 26 years and this age has been previously used to estimate the instantaneous rate of natural mortality (M) using the equation $M = \log_e 100/\text{maximum age}$ (Jones et al 1992). The resulting estimate of M of 0.18 assumes that this maximum observed age equates to that at which 1% of the population would survive in an unexploited stock, but a higher value for M is now considered more likely. This is because a re-analysis of purse seine catch-at-age data collected by Eggleston from KAH 2 & 3 between 1973 and 1975 suggested that 1% of the unexploited population would have lived for 20 years, which equates to an M of 0.23. A Chapman-Robson estimate of M of 0.22 was also derived from these catch-at-age data. Estimates of M ranging from 0.18 to 0.23 were therefore considered in the 2015 stock assessment and the assumed value used in the base case model was 0.20.

Table 10: Estimates of biological parameters.

Fishstock		Estimate			Source
1. Natural mortality (M)					
All				0.20	Hartill & Bian (2016)
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)
	KAH 1 & 3 (all)		0.0236	2.89	Hartill & Walsh (2005)
3. von Bertalanffy growth parameters					
		K	t_0	L_∞	
KAH 1		0.35	0.13	54.6	Hartill & Bian (2016)
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

Kahawai are presently 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 (FMA 4); KAH 8 (FMAs 8 & 9), and KAH 10 (FMA 10).

Returns from tagging programmes do not provide definitive information on the level of potential mixing between KAH QMAs, but tagging returns suggest that most kahawai (*A. trutta*) remain in 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 that are consistent with limited mixing between regions.

Smith et al (2008) compared otolith micro-chemistry (multi-element chemistry and stable isotopes) and meristics (e.g., fin counts) from 0-group kahawai from two regions (Okahu Bay, Waitematā Harbour and Hakahaka Bay, Port Underwood). Two distant sites were chosen to provide the best chance of successful discrimination. Neither meristics nor stable isotopes provided any discrimination, and magnesium and barium concentrations provided only weak discriminatory power.

On balance it seems possible that there are least two stocks of kahawai (*A. trutta*) within New Zealand waters with centres of concentration around the Bay of Plenty and the northern tip of the South Island. These two areas could be assumed to be separate for management purposes. Tagging data show that there is some limited mixing between these areas. Due to the shared QMA boundaries in the lower North Island and South Island, there is likely to be more mixing between the southern KAH QMAs than with the northern QMA (KAH 1).

There is no information about stock structure of *A. xylabion*.

4. STOCK ASSESSMENT

An age-structured assessment of the KAH 1 stock was first undertaken in 2007 (Hartill 2009) and was updated and revised in 2015 (Hartill & Bian 2016). Both assessments were undertaken using CASAL (Bull et al 2004). This assessment is reported below.

There are no accepted assessments for kahawai stocks outside KAH 1, although there are some catch curve estimates of *Z* from these areas from the early 1990s, which are reported here.

4.1 KAH 1

4.1.1 Estimates of catch, selectivity, and abundance indices

(i) Commercial catch
The commercial catch history used in the assessment is provided in Table 11. Annual catch by method landings statistics up until 1981–82 were provided by Francis & Paul (2013), and Fisheries Statistics Unit data were used to generate landings statistics for 1982–83 to 1988–89. It is noted that catches during these early years are less certain due to reporting issues (e.g., see Table 4 legend).

(ii) Recreational catch
The recreational catch history in KAH 1 is poorly known. Aerial overflight estimates are available for the Hauraki Gulf in 2003–04 (Hartill et al 2007b) and for all three regions of KAH 1 in 2004–05 (Hartill et al 2007c) and in 2011–12 (Hartill et al 2013). Recreational harvest estimates for all three regions of KAH 1 are also available from a National Panel Survey undertaken in 2011–12 (Wynne-Jones et al 2014), which were of a similar magnitude to those provided by the aerial-access survey.

Levels of recreational harvesting vary from year to year, however, and the aerial-overflight estimates were therefore used to scale up regional catch per trip (landed catch weight per hour fished) indices derived from creel surveys conducted since 1990, to gauge likely levels of harvesting taking place across a wider range of years (Figure 2). The coefficient used to scale up the catch rate index in each region was the geometric mean of the aerial overflight estimates divided by the geometric mean of catch index during the aerial overflight survey years. The 2011–12 aerial overflight estimate was not used to inform the Bay of Plenty recreational catch history because the closure of waters of around Motiti Island following the grounding of the M.V. *Rena* in early October 2011 would have reduced levels of recreational catch and effort in an atypical fashion. The constant catch history estimates given in Figure 2 were used to inform regional constant catch histories for 1974–75 to 2012–13.

Table 11: Commercial catch (t) time series used in the 2015 stock assessment of KAH 1.

Fishing	Bottom		Purse		
year	trawl	set net	seine	Other	KAH 1
1930–31	0.1	0.3	–	0.1	1
1931–32	0.3	0.8	–	0.3	1
1932–33	–	–	–	–	–
1933–34	–	–	–	–	–
1934–35	–	–	–	–	–
1935–36	–	–	–	–	–
1936–37	0.4	1.3	–	0.4	2
1937–38	0.3	0.9	–	0.3	2
1938–39	0.3	0.9	–	0.3	1
1939–40	0.3	0.8	–	0.3	1
1940–41	0.4	1.1	–	0.4	2
1941–42	4.2	12.6	–	4.2	21
1942–43	11.6	34.9	–	11.6	58
1943–44	18.0	53.9	–	18.0	90
1944–45	20.4	61.3	–	20.4	102
1945–46	18.7	56.2	–	18.7	94
1946–47	10.7	32.2	–	10.7	54
1947–48	11.6	34.7	–	11.6	58
1948–49	4.6	13.8	–	4.6	23
1949–50	6.7	20.1	–	6.7	34
1950–51	4.4	13.2	–	4.4	22
1951–52	5.4	16.2	–	5.4	27
1952–53	2.7	8.2	–	2.7	14
1953–54	3.6	10.9	–	3.6	18
1954–55	3.9	11.6	–	3.9	19
1955–56	3.3	9.8	–	3.3	16
1956–57	5.0	15.0	–	5.0	25
1957–58	6.5	19.6	–	6.5	33
1958–59	6.2	18.6	–	6.2	31
1959–60	8.1	24.2	–	8.1	40
1960–61	7.9	23.7	–	7.9	40
1961–62	10.9	32.6	–	10.9	54
1962–63	12.0	35.9	–	12.0	60
1963–64	15.0	45.1	–	15.0	75
1964–65	17.0	50.9	–	17.0	85
1965–66	28.5	85.5	–	28.5	143
1966–67	29.4	88.2	–	29.4	147
1967–68	21.4	64.2	–	21.4	107
1968–69	32.5	97.6	–	32.5	163
1969–70	28.1	84.4	–	28.1	141
1970–71	36.9	110.8	–	36.9	185
1971–72	33.6	100.9	–	33.6	168
1972–73	58.9	176.7	–	58.9	295
1973–74	71.4	214.3	–	71.4	357
1974–75	19.0	63.8	37.7	19.8	140
1975–76	65.0	148.4	139.5	47.7	401
1976–77	122.7	163.0	270.6	74.5	631
1977–78	200.4	460.6	431.8	144.2	1 237
1978–79	379.5	228.2	875.4	159.4	1 642
1979–80	249.6	270.4	561.3	132.1	1 213
1980–81	131.7	158.6	292.3	76.7	659
1981–82	201.9	357.0	439.5	134.9	1 133
1982–83	105.6	526.4	169.1	180.9	982
1983–84	64.4	320.9	1 445.4	110.3	1 941
1984–85	82.5	410.9	882.4	141.2	1 517
1985–86	52.8	263.1	1 190.8	90.4	1 597
1986–87	44.9	223.8	1 544.4	76.9	1 890
1987–88	42.6	212.4	3 964.0	73.0	4 292
1988–89	68.2	339.8	1 644.0	116.8	2 169
1989–90	42.0	293.6	1 699.4	58.6	2 094
1990–91	66.6	321.2	1 562.9	62.1	2 013
1991–92	38.8	319.8	1 725.4	68.8	2 153
1992–93	70.5	532.5	3 066.3	111.5	3 781
1993–94	31.2	538.2	1 322.8	105.8	1 998
1994–95	35.0	389.0	1 290.8	135.9	1 851
1995–96	74.8	294.6	1 270.0	131.9	1 771
1996–97	69.6	253.8	1 291.4	100.3	1 715
1997–98	42.0	318.3	1 056.4	62.9	1 480
1998–99	94.3	167.9	1 573.8	75.3	1 911
1999–00	105.8	196.7	1 352.7	36.8	1 692
2000–01	74.6	199.5	1 393.3	52.7	1 720
2001–02	58.8	244.8	938.9	61.4	1 304
2002–03	44.1	199.0	765.6	33.2	1 042
2003–04	45.8	178.0	1 263.0	21.4	1 508
2004–05	48.5	161.5	833.5	35.6	1 079
2005–06	68.1	199.6	570.8	51.7	890
2006–07	39.2	255.3	686.8	52.9	1 034
2007–08	57.6	253.1	767.9	32.7	1 111
2008–09	30.2	266.2	658.7	33.3	988
2009–10	61.9	307.0	554.9	40.7	964
2010–11	61.5	292.0	700.1	56.3	1 110
2011–12	67.5	178.9	862.9	80.1	1 189
2012–13	114.7	211.1	706.4	50.8	1 083

Constant harvest tonnages were used because there was concern that if a catch history with an assumed trend was used, this trend could influence the model results, despite being essentially unknown. Estimates of recreational harvest were required back to 1930–31, however, and the harvest at that time was assumed to be 10% of that in 1974–75, which was then ramped up to that value over the intervening years. These regional catch histories were then combined into a single catch history for KAH 1, which is assumed to include harvests taken by customary fishers (Figure 3).

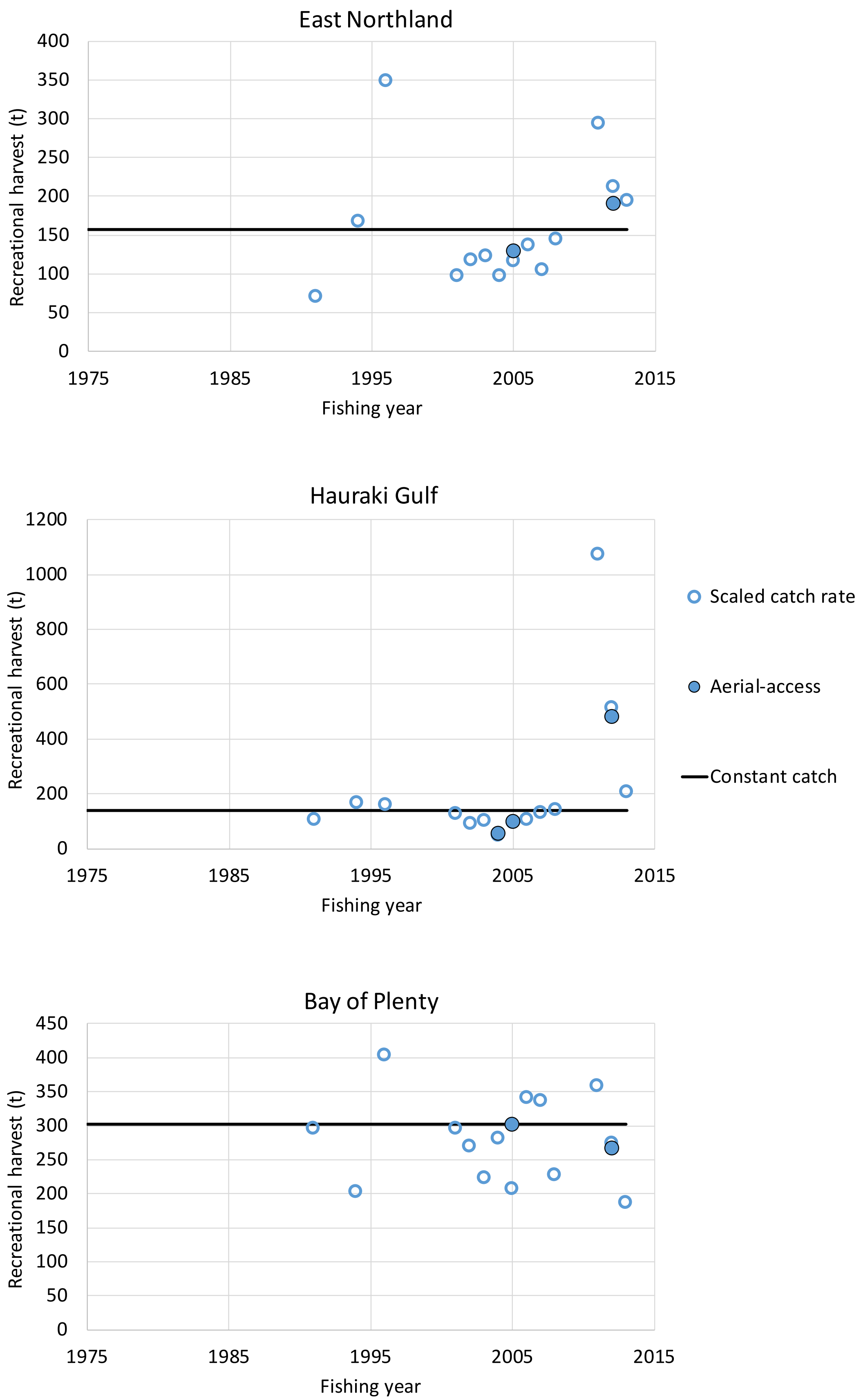


Figure 2: Regional recreational catch histories based on estimates provided by recent aerial-access surveys in 2004–05 and 2011–12. The 2011–12 estimate for the Bay of Plenty was not used because harvests in this year may have been adversely affected by the grounding of the M.V. *Rena*.

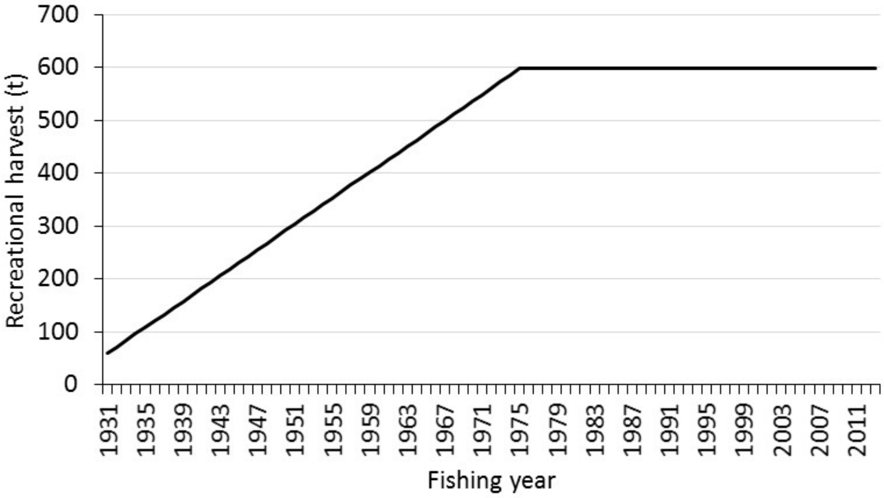


Figure 3: Recreational catch history for KAH 1 from 1931 to current that was assumed in the 2015 assessment.

(iii) Catch composition data and selectivity estimates

The earliest catch-at-age data that are available were collected from single trawl and purse seine landings sampled in 1991, 1992, and 1993. Purse seine landings were also sampled in 2005, 2011, and 2012. Catch-at-age data were available from set net landings from the Hauraki Gulf in 2011 and 2012, which were sampled so that the selectivity for this method could be estimated.

Recreational landings sampled during 10 years between 2001 and 2012 provided the most consistently sampled source of catch-at-age data used in the assessment (Hartill et al 2007a, 2007d, 2008, Armiger et al 2006, 2009, 2014). Boat ramp surveys were conducted in East Northland, the Hauraki Gulf, and the Bay of Plenty between January and April in each year. Annual catch-at-age distributions for each of the three regions were weighted together given the assumed catch history for each region, to provide a single time series for KAH 1 for this fishery.

All composition data were iteratively reweighted following the Francis method, which resulted in effective sample sizes being down weighted by about 98% for the recreational and purse seine catch-at-age data and by 85% for the single trawl data. This process maintained CVs for the abundance indices at the level originally estimated outside of the model.

Logistic selectivity ogives were estimated for the purse seine, single trawl, and recreational fisheries, and the single trawl ogive was also used when accounting for the relatively small tonnage landed by other methods such as Danish seine and beach seine. A double normal selectivity was estimated from the set net catch-at-age data and subsequently fixed at MPD parameter values.

(iv) Indices of abundance

Three indices of abundance were available for the assessment, but only two of these were ultimately offered to the model. Both a recreational CPUE and an aerial Sightings per Unit Effort (SPUE) were considered informative, but the set net CPUE index used in the 2007 assessment was no longer considered reliable because ring net fishing is often reported as set net fishing.

Recreational CPUE index

The recreational CPUE index used in the model was based on creel survey data collected at boat ramps during surveys conducted intermittently since 1991. Creel survey data were only used from East Northland and the Bay of Plenty, because catch rates in the Hauraki Gulf in about 2008 increased as a result of an influx of large kahawai, reflecting localised availability rather than abundance.

Separate CPUE (kg/hr) indices were initially calculated for East Northland and the Bay of Plenty, which were then weighted together based on the relative harvest taken from these regions, to provide a single abundance index for the KAH 1 stock. These indices were calculated from data collected between January and April only, because few surveys were conducted at other times of the year. Rod and line catch rate data were used from a core set of ramps only, which were surveyed in all past surveys.

Attempts were made to generate a standardised index but very few variables were available to inform any standardisation, especially as neither fisher nor vessel identifiers are recorded during creel surveys. The first term selected by any of the standardisations attempted was always fishing year, and remaining terms such as fishing location and month were often not selected or had little effect on the indices produced. The recreational CPUE index used in this assessment was therefore unstandardised (Figure 4).

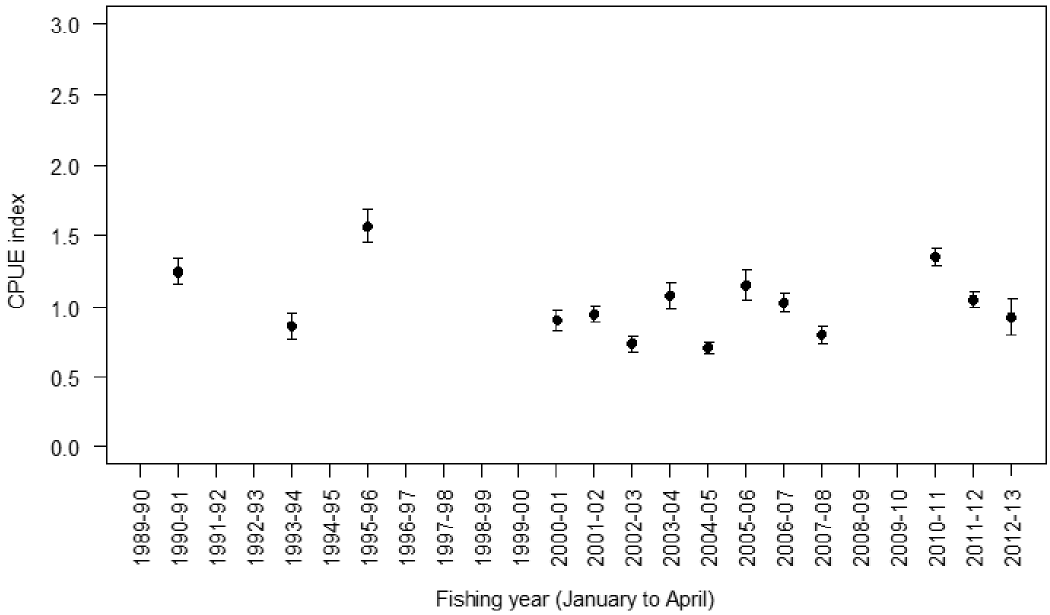


Figure 4: Unstandardised recreational CPUE (kg/hr). Vertical lines are bootstrap 95% confidence intervals.

Aerial sightings index

In 2012, an index of abundance [sightings per unit effort (SPUE)] based on commercial aerial sightings data was accepted by the Northern Inshore Working Group. This index was calculated using data from the *aer_sight* database and applying a generalised additive model (GAM) to produce standardised annual relative abundance indices (Taylor 2014).

Flights were restricted to those that were exclusive to the Bay of Plenty (BoP) (i.e., those having flight paths that remained within an area defined as the BoP), only flown by pilot #2 and were the first flight of the day (apart from some defined exceptions, e.g., short refuelling flights at the start of the day).

Estimates of relative year effects were obtained using a forward stepwise GAM, where the data were fitted using two models: 1) the probability of a flight having a positive sighting modelled using a binomial regression; and 2) the tonnage sighted on positive flights modelled using a lognormal regression. These two models were combined into a single index. The data used for the SPUE analyses consisted of aerial sightings of kahawai, trevally, jack mackerel, blue mackerel, and skipjack tuna collected over the period 1986–87 to 2010–11, with missing years in 1988–89, from 1994–95 to 1996–97, and in 2006–07. Most of these missing years were the result of there being no available data. By contrast, 2006–07 was dropped because the working group identified a bias in the annual index for that year because of the low number of available flights. The first year of the original series (1985–86) was dropped by the working group for the same reason.

The species with the maximum daily purse seine catch from the vessels that the pilot was working with in the BoP was used as a proxy for target species. Catch data before 1989 were from the *fsu-new* database and data from 1989 to 2013 were from the *warehou* database.

The working group accepted the combined model of SPUE for kahawai as an index of abundance in the BoP. The BoP combined SPUE index for kahawai shows substantial inter-annual variation with an overall gradual declining trend from 1986–87 to 2002–03; thereafter increasing sharply to a peak in 2007–08, and then declining to points above the long-term mean (Table 12, Figure 5).

Table 12: Standardised sightings per unit effort (SPUE) indices for the Bay of Plenty KAH 1 stock, derived as a combination of year effect estimates from a lognormal and a binomial regression for 1986–87 to 2012–13.

Fishing year	Combined	CV
1986–87	1.14	0.31
1987–88	0.86	0.27
1988–89	No data	No data
1989–90	0.58	0.27
1990–91	0.78	0.27
1991–92	0.66	0.28
1992–93	1.19	0.27
1993–94	1.17	0.30
1994–95	No data	No data
1995–96	No data	No data
1996–97	No data	No data
1997–98	0.81	0.28
1998–99	0.45	0.28
1999–00	0.47	0.54
2000–01	0.70	0.29
2001–02	0.66	0.29
2002–03	0.36	0.29
2003–04	1.30	0.35
2004–05	1.67	0.30
2005–06	1.93	0.29
2006–07	Insufficient data	Insufficient data
2007–08	2.45	0.27
2008–09	1.25	0.28
2009–10	1.49	0.28
2010–11	1.72	0.27
2011–12	1.78	0.32
2012–13	1.43	0.28

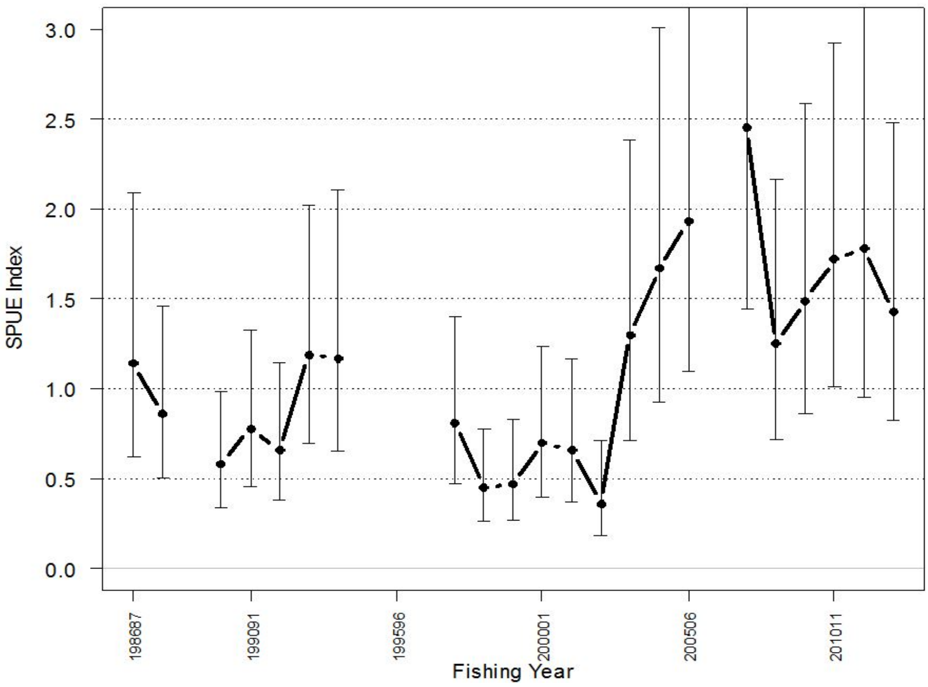


Figure 5: Standardised sightings per unit effort (SPUE) indices for the Bay of Plenty KAH 1 stock, derived as a combination of year effect estimates from a lognormal and a binomial regression. Vertical lines are 95% confidence intervals.

4.1.2 Model structure

The stock assessment was restricted to KAH 1, because this is the QMA where most of the observational data have been collected. Future assessments may consider a broader stock definition, but improved understanding of the movement dynamics of this species and further development of this model are required before this can be attempted. Even within KAH 1 there is little information on connectivity between the three main areas of the fishery: East Northland, Hauraki Gulf, and the Bay of Plenty. There are few tag data available that can be used to estimate these migration processes, because almost all of the kahawai that have been tagged have been released in the Bay of Plenty. This provides little information about emigration from the Hauraki Gulf and from East Northland. Recreational catch-at-age data collected since the 2007 assessment now suggest that size based migration between areas may vary more considerably and unpredictably than previously thought. For these reasons, the data used in the assessment were no longer regionally partitioned, but were combined into a single stock model which includes most of the currently available data.

In the stock assessment model it is assumed that KAH 1 is a single biological stock, exploited by several fisheries. Deviations from the spawner recruitment curve were estimated for those years when there were three or more years of observational catch-at-age data and were constrained to a mean of 1.0 across all fishing years from 1974–75 to 2012–13.

A single annual time step was used, in which ageing was followed by recruitment, maturation, growth, and then mortality (natural and fishing). The relationships between length and age, and length and weight, were both assumed to be constant through time and were based on updated parameter values given in Table 10. Annual abundances of the age classes 1 to 20 were estimated in the model, with 20 year olds representing all fish older than 19 years. The model was not sex specific. Maturation was knife-edged at four years of age. There is no information on the relationship between stock size and recruitment, and the rate of natural mortality is uncertain. Sensitivity to these parameters is discussed in the next section.

It was assumed that the population was at an unfished equilibrium state (B_0) in 1930, as reported commercial landings between 1930 and 1940 were only in the order of 1 to 2 tonnes per year. Key model outputs are probably robust to this assumption because commercial landings were only of the order of a few hundred tonnes and recreational landings were assumed to be low relative to stock size prior to this time. Total fishing mortality was apportioned between fisheries according to observed catches and estimated selectivities. Method specific annual landings from five fishing methods were considered: recreational, purse seine, single trawl, set net, and other minor commercial fisheries.

4.1.3 Evaluation of uncertainty

Evaluations of preliminary models identified three sources of uncertainty which were subsequently investigated in more detail: the assumed value for natural mortality (M); choice of abundance index; and the assumed steepness (h) of the Beverton-Holt stock recruitment relationship.

Alternative values of steepness of 0.75 and 0.90 appeared to have little influence on either current biomass or stock status, because sensitivity model runs suggested the spawning stock biomass has never fallen to low enough levels for this to have an effect. A base case value of 0.75 was assumed for all subsequent model runs.

An M of 0.20 was assumed for the base case model, in which both the SPUE and Recreational CPUE were considered. Three sensitivity models were also considered: two with alternative M estimates (0.18 and 0.23), and another where M was assumed to be 0.20, but only the recreational CPUE index was offered to the model (i.e., the SPUE index was omitted).

MCMCs were run for all four of these models. However, the $M = 0.23$ sensitivity model performed poorly despite an extended burn-in period of 2 million iterations. MCMC traces for some parameters fluctuated markedly and the run terminated as it approached its 4 millionth iteration. This model was rejected due to the lack of convergence and results are not reported here.

The three remaining models were projected for a five year period (2014 to 2019), with future catches for each fishing year being set to those in 2012–13. Year class strengths were drawn from the 10-year period, 2000–2009.

4.1.4 Results

All models suggested that the stock was gradually fished down until the late 1970s, followed by a steeper decline that coincided with the development of the purse seine fishery during the 1980s. There have since been marked fluctuations in stock size but there is general evidence of a rebuild since the early 2000s.

The assumed value for M had the greatest influence on the model results, with the base case of $M = 0.2$ producing higher stock biomass and stock status (Figure 6). The lower value of 0.18 resulted in lower biomass estimates and lower current stock status when both abundance indices were offered to the model. Dropping the SPUE index suggested there had been less of a rebuild since the early 1990s, but there was still evidence of an increase in spawning stock biomass in recent years.

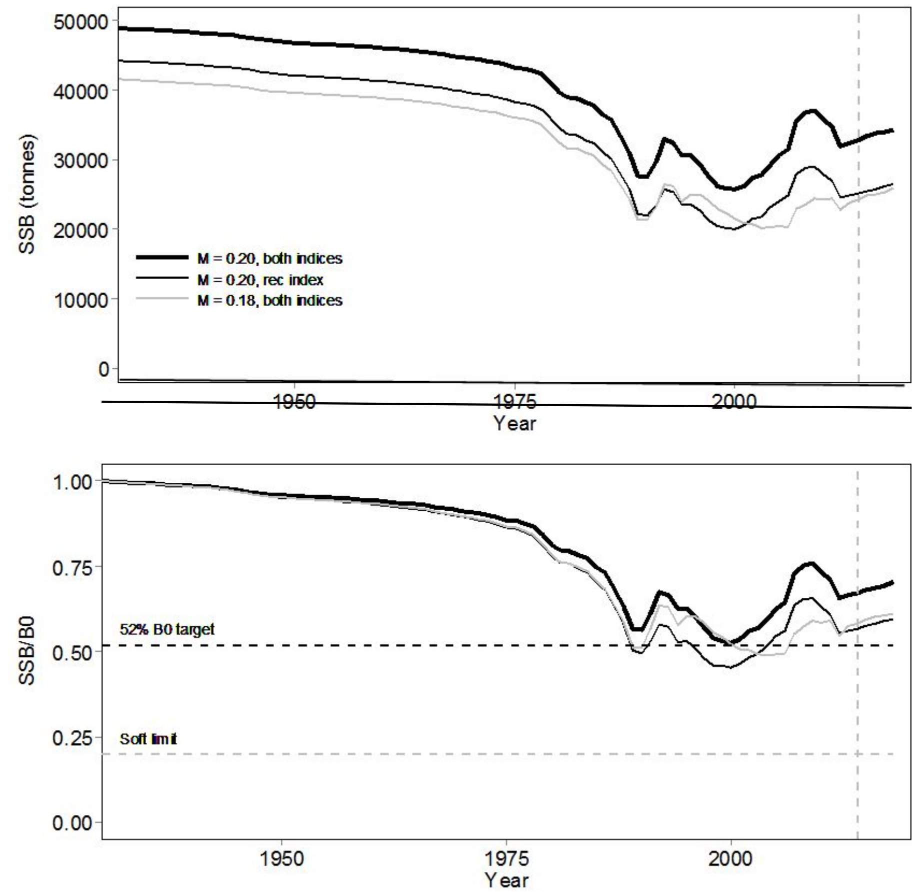


Figure 6: Comparison of spawning stock biomass (upper panel) and stock status trajectories (lower panel) for the base case (where M was assumed to be 0.20 and both the recreational CPUE and SPUE indices were offered to the model) and for two other sensitivities. The vertical dashed line denotes first year of the projection period (2014).

All three model runs suggest that the KAH 1 stock has never fallen below about 40% B_0 (Figure 6). Median %B_0 in 2013 was estimated to be 66% for the base case, 56% for the case with lower M and 58% when the SPUE was excluded (Table 13). In 2010 the Minister of Fisheries set a target reference point of 52% B_0 for this shared fishery, and although two of the sensitivity runs suggest that the KAH 1 stock biomass has fallen below this level at times, there is a high probability that the current biomass predicted by each model is well above this level (Tables 13 & 14).

Table 13: Biomass (t) and stock status estimates derived from MCMC runs for the base model (M20_both; three chains combined) and two sensitivity models (medians with 95% credible intervals in parentheses).

Model	SSB_0	SSB_{2013}	$SSB_{52\%}$	SSB_{2013}/SSB_0	$SSB_{2013}/SSB_{52\%}$
M20_both	48 888	31 889	25 225	0.663	1.275
(Base case)	(38 973–92 822)	(20 334–79 232)	(20 266–48 267)	(0.521–0.854)	(1.000–1.641)
M18_both	44 340	24 952	17 736	0.563	1.407
	(38 536–56 991)	(17 250–39 700)	(15414–22 796)	(0.448–0.697)	(1.119–1.7415)
M20_rec	41 569	23 933	16 628	0.576	1.439
	(38 305–46 362)	(20 054–29 511)	(15 322–18 545)	(0.524–0.637)	(1.309–1.591)

Table 14: Probability of the KAH 1 stock in 2013 falling below soft and hard limits and being at or above the target reference point. The target reference point of 52% B_0 was set by the Minister of Fisheries for this stock in 2010. Probabilities are calculated from the distribution of MCMC estimates calculated from each model.

Model	Pr(SSB_{2013} < 10% SSB_0)	Pr(SSB_{2013} < 20% SSB_0)	Pr(SSB_{2013} > 52% SSB_0)
M20_both	0.000	0.000	0.975
M18_both	0.000	0.000	0.738
M20_rec	0.000	0.000	0.755

4.1.5 Projections and yield estimates

The base and sensitivity models were projected forward five years, with empirical resampling from the 10-year period, 2000–2009, using the reported 2013 catch. These projections suggest that current stock status is likely to improve further under all three scenarios, with a faster level of increase seen in the less optimistic lower *M* scenario (Table 15, Figure 7). The probability of the stock being at or above 52% B_0 in 2018 is 0.945 for the base case.

Table 15: Probability of the KAH 1 stock in 2018 falling below soft and hard limits and being at or above the target reference point. The target reference point of 52% B_0 was set by the Minister of Fisheries for this stock in 2010. Probabilities are calculated from the distribution of MCMC estimates calculated from each model (three chains combined for the base model).

Model	SSB_{2018}/SSB_0	Pr(SSB_{2018} < 10% SSB_0)	Pr(SSB_{2018} < 20% SSB_0)	Pr(SSB_{2018} > 52% SSB_0)
M20_both	0.693 (0.629–0.742)	0.000	0.000	0.940
M18_both	0.596 (0.563–0.648)	0.000	0.000	0.756
M20_rec	0.620 (0.557–0.673)	0.000	0.000	0.755

The deterministic yield corresponding to 52% B_0 from the base case model is 2414 t.

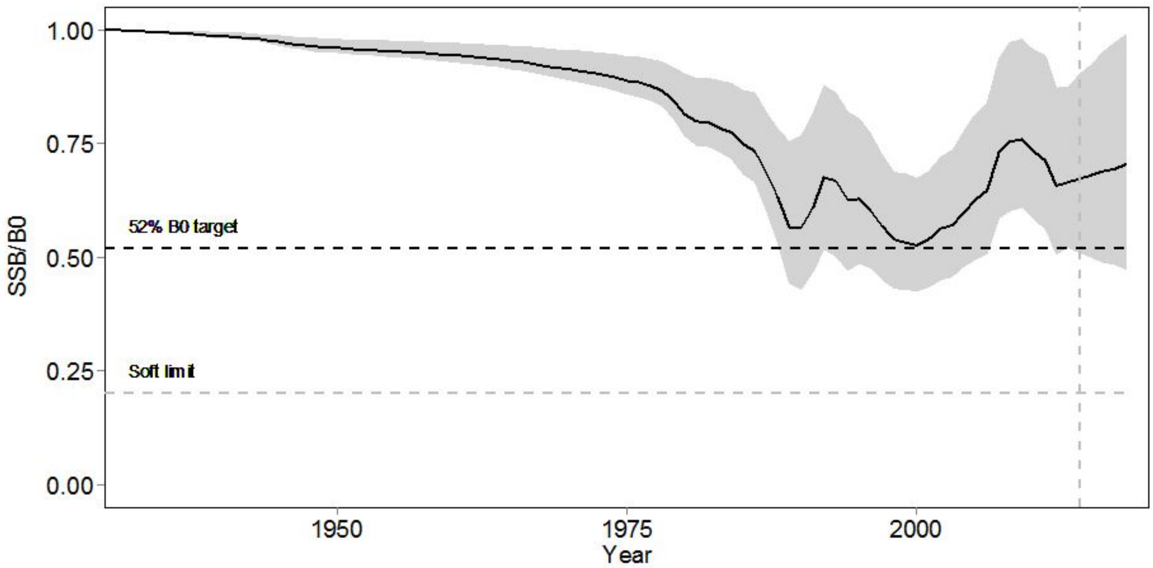


Figure 7: Spawning stock biomass relative to B_0 for the base model (M = 0.20, both abundance indices used; three chains combined). The 52% B_0 target set by the Minister of Fisheries in 2010 is denoted by a black dashed line and the 20% B_0 soft limit is denoted by the grey dashed line. The grey shaded area denotes 95% credible intervals derived from the MCMC model run and the black line denotes the median estimate for each year. The vertical dashed line denotes the first year of the projection period (2014).

4.1.6 Catch-curve analysis

Annual estimates of total mortality (*Z*) have also been derived from recreational catch data sampled in East Northland and the Bay of Plenty (Figure 8). They were calculated using a Chapman-Robson estimator independently from the stock assessment model (Table 16). These estimates were calculated using a range of assumed ages for full recruitment to demonstrate the sensitivity of the results to this assumption.

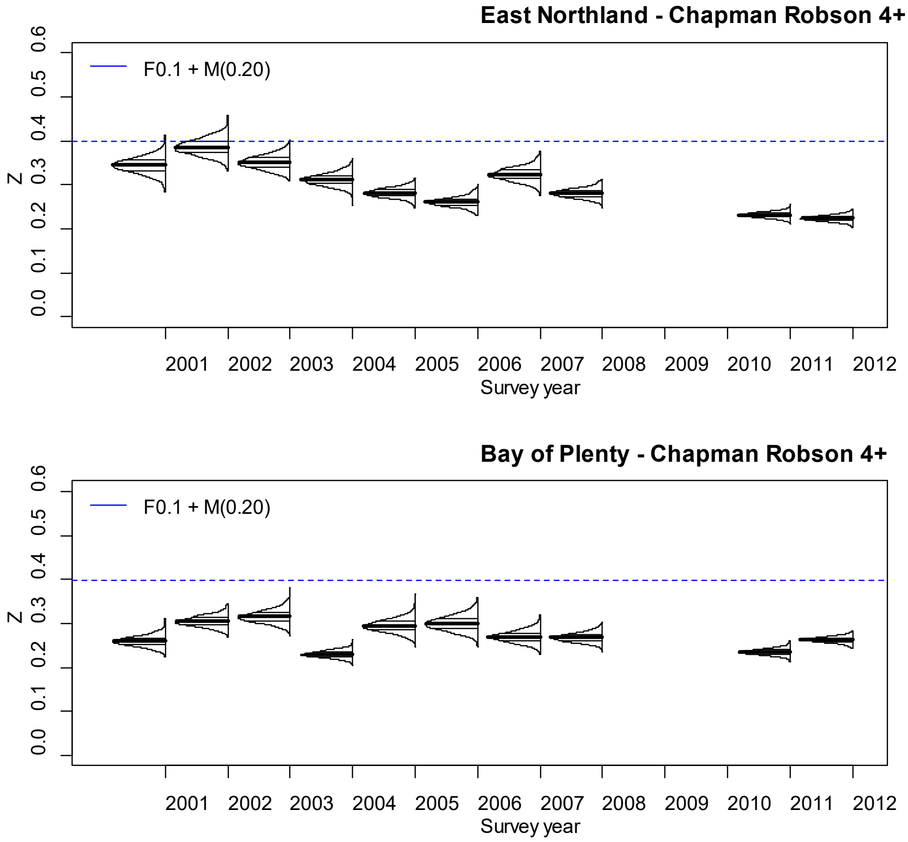


Figure 8: The distribution of bootstrap Chapman-Robson estimates of total mortality (*Z*) by survey year for East Northland (top panel) and the Bay of Plenty (lower panel). A theoretical optimal level of *Z* derived from a YPR curved generated from the 2015 assessment is denoted as a horizontal line for reference purposes (adapted from Armiger et al 2014).

Table 16: Estimates of *Z* derived from recreational catch sampling in KAH 1, by survey year by assumed age-at-recruitment (from Armiger et al 2014).

	Year										East Northland	
Area	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
3	0.33	0.33	0.32	0.28	0.24	0.23	0.28	0.24	–	–	0.20	0.21
4	0.34	0.38	0.35	0.31	0.28	0.26	0.32	0.28	–	–	0.23	0.22
5	0.30	0.37	0.39	0.33	0.33	0.32	0.35	0.33	–	–	0.27	0.25
6	0.30	0.40	0.41	0.38	0.36	0.36	0.41	0.34	–	–	0.32	0.28

	Year										Bay of Plenty	
Area	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
3	0.23	0.25	0.28	0.20	0.27	0.25	0.24	0.24	–	–	0.20	0.23
4	0.26	0.30	0.32	0.23	0.29	0.30	0.27	0.27	–	–	0.23	0.26
5	0.28	0.33	0.34	0.26	0.30	0.30	0.24	0.29	–	–	0.26	0.29
6	0.30	0.36	0.38	0.32	0.30	0.32	0.26	0.29	–	–	0.31	0.31

4.1.7 Future research needs

- Otoliths from the Hauraki Gulf should be collected in future recreational catch-at-age creel surveys so that they are available for reading if required, as this was not done in 2011 and 2012.
- A spatial model should be considered for the next assessment if there are data to inform it on movements of different age/size classes between sub-areas. This may reduce the patterns in residuals for model fits to recreational catch at age.

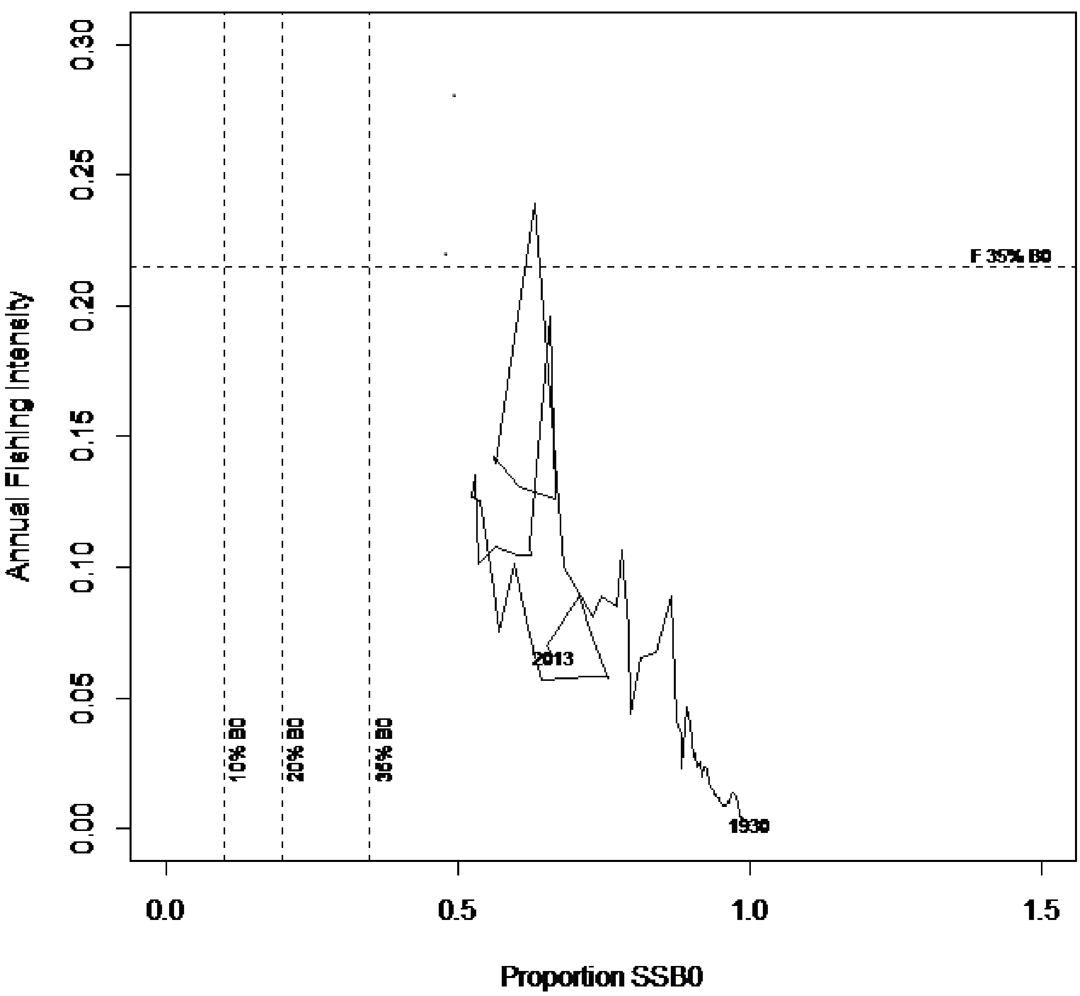
5. STATUS OF THE STOCKS

KAH 1

Stock Structure Assumptions
Two stocks of kahawai (*A. trutta*) are assumed to exist within New Zealand waters with centres of concentration around the Bay of Plenty and the northern tip of the South Island. Tagging data show that there is limited mixing between these areas.

Stock Status	
Year of Most Recent Assessment	2015: Age based stock assessment
Assessment Runs Presented	Base case model with M=0.2 and two abundance indices (recreational CPUE and aerial sightings)
Reference Points	Target: 52% B_0 (set by Minister of Fisheries in 2010) Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: $F_{35\%B0}$
Status in relation to Target	Very Likely (> 90%) to be at or above
Status in relation to Limits	Soft Limit: Very Unlikely (< 10%) to be below. Hard Limit: Exceptionally Unlikely (< 1%) to be below
Status in relation to Overfishing	Overfishing is Very Unlikely (<10%) to be occurring

Historical Stock Status Trajectory and Current Status



Trajectory of spawning stock biomass relative to B_0 for the base model (M = 0.20, both abundance indices used) and annual fishing intensity. The 52% B_0 target set by the Minister of Fisheries in 2010 is denoted by a black dashed line and the 20% B_0 soft limit and 10% B_0 hard limit are denoted by the grey dashed lines.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Stock biomass has increased in recent years.
Recent Trend in Fishing Mortality or Proxy	Fishing mortality has declined since the early 1990s and is now well below the overfishing threshold.
Other Abundance Indices	None available other than regional set net CPUE indices which are not considered to be reliable because of confusion between set net and ring net effort reporting.
Trends in Other Relevant Indicators or Variables	- A time series of total mortality estimates for East Northland and the Bay of Plenty from 2001 to 2012, based on recreational catch-at-age data, suggests that there has been little change in fishing mortality over this period. Estimates of total mortality were at or below that associated with $F_{0.1}$ suggesting that fishing mortality was at or below F_{MSY}.

Projections and Prognosis	
Stock Projections or Prognosis	The KAH 1 stock is likely to increase over the next five years at 2013 catch levels.
Probability of Current Catch or TAC causing biomass to remain below or to decline below Limits	Soft Limit: Very Unlikely (< 10%) Hard Limit: Exceptionally Unlikely (< 1%)
Probability of current catch or TAC causing overfishing to continue or to commence	Exceptionally Unlikely (< 1%)

Assessment Methodology and Evaluation		
Assessment Type	Level 1 – Full Quantitative Stock Assessment	
Assessment Method	Statistical catch at age model implemented under CASAL	
Assessment Dates	Latest assessment: 2015	Next assessment: 2020
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- Proportions-at-age from purse seine, single trawl, set net and recreational fisheries	1 – High Quality: but set net data were only used to estimate MPD selectivity
	- Unstandardised recreational CPUE index	1 – High Quality
	- Estimates of biological parameters (e.g. growth, age-at-maturity, length/weight)	1 – High Quality
	- Estimates of recreational harvest	1 – High Quality
	- Commercial catch statistics	1 – High Quality
	- Aerial SPUE index	2 – Medium or Mixed Quality: only covers western Bay of Plenty
Data not used (rank)	- Set net CPUE indices	3 – Low Quality: confusion between set net and ring net fishing reporting
Changes to Model Structure and Assumptions	-Change from grid to age structured base case with MCMC -Change from quasi regional to single stock structure -Dropped set net CPUE -Included age composition for set net catch -Included SPUE -Started model in 1930 at equilibrium instead of 1975 -Changed default *M* from 0.18 to 0.20	

Major Sources of Uncertainty	- Under-reported commercial catch prior to 1980 - Recreational catch history, especially prior to 1990 - Assumption of constant selectivity and catchability in the abundance indices may compromise their ability to index biomass - Spatial complexity in the movement of different sizes/ages of kahawai - Age composition and selectivity of purse seine unlikely to be consistent from year to year due to kahawai schooling by age/size

Qualifying Comments
-

Fishery Interactions
Commercial catches of KAH 1 are primarily taken by purse-seine in association with jack mackerel, blue mackerel and trevally. Interactions with other species are currently being characterised.

All other KAH regions

No accepted assessment is available that covers these regions. It is not known if the current catches, allowances or TACCs are sustainable. The status of KAH 2, 3 and 8 relative to B_{MSY} is unknown.

6. FOR FURTHER INFORMATION

Armiger, H; Hartill, B; Rush, N; Buckthought, D; Smith, M (2014) Length and age compositions of recreational landings of kahawai in KAH 1 in January to April in 2011 and 2012. *New Zealand Fisheries Assessment Report 2014/60*. 39 p.

Armiger, H; Hartill, B; Rush, N; Vaughan, M; Smith, M; Buckthought, D (2009) Length and age compositions of recreational landings of kahawai in KAH 1 in January to April 2008 and KAH 8 in January to April 2007. *New Zealand Fisheries Assessment Report 2009/36*. 40 p.

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 p. (Unpublished report held by Fisheries New Zealand, Wellington.)

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 Research Report. (Unpublished report held by Fisheries New Zealand, Wellington.)

Boyd, R O; Reilly, J L (2002) 1999/2000 National marine recreational fishing survey: harvest estimates. Draft New Zealand Fisheries Research Report. (Unpublished report held by Fisheries New Zealand, Wellington.)

Bradford, E (1997) Estimated recreational catches from Ministry of Fisheries North region marine recreational fishing surveys, 1993–94. New Zealand Fisheries Assessment Research Document 1997/7. 16 p. (Unpublished report held by NIWA library, Wellington.)

Bradford, E (1998) Harvest estimates from the 1996 national recreational fishing surveys. New Zealand Fisheries Assessment Research Document. 1998/16. 27 p. (Unpublished report held by NIWA library, Wellington.)

Bradford, E; Fisher, D; Bell, J (1998) National recreational fishing survey 1996: overview of catch and effort results. *NIWA Technical Report* 18. 55 p.

Bull, B; Francis, R I C C; Dunn, A; McKenzie, A; Gilbert, D J; Smith, M H (2004) CASAL (C++ algorithmic stock assessment laboratory): CASAL User Manualv2.01.2003/08/01. *NIWA Technical Report* 124. 223 p.

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: 565–569.

Francis, M P; Paul, L J (2013) New Zealand inshore finfish and shellfish commercial landings, 1931–82. *New Zealand Fisheries Assessment Report 2013/55*. 136 p.

Francis, R.I.C.C (2011) Data weighting in statistical fisheries stock assessment models. *Canadian Journal of fisheries and Aquatic Science* 68: 1124–1138.

Hartill, B (2009) Assessment of the KAH 1 fishery for 2006. *New Zealand Fisheries Assessment Report 2009/24*. 43 p.

Hartill, B; Armiger, H; Tasker, R; Middleton, C; Fisher, D (2007a) Monitoring the length and age composition of recreational landings of kahawai in KAH 1 in 2000–01, 2001–02 and 2002–03. *New Zealand Fisheries Assessment Report 2007/6*. 38 p.

Hartill, B; Armiger, H; Vaughan, M; Rush, N; Smith, M (2008) Length and age compositions of recreational landings of kahawai in KAH 1 from January to April 2007. *New Zealand Fisheries Assessment Report 2008/63*. 40 p.

Hartill, B.; Bian, R. (2016). Stock assessment of kahawai (*Arripis trutta*) in KAH 1. *New Zealand Fisheries Assessment Report 2016/26*. 42 p.

Hartill, B; Bian, R; Armiger, H; Vaughan, M; Rush, N (2007c) Recreational marine harvest estimates of snapper, kahawai, and kingfish in QMA 1 in 2004–05. *New Zealand Fisheries Assessment Report 2007/26*. 44 p.

Hartill, B; Bian, R; Rush, N; Armiger, H (2013) Aerial-access recreational harvest estimates for snapper, kahawai, red gurnard, tarakihi and trevally in FMA 1 in 2011–12. *New Zealand Fisheries Assessment Report 2013/70*. 44 p.

Hartill, B.; Bian, R.; Rush, N.; Armiger, H. (2019). Aerial-access recreational harvest estimates for snapper, kahawai, red gurnard, tarakihi and trevally in FMA 1 in 2017–18. *New Zealand Fisheries Assessment Report 2019/23*. 39 p.

Hartill, B; Davey, N (2015) Mean weight estimates for recreational fisheries in 2011–12. *New Zealand Fisheries Assessment Report 2015/25*. 37 p.
Hartill, B; Smith, M; Rush, N; Vaughan, M; Armiger, H (2007d) Length and age composition of recreational landings of kahawai in KAH 1 from January to April 2005–06. *New Zealand Fisheries Assessment Report 2007/28*. 30 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. (Unpublished report held by Fisheries New Zealand, Wellington.)
Hartill, B; Watson, T; Cryer, M; Armiger, H (2007b) Recreational marine harvest estimates of snapper and kahawai in the Hauraki Gulf in 2003–04. *New Zealand Fisheries Assessment Report 2007/25* 55 p.
Jones, J B; Cresswell, P; Drummond, K; McKenzie, J (1992) Kahawai. New Zealand Fisheries Assessment Research Document 1992/2. 27 p. (Unpublished report held by NIWA library, Wellington.)
Kimura, D K (1980) Likelihood methods for the von Bertalanffy growth curve. *Fishery Bulletin* 77: 765–776.
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.
Reilly, J L (2002) 1999/2000 National marine recreational fishing survey: weighting methodology for harvest estimates. Draft report by Statistical Insights Ltd. 25 p.
Smith, P J; Hartill, B; Hamer, P; McKenzie, A (2008) Stock structure of kahawai, *Arripis trutta*. *New Zealand Fisheries Assessment Report 2008/20.* 42 p.
Stevens, D W; Kalish, J (1998) Validated age and growth of kahawai (*Arripis trutta*) in the Bay of Plenty and Tasman Bay. *NIWA Technical Report* 11. 33 p.
Sylvester, C T A (1989) Kahawai fishery assessment 1989. New Zealand Fisheries Assessment Research Document 1989/10. 17 p. (Unpublished report held by Fisheries New Zealand, Wellington.)
Taylor, P R (2014) Developing indices of relative abundance from observational aerial sightings of inshore pelagic finfish; step 1, exploring the data. *New Zealand Fisheries Assessment Report 2014/44*. 66 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. New Zealand Fisheries Assessment Research Document 1997/15. 43 p. (Unpublished report held by Fisheries New Zealand, Wellington.)
Watkinson, J G; Smith, R (1972) *New Zealand Fisheries*. New Zealand Government Print. 91 p.
Wright, P; McClary, D; Boyd, R O (2004) 2000/2001 National Marine Recreational Fishing Survey: direct questioning of fishers compared with reported diary data. Final Research Report for Ministry of Fisheries Project REC2000–01: Objective 2.
Wynne-Jones, J; Gray, A; Heinemann, A; Hill, L; Walton, L (2019). National Panel Survey of Marine Recreational Fishers 2017–2018. *New Zealand Fisheries Assessment Report 2019/24*. 104 p.
Wynne-Jones, J; Gray, A; Hill, L; Heinemann, A (2014) National Panel Survey of Marine Recreational Fishers 2011–12: Harvest estimates. *New Zealand Fisheries Assessment Report 2014/67*. 139 p.