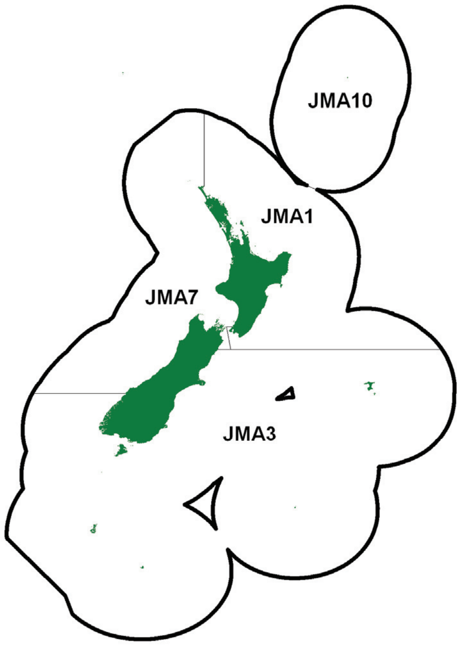
JACK MACKERELS (JMA)

(*Trachurus declivis*, *Trachurus novaezelandiae*, *Trachurus murphyi*)
Hauture



1. FISHERY SUMMARY

The jack mackerel fisheries catch three species; two New Zealand species, *Trachurus declivis* and *T. novaezelandiae,* and *T. murphyi* which appeared in New Zealand in the 1980's.

Jack mackerels have been included in the QMS since 1 October 1996, with four QMAs. Previously jack mackerels were considered part of the QMS, although ITQs were issued only in JMA 7. In JMA 1 and JMA 3, quota for the fishery was fully allocated as IQs by regulation with the exception of the 20% allocated to customary non-commercial. Before the 1995 jack mackerel regulations were issued, catch in JMA 1 taken in the Muriwhenua area north of 36°S to the limit of the Territorial Sea was not covered by the JMA 1 regulations. Allowances for customary non-commercial fishers, recreational fishers and an allowance for other sources of mortality have not yet been set.

1.1 Commercial fisheries

In JMA 1, the jack mackerel catch is largely (about 96% of annual landings) taken by the purse seine fishery operating in the Bay of Plenty and on the east Northland coast, which was, prior to 1992, dominated by *T. novaezelandiae,* but included a small component of *T. declivis*. Between 1991–92 and 1995–96 the proportion of *T. murphyi* in the catch increased considerably, and markets were developed for large jack mackerels, but, by 1996–97, their low value resulted in less targeting of large fish. In recent years the proportion of *T. novaezelandiae* has been variable with an initial return to more than 95% in 1999–2000 and 2000–01, a decline to 46% in 2003–04, and an increase to 81% in 2004–05. Some trawl bycatch of jack mackerel has been recorded in JMA 1.

Since 1991–92, jack mackerel targeted landings in JMA 1 have represented more than 80% of total catch. The highest rates of bycatch are from kahawai and blue mackerel targeted operations which each accounting for about 7% of the total jack mackerel catch. The majority of JMA 1 catch over these years has been taken from statistical areas 008 and 009 (Bay of Plenty) between June and November; considerably less has been taken in statistical areas 002 and 003, although high catches were recorded from these areas in 1993–94 and 1994–95.

Jack mackerel catch in JMA 3 is almost exclusively *T. murphyi* and little targeting occurred before 1992–93. During the 1990s targeting increased and accounted for the majority of catch (about 50% between 1991–92 and 1996–97), but, after a peak of more than 80% in 1997–98 and 1998–99, has decreased again to about 50–60% in recent years. The balance of the catch in this area comes from trawl bycatch (squid 15–30%; barracouta 15–20%) on the Chatham Rise and in the Southland/Sub-Antarctic region. A purse seine fishery has operated between the Clarence River mouth and the Kaikoura Peninsula, which peaked at 4400 t in 1992–93 and averaged more than 3000 t between 1989–90 and 1993–94. Purse seine catches have shown a steady decline since, dropping from 1000 t in 1994–95, to 100 t in 2001–02 and 2002–03; no catch was recorded for 2003–04.

Increased availability of jack mackerels caused by the influx of *T. murphyi* resulted in increased quotas in JMA 1 and JMA 3, to 8000 t and 9000 t respectively for the 1993–94 fishing year, and a further increase to 10,000 t and 18,000 t respectively for the 1994–95 year. The latter increases were made under the proviso that they be accounted for by increased catches of *T. murphyi* only; combined landings of *T. declivis* and *T. novaezelandiae* in JMA 1 and JMA 3 must not exceed the original quotas of 5970 t and 2700 t respectively. Industry agreed to these limits and voluntarily introduced monitoring programmes to provide the information necessary for them to be met.

The three species occur in each of the Fishstocks, but are not individually identified in catch records. Landings and TACCs for 1983–84 to 2008–09 are shown for all Fishstocks in Table 1, while Figure 1 shows the historical landings and TACC values for the main JMA stocks.Total annual landings have ranged between 21061 t and 47855 t since 1986-87.

Table 1: Reported landings (t) of jack mackerel by Fishstock from 1983–84 to 2008–09 and actual TACCs (t) for 1986–87 to 2008–09. QMS data from 1986-present.

	JMA 1		JMA 3		JMA 7		JMA 10		Total	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings§	TACC
1983–84*	3 682	–	715	–	12 464	–	0	–	16 880	–
1984–85*	1 857	–	1 223	–	16 013	–	0	–	19 659	–
1985–86*	1 173	–	2 228	–	10 002	–	0	–	14 773	–
1986–87	4 056	5 970	1 638	2 700	19 815	20 000	0	10	25 509	28 680
1987–88	3 108	5 970	1 883	2 700	17 827	22 697	0	10	22 818	31 377
1988–89	2 986	5 970	1 919	2 700	17 402	26 008	0	10	22 308	34 688
1989–90	4 226	5 970	4 013	2 700	21 776	32 027	0	10	30 102	40 707
1990–91	6 472	5 970	6 403	2 700	17 786	32 069	0	10	30 661	40 749
1991–92	7 017	5 970	5 779	2 700	25 880	32 069	0	10	38 676	40 749
1992–93	7 529	5 970	15 399	2 700	24 767	32 536	83	10	47 778	41 216
1993–94‡	14 256	8 000	9 115	9 000	22 377	32 536	0	10	45 748	49 546
1994–95‡	7 832	10 000	11 519	18 000	18 913	32 536	0	10	38 264	60 547
1995–96	6 874	10 000	19 803	18 000	12 270	32 536	0	10	38 947	60 547
1996–97	6 912	10 000	15 687	18 000	12 056	32 536	0	10	34 655	60 547
1997–98	7 695	10 000	15 452	18 000	14 292	32 536	0	10	37 439	60 547
1998–99	5 767	10 000	15 111	18 000	13 574	32 536	0	10	37 439	60 547
1999–00	2 866	10 000	10 306	18 000	7 889	32 536	0	10	21 061	60 547
2000–01	8 360	10 000	2 744	18 000	15 703	32 536	0	10	26 806	60 547
2001–02	5 247	10 000	5 000	18 000	22 338	32 536	0	10	32 586	60 547
2002–03	6 172	10 000	2 225	18 000	26 084	32 536	0	10	34 483	60 547
2003–04	7 396	10 000	705	18 000	28 883	32 536	0	10	36 989	60 547
2004–05	9 418	10 000	716	18 000	36 507	32 536	0	10	46 641	60 547
2005–06	9 924	10 000	5 000	18 000	27 782	32 536	0	10	42 706	60 547
2006–07	5 293	10 000	1 857	18 000	32 039	32 537	0	10	39 189	60 547
2007–08	11 167	10 000	2 629	18 000	34 059	32 537	0	10	47 855	60 547
2008–09	9 791	10 000	1 964	18 000	28 828	32 537	0	10	40 583	60 547

* FSU data.
§ Includes landings from unknown areas before 1986–87.
‡ JMA 1 & 3 landings are totals from CLR & CELR data.

Landings in JMA 1 before 1989–90 were generally well below the quota of 5970 t (Table 1), with the maximum in 1986–87 only slightly above 4000 t. Landings increased to 7529 t in 1992–93, followed by a substantial increase to the highest recorded value of 14 256 t in 1993–94, which was more than twice the original quota and exceeded the quota of 8000 t set for that year. In 1994–95 reported landings (7832 t) were half those of 1993–94. Landings from 1994–95 to 1997–98 were around 7000 t. Since 1997–98 landings have fluctuated with no real pattern between a low of 2866 t in 1999–00 to the high of 11 167 t in 2007–08.

Total landings in JMA 3 over the period 1984–85 to 1988–89 were relatively constant, at a level below the quota of 2700 t. Landings increased over subsequent years to peak in 1992–93 at almost three times that of the preceding year and more than five times the quota. Under the first of two consecutive annual increases to the JMA 3 TACC in 1993–94, landings were slightly above the limit set, but fell below the higher TACC level in 1994–95. The lower 1994–95 catch relative to that in 1992–93 has been attributed to the delayed implementation of the quota, less targeting of jack mackerel, and low bycatch in the squid trawl fishery. The reduced effort is thought to be a result of marketing difficulties for the relatively lower valued *T. murphyi*. Landings in JMA 3 increased markedly in 1995–96 (19 803 t) to a value exceeding the quota, with catches remaining stable around 15 500 t over three subsequent years. More recently, landings have decreased to levels well below the TACC, fluctuating between 705t and 5000t since 2000-01. Declines in landings are attributed to declining abundance of *T. murphyi*, which historically comprised the bulk of JMA 3 landings.

Landings in JMA 7 represent the greatest proportion of total landings and are mainly taken by chartered trawlers. Landings fluctuated between 17 402 t and 25 880 t from the mid 1980s through the mid 1990s. The marked decrease to 12 270 t in 1995–96 is attributed to changes in fishing strategies (mid-water trawling between 2 a.m. and 4 a.m. is banned under a code of practice to eliminate dolphin bycatch in JMA 7 that has been operational since 1995–96), the withdrawal of a major company from the fishery for much of the season, and difficulty marketing the relatively low valued *T. murphyi*. From 1995–96 to 1998–99, landings were in the range 12 056–14 292 t. Recently, landings have increased steadily from 15 703 t in 2000–01 to 28 883 t in 2003–04 and to 36 497 t in 2004–05. The 2004–05 landings were 3961 t in excess of the TACC. This increase in JMA 7 landings has been attributed to market demand and a lack of availability of preferred species quota as a result of cuts in quotas for other species. The 2007-08 landings were 34 000 t, about 1500 t larger than the TACC. In 2008–09 catches decreased below the TACC by nearly 4000 t.

A number of factors have been identified that can influence landing volumes in the jack mackerel fisheries. In the purse seine fishery, jack mackerel is often mixed with kahawai. Fishing companies will avoid these mixed schools to conserve kahawai quota, particularly at the beginning of the fishing year. When mixing of the two species is prevalent, low kahawai TACC can result in the targeting of jack mackerel being inhibited. Both skipjack tuna and blue mackerel are fished in preference to jack mackerel in the purse seine fishery, and the length of the jack mackerel season is influenced by the availability of these species.

A number of bycatch issues exist in the JMA 7 fishery. A large bycatch fishery for blue mackerel operates for many months of the year and other bycatch species taken in this fishery include barracouta, gurnard, John dory, kingfish, and snapper. Although non-availability of ACE is unlikely to be constraining in the first three of these additional species, the same is not true of kingfish, blue mackerel, and snapper. Fishing company spokespersons have stated that known hotspots of snapper are avoided.

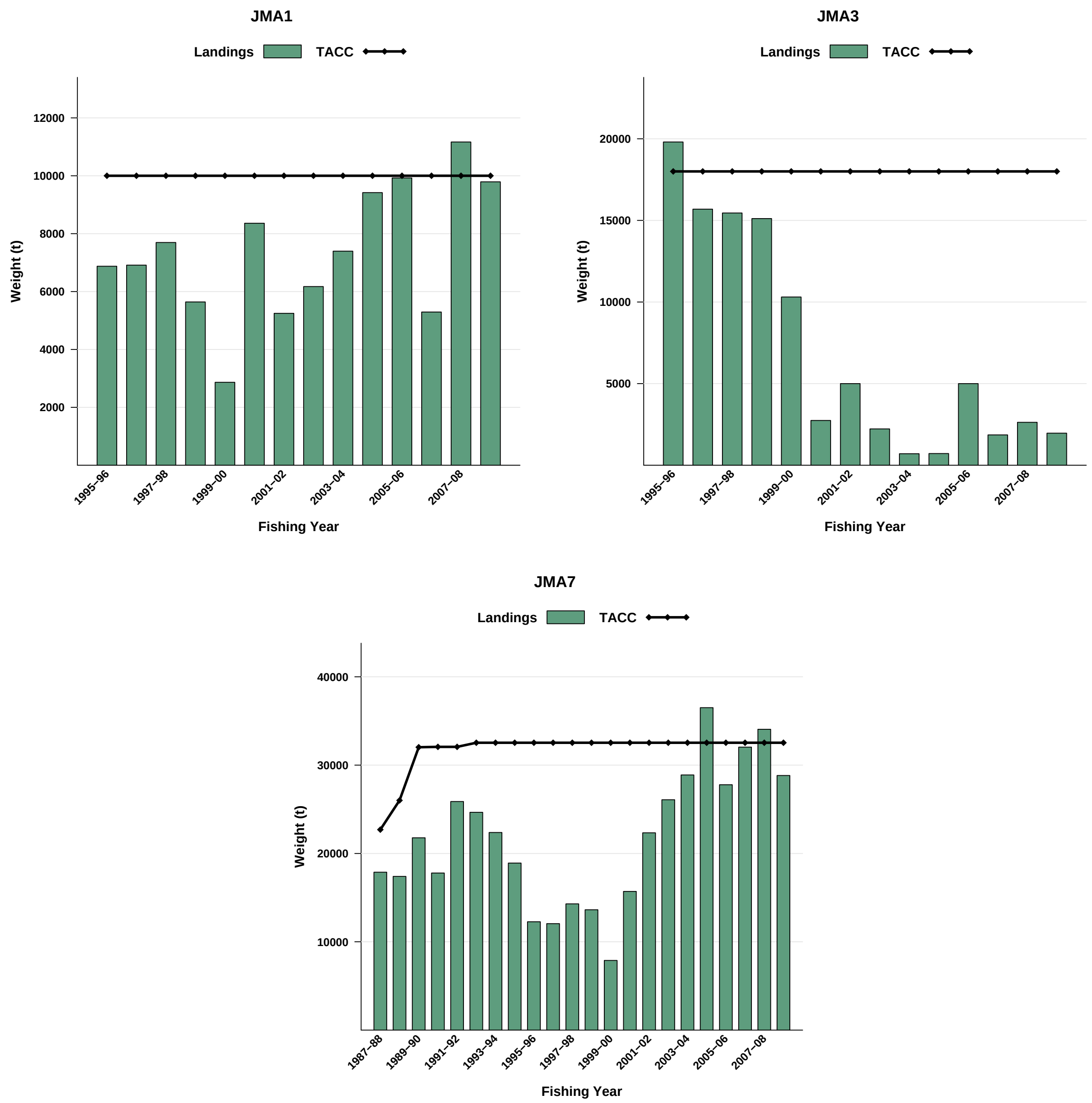


Figure 1: Historical landings and TACC for the three main JMA stocks. From top left: JMA1 (Auckland East, Central East), JMA3 (South East coast, South East Chatham Rise, Sub Antarctic, Southland), and JMA7 (Challenger, Central Egmont, Auckland West). Note that these figures do not show data prior to entry into the QMS.

1.2 Recreational fisheries

Jack mackerels do not rate highly as a recreational target species although they are popular as bait.

There is some uncertainty with all recreational harvest estimates for jack mackerels and there is some confusion between blue and jack mackerels in the recreational data. 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 estimates are implausibly high for many important fisheries.

Recreational catch in the northern region (JMA 1) was estimated at 333,000 fish (CV 0.13) by a diary survey in 1993–94 (Bradford 1996), 79,000 fish (CV 0.16) in a national recreational survey in 1996 (Bradford 1998), 349,000 fish (CV 39%) in the 2000 survey (Boyd & Reilly 2002) and 295,000 fish (CV 0.2%) in the 2001 survey (Boyd *et al*. 2004). The surveys suggest a harvest of 80–110 t per year for JMA 1, insignificant in the context of the commercial catch. Estimates from other areas are very low (between 500 and 47,000 fish) and are likely to be insignificant in the context of the commercial catch.

1.3 Customary non-commercial fisheries
Quantitative information on the current level of Maori customary non-commercial catch is not available.

1.4 Illegal catch
There is no information on illegal activity or catch but it is considered to be insignificant.

1.5 Other sources of mortality
There is no information on other sources of mortality.

2. BIOLOGY

The three species of jack mackerel in New Zealand have different geographical distributions, but their ranges partially overlap. *T. novaezelandiae* predominates in waters shallower than 150 m and warmer than 13°C; it is uncommon south of latitude 42°S. *T. declivis* generally occurs in deeper (< 300 m) waters less than 16°C, north of latitude 45°S. *T. murphyi* occurs to depths of least 500 m and has a wide latitudinal range (0°S at the Galapagos Islands and coastal Ecuador, to south of 40°S off the Chilean coast).

T. murphyi was first described in New Zealand waters in 1987. Its presence was recorded off the south and east coasts of the South Island in the mid 1980s. It expanded onto the west coast of the South Island and the North and South Taranaki Bights by the late 1980s, reaching the Bay of Plenty in appreciable quantities by 1992 and becoming common on the east coast of Northland by June 1994. However, this extensive distribution has decreased in more recent years and, since the late 1990s, its presence north of Cook Strait has been sporadic with occasional landings in the JMA 1 purse seine fishery north of East Cape and from the JMA 1 inshore trawl fishery south of East Cape. The total range of *T. murphyi* now extends along the west coast of South America, across the South Pacific, through much of the New Zealand EEZ, and into waters off southeastern Australia.

All species can be caught by bottom trawl, mid-water trawl, or by purse seine targeting surface schools.

The vertical and horizontal movement patterns are poorly understood. Jack mackerels are presumed to be generally off the bottom at night, and surface schools can be quite common during the day.

Jack mackerels have a protracted spring-summer spawning season. *T. novaezelandiae* probably matures at about 26–30 cm fork length (FL) at an age of 3–4 years, and *T. declivis* matures when about 26–30 cm FL at an age of 2–4 years. Spawning occurs in the North and South Taranaki Bights, and probably in other areas as well.

The reproductive biology of *T. murphyi* in New Zealand waters is not well understood. Pre and post-spawning fish have been recorded from the Chatham Rise, Stewart-Snares shelf, Northland east coast and off Kaikoura in summer, but it is unknown whether there has been any resulting recruitment in New Zealand waters. A recent study showed that older size/age groups become increasingly dominant in catches as one moves westward from the South American coast, suggesting that an eastward migration of oceanic spawned larvae and juveniles occurs in the South Pacific.

Initial ageing of *T. murphyi* taken in New Zealand waters has been recently completed, but the estimates are yet to be validated. Initial growth is rapid, slowing at 6–7 years, and *T. murphyi* is a moderately long-lived species with a maximum observed age of 32 years. *T. novaezelandiae* and *T. declivis* have moderate initial growth rates that slow after about 6 years. Both species reach a maximum age of 25+ years.

The best available estimate of M for *T. novaezelandiae* and *T. declivis* is 0.18 based on the age-frequency distributions of lightly exploited populations in the Bay of Plenty. Assuming $M = 0.18$, estimates of Z made in 1989 suggest that F is less than 0.05 for both endemic species off the central west coast (the main jack mackerel fishing ground). Biological parameters relevant to the stock assessment are shown in Table 2.

3. STOCKS AND AREAS

There are no new data that would alter the stock boundaries given in previous assessment documents. For assessment purposes the three jack mackerel species are treated separately where possible.

Table 2: Estimates of biological parameters.

Fishstock				Estimate	Source
1. Natural mortality (*M*)					
All				0.18	Horn (1991a)
	considered best estimate for both endemic species from all areas.				
2. Weight = a(length)^b (Weight in g, length in cm fork length).					
			All		
	a		b		
T. declivis	0.023		2.84		Horn (1991a)
T. novaezelandiae	0.028		2.84		Horn (1991a)
3. von Bertalanffy growth parameters					
			All		
	L_∞	k	t_0		
T. declivis	46cm	0.28	-0.40		Horn (1991a)
T. novaezelandiae	36cm	0.30	-0.65		Horn (1991a)
T. s. murphyi	51.2cm	0.155	-1.4		Taylor *et al*. (2002)

There are two possible hypotheses on the stock structure of *T. murphyi* in New Zealand waters: it is either a separate stock established by fish migrating from South America, or part of a single, extensive trans-Pacific stock. While successful recruitment in New Zealand waters would indicate the establishment of a separate stock, current evidence favours the latter hypothesis with an extensive stock between latitudes 35–50^{o}S, linking the coasts of Chile and New Zealand across what has been described as 'the jack mackerel belt'. Few detailed data are available to document the process of range expansion by *T. murphyi* or indicate the relative abundance of the three species in particular areas. Data from jack mackerel catch monitoring, which is a requirement of the increased TACCs introduced in 1994–95, will be useful in quantifying species composition and the relative abundance in JMA 1 and JMA 3.

4. ENVIRONMENTAL EFFECTS OF FISHING

This section is new for the May 2010 Plenary and has been considered by the Aquatic Environment Working Group (AEWG). It includes only a summary of the incidental bycatch of marine mammals and seabirds in this fishery and does not consider other potential environmental effects. A more detailed assessment of environmental effects across all fisheries will be available in the Ministry's Aquatic Environment Plenary that is under development.

4.1 Role in the ecosystem
Not discussed by the AEWG.

4.2 Incidental catch (fish and invertebrates)
Not discussed by the AEWG.

4.3 Incidental catch (seabirds and mammals)
This section provides an overview of the incidental captures of seabirds and marine mammals in the jack mackerel fishery. Capture estimates include only those animals landed (alive, injured or dead) on fishing vessels but may not include all sources of cryptic mortality e.g. seabirds struck by the warp but not landed onboard the vessel. Various projects have estimated the total incidental captures in this fishery. This section refers to ratio estimates of incidental captures for all years and model based

estimates where available (for methods see MacKenzie and Fletcher 2006, Abraham et al. 2010. Thompson & Abraham 2009, Thompson et al. in press).

Annual observed seabird capture rates ranged from 0.00 to 2.56 per hundred tows in jack mackerel fisheries between 1998-99 and 2007-08. Estimated means of total annual captures ranged from 5 to 32 seabirds (ratio estimated) and 6 to 37 (model estimated) with a declining trend (Table 3).

Seabird species that were observed caught in the jack mackerel fishery from 1998-99 to 2007-08 are (with total numbers of each species observed caught during this period); sooty shearwater (15), white-capped albatross (13), Buller's albatross (4), petrel (unidentified) (3), cape petrels (2), Campbell albatross (2), fairy prion (2), white-chinned petrel (2), Salvin's albatross (1), seabird – large (1), common diving petrel (1), and prions (unidentified) (1) (Abraham et al. 2010). Note that identification to species or group level is done by observers onboard and some birds are not readily identifiable.

Table 3: Summary of all bird captures in the jack mackerel trawl fishery, for 10 fishing years, with the number of tows, number of tows observed, percentage of tows observed, number of observed captures, capture rate per hundred tows, total estimated captures with 95% confidence intervals, and percentage of tows included in the estimate (from Abraham et al. 2010) and model based estimate of captures with 95% confidence intervals for vessels over 28 m only (from MacKenzie & Fletcher 2006).

	Observed					Ratio estimated			Model based estimate	
	Tows	No. obs	% obs	Captures	Rate	Captures	(95% c.i.)	% effort in estimate	Captures	(95% c.i.)
1998–99	3 866	626	16.2	5	0.80	38	(22 - 58)	98.8	37	(20 - 62)
1999–00	2 290	516	22.5	9	1.74	31	(22 - 41)	99.7	22	(13 - 35)
2000–01	1 941	404	20.8	9	2.23	16	(13 - 19)	98.7	24	(14 - 39)
2001–02	3 002	351	11.7	9	2.56	32	(22 - 45)	99.8	32	(19 - 51)
2002–03	3 067	346	11.3	4	1.16	14	(9 - 19)	94.8	21	(11 - 35)
2003–04	2 383	152	6.4	0	0.00	5	(2 - 9)	98.5	6	(1 - 14)
2004–05	2 509	558	22.2	8	1.43	13	(10 - 16)	98.2		
2005–06	2 808	709	25.2	0	0.00	13	(5 - 21)	96.9		
2006–07	2 711	802	29.6	1	0.12	7	(4 - 11)	98.8		
2007–08	2 646	817	30.9	2	0.24	9	(5 - 13)	99.5		

This is the only well observed fishery with incidental captures of cetaceans, predominantly common dolphins. Common dolphins have been observed caught only in the JMA7 trawl fishery not in other areas of the jack mackerel fisheries (Abraham et al. 2010). Annual observed common dolphin capture rates ranged from 0.00 to 10.37 per hundred tows in jack mackerel fisheries between 1998-99 and 2007-08. Model based estimated means of total annual captures ranged from 0 to 184 common dolphins and show an increasing trend from 2002–03 (Table 4).

Table 4: Total number of tows, observed tows, observer coverage, observed common dolphin captures, observed catch rate, model based estimate of captures and catch rate for the large vessel (>28m) mackerel fishery on the west coast of the North Island between 1 October 1995 and 30 September 2008. The catch rates are expressed as common dolphin captures per 100 trawls (from Thompson and Abraham 2009).

	Observed					Model based estimate			
	Effort	Tows	% obs.	Captures	Rate	Captures	(95% c.i.)	Rate	95% c.i.
1995–96	405	120	30	2	1.67	3.5	(2 - 18)	0.86	(0.49 - 4.44)
1996–97	232	163	70	0	0.00	0	(0 - 4)	0.00	(0 - 1.72)
1997–98	558	217	39	0	0.00	0	(0 - 13)	0.00	(0 - 2.33)
1998–99	350	85	24	0	0.00	2	(0 - 17)	0.57	(0 - 4.86)
1999–00	415	72	17	1	1.39	8	(1 - 38)	1.93	(0.24 - 9.16)
2000–01	972	122	13	1	0.82	11	(1 - 46)	1.13	(0.1 - 4.73)
2001–02	1 577	111	7	1	0.90	31	(4 - 128)	1.97	(0.25 - 8.12)
2002–03	2 249	222	10	21	9.46	184	(76 - 394)	8.18	(3.38 - 17.52)
2003–04	2 309	164	7	17	10.37	101	(47 - 197)	4.37	(2.03 - 8.54)
2004–05	2 424	561	23	21	3.74	90	(50 - 153)	3.71	(2.06 - 6.31)
2005–06	2 119	647	31	2	0.31	11	(2 - 36)	0.52	(0.09 - 1.7)
2006–07	2 164	608	28	11	1.81	55	(23 - 109)	2.54	(1.06 - 5.04)
2007-08	2 164	725	34	20	2.76	43	(24 - 76)	1.99	(1.11 - 3.51)

Annual observed fur seal capture rates ranged from 0.29 to 3.04 per hundred tows in jack mackerel fisheries between 1998-99 and 2007-08. Estimates of total annual captures ranged from 2 to 87 fur seals (Table 5). This represents a small proportion of total fur seal captures, which has varied annually in jack mackerel fisheries throughout the period 1998-99 to 2007-08.

Table 5: Summary of New Zealand fur seal captures in the jack mackerel trawl fishery, for 10 fishing years, with the number of tows, number of tows observed, percentage of tows observed, number of observed captures, capture rate per hundred tows, total estimated captures with 95% confidence intervals, percentage of tows included in the estimate (from Abraham et al. 2010) and model based estimate of captures with 95% confidence intervals (from Thompson et al. in press).

		Observed				Ratio estimated			Model based	
	Tows	No.	% obs	Captures	Rate	Captures (95% c.i.)		% effort in	Captures	
1998–99	3 866	626	16.2	19	3.04	87	(54 - 133)	98.8		
1999–00	2 290	516	22.5	4	0.78	16	(9 - 23)	60.6		
2000–01	1 941	404	20.8	5	1.24	7	(6 - 8)	76.1		
2001–02	3 002	351	11.7	5	1.42	12	(8 - 17)	84.3		
2002–03	3 067	346	11.3	1	0.29	6	(3 - 10)	89.0	15	(4 - 34)
2003–04	2 383	152	6.4	2	1.32	2	(2 - 3)	97.0	13	(4 - 30)
2004–05	2 509	558	22.2	5	0.90	23	(9 - 40)	97.1	20	(8 - 40)
2005–06	2 808	709	25.2	6	0.85	28	(15 - 43)	93.4	25	(11 - 48)
2006–07	2 711	802	29.6	2	0.25	9	(4 - 16)	99.6	13	(4 - 28)
2007–08	2 646	817	30.9	7	0.86	15	(10 - 21)	93.3	28	(13 - 54)

4.4 Benthic interactions
Not discussed by the AEWG.

4.5 Other considerations
Not discussed by the AEWG.

5. STOCK ASSESSMENT

Stock assessments for jack mackerel are complicated by the reporting and management of three species under a single code. Preliminary stock assessments for *T. declivis* and *T. novaezealandiae* in JMA 7 were undertaken in 2007 based on data from a new Bayesian analysis for splitting the recorded commercial catch into *T. declivis*, *T. novaezealandiae*, and *T. murphyi* components. This analysis was used to derive a catch history and CPUE indices for the *T. declivis* fishery in JMA 7, which were incorporated along with a proportions-at-age series into the assessments.

The assessment for *T. declivis* is described below, but the assessment for *T. novaezealandiae* is not included because of convergence problems with the assessment model which led to its rejection by the working group.

Otherwise, there are no new data that would alter the yield estimates given in the 1996 Plenary Report. Estimates of MCY for JMA 1 and JMA 3 have not changed since the 1993 Plenary Report. Other yield estimates have not changed since the 1991 Plenary Report. The yield estimates are based on biomass estimates from a stock reduction analysis and aerial sightings data.

5.1 *T. declivis* in Challenger, Central West and Auckland West (JMA 7)

Species Proportion Estimates
A Bayesian species proportions model was used to estimate the proportion of *T. declivis* in the reported (TCEPR) catch for the JMA 7 fishery from 1989–09 through to 2004–05. Six spatial-temporal strata were used in the model: three spatial strata in combination with two temporal strata. The three spatial strata consisted of three regions with differing patterns in the relative proportions of the three jack mackerel species. The two temporal strata are a summer fishery (October-March) and a winter fishery (April-September). In the model the species proportions are estimated for each year (1989–90 to 2004–05), and the six strata for that year.

CPUE
The Bayesian species proportions model was used to estimate the *T. declivis* catch for each TCEPR tow, and the derived catch-effort data used in a standardised CPUE analysis. Based on changes in jack mackerel fishery practice, and changes in vessel composition over time, the CPUE analysis was split into two time periods: into an early period covering the years 1989-90 to 1995–96, and a late period covering 1996–97 to 2004–05 (Table 6).

Table 6: Standardised CPUE indices (relative year effects) with number of tows from 1989–90 to 2004–05.

	Year	CPUE index	CV	Number of tows
1989–90	1990	2.07	0.1	716
1990–91	1991	2.05	0.1	688
1991–92	1992	1.9	0.1	947
1992–93	1993	1.56	0.09	1 088
1993–94	1994	1.37	0.09	1 444
1994–95	1995	1.28	0.09	597
1995–96	1996	0.89	0.1	502
1996–97	1997	1.69	0.13	160
1997–98	1998	0.92	0.11	252
1998–99	1999	2.7	0.08	712
1999–00	2000	2.15	0.08	717
2000–01	2001	2.67	0.07	1 240
2001–02	2002	2.85	0.07	1 760
2002–03	2003	2.38	0.06	2 272
2003–04	2004	2.59	0.07	2 055
2004–05	2005	3.23	0.07	2 002

Catch History

Catch records for jack mackerel extend back to 1946, though landings are small until the mid 1960s. The Bayesian model annual species proportions were used to estimate the *T. declivis* landings from 1991–92 to 2004–05, while previous species proportions were used to estimate landings for the earlier years (Table 7)

Recreational catch, illegal catch, and customary non-commercial catch are not well known, though are thought to be small relative to the commercial catch, so no components are included for these in the catch history.

Catch at Age

Catch-at-age data were used from the commercial fishery in the years 1989–90, 1990–91, 1995–96, and 2004–05.

Table 7: Catch history (t) for *T. declivis* in the JMA 7 fishery. The year denotes the year at the end of the fishing year.

Year	Estimated catch	Year	Estimated catch	Year	Estimated catch
1946	3	1967	3 326	1988	10 340
1947	1	1968	3 326	1989	10 963
1948	2	1969	3 326	1990	6 315
1949	8	1970	2 787	1991	6 759
1950	0	1971	4 634	1992	12 422
1951	0	1972	6 405	1993	7 925
1952	3	1973	5 284	1994	10 741
1953	4	1974	6 423	1995	6 809
1954	0	1975	4 591	1996	5 276
1955	5	1976	5 518	1997	4 702
1956	1	1977	6 151	1998	5 002
1957	3	1978	2 197	1999	10 045
1958	4	1979	2 524	2000	4 339
1959	0	1980	1 522	2001	6 595
1960	2	1981	3 547	2002	13 403
1961	2	1982	3 372	2003	12 781
1962	2	1983	5 540	2004	16 752
1963	5	1984	6 980	2005	17 154
1964	4	1985	8 967	2006	
1965	3	1986	6 801	2007	
1966	23	1987	11 493	2008	

Model Structure

In 2007, the observational data were incorporated into an age-based Bayesian stock assessment to estimate stock size. The stock was considered to reside in a single area, with no partition by sex or maturity. In the model age groups were 1-25 years, with a plus group of 25+. The model covered the period 1965–2005 (estimated catch was insignificant before 1965).

There was a single time step in the model, in which the order of processes is ageing, recruitment, and mortality (natural and fishing). Recruitment numbers followed a Beverton-Holt relationship with steepness of 0.924 derived from a mean value over a number of species similar to jack mackerel. Maturation was not explicitly modeled; instead a maturity-at-age logistic ogive was used with an a_{50} of 3 and an a_{to95} of 9 years. Growth follows a von Bertalanffy curve.

The model was fitted to: (a) an early CPUE series covering the years 1990 to 1996, (b) a late CPUE series covering the years 1997 through to 2005, (c) and a commercial proportions-at-age series for 1990, 1991, 1996, and 2005. A research trawl proportions-at-age for 1981 was not entered into the model, but the fit to it was evaluated outside the model assuming that the research trawl selectivity is the same as the commercial trawl selectivity. A double half normal curve was used to model the commercial trawl selectivity.

The relative influence of the different data series in the model were evaluated by dropping the early CPUE series, dropping the late CPUE series, and putting more weight on the proportions-at-age data by increasing their effective sample size.

Results
For the base model in this preliminary assessment it was estimated that current biomass is at 53% of virgin biomass (B_0). The biomass trajectory indicates a decline in biomass until the mid 1990s, followed by an increase in biomass until 2002, subsequently followed by a slight decline (Figure 2).

Dropping the early CPUE series estimated the current biomass to be at 76% B_0, in contrast dropping the late CPUE series put the current biomass at only 30% B_0. Doubling the effective sample sizes for all the proportions-at-age data estimated the current biomass at 66% B_0.

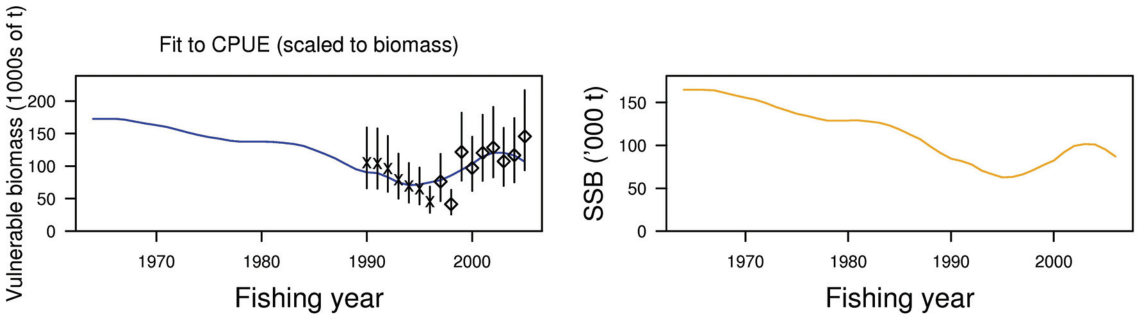


Figure 2: Biomass trajectories for the base case. The left-hand graph shows the fit of the CPUE indices to the vulnerable biomass; the right-hand graph the mature biomass trajectory. The year denotes the year at the end of the fishing year.

5.2 Estimates of fishery parameters and abundance
Estimates of fishery parameters are given in Table 8.

Table 8: Estimates of fishery parameters.

Parameter	Fishstock	Estimate	Comments	Source
F	JMA 7	0.05	During 1989	Horn (1991a)
Z	JMA 7	0.22	During 1989	Horn (1991a)
$F_{0.1}$	JMA 7	0.23	*T. declivis*	Horn (1991a)
		0.33	*T. novaezelandiae*	Horn (1991a)

5.3 Biomass estimates
Biomass estimates are discussed in the section on estimation of MCY. Estimates of current biomass are not available.

5.4 Estimation of Maximum Constant Yield (MCY)
The 2007 assessment for *T. declivis* did not include yield estimates so there is no information to update the historical estimates described below.

(i) Challenger, Central (West) and part of Auckland (West) (QMAs 7, 8, and part of 9)

MCY was estimated in the early 1990s for the two endemic jack mackerel species separately using the equation MCY = 2/3 MSY (Method 3). The deterministic MSY values (8.8% and 14.7% of B_0 for *T. declivis* and *T. novaezelandiae* respectively) were calculated using a yield per recruit analysis and a Beverton and Holt stock-recruitment relationship with an assumed steepness of 0.95. B_0 was estimated using a backward projection of a stock reduction analysis that produced biomass trajectories over the period 1970–90.

For *Trachurus declivis*, B_0 = 200 000 t,
MCY = 2/3 * (0.088 * 200 000 t) = 11 800 t

For *Trachurus novaezelandiae*, B_0 = 100 000 t,
MCY = 2/3 * (0.147 * 100 000 t) = 9800 t

Because these yield estimates are based on an assumed stock-recruitment relationship, they are highly uncertain.

(ii) Northland, Bay of Plenty, east coast North Island (QMAs 1 and 2)

Annual landings before 1990–91 ranged from 1173t to less than 5000 t. Since then, landings have increased markedly as a result of the increased availability of *T. murphyi* to a maximum in excess of 14,000 t in 1993–94. Concerns about the assumptions used to produce the original yield estimate and the production of time series abundance indices from aerial sightings data resulted in a revised yield estimate in the mid 1990s. The aerial sightings indices showed little change in jack mackerel abundance estimates in JMA 1 between 1976 and 1990.

MCY was estimated in 1993 using the equation MCY = cY_{AV} (method 4) incorporating the mean of removals from 1983–84 to 1989–90, before the *T. murphyi* invasion influenced total catches. It is assumed that this represents a period when fishing effort was relatively stable, thus satisfying the criterion for the use of method 4. The calculated MCY applies only to *T. declivis* and *T. novaezelandiae*.

Using M = 0.18 and therefore c = 0.8, MCY = 0.8 * 3013 = 2410 t (rounded to 2400 t).

(iii) Rest of the EEZ (QMAs 3–6)

Trawl surveys in QMAs 3–6 are not considered to be a suitable means to estimate biomass of jack mackerels, due primarily to the slow towing speed. Landings from JMA 3 have fluctuated widely since 1983–84, and were relatively high in the 1990s due probably to an increased abundance of *T. murphyi*. In the two most recent years, catches were equivalent to the lowest on record, which was last experienced in 1984–85.

For JMA 3 there are no available estimates of biomass and no series of catch data from a period of relatively constant fishing mortality. Therefore, it is not possible to estimate MCY for this Fishstock.

The level of risk to the stock by harvesting the population at the estimated MCY value cannot be determined.

5.5 Estimation of Current Annual Yield (CAY)

Estimates of current biomass are not available for any jack mackerel stock, so CAY cannot be estimated.

Yield estimates for *T. declivis* and *T. novaezelandiae* are shown in Table 9.

Table 9: Yield estimates for *T. declivis* and *T. novaezelandiae* (t).

Parameter	Fishstock	Estimate
MCY	JMA 1	2 400
	JMA 3	Cannot be determined
	JMA 7	21 600
CAY	All	Cannot be determined

5.6 Other yield estimates and stock assessment results

No other information is available for jack mackerels.

5.7 Other factors

The estimates of MCY given above are likely to be conservative as they do not take into account the presence of the third species, *T. murphyi*, which has been known at times to comprise a substantial proportion of the purse seine catches in the area between Cook Strait and Kaikoura, in the Bay of Plenty and on the east Northland coast, although the proportion of this component seems to have declined considerably since the late 1990s. It is also the main trawl-caught mackerel on the Chatham Rise and the Stewart Island-Snares shelf region and has been a major proportion of jack mackerel catches on the west coast South Island. *T. murphyi* has also been an important component of the west coast North Island jack mackerel trawl fishery, but its presence appears to have declined in recent years with a very low representation in the TCEPR fishery in 2004–05. Thus, there has been a contraction in the range of this species in New Zealand waters, although it is unknown yet whether this represents a decrease in its overall abundance here. The effect of in *T. murphyi* on the range and abundance of the other two species is unknown.

Aerial sightings data were used to produce a time series of relative abundance indices for jack mackerel. The time series covered the period from the beginning of the purse seine fishery in 1976, to 1993. They indicated increases in abundance in JMA 1 from the early 1990s, and, although the result is not as clear, similar trends in JMA 3 and JMA 7. These increases were attributed to the invasion of *T. murphyi*.

The validity of this early aerial sightings abundance index is uncertain. Further analysis of these data have been the focus of considerable effort in recent years and in 2006 the Pelagic Working Group had not yet accepted revised abundance indices due to data and model concerns. Research into developing abundance indices from aerial sightings data is continuing.

The stipulation that catches in JMA 1 and JMA 3 above the original TACs (5970 t and 2700 t, respectively) be accounted for by increases in *T. murphyi* only, is a method of managing this species independently of the other two. This approach was introduced as a means of maintaining stocks of the endemic species while allowing exploitation of increased stocks of *T. murphyi* resulting from its invasion.

6. STATUS OF THE STOCKS

Assessment of the status of JMA is complicated by the reporting and management of three species under a single code. This is further complicated by the uncertain ‘status’ of *T. murphyi*. The effect of the *T. murphyi* invasion on stocks of the New Zealand jack mackerels is unknown.

JMA 1 and JMA 3

Little is known about the resource in JMA 3, though estimated species proportions indicate a catch dominated by *T. murphyi*. For JMA 1 and 3 it is not known whether catches at the level of the current TACCs or recent catch levels are sustainable in the long-term. The status of JMA3 relative to B_{MSY} is unknown.

JMA 7

Of the three jack mackerel species taken in JMA 7, recent information on stock status is only available for *T. declivis*. The current TACC is approximately 50% greater than the historical MCY-based yield estimates for *T. declivis* and *T. novaezelandiae* combined. These estimates of yield do not include *T. murphyi* which comprise an important part of the catches from JMA 7 in some years.

The 2007 preliminary assessment for *T. declivis* did not indicate sustainability concerns with this component of JMA 7 at that time though there are uncertainties in the assessment relating to the catch histories and abundance indices. The preliminary stock assessment indicates that current biomass is 53% of B_0, so the stock is probably above B_{MSY}. The historical estimate of B_0 (see MCY section) is similar to that from the 2007 assessment.

The status of *T. novaezelandiae* and *T. murphyi* in JMA 7 is not known, nor is the sustainability of current removals of these species.

Overall it cannot be determined if the TAC or current removals are sustainable for JMA 7, but it is likely that the removals from one component of the fishery (*T. declivis*) are sustainable at this time. Given increased catches in recent years continued monitoring of the catch composition is strongly recommended as is further work on potential abundance indices.

Yield estimates, TACCs and reported landings for the 2008–09 fishing year are summarised in Table 10.

Table 10: Summary of yields estimates (t) for *T. declivis* and *T. novaezelandiae* only, TACCs (t), and reported landings (t) for all three species in the most recent fishing year.

Fishstock		QMA	MCY	2008–09 Actual TAC	2008–09 Reported landings
JMA 1	Auckland (East)/ Central (East)	1, 2	2 400	10 000	9 791
JMA 3	South–East/Southland/Sub–Antarctic	3, 4, 5, 6	–	18 000	1 964
JMA 7	Challenger/Central (West)/Auckland (West)	7, 8, 9	21 600	32 536	28 828
JMA 10	Kermadec	10	–	10	0
Total				60 546	40 583

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