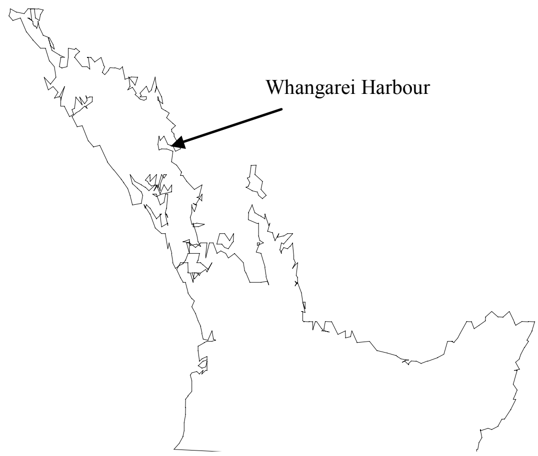
PPI (PPI 1A) Mair Bank (Whangarei Harbour)

(*Paphies australis*)



1. FISHERY SUMMARY

(a) Commercial fisheries

Prior to the introduction of pipi, in Whangerei Harbour (PPI 1A) and FMA PPI 1, to the QMS in 2004, the commercial fishery area was defined in regulation as that area within 1.5 nautical miles of the coastline from Home Point, at the northern extent of the Whangarei Harbour entrance, to Mangawhai Heads, south of the harbour. Commercial fishers tend to gather pipi from the seaward edge of Mair Bank, particularly the southern end, and avoid the centre of the bank itself where there is a lot of shell debris. Regulations require that all gathering be done by hand, and fishers typically use a mask and snorkel. There is no minimum legal size (MLS) for pipi, although all fishers probably favour larger pipi (> 60 mm SL). Pipi are available for harvest year-round, so there is no apparent seasonality in the fishery.

Over 99% of the total commercial landings of pipi in New Zealand have been from general statistical area 003 and PPI 1. In the most recent years, where a distinction has been made, virtually all the landings have been from PPI 1A (Whangerei Harbour). Total commercial landings of pipi reported by Licensed Fish Receiver Returns (LFRRs) have remained reasonably stable through time, averaging 187 t annually in New Zealand since 1986–87 (Table 1). The highest recorded landings were in 1991–92 (326 t). There is no evidence of any consistent seasonal pattern in either the level of effort or catch per unit effort (CPUE) in the pipi fishery. Annual CPUE in the pipi targeted fishery increased in the early stages of the series (1989/90 to 1992/93), then appears to have remained relatively stable, showing an increase in the most recent years.

Prior to the introduction of PPI 1A to the QMS there were nine permit holders for Whangerei Harbour. No new entrants have entered the fishery since 1992 when commercial access to the fishery was constrained by the general moratorium on granting new fishing permits for non-QMS fisheries. Access to the fishery has, however, been restricted through other regulations since the mid-1980s, and more formally since 1988. Under previous non-QMS management arrangements, there was a daily catch limit of 200 kg per permit holder, meaning that, collectively, the nine permit holders could, theoretically, take 657 t of pipi per year. The permit holders have indicated that annual harvest quantities have been considerably less than the potential maximum, because of the relatively low market demand for commercial product rather than the availability of the resource. On 1 October 2004, pipi in Whangerei Harbour (PPI 1A) were introduced into the QMS, and the nine existing permits were replaced with individual transferable quotas. The 200 kg daily catch limit no longer applies. A total allowable catch (TAC) of 250 t was set, comprised of a total allowable commercial catch (TACC) of 200 t, a customary allowance of 25 t, and a recreational allowance of 25 t.

Table 1: Reported commercial landings (from Licensed Fish Receiver Returns; LFRR) of pipi (t greenweight) in New Zealand since 1986–87. Prior to the introduction of PPI 1A to the QMS on 1 October 2004, the fishery was limited by daily limits which summed to 657 t greenweight in a 365 day year, but there was no explicit annual restriction. A TACC of 200 t was set for PPI 1A on 1 October 2004.

Year	Reported landings (t)	Limit (t)	Year	Reported landings (t)	Limit (t)
1986–87	131	657	1996–97	146	657
1987–88	133	657	1997–98	122	657
1988–89	134	657	1998–99	130	657
1989–90	222	657	1999–00	143	657
1990–91	285	657	2000–01	184	657
1991–92	326	657	2001–02	191	657
1992–93	184	657	2002–03	191	657
1993–94	258	657	2003–04	266	657
1994–95	172	657	2004–05	206	200
1995–96	135	657	2005-06	206	200

(b) Recreational fisheries

The recreational fishery is harvested entirely by hand digging. Large pipi 50 mm (maximum shell length) or greater are probably preferred. Although pipi attract intense recreational interest, no quantitative information on the level of recreational harvest exists. Compared with commercial landings, however, the recreational take of pipi is likely to be small. The 1996, 1999/2000, and 2000/2001 national marine recreational fishing surveys recorded recreational harvests for pipi in FMA 1. The estimated numbers of pipi harvested were 2.1, 6.6, and 7.2 million respectively. The Marine Recreational Fisheries Technical Working Group (RFTWG) has reviewed harvest estimates from the national surveys and concluded that the 1996 estimates are unreliable due to a methodological error. Estimates from the 1999/2000 and 2000/2001 surveys for some fishstocks were unbelievably high. No mean harvest weight was available. No recreational harvest estimates specific to the Mair Bank fishery are available.

(c) Maori customary fisheries

In common with many other intertidal shellfish, pipi are very important to Maori as a traditional food. However, no quantitative information on the level of customary take is available.

(d) Illegal catch

No quantitative information on the level of illegal catch is available.

(e) Other sources of mortality

No quantitative information on the level of other sources of mortality is available. Concern was expressed in the 1980s that removal of large numbers of pipi from Mair Bank might adversely affect the sediment dynamics of the bank, and impact upon the Marsden Point facility (Haddon, 1989); although no major impacts seem to have occurred. However, there is currently some concern about the possibility of changes in bank stability that could arise from operations other than fishing (e.g., harbour dredging, port developments), which could lead to changes in the pipi fishery. As suspension feeders, pipi may be adversely affected by increased sedimentation loads in the water column. Dense beds of pipi filter large volumes of water, and may play an important role in maintaining water clarity and quality in estuarine environments.

2. BIOLOGY

The pipi (*Paphies australis*) is a common burrowing bivalve mollusc of the family Mesodesmatidae. Pipi are distributed around the New Zealand coastline, including the Chatham and Auckland Islands (Powell, 1979), and are characteristic of protected beaches, bays and estuaries (Morton & Miller, 1968). Pipi are tolerant of moderate wave action, and commonly inhabit coarse shell sand substrata in bays and at the mouths of estuaries where silt has been removed by waves and currents (Morton & Miller, 1968). They have a broad tidal range, occurring intertidally and subtidally in high-current harbour channels to water depths of at least 7 m (Dickie, 1986a; Hooker, 1995a), and are locally abundant, with densities greater than 1000 m^{-2} in certain areas (Grace, 1972).

Pipi reproduce by free-spawning, and most individuals are sexually mature at about 40 mm shell length (Hooker & Creese, 1995a). Gametogenesis begins in autumn, and by late winter many pipi have mature, ready-to-spawn gonads (Hooker & Creese, 1995a). Pipi have an extended breeding period from late winter to late summer, with greatest spawning activity occurring in spring and early summer. Fertilised eggs develop into planktotrophic larvae, and settlement and metamorphosis occur about three weeks after spawning (Hooker, 1997). In general, pipi have been considered sedentary when settled, although Hooker (1995b) found that pipi may utilise water currents to disperse actively within a harbour. The trigger for movement is unknown, but this ability to migrate may have important implications to their population dynamics.

Pipi growth dynamics are not well known. Growth appears to be fairly rapid, at least in dynamic, high-current environments such as harbour channels. Hooker (1995a) showed that pipi at Whangateau Harbour (northeastern New Zealand) grew to about 30 mm in just over one year (16–17 months), reached 50 mm after about three years, and grew very slowly after attaining 50 mm. There was a strong seasonal component to growth, with rapid growth occurring in spring and summer, and little growth in autumn and winter. Williams et al. (2006) used Hooker's (1995a) tag-recapture and length frequency time series data to generate formal growth estimates for Whangateau Harbour pipi (Table 2). Estimates are available also from time series of size frequencies on sheltered Auckland beaches (Table 2; Morrison & Browne, 1999; Morrison et al., 1999), although these estimates were likely to have been poorly estimated due to variability in the length data.

Little is known about the natural mortality or maximum longevity of pipi. Haddon (1989) suggested pipi are unlikely to live much more than 10 years, and used assumed maximum ages of 10, 15 and 20 years old to estimate maximum constant yield for Mair Bank pipi in 1989. The estimation of the rate of instantaneous natural mortality (*M*) is difficult for pipi owing to the immigration and emigration of individuals from different areas. As the timing and frequency of these movements are largely unknown, the separation of mortality from movement effects is likely to be problematic. Williams et al. (2006) assumed values of M = 0.3, 0.4, and 0.5 to estimate yields for Mair Bank in 2005–06.

Table 2: Estimates of biological parameters for pipi.

Growth		**Location**	**Year**	**Source**
L_∞ (mm SL)	K			
57.3	0.46	inner Whangateau Harbour site	1992–93	Williams et al. (2006)
63.9	0.57	Whangateau Harbour entrance	1992–93	Williams et al. (2006)
41.1	0.48	Cheltenham Beach, North Shore	1997–98	Morrison et al. (1999)
58.9	0.15	Mill Bay, Manukau Harbour	1997–98	Morrison et al. (1999)
84.6	0.09	Mill Bay, Manukau Harbour	1998–99	Morrison & Browne (1999)
Natural mortality				
M = 0.3–0.5 (assumed values)		-	-	Williams et al. (2006)
Size at maturity				
40 mm SL		Whangateau Harbour	-	Hooker & Creese (1995a)

3. STOCKS AND AREAS

Little is known of the stock structure of pipi. The commercial fishery based on Mair Bank in Whangerei Harbour (PPI 1A) forms a geographically discrete area and it is assumed for management purposes that PPI 1A is a separate stock from pipi elsewhere in the region. There have been no biological studies directly relevant to the identification of separate stocks of pipi around New Zealand, although pipi "stocks" are likely to be linked by larval dispersal.

4. STOCK ASSESSMENT

Stock assessment for Mair Bank pipi was conducted in 2005 using an absolute biomass survey, and yield per recruit and spawning stock biomass per recruit modelling.

(a) Estimates of fishery parameters and abundance

Estimates of the fishing mortality reference points $F_{0.1}$ and F_{max} are available from yield per recruit and spawning stock biomass per recruit modeling (Table 3). These estimates are sensitive to the assumed value of natural mortality (*M*) and uncertainty in pipi growth parameters.

Table 3: Estimates of fishing mortality rates for the reference points $F_{0.1}$ and F_{max} that maximise yield per recruit (YPR) at three different assumed rates of natural mortality (*M*) for two harvest strategies ('no restriction' and 'current'). The corresponding spawning stock biomass per recruit values are also shown. Values were calculated for 0.5 y increments in age at first recruitment to the fishery. Source: Williams et al. (2007).

'No restriction' strategy (no restriction on size at first recruitment)

M	Age (y)	SL (mm)	$F_{0.1}$	YPR (g)	SSBPR (%)	F_{max}	YPR (g)	SSBPR (%)
0.3	2.5	49	0.26	3.14	48	0.42	3.35	36
0.4	2.5	49	0.31	2.03	51	0.50	2.16	40
0.5	2.0	44	0.33	1.38	49	0.51	1.46	37

'Current' strategy (select pipi 60mm and over)

M	Age (y)	SL (mm)	$F_{0.1}$	YPR (g)	SSBPR (%)	F_{max}	YPR	SSBPR (%)
0.3	5.0	60	0.32	2.30	69	0.56	2.47	62
0.4	5.0	60	0.39	1.22	76	0.64	1.3	71
0.5	5.0	60	0.45	0.66	82	0.71	0.70	78

(b) Biomass estimates

Virgin biomass (B_0) and the biomass that will support the maximum sustainable yield (B_{msy}) are unknown for Mair Bank pipi. Only two biomass estimates have been made for the Mair Bank pipi population: 1) in 1989, using a grid survey; and 2) in 2005, using stratified random sampling. The 1989 estimate of 2245 t (± 10%) can be considered conservative because only the intertidal area of the bank was surveyed, and pipi are known to exist in the shallow subtidal area of the bank. Estimates of current biomass are available for Mair Bank and are sensitive to the assumed size at recruitment (Table 4).

Table 4: Estimated recruited biomass (*B*) of pipi on Mair Bank in 2005 for different assumed sizes at recruitment to the fishery. Source: Williams et al. (2007).

Assumed shell length at recruitment (mm)	Intertidal stratum		Subtidal stratum		Mair Bank Total	
	B (t)	*C.V.* (%)	*B* (t)	*C.V.* (%)	*B* (t)	*C.V.* (%)
1 (absolute biomass)	3602	11.4	6940	19.5	10 542	13.4
40	3569	11.4	6922	19.5	10 490	13.4
45	3434	11.4	6791	19.6	10 226	13.6
50	2986	11.3	5989	20.1	8975	14.0
55	2022	11.1	3855	23.8	5877	16.0
60	1004	13.1	2013	37.5	3017	25.4

(c) Estimation of Maximum Constant Yield (MCY)

Maximum Constant Yield (MCY) can be estimated using methods 1 and 2 (Sullivan et al., 2005):

Method 1 $\text{MCY} = 0.25 F_{0.1} B_0$ (assumes B_{2005} is very close to virgin biomass)

Method 2 $\text{MCY} = 0.5 F_{0.1} B_{av}$ (assumes B_{2005} is an estimate of the average biomass since the fishery was developed)

Because estimates of virgin recruited biomass, B_0, and historical average recruited biomass, B_{av}, for Mair Bank are unavailable, the 2005 recruited (60 mm and over shell length) biomass estimate of 3017 t was used to calculate MCY. Estimates of $M = 0.3$ and $F_{0.1} = 0.32$ were used.

Method 1 $\text{MCY} = 0.25 \times 0.32 \times 3017 = 241\,\text{t}$

Method 2 $\text{MCY} = 0.5 \times 0.32 \times 3017 = 483\,\text{t}$

These estimates of MCY would have a C.V. at least as large as that associated with the 2005 recruited (60 mm and over shell length) biomass (25.4%). These estimates are also sensitive to the assumed size at recruitment to the fishery (Table 5), and to uncertainty in $F_{0.1}$ (arising from the considerable uncertainty in both growth parameters and *M*). The level of risk to the stock by harvesting the population at the estimated MCY values cannot be determined.

(d) Estimation of Current Annual Yield (CAY)

CAY can be estimated for the current year based on a survey conducted in 2005. As fishing is conducted year round on Mair Bank, the full version of the Baranov catch equation is appropriate (Method 1, Sullivan et al., 2005), where:

$$\text{CAY} = \frac{F_{ref}}{F_{ref} + M}\left(1 - e^{-(F_{ref}+M)}\right) B_{beg}$$

The current estimate of recruited biomass (B_{curr}) derived from the 2005 survey of Mair Bank was substituted for B_{beg} to calculate CAY. Estimates of $M = 0.3$, $F_{0.1} = 0.26$, and B_{beg} (60 mm and over shell length) = 3017 t were used.

Using $F_{0.1}$, $$\text{CAY} = \frac{0.32}{0.32 + 0.3} \times \left(1 - e^{-(0.32+0.3)}\right) \times 3017 = 720\ \text{t}$$

This estimate of CAY would have a C.V. at least as large as that associated with the estimate of the start of season recruited biomass in 2005 (12.8%). The estimate of CAY is sensitive to the assumed size at recruitment to the fishery (Table 5), and to uncertainty in $F_{0.1}$ (arising from the considerable uncertainty in both growth parameters and *M*). The level of risk to the stock by harvesting the population at the estimated CAY value cannot be determined.

Table 5: Sensitivity of maximum constant yield (MCY) and current annual yield (CAY) to the assumed size at recruitment to the fishery. Biomass was estimated for two sizes (50 and 60 mm) at recruitment to the fishery using the 2005 survey data only, values of *M* were assumed, and estimates of $F_{0.1}$ were generated using equilibrium yield per recruit modelling. Source: Williams et al. (2007).

Size at recruitment (mm shell length)	Biomass (2005)	*M*	$F_{0.1}$	MCY Method 1 (t)	MCY Method 2 (t)	CAY (t)
50	8975	0.3	0.26	583	1167	1787
		0.4	0.32	718	1436	2047
		0.5	0.37	830	1660	2218
60	3017	0.3	0.32	241	483	720
		0.4	0.39	294	588	814
		0.5	0.45	339	679	877

(e) Other yield estimates and stock assessment results

$F_{0.1}$ and F_{max} were estimated through yield per recruit modelling using the following input information: growth rate parameters from a MULTIFAN analysis of 1992–93 length frequencies for pipi at Whangateau Harbour; an assumed estimate of $M = 0.30$ (range 0.30–0.50); length weight data from the 2005 survey of Mair Bank; size at maturity of 40 mm; and size at recruitment of 60 mm.

(f) Other factors

The first full estimate of pipi biomass on Mair Bank was made in 2005. Because there is no stock assessment model for Mair Bank pipi, yield estimates were generated by applying reference rates of fishing mortality to estimates of recruited biomass. The reference rates were obtained from an equilibrium yield per recruit model that was constructed using data for pipi in Whangateau Harbour, northeastern New Zealand. Although this is an approximate approach, it is probably the best possible given the current paucity of biological data for Mair Bank pipi. More information on the growth and mortality of pipi specific to Mair Bank are required.

5. STATUS OF THE STOCKS

Depending on the assumed size at recruitment to the fishery and the assumed rate of *M*, current estimates of MCY (241–1660 t) and CAY (720–2218 t) are higher than the TACC (200 t). Reported landings have averaged about 187 t annually in New Zealand since 1986–87, which is less than all of the yield estimates. Recent catches have been at about the level of the current TACC. There appears to have been an increase in CPUE in recent years that could be associated with the apparent increase in biomass. Overall, the 2005 biomass and simple yield estimates suggest that fishing at the level of recent average landings is likely to be sustainable in the short term. However, these yield estimates are based on estimates of biological parameters for pipi elsewhere in northeastern New Zealand, and potential differences in the biology of Mair Bank pipi could significantly affect yield estimates. It is, therefore, unknown whether fishing at the level of the current TACC is likely to be sustainable in the long term.

Estimated yields, TACCs and reported landings are summarized in Table 6.

Table 6: Summary of TACCs (t) and reported landings (t) of pipis for the most recent fishing year.

Fishstock	MCY Method 1	MCY Method 2	CAY	2005–06 Actual TACC	2005–06 Reported landings
PPI 1A	241	483	720	200	206 t

6. FOR FURTHER INFORMATION

Cranfield, H.J.; Michael, K.P.; Stotter, D. (1993). Estimates of growth, mortality, and yield per recruit for New Zealand surf clams. *New Zealand Fisheries Assessment Research Document* 93/20. 47 p.

Dickie, B.N. (1986a). Physical and biological survey of a subtidal *Paphies australis* population in the lower Whangerei Harbour. Whangerei Water Quality Management Plan. Working Report 4. 45 p. (Unpublished report to the Northland Catchment Commission and Regional Water Board, New Zealand).

Dickie, B.N. (1986b). Topographic survey of three intertidal *Paphies australis* habitats in the lower Whangerei Harbour. Whangerei Water Quality Management Plan. Working Report 2. 45 p. (Unpublished report to the Northland Catchment Commission and Regional Water Board, New Zealand).

Fournier, D.A.; Sibert, J.R.; Majkowski, J.; Hampton, J. (1990). MULTIFAN: a likelihood-based method for estimating growth parameters and age composition from multiple length frequency data sets illustrated using data for southern bluefin tuna (*Thunnus maccoyi*). *Canadian Journal of Fisheries and Aquatic Sciences 47*: 301-317.

Francis, R.I.C.C. (1988). Maximum likelihood estimation of growth and growth variability from tagging data. *New Zealand Journal of Marine and Freshwater Research 22(1)*: 43-51.

Grace, R.G. (1972). The benthic ecology of the entrance to the Whangateau Harbour, Northland, New Zealand. Unpublished PhD thesis. University of Auckland, Auckland, New Zealand. p.

Haddon, M. (1989). Biomass estimate of the pipi *Paphies australis* on Mair Bank, Whangerei Harbour. 23 p. (Unpublished draft report to MAF Fisheries North, Auckland, New Zealand).

Hewitt, D.A.; Hoenig, J.M. (2005). Comparison of two approaches for estimating natural mortality based on longevity. *Fishery Bulletin 103(2)*: 433-437.

Hoenig, J.M. (1983). Empirical use of longevity data to estimate mortality rates. *Fishery Bulletin 82(1)*: 898-903.

Hooker, S.H. (1995a). Life history and demography of the pipi *Paphies australis* (Bivalvia: Mesodesmatidae) in northeastern New Zealand. Unpublished PhD thesis. University of Auckland, Auckland, New Zealand. 230 p.

Hooker, S.H. (1995b). Preliminary evidence for post-settlement movement of juvenile and adult pipi, *Paphies australis* (Gmelin, 1790) (Bivalvia: Mesodesmatidae). *Marine and Freshwater Behaviour and Physiology 27(1)*: 37-47.

Hooker, S.H. (1997). Larval and postlarval development of the New Zealand pipi, *Paphies australis* (Bivalvia : Mesodesmatidae). *Bulletin of Marine Science 61(2)*: 225-240.

Hooker, S.H.; Creese, R.G. (1995a). The reproductive biology of pipi, *Paphies australis* (Gmelin, 1790) (Bivalvia: Mesodesmatidae). I. Temporal patterns of the reproductive cycle. *Journal of Shellfish Research 14(1)*: 7-15.

Hooker, S.H.; Creese, R.G. (1995b). The reproductive biology of pipi, *Paphies australis* (Gmelin, 1790) (Bivalvia: Mesodesmatidae). II. Spatial patterns of the reproductive cycle. *Journal of Shellfish Research 14(1)*: 17-24.

Morrison, M.A.; Browne, G.N. (1999). Intertidal shellfish population surveys in the Auckland region, 1998-99, and associated yield estimates. New Zealand Fisheries Assessment Research Document 99/43. 21 p. (Unpublished report held in NIWA library, Wellington).

Morrison, M.A.; Pawley, M.D.M.; Browne, G.N. (1999). Intertidal surveys of shellfish populations in the Auckland region, 1997-98, and associated yield estimates. *New Zealand Fisheries Assessment Research Document* 99/25. 25 p.

Morton, J.E.; Miller, M.C. (1968). The New Zealand Sea Shore. Collins, Auckland, New Zealand. 653 p.

OtterResearch (1992). MULTIFAN 32(f). User's Guide and Reference Manual. Otter Research Ltd., Nanaimo, Canada. 67 p.

Pauly, D. (1980). On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. *Journal du Conseil: counseil international pour l'exploration de la mer 39(2)*: 175-192.

Powell, A.W.B. (1979). New Zealand Mollusca: Marine, Land and Freshwater Shells. Collins, Auckland, New Zealand. 500 p.

Ricker, W.E. (1975). Computation and Interpretation of Biological Statistics of Fish Populations. Department of the Environment, Fisheries and Marine Service, Ottawa, Canada. 382 p.

Snedecor, G.W.; Cochran, W.G. (1989). Statistical Methods. 8th Edition. Iowa State University Press, Ames, Iowa, USA. 503 p.

Sullivan, K.J.; Mace, P.M.; Smith, N.W.M.; Griffiths, M.H.; Todd, P.R.; Livingston, M.E.; Harley, S.J.; Key, J.M.; Connell, A.M. (Comps.) (2005). Report from the Fishery Assessment Plenary, May 2005: stock assessments and yield estimates. 792 p. (Unpublished report held in NIWA library, Wellington).

Venus, G.C. (1984). *Paphies australis* (pipis) in Whangerei Harbour. *Whangerei Harbour Study Technical Report No. 6*. 60 p. (Unpublished technical report coordinated by the Northland Harbour Board).

Vetter, E.F. (1988). Estimation of natural mortality in fish stocks: a review. *Fishery Bulletin 86(1)*: 25-43.

von Bertalanffy, L. (1938). A quantitative theory of organic growth. *Human Biology 10*: 181-213.

Williams, J.R.; Cryer, M.; Hooker, S.H.; Smith, M.D.; Watson, T.G.; MacKay, G.; Tasker, R. (2007) Biomass survey and stock assessment of pipi (*Paphies australis*) on Mair Bank, Whangerei Harbour, 2005. *New Zealand Fisheries Assessment Report*. 2007/03, 29 p.