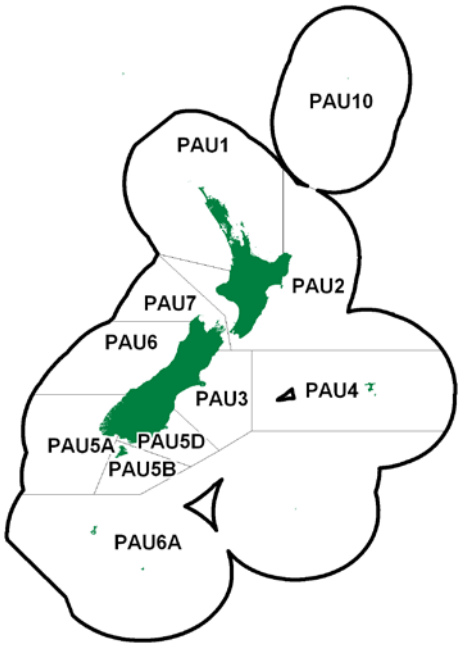
PAUA (PAU)

(*Haliotis iris, Haliotis australis*)
Paua



1. INTRODUCTION

Specific Working Group reports are given separately for PAU 2, PAU 3, PAU 4, PAU 5A, PAU 5B, PAU 5D and PAU 7. The TACC for PAU 1, PAU 6 and PAU 10 is 1.93 t, 1 t and 1 t respectively. Commercial landings for PAU 10 since 1983 have been 0 t.

1.1 Commercial fisheries

The commercial fishery for paua dates from the mid-1940s. In the early years of this commercial fishery the meat was generally discarded and only the shell was marketed, however by the late 1950s both meat and shell were being sold. Since the 1986-87 fishing season, the fishery has been managed with an individual transferable quota system and a total allowable commercial catch (TACC) for each of the eight Quota Management Areas.

Fishers gather paua by hand while free diving (use of underwater breathing apparatus is not permitted). Most of the catch is from the Wairarapa coast southwards: the major fishing areas are in the South Island, Marlborough (PAU 7), Stewart Island (PAU 5A, 5B and 5D) and the Chatham Islands (PAU 4). Virtually the entire commercial fishery is for the black-foot paua, *Haliotis iris*, with a minimum legal size for harvesting of 125 mm shell length. The yellow-foot paua, *H. australis* is less abundant than *H. iris* and is caught only in small quantities; it has a minimum legal size of 80 mm. Catch statistics include both *H. iris* and *H. australis.*

Figure 1 shows the historical landings for the main PAU stocks. On 1 October 1995 PAU 5 was divided into 3 separate QMAs: PAU 5A, PAU 5B and PAU 5D. Up until the 2002 fishing year, catch was reported by general statistical areas, however from 2002 onwards, a more finely scaled system of paua specific statistical areas were put in place throughout each QMA (refer to the QMA specific Working Group reports).

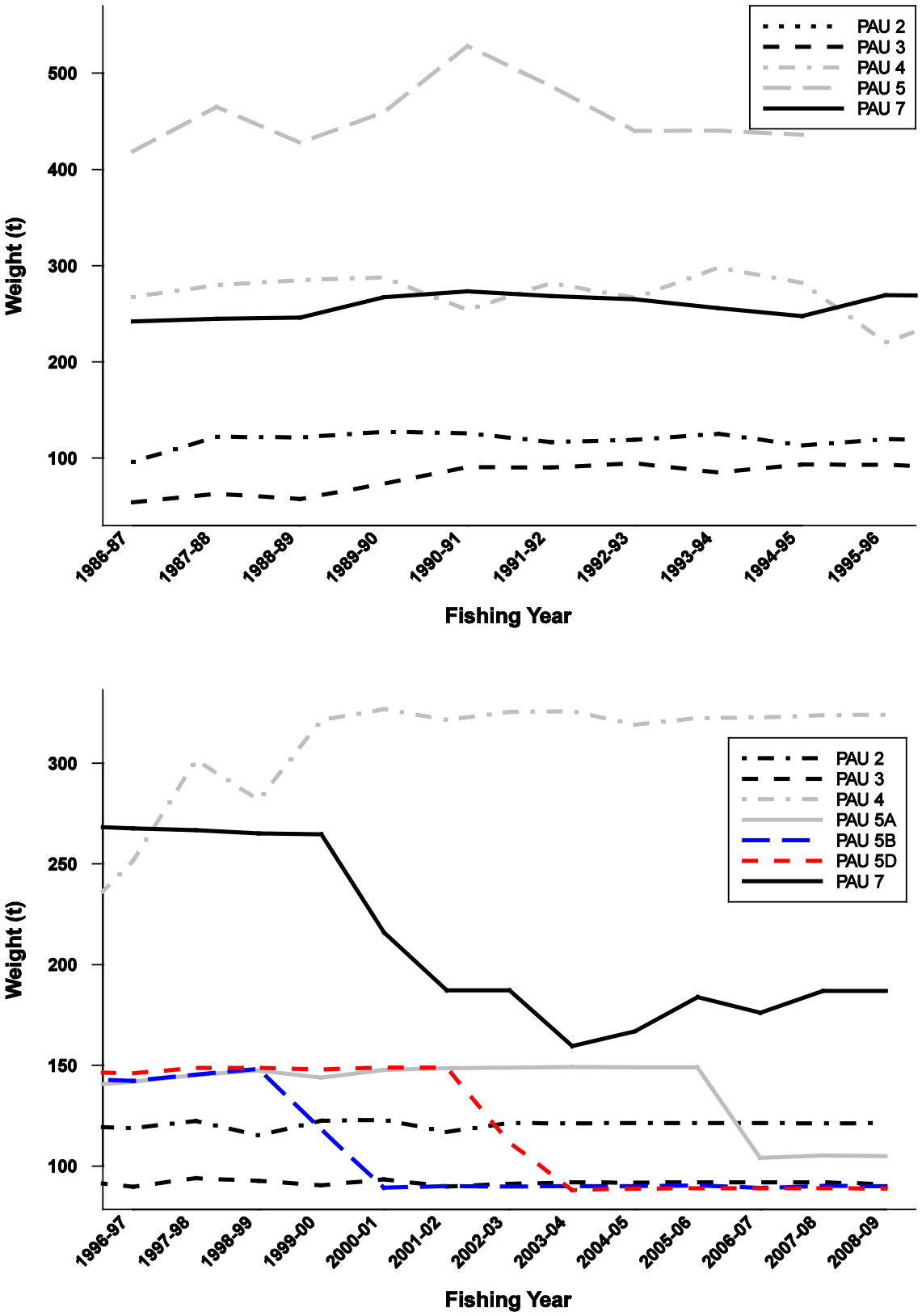


Figure 1: Historic landings for the major paua QMAs from 1983-84 to 1995-96 (top) and from 1996-97 to 2009-10 (lower).

Landings for PAU 1, PAU 6, PAU 10 and PAU 5 (prior to 1995) are shown in Table 1. For information on landings specific to other paua QMAs refer to the specific Working Group reports.

Table 1: TACCs and reported landings (t) of paua by Fishstock from 1983-84 to 2010-11.

	PAU 1		PAU 5		PAU 6		PAU 10	
PAU	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1983-84*	1	-	550	-	0.00	-	0.00	-
1984-85*	0	-	353	-	3.00	-	0.00	-
1985-86*	0	-	228	-	0.00	-	0.00	-
1986-87*	0.01	1.00	418.9	445	0.00	1.00	0.00	1.00
1987-88*	0.98	1.00	465	448.98	0.00	1.00	0.00	1.00
1988-89*	0.05	1.93	427.97	449.64	0.00	1.00	0.00	1.00
1989-90	0.28	1.93	459.46	459.48	0.00	1.00	0.00	1.00
1990-91	0.16	1.93	528.16	484.94	0.23	1.00	0.00	1.00
1991-92	0.27	1.93	486.76	492.06	0.00	1.00	0.00	1.00
1992-93	1.37	1.93	440.15	442.85	0.88	1.00	0.00	1.00
1993-94	1.05	1.93	440.39	442.85	0.10	1.00	0.00	1.00
1994-95	0.26	1.93	436.13	442.85	18.21H	1.00	0.00	1.00
1995-96	0.99	1.93	-	-	28.62H	1.00	0.00	1.00
1996-97	1.28	1.93	-	-	0.11	1.00	0.00	1.00
1997-98	1.28	1.93	-	-	0.00	1.00	0.00	1.00
1998-99	1.13	1.93	-	-	0.00	1.00	0.00	1.00
1999-00	0.69	1.93	-	-	1.04	1.00	0.00	1.00
2000-01	1.00	1.93	-	-	0.00	1.00	0.00	1.00
2001-02	0.32	1.93	-	-	0.00	1.00	0.00	1.00
2002-03	0.00	1.93	-	-	0.00	1.00	0.00	1.00
2003-04	0.05	1.93	-	-	0.00	1.00	0.00	1.00
2004-05	0.27	1.93	-	-	0.00	1.00	0.00	1.00
2005-06	0.45	1.93	-	-	0.00	1.00	0.00	1.00
2006-07	0.76	1.93	-	-	1.00	1.00	0.00	1.00
2007-08	1.14	1.93	-	-	1.00	1.00	0.00	1.00
2008-09	0.47	1.93	-	-	1.00	1.00	0.00	1.00
2009-10	0.20	1.93	-	-	1.00	1.00	0.00	1.00
2010-11	0.12	1.93	-	-	1.00	1.00	0.00	1.00

H experimental landings
* FSU data

1.2 Recreational fisheries

There is a large recreational fishery for paua. Estimated catches from telephone and diary surveys of recreational fishers (Teirney *et al*. 1997, Bradford 1998, Boyd & Reilly 2004, Boyd *et al.* 2004) are shown in Table 2. In 1996-97 sufficient diary data were available for an estimate in PAU 5D only (Bradford 1998, NIWA unpublished data). The Marine Recreational Fisheries Technical Working Group (RFTWG) has reviewed the harvest estimates from the national surveys. Due to a methodological error in the methodology, the harvest estimates for 1991-92 to 1993-94 and 1996-97 are not considered to be reliable. The harvest estimates for the 1999-2000 and 2000-01 surveys may be very inaccurate and some implausibly high. This may be due to a number of factors including the accuracy of the mean weight used to derive total harvest weight from the estimated numbers of paua caught by diarists, and the small number of diarists harvesting the stock in some areas. However relative comparisons can be made between stocks within the surveys.

Table 2: Estimated annual harvest of paua (t) by recreational fishers*.

Fishstock	PAU 1	PAU 2	PAU 3	PAU 5	PAU 5D	PAU 6	PAU 7
1991-92	-	-	35-60	50-80	-	-	-
1992-93	-	37-89	-	-	-	0-1	2-7
1993-94	29-32	-	-	-	-	-	-
1995-96	10-20	45-65	-	20-35	-	-	-
1996-97	-	-	-	N/A	22.5	-	-
1999-00	40-78	224-606	26-46	36-70	26-50	2-14	8-23
2000-01	16-37	152-248	31-61	70-121	43-79	0-3	4-11

*1991-1995 Regional telephone/diary estimates, 1995/96, 1999/00 and 2000/01 National Maine Recreational Fishing Surveys.

1.3 Customary fisheries

There is an important customary use of paua by Maori for food, and the shells have been used extensively for decorations and fishing devices. Limited data is available for reported customary landings in PAU 3; however no information is available for current levels of customary take for any other paua QMA. Kaitiaki are now in place in many areas and estimates of customary harvest can be expected in the near future.

1.4 Illegal catch

Current levels of illegal harvests are not known. In the past, annual estimates of illegal harvest for some Fishstocks have been provided by MFish compliance based on seizures. In the current paua stock assessments, nominal illegal catches are used.

1.5 Other sources of mortality

Paua may die from wounds caused by removal desiccation or osmotic and temperature stress if they are bought to the surface. Sub-legal paua may be subject to handling mortality by the fishery if they are removed from the substrate to be measured. Further mortality may result indirectly from being returned to unsuitable habitat or being lost to predators or bacterial infection. Gerring (2003) observed paua (from PAU 7) with a range of wounds in the laboratory and found that only a deep cut in the foot caused significant mortality (40% over 70 days). In the field this injury reduced the ability of paua to right themselves and clamp securely onto the reef, and consequently became more vulnerable to predators. The tool generally used by divers in PAU 7 is a custom made stainless steel knife with a rounded tip and no sharp edges. This design makes cutting the paua very unlikely (although abrasions and shell damage may occur). Gerring (2003) estimated that in PAU 7, 37% of paua removed from the reef by commercial divers were undersize and were returned to the reef. His estimate of incidental mortality associated with fishing in PAU 7 was 0.3% of the landed catch. Incidental fishing mortality may be higher in areas where other types of tools and fishing practices are used. Mortality may increase if paua are kept out of the water for a prolonged period or returned onto sand. To-date, the stock assessments developed for paua have assumed that there is no mortality associated with capture of undersize animals.

2. BIOLOGY

Paua are herbivores which can form large aggregations on reefs in shallow subtidal coastal habitats. Movement is over a sufficiently small spatial scale that the species may be considered sedentary. Paua are broadcast spawners and spawning is thought to be annual. Habitat related factors are an important source of variation in the post-settlement survival of paua. Growth, morphometrics, and recruitment can vary over short distances and may be influenced by factors such as wave exposure, habitat structure, availability of food and population density. A summary of generic estimates for biological parameters for paua are presented in Table 3. Parameters specific to individual paua QMAs are reported in the specific Working Group reports.

Table 3: Estimates of biological parameters for paua (H. *iris*).

Fishstock	Estimate	Source
1. Natural mortality (*M*)		
All	0.02-0.25	Sainsbury (1982)
2. Weight = a (length)^{b} (weight in kg, shell length in mm)		
a = 2.99E^{-08}	b = 3.303	Schiel & Breen (1991)

3. STOCKS AND AREAS

Using both mitochondrial and microsatellite markers Will & Gemmell (2008) found high levels of genetic variation within samples of *H. Iris* taken from 25 locations spread throughout New Zealand. They also found two patterns of weak but significant population genetic structure. Firstly, *H. iris* individuals collected from the Chatham Islands were found to be genetically distinct from those collected from costal sites around the North and South Islands. Secondly a genetic discontinuity was found loosely associated with the Cook Strait region. Genetic discontinuities within the Cook Strait region have previously been identified in sea stars, mussels, limpets, and chitons and are possibly related to contemporary and/or past oceanographic and geological conditions of the region. This split may have some implications for management of the paua stocks, with populations on the south of North Island, and north of South Island likely warranting management as separate entities; a status they already receive under the zonation of the current fisheries regions, PAU 2 in the North Island, and PAU 7 on the South Island.

4. STOCK ASSESSMENT

The dates of the most recent survey or stock assessment for each QMA are listed in Table 4.

Table 4: Recent survey and stock assessment information for each paua QMA

QMA	Type of survey or assessment	Date	Comments
PAU 1	No surveys or assessments have been undertaken		
PAU 2	Relative abundance estimate using standardised CPUE index based on commercial catch	2007	Standardised CPUE increased between 1992 and 2000 and has remained fairly stable up to 2007.
PAU 3	Relative abundance estimate using standardised CPUE index based on commercial catch	2007	Standardised CPUE decreased between 1990 and 1992 and has since remained fairly stable up to 2007.
PAU 4	Quantitative assessment using a Bayesian length based model	2004	In February 2010 the Shellfish Working Group (SFWG) agreed that due to the lack of adequate data as input into the Bayesian length-based model, a stock assessment for PAU 4 using this model was not appropriate.
PAU 5A	Quantitative assessment using a Bayesian length based model	2010	The 2010 stock assessment was conducted over two subareas of the QMA. The SFWG was satisfied that the stock assessment for both the Southern and Northern areas was reliable based on the available data. It was agreed by the SFWG that the range of estimated indicators for both the base case and hyperstability models used in the Northern area assessment were acceptable, but where within the range of estimates the actual status of the fishery is located is not clear.
PAU 5B	Quantitative assessment using a Bayesian length based model	2007	Spawning biomass was more likely to increase than decrease under levels of total catch and was likely to remain below S_{AV} for the next three years. Recruited biomass showed a tendency to decrease and remain below B_{AV}. For recruited biomass, however, it could not be concluded strongly that current biomass was less than the B_{AV} reference level.
PAU 5D	Quantitative assessment using a Bayesian length based model	2006	The stock assessment results were equivocal. In 2006 the Working Group noted the future direction of recruited biomass was uncertain because of the range of possible results that were dependent on modelling decisions.
PAU 6	Biomass estimate	1996	This fishery has a TACC of 1 t
PAU 7	Quantitative assessment using a Bayesian length based model	2012	The SFWG agreed the stock assessment was reliable based on the available data. Currently, spawning stock biomass is estimated at 22% B_0 Results suggest an increase to 23.4% B_0 in over the next three years at current levels of catch.
PAU 10	No surveys or assessments have been undertaken		

4.1 Estimates of fishery parameters and abundance

For further information on fishery parameters and abundance specific to each paua QMA refer to the specific Working Group report.

In 2008 standardised CPUE indices were constructed to assess relative abundance in PAU 2 and PAU 3. In QMAs where quantitative stock assessments have been undertaken, standardised CPUE is also used as input data for the Bayesian length-based stock assessment model. There is however a large

amount of literature on abalone which suggests CPUE may not be proportional to abundance as it is possible to maintain high catch rates despite a falling biomass. This occurs because paua tend to aggregate and divers move among areas to maximise their catch rates. Therefore, any apparent stability in CPUE should be interpreted with caution.

In PAU 4, 5A, 5B, 5D and 7 the relative abundance of paua has also been estimated from independent research diver surveys (RDS). In PAU 7, seven surveys have been completed over a number of years but only two surveys have been conducted in PAU 4. In 2009 and 2010 several reviews were conducted (Cordue P.L. (2009) and Haist V.(in press)) to assess; i) the reliability of the research diver survey index as a proxy for abundance; and ii) if the RDS data when used in the paua stock assessment models, results in model outputs that do not adequately reflect the status of the stocks. The reviews concluded that:

- Due to inappropriate survey design the RDS data appear to be of very limited use for constructing relative abundance indices
- There was clear non-linearity in the RDS index, the form of which is unclear and could be potentially complex.
- CVs of RDS index 'year' effects are likely to be underestimated, especially at low densities
- Different abundance trends among strata reduces the reliability of RDS indices, and the CVs are likely not to be informative about this
- It is unlikely the assessment model can determine the true non-linearity of the RDS index-abundance relationship because of the high variability in the RDS indices
- The non-linearity observed in the RDS indices is likely to be more extreme at low densities, so the RDSI is likely to mask trends when it is most critical to observe them.
- Existing RDS data is likely to be most useful at the research stratum level.

4.2 Biomass estimates

Biomass was estimated for PAU 6 in 1996 (McShane *et al*. 1996). However the survey area was only from Kahurangi Point to the Heaphy River.

Biomass has been estimated, as part of the stock assessments, for PAU 4, 5A, 5B, 5D and 7 (Table 4). For further information on biomass estimates specific to each paua QMA refer to the specific Working Group report.

4.3 Estimation of Maximum Constant Yield (*MCY*)

The only estimate of *MCY* is for PAU 6 (McShane *et al*. 1996). This QMA has a TACC of 1 t

MCY has not been estimated for any other fishstocks.

4.4 Estimation of Current Annual Yield (*CAY*)

The only estimate of *CAY* available is for the area from Kahurangi Point to the Heaphy River in PAU 6 (McShane *et al*. 1996).

CAY was not estimated for any other fishstocks.

5. STATUS OF THE STOCKS

The status of paua stocks PAU 2, PAU 3, PAU 4, PAU 5A, PAU 5B, PAU 5D and PAU 7 are given in the relevant Working Group reports.

6. FOR FURTHER INFORMATION

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