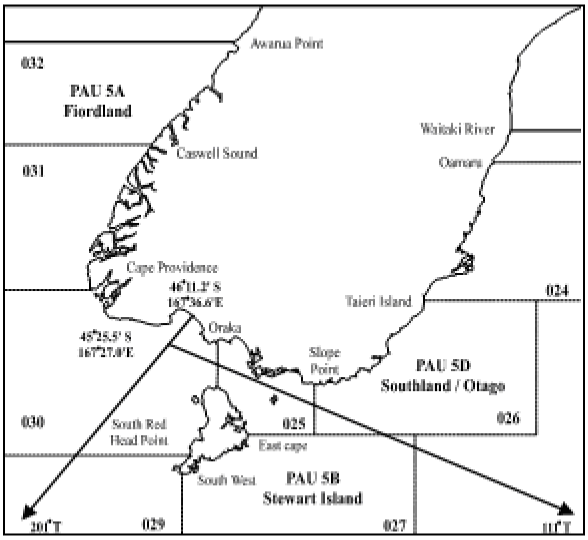
PAUA (PAU 5A) – Fiordland

(Haliotis iris)
Paua



1. FISHERY SUMMARY

Prior to 1995, PAU 5A was part of the PAU 5 QMA, which was introduced to the QMS in 1986 with a TACC of 445 t. As a result of appeals to the Quota Appeal Authority, the TACC increased to 492 t by the 1991-92 fishing year; PAU 5 was then the largest QMA by number of quota holders and TACC. Concerns about the status of the PAU 5 stock led to a voluntary 10% reduction in the TACC in 1994-95. On 1 October 1995, PAU 5 was divided into three QMAs (PAU 5A, PAU 5B, and PAU 5D; see the figure above) and the TACC was divided equally among them; the PAU 5A quota was set at 148.98 t.

There is no TAC for PAU 5A (Table 1): before the Fisheries Act (1996) a TAC was not required. When changes have been made to a TACC after 1996, stocks have been assigned a TAC. No allowances have been made for customary, recreational or other mortality

Table 1: Total allowable catches (TAC, t) allowances for customary fishing, recreational fishing, and other sources of mortality (t) and Total Allowable Commercial Catches (TACC, t) declared for PAU 5 and PAU 5A since introduction to the QMS.

Year	TAC	Customary	Recreational	Other mortality	TACC
1986 - 1991*	-	-	-	-	445
1991 - 1994*	-	-	-	-	492
1994 - 1995*	-	-	-	-	442.8
1995 - present	-	-	-	-	148.98

*PAU 5 TACC figures

1.1 Commercial fisheries

The fishing year runs from 1 October to 30 September.

On 1 October 2001 it became mandatory to report catch and effort using fine-scale reporting areas developed by the New Zealand Paua Management Company for their voluntary logbook program (Figure 1). These reporting areas were subsequently adopted on MFish PCELRs.

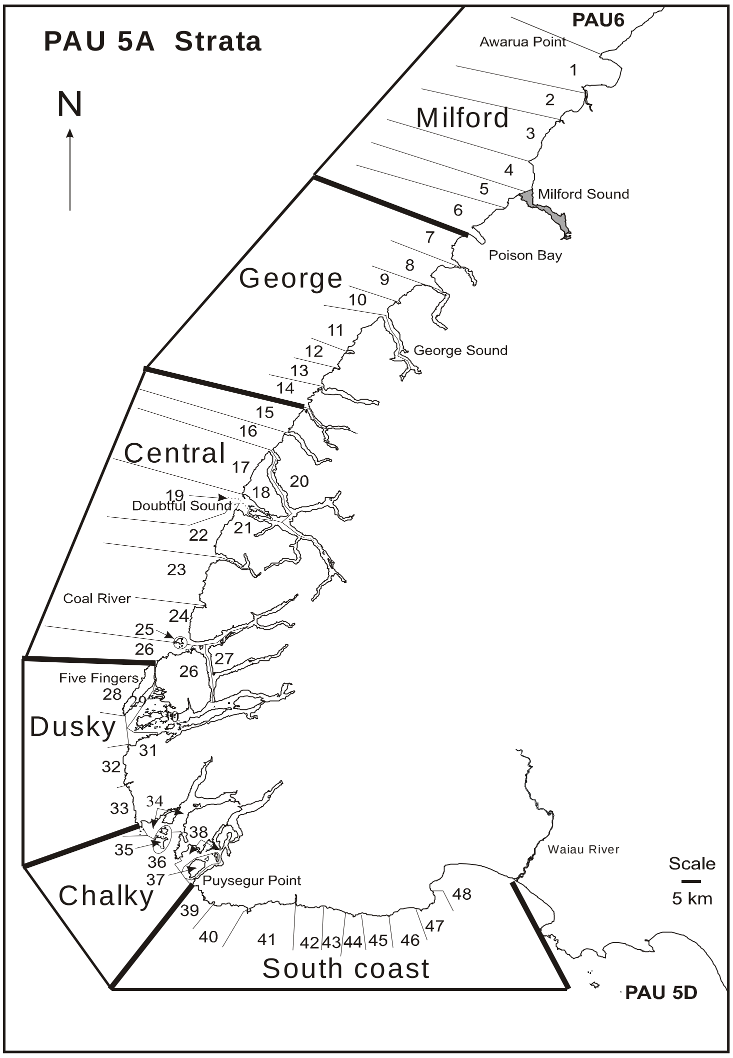


Figure 1: Map of statistical areas, fine scale statistical areas and voluntary management strata in PAU 5A.

Landings for PAU 5A are shown in Table 2. Landings for PAU 5 are reported in the introductory PAU Working Group Report.

Table 2: TACC and reported landings (t) of paua in PAU 5A from 1995-96 to present from MHR returns.

Year	Landings	TACC
1995-96	139.53	148.98
1996-97	141.91	148.98
1997-98	145.22	148.98
1998-99	147.36	148.98
1999-00	143.91	148.98
2000-01	147.70	148.98
2001-02	148.53	148.98
2002-03	148.76	148.98
2003-04	148.98	148.98
2004-05	148.95	148.98
2005-06	148.92	148.98
2006-07	104.03	148.98
2007-08	105.13	148.98
2008-09	104.82	148.98
2009-10	105.74	148.98
2010-11	104.40	148.98
2011-12	106.23	148.98

1.2 Recreational fisheries

For the purpose of the stock assessment model, the Shellfish Working Group (SFWG) agreed to assume that the 1974 recreational catch was 1 t, increasing linearly to 2 t in 2005. For further information on recreational fisheries refer to the introductory PAU Working Group Report.

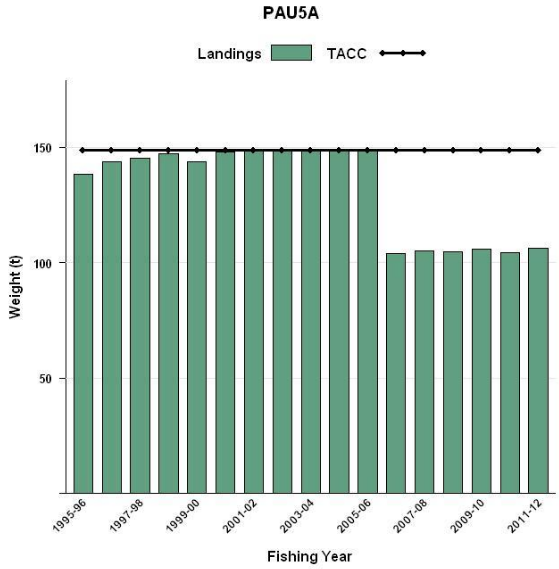


Figure 2: Landings and TACC for PAU5A from 1995-96 to present. For historical PAU5 landings prior to 1995-96 refer to the PAU introduction chapter, Figure 1 and Table 1.

1.3 Customary fisheries

For the purpose of the stock assessment model, the SFWG agreed to assume that customary catch has been constant at 1 t. For further information on customary fisheries refer to the introductory PAU Working Group Report.

1.4 Illegal catch

There are no estimates of illegal catch for PAU 5A. For the purpose of the stock assessment model, the SFWG agreed to assume that illegal catches have been a constant 5 t. For further information on illegal catch refer to the introductory PAU Working Group Report.

1.5 Other sources of mortality

For further information on other sources of mortality refer to the introductory PAU Working Group Report.

2. BIOLOGY

For further information on paua biology refer to the introductory PAU Working Group Report. Biological parameters derived using data collected from PAU 5A are summarised in Table 3. Size-at-maturity, natural mortality and annual growth increment parameters were estimated within the assessment model.

Table 3: Estimates of biological parameters (*H. iris*). All estimates are external to the model.

Stock area		Estimate	Source
1. Weight = a (length)^b (weight in kg, shell length in mm)			
PAU 5A	a = 2.99E-08	b = 3.303	Schiel & Breen (1991)
2. Size at maturity (shell length)			
PAU 5A	50% mature	93 mm	Samples from Dusky, George, and Milford areas
	95% mature	109 mm	(Fu *et al*. 2010)
3. Estimated annual increments (both sexes combined)			Samples from Central, Dusky, George, Chalky and
PAU 5A	At 75 mm	25.2 mm	the South Coast (Fu *et al*. 2010)
	At 120 mm	6.9 mm	

3. STOCKS AND AREAS

For further information on stocks and areas refer to the introductory PAU Working Group Report.

4. STOCK ASSESSMENT

The stock assessments for PAU 5A have previously been carried out at the QMA level. In 2010 the Shellfish Working Group decided to conduct the stock assessment for the two subareas of PAU 5A separately: a southern area including the Chalky and South Coast strata, and a northern area including the Milford, George, Central, and Dusky strata (Figure 1). The division was based on the availability of data, and differences in exploitation history and management initiatives.

4.1 Estimates of fishery parameters and abundance

Standardised CPUE data from CELR and PCELR records shows a steady decline in CPUE in the Southern areas from 1990 to 2008, but appears to have increased since then (Figure 3, Upper graphs). CPUE shows a general increase in the northern areas from 1990 to 2003 but declined in 2004 and remained relatively stable since (Figure 3, Lower graphs). The stock assessment assumes that commercial CPUE is proportional to abundance; however, this may not be the case for paua stocks because serial depletion tends to maintain catch rates despite a declining biomass. Apparent stability in CPUE must therefore be interpreted with caution.

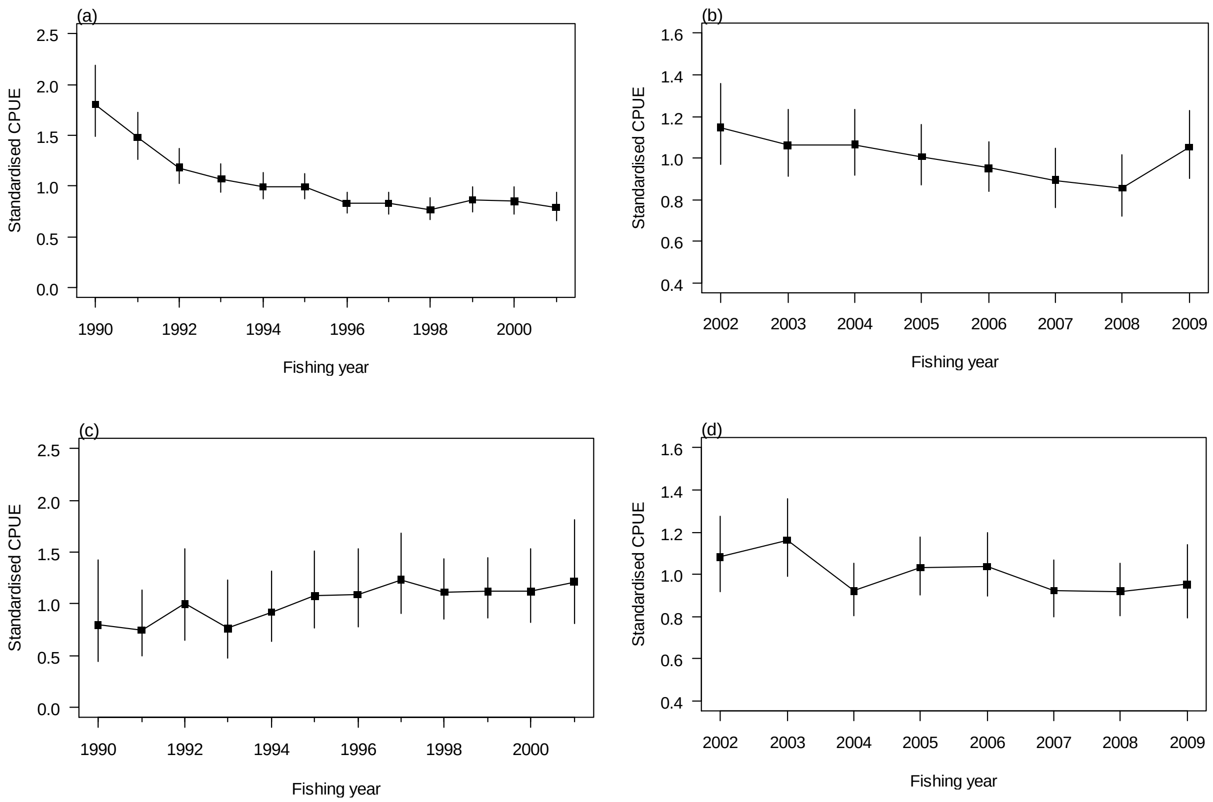


Figure 3: Standardised CPUE indices for the southern area of PAU 5A based on the CELR 1990–2001 (a) and PECLR 2002–2009 (b), and for the northern area based on CELR 1990–2001 (c) and PECLR 2002–2009 (d).

The abundance of paua in PAU 5A was also estimated from research diver surveys in 1996, 2002, 2003, 2006, and 2008–2010. Not every stratum was surveyed in each year, and before 2005-06 surveys were conducted only in the area from Dusky south (Table 4). Concerns about the reliability of this data as an estimate of relative abundance instigated several reviews in 2009 (Cordue 2009) and 2010 (Haist 2010). The reviews assessed i) the reliability of the research diver survey index as a proxy for abundance and ii) whether the RDSI, when used in the paua stock assessment models, results in model outputs that do not adequately reflect the status of the stocks. Both reviews suggest that outputs from paua stock assessments using the RDSI should be treated with caution. For a summary of the conclusions from the reviews refer to the introductory PAU Working Group Report.

4.2 Biomass estimates

The 2010 assessment for the southern (Fu & McKenzie 2010a) and northern (Fu & McKenzie 2010b) areas of PAU 5A incorporated revision of the length-based model first used in 1999 for PAU 5B (Breen *et al*. 2000a), and used in revised form for subsequent assessments in many paua stocks (Breen *et al*. 2003, Breen & Kim 2005, McKenzie & Smith 2009). For more information on the model structure and the data used refer to Fu & McKenzie (2010/35, 2010/36 & 2010/46).

The model partitioned the paua stock into a single sex population, with length classes from 70 mm to 170 mm, in groups of 2 mm. The stock was assumed to reside in a single, homogeneous area. The partition accounted for numbers of paua by length class within an annual cycle, where movement between length classes was determined by the growth parameters. Paua entered the partition following recruitment and were removed by natural mortality and fishing mortality.

The model simulates the population dynamics from 1965 to the current fishing year. Catches were available for 1974-2010 (commercial catch in 2010 was assumed to be the harvest cap), and were assumed to increase linearly between 1965 and 1973 from 0 to the 1974 catch level. Catches included commercial, recreational, customary, and illegal catch.

Recruitment was assumed to take place at the beginning of the annual cycle, and length at recruitment was defined by a uniform distribution with a range between 70 and 80 mm. Recruitment is modeled as an estimated baseline value with estimated annual deviations. No explicit stock-recruitment relationship was modelled in this assessment.

Maturity does not feature in the population partition. The model estimated proportions mature with the inclusion of length-at-maturity data. Growth and natural mortalities were also estimated within the model.

The models used two selectivities: the commercial fishing selectivity and research diver survey selectivity, both assumed to follow a logistic curve. From 2007 onward, following voluntary changes in the minimum harvest size, the commercial fishing selectivity was shifted by 5 mm for the southern area assessment, and 2 mm for the northern area assessment.

A point estimate of the mode of the joint posterior distribution (MPD) serves as the starting point for the Bayesian estimations and as the basis for some sensitivity tests. Markov Chain Monte Carlo (MCMC) simulations are used to estimate the marginal posterior distributions of model parameters, indicators and state of the stock. Indicators are based on current and projected states of the stock, and comparisons with a reference period, for both spawning and recruited biomass.

For both the Northern and Southern areas the data fitted in the assessment model were: (1) a standardised CPUE series based on the early CELR data, (2) a standardised CPUE series covering based on recent PCELR data, (3) a standardised research diver survey index (RDSI), (4) a research diver survey proportions-at-lengths series, (5) a commercial catch sampling length frequency series, (6) tag-recapture length increment data, and (7) maturity-at-length data. The catch history used as the model input included commercial, recreational, customary, and illegal catch. It was assumed that 80% of the non-commercial catch was taken from the southern area of PAU 5A, with the remainder being taken from the northern area.

For the Southern area the commercial catch history estimates were made under assumptions concerning the split of the catch between sub-stocks of PAU 5, and between subareas within PAU 5A. The base case model run has assumed 40% of the catch in Statistical Area 030 were taken from PAU 5A between 1985 and 1996. Estimates made under alternative assumptions (a lower bound of 18% and an upper bound of 61%) were used in sensitivity trials. The maturity and growth data included in the model were based on samples collected throughout PAU 5A, and the abundance and length frequency data were from Chalky and South Coast. The CPUE indices between 1990 and 2001 were based on catch effort data from Statistical Area 030. Only four years of catch sampling length frequencies (2002-2005) were included in the base case, as the sampling coverage is low since then and dubious before then. The additional catch sampling data were used in sensitivity trials.

For the Northern area the commercial catch history estimates between 1984 and 2010 were based on reported catch from Statistical Area 031 and 032, and estimates before 1984 were made using assumptions about the split of the catch between subareas within PAU 5A. The split proportions were inferred from the total estimated catch between 1984 and 95 from Statistical Areas 030, 031, and 032, assuming that 18% (upper bound), 40% (base case), or 61% (lower bound) of the annual catch in 030 was taken from PAU 5A. The maturity and growth data included in the model were based on samples collected throughout PAU 5A, and the abundance and length frequency data were from Milford, George, Central, and Dusky. As for the southern area assessment only four years of catch sampling length frequencies (2002-2005) were included, as the sampling coverage has been low since then and is unreliable before 2002. The decision was made following the southern area assessment.

A base case model was chosen by the SFWG for each of the assessments. For the southern area, the base case used the catch vector estimated under the base case assumption (the lower bound and upper bound estimates were investigated in sensitivities), and included CSLF data for 2002-2005 (the full CSLF series were used in the sensitivity). Recruitment deviations were estimated for 1986-2006. The commercial fishing selectivity was shifted by 5 mm after 2007 in line with the increase of the minimum harvest size (MHS). Each dataset was weighted so that the standard deviations of the normalised residuals were close to 1.0 for each dataset.

For the northern area, the base case used the catch vector estimated under the base case assumption and included CSLF data for 2002-2005. Recruitment deviations were estimated for 1982-2006. The initial run suggested that the model fitted poorly to the recent CPUE indices. Therefore two alternative runs were proposed: a base case model which up-weighted the recent CPUE series, and a hyperstability model which assumed a non-linear relationship between CPUE and vulnerable biomass. Another source of uncertainty relates to changes in fishing selectivity due to an increase in Minimum Harvest Size in 2007, which varied by region. The base case and hyperstability model assumed a shift of fishing selectivity by 2 mm since 2007, with alternatives of 3 and 4 mm investigated in sensitivity trials.

The assessment reported B_{init}, the spawning stock biomass at the end of initialisation phase, and B_0 the equilibrium spawning stock biomass assuming that recruitment is equal to the average recruitment from the period for which recruitment deviation were estimated. B_0 will differ from B_{init} if estimated average recruitment deviates from base recruitment. The assessment used the ratio of current and projected spawning stock biomass ($B_{current}$ and B_{2012}) to B_0 as preferred indicators of stock status (B_{init} was considered to have little biological meaning). The assessment also reported $B^r_{current}$, B^r_{init}, and B^r_0 being the current, initial, and virgin recruit-sized biomass respectively.

Recent practice has been to define a reference period in which biomass was stable, catches were good and the exploitation rate was sustainable. However, different biomass trajectories in sensitivity runs suggested that this approach was inappropriate for this assessment. Therefore S_{AV} and B_{AV} were not used as indicators in this assessment.

Projections were made until 2012 (a three- and two-year projection for the southern and northern area assessment respectively). Recruitments for projections were obtained by randomly re-sampling model estimates from 1996 until 2006. Catch assumed in the projection included the 2009-10 harvest cap and the estimates for recreational, customary and illegal harvest. Catches were not fully taken if the corresponding exploitation rate exceeded the upper bound of 0.65. For the northern area assessment, projections made under current catch levels suggested that biomass is likely to decrease over the next two years, therefore additional projections were made assuming reduced catch levels, and the model output $Pr(B_{2012} > B_{2010})$, the probability that projected spawning biomass in 2012 would be higher than in 2010.

4.2.1 Stock assessment results

Southern Area

For the southern area, the base case fitted most data credibly. However, it was unable to fit the steep decline in the CPUE between 1990 and 1994, and was also unable to explain the inter-annual changes in the observed RDSI. The estimates of recruitment were lower than average in the late 1980 and about average through the 1990s. Exploitation rate was generally below 0.4 but was variable. The exploitation rate has been high since the late 1990s, but showed decreases over the last few years, in line with the reduction of catch levels.

The summaries of indicators from the base case for the southern area assessment are shown in Table 4. The median of the posterior of B_0 was estimated to be 1155 t. The posterior trajectory of spawning stock biomass is shown in Figure 4. Current estimates from the base case suggest that the spawning stock population in 2009 (B_{current}) was about 35% (28-42%) B_0, and recruit-sized stock abundance ($B^r_{cureent}$) was about 24% (19-29%) of the initial state (B^r_0).

The projection suggested that the stock abundance will continue to increase over the next three years and the spawning stock biomass in 2012 is projected to be about 39% (31-50%) of B_0, or 14% (2-26%) more than current levels (Table 5). Based on the 1000 posterior samples, the probability that the spawning stock biomass will decrease in three year’s time is less than 7%.

The Effects of using alternative catch history estimates (upper and lower-bound) were also investigated. The MPD estimates of $B_{current}$ ranged from 30% to 52% of B_0 for those estimates.

Table 4: Summaries of the marginal posterior distributions of indicators for the base case of the southern area assessment. Columns show the 5th and 95th quantiles, median, minimum and maximum of each distribution. Biomass is in tonnes.

	Min	5%	Median	95%	Max
B_0	996	1066	1155	1252	1345
B_{init}	906	962	1025	1088	1152
$B_{\min}$	285	331	382	447	513
$B_{current}$	288	338	397	478	567
$B_{current} / B_0$	0.24	0.28	0.35	0.42	0.49
B^r_0	844	913	1007	1111	1206
B^r_{init}	776	835	894	945	999
$B^r_{\min}$	140	172	204	251	300
$B^r_{current}$	170	201	237	286	349
$B^r_{current} / B^r_0$	0.16	0.19	0.24	0.29	0.36
$U_{current}$	0.15	0.18	0.22	0.25	0.29

Table 5: Summary of key indicators from the projection for the base case of the southern area assessment: projected biomass as a percentage of the virgin and current stock status, for spawning stock and recruit-sized biomass, respectively.

Projection	2009	2010	2011	2012
% B_0	34.6 (27.3-43.9)	35.6 (27.8-45.2)	37.5 (29.3-47.7)	39.4 (30.9-50)
% B^r_0	20.7 (16.3-25.8)	21.5 (16.7-27.1)	22.2 (17.1-28.4)	23.2 (17.9-30)
% $B_{current}$	100 (100-100)	103 (99-107)	108 (100-117)	114 (102-126)
% $B^r_{current}$	100 (100-100)	104 (99-110)	108 (100-117)	112 (103-123)

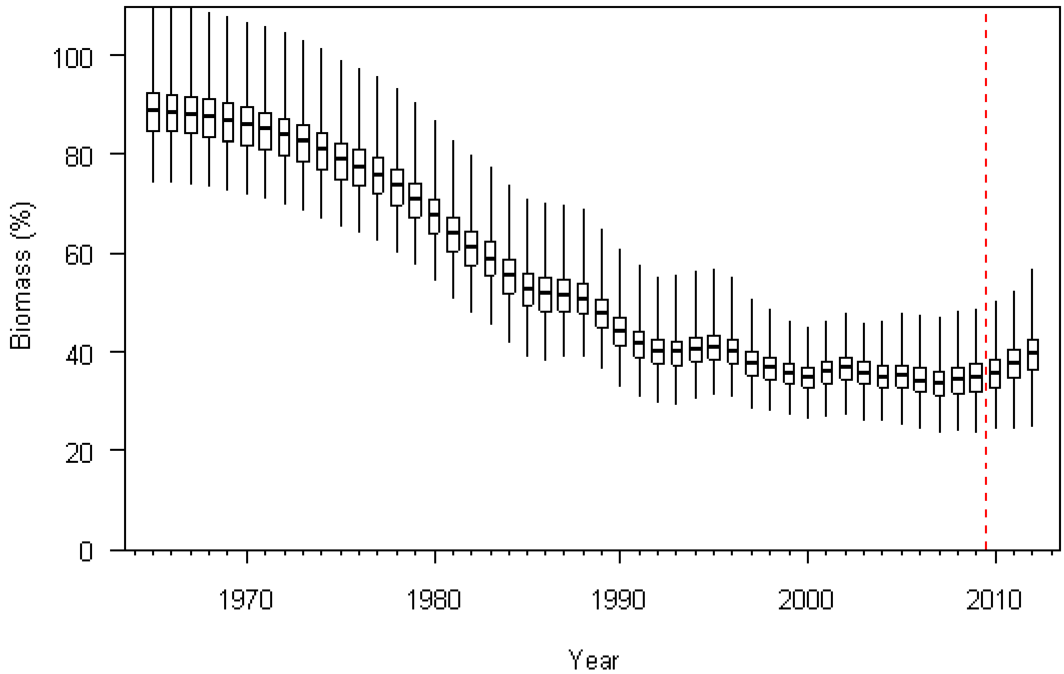


Figure 4: Posterior distributions of spawning stock biomass (including projection) as a percentage of B_0 for the southern area assessment. The box shows the median of the posterior distribution (horizontal bar), the 25th and 75th percentiles (box), with the whiskers representing the full range of the distribution. The boxes to the right of the dashed line indicate the projected spawning biomass to 2012 for each model assuming current catch level.

Northern area

The base case model suggested that recruitment was lower than average in the early 1980s and above average through the 1990s, and that the exploitation rate has increased since the mid 1990s, and remained at relatively high levels over the last few years. The initial run of the base case model suggested that the model fitted poorly to the recent CPUE indices. Therefore two alternative runs were proposed by the SFWG: a base case model which up-weighted the recent CPUE series, and a hyperstability model which assumed a non-linear relationship between CPUE and vulnerable biomass.

The summaries of indicators from the base case are shown in Table 6. The estimated spawning stock population in 2010 ($B_{current}$) is 41% (34-50%) B_0, and the recruit-sized stock abundance ($B^r_{current}$) is 26% (21-33%) of initial state (B^r_0). Estimates from the hyperstability model suggest that $B_{current}$ is 26% (21-35%) B_0, and $B^r_{current}$ is 16% (12-22%) of B^r_0 (Table 7).

Table 6: Summaries of the marginal posterior distributions of indicators for the base case of the northern area assessment. Columns show the 5th and 95th quantiles, median, minimum and maximum of each distribution. Biomass is in tonnes.

	Min	5%	Median	95%	Max
B_0	913	960	1012	1065	1123
B_{init}	727	782	858	961	1065
$B_{current}$	300	351	417	498	580
$B_{current}/B_0$	0.29	0.35	0.41	0.49	0.54
B^r_0	694	737	787	843	926
B^r_{init}	545	613	670	734	809
$B^r_{current}$	150	175	207	250	305
$B^r_{current}/B^r_0$	0.18	0.22	0.26	0.31	0.38
$U_{current}$	0.22	0.27	0.31	0.36	0.41

Table7: Bayesian median and 95% credible intervals of key indicators for the hyperstability model for the northern area assessment. Biomass is in tonnes.

Model	B_0 (t)	B^r(t)	B_{2010} (% B_0)	B^r_{2010} (%B^r_0)
Hyperstability	989 (923-1065)	805 (727-887)	26.4 (20.5-34.7)	16.1 (11.8-22.3)

Assuming greater selectivity shifts of 2 to 4mm since 2007 led to more optimistic estimates of stock status:, the median of B_{current} (%B_0) ranged from 41% to 50% for the base case, and from 26% to 30% for the hyperstability model . The posterior trajectories of spawning stock biomass for the base case and hyperstability models are shown in Figures 5 & 6.

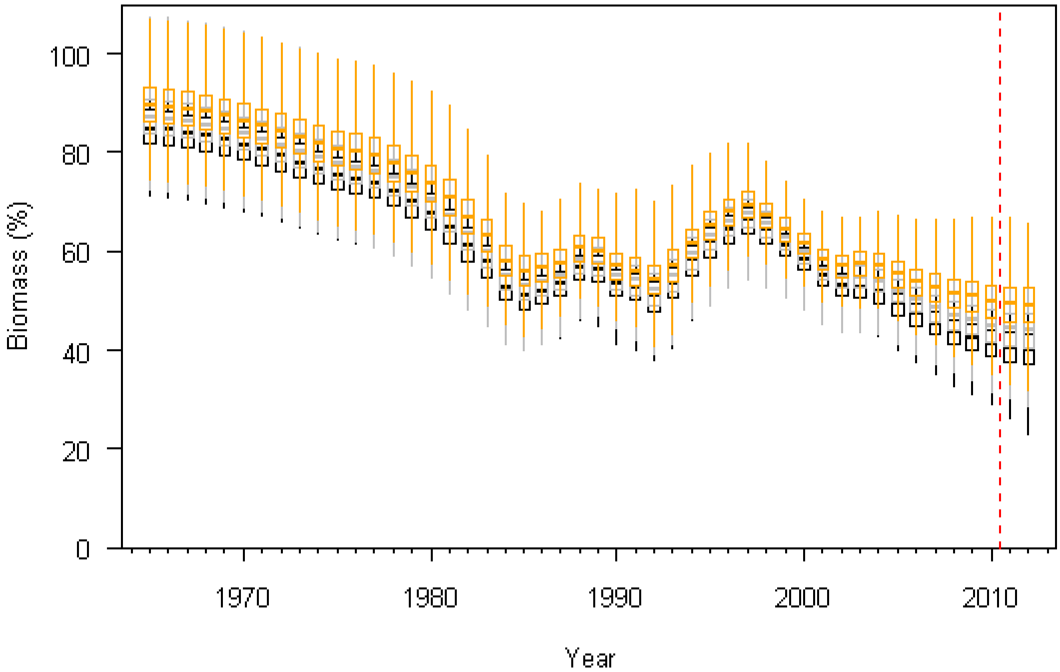


Figure 5 Posterior distributions of spawning stock biomass trajectory for base case (black), 6.1 (gray), and 6.2 (orange) for the northern area assessment. The box shows the median of the posterior distribution (horizontal bar), the 25th and 75th percentiles (box), with the whiskers representing the full range of the distribution. The boxes to the right of the dashed line indicate the projected spawning biomass to 2012 for each model assuming current catch level. Model 6.1 and 6.2, base case but commercial selectivity shifted by 3 and 4 mm respectively from 2007.

The projection made for the base case suggested that the stock abundance will decrease slightly over the next two years. The projected spawning stock biomass in 2012 has a median of 40% of B_0, about 3% less than current level (Table 8). The probability that the spawning stock biomass will increase in two year's time (Pr{ $B_{2012} > B_{current}$ }) is about 22%. The hyperstability model predicted a larger decline in abundance, with B_{2012} predicted to be 6% less than current state (Table 8). Projections made with alternative future catches suggested that Pr{ $B_{2012} > B_{current}$ } will increase with reduced catch levels. For the base case, Pr{ $B_{2012} > B_{current}$ } will be greater than 50% if the catch is reduced by 10 t each year for the next two years; for the hyperstability model, catch shelving of up to 20 t each year is required. Projections made with larger selectivity shifts have all predicted declines in future stock abundance, but generally with smaller risks.

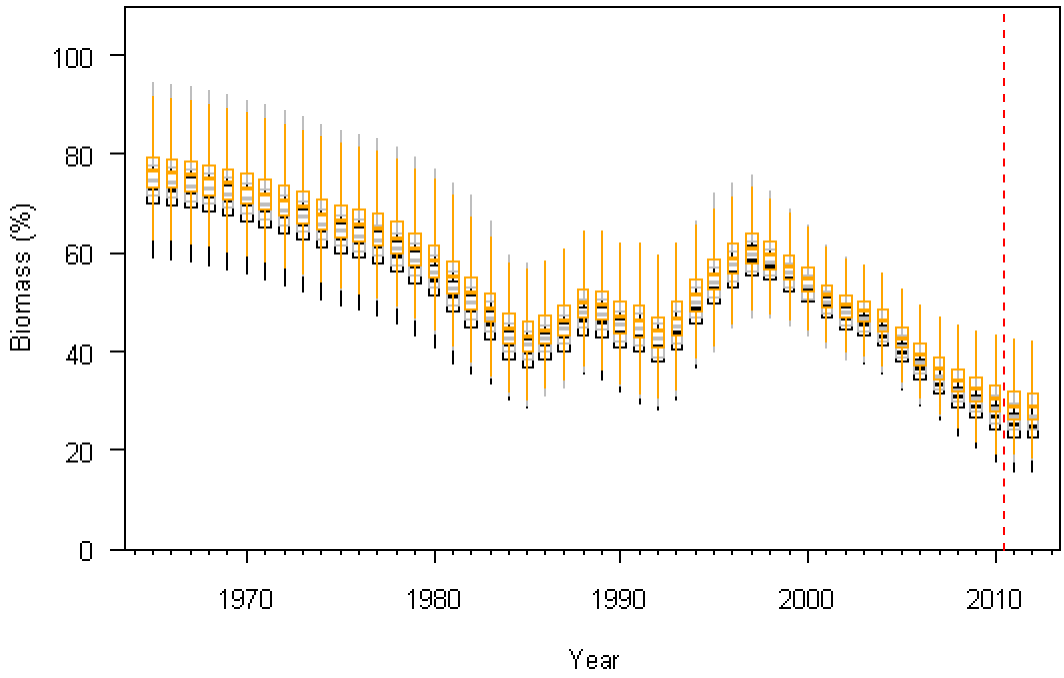


Figure 6: Posterior distributions of spawning stock biomass trajectory for hyperstability model (black), 8.1 (gray), and 8.2 (orange). The box shows the median of the posterior distribution (horizontal bar), the 25th and 75th percentiles (box), with the whiskers representing the full range of the distribution. The boxes to the right of the dashed line indicate the projected spawning biomass to 2012 for each model assuming current catch level. Model 8.0 and 8.2, hyperstability model but commercial selectivity shifted by 3 and 4 mm respectively from 2007.

Table 8: Bayesian median and 95% credible intervals of key indicators of projection assuming various future catch levels, the base case and hyperstability models for the northern area assessment.

Model	Catch	B_{2012} (% B_0)	B_{2012} (% B_{2010})	$Pr(B_{2012} > B_{2010})$
Base case	74 330	40.0 (31.8-49.5)	0.97 (0.89-1.05)	0.218
	69 330	40.7 (32.5-50.2)	0.99 (0.91-1.06)	0.364
	64 330	41.4 (33.2-50.8)	1.00 (0.93-1.08)	0.520
Hyperstability	74 330	24.7 (19.1-33.3)	0.94 (0.82-1.06)	0.140
	64 330	25.4 (19.1-34.7)	0.97 (0.85-1.07)	0.278
	54 330	26.8 (19.7-36.1)	1.01 (0.89-1.12)	0.598

The Shellfish Working Group was satisfied that the stock assessment for both the Southern and Northern areas of PAU 5A 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.

4.3 Yield estimates and projections

No estimate of *MCY* has been made for PAU 5A.

No estimate of *CAY* has been made for PAU 5A.

4.5 Other factors

A number of factors affected the overall validity of the assessment.

There were uncertainties in the estimated catch history for PAU 5A and its subareas before 1995. The results from the southern area assessment suggested that estimates of stock status are sensitive to the range of assumptions made for the estimated catch history. For the northern area of PAU 5A, the commercial catch history is well determined back to 1984, although uncertainty exists for the pre-1984 catch, which is expected to have minor effects on the overall assessment. There is little information on the historical catches in Fiordland, but anecdotal evidence suggested that the catch between 1981 and 1984 was about 60-70 t annually (Storm Stanley pers. comm.). The lower and upper-bound catch estimates used in the assessment may have encompassed many of the uncertainties in the historical catches. In addition, non-commercial catch estimates are also very uncertain, and large differences may exist between the catches assumed and the catch actually taken. In both assessments, the modelled area is treated as if it were a single stock with homogeneous biology, habitat and fishing pressure. It is assumed that:

- recruitment affects the modelled area in the same way
- natural mortality does not vary by size or year in the modelled area
- growth has the same mean and variance in the modelled area, although in reality growth may be stunted in some areas and fast-growing in others

Variation in growth is addressed to some extent by having a stochastic growth transition matrix based on increments observed in several different sites. Similarly, the length frequency data are integrated across samples from many places. An open question is whether a model fitted to data aggregated from a large area, within which smaller populations respond differently to fishing, results in credible estimates of the response of the aggregated sub-populations.

This effect is likely to make model results optimistic. For instance, if some local stocks are fished very hard and others are not fished, recruitment failure can result due to the depletion of spawners, because spawners must breed close to each other, and because the dispersal of larvae may be limited. Recruitment failure is a common observation in abalone fisheries internationally. Local processes may decrease recruitment, an effect that cannot be accounted for in the current model.

A significant source of uncertainty is that fishing may cause spatial contraction of populations or that some populations become relatively unproductive after initial fishing due, for example, to reductions in density that may impede successful spawning. If this happens, the model will overestimate productivity in the population as a whole. Historical catches may have been interpreted in the model as good recruitments, whereas they may actually have been the result of serial depletion.

5. STATUS OF THE STOCKS

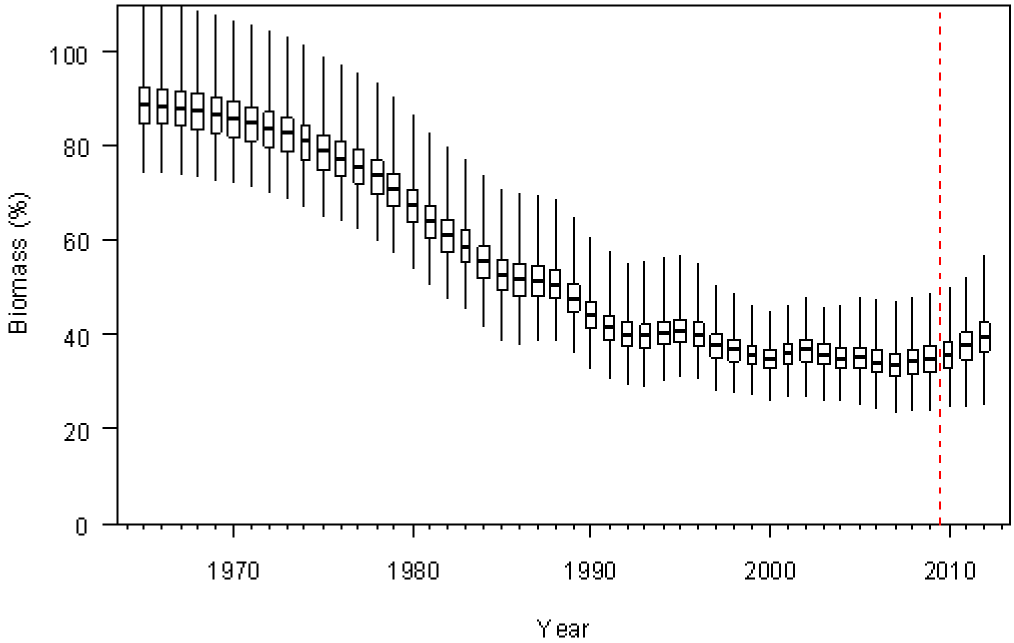
Stock Structure Assumptions
A genetic discontinuity between North Island and South Island paua populations was found approximately around the area of Cook Strait (Will & Gemmell 2008).

- **PAU 5A - *Haliotis iris***

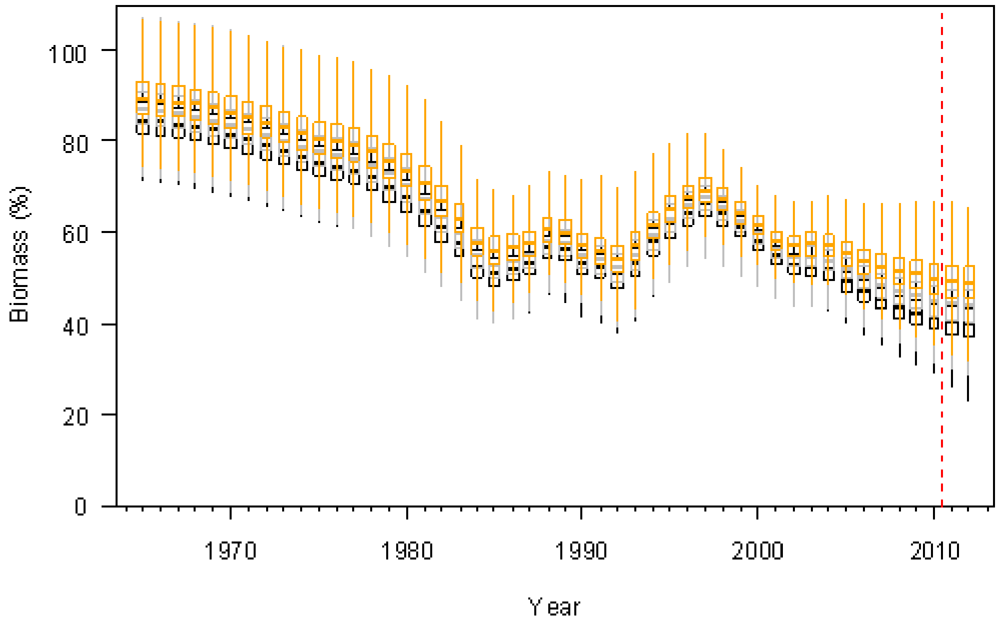
Stock Status	
Year of Most Recent Assessment	2010
Assessment Runs Presented	Southern Area: base case model Northern Area: base case and hyperstability models
Reference Points	Target: 40% B_0 (Default as per HSS) Soft Limit: 20% B_0 (Default as per HSS) Hard Limit: 10% B_0 (Default as per HSS)
Status in relation to Target	Southern Area: Spawning stock biomass was estimated at 35% B_0. Northern Area: Spawning stock biomass was estimated at 41% B_0 by the base case model but only at 26% B_0 by the hyperstability model. 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. The status in reflection to the target is therefore unkown.
Status in relation to Limits	Southern Area: Very Unlikely (< 10%) to be below the soft and hard limits. Spawning stock biomass was estimated at 35% $B_{0.}$ Northern Area: Unlikely (< 40%) to be below the soft limit. Very Unlikely (< 10%) to be below the hard limit.

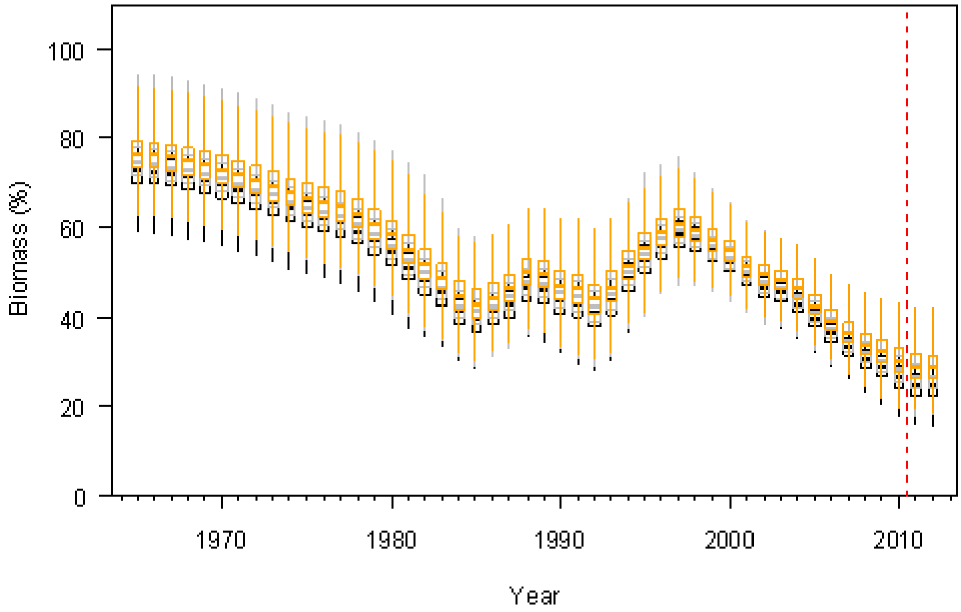
Historical Stock Status Trajectory and Current Status



Posterior distributions of spawning stock biomass (including projection) as a percentage of B_0 for the southern area assessment. The box shows the median of the posterior distribution (horizontal bar), the 25th and 75th percentiles (box), with the whiskers representing the full range of the distribution. The boxes to the right of the dashed line indicate the projected spawning biomass to 2012 for each model assuming current catch level.



Posterior distributions of spawning stock biomass trajectory for base case (black), 6.1 (gray), and 6.2 (orange) for the northern area assessment. The box shows the median of the posterior distribution (horizontal bar), the 25th and 75th percentiles (box), with the whiskers representing the full range of the distribution. The boxes to the right of the dashed line indicate the projected spawning biomass to 2012 for each model assuming current catch level. Model 6.1 and 6.2, base case but commercial selectivity shifted by 3 and 4 mm respectively from 2007.



Posterior distributions of spawning stock biomass trajectory for hyperstability model (black), 8.1 (gray), and 8.2 (orange) for the northern area assessment. The box shows the median of the posterior distribution (horizontal bar), the 25th and 75th percentiles (box), with the whiskers representing the full range of the distribution. The boxes to the right of the dashed line indicate the projected spawning biomass to 2012 for each model assuming current catch level. Model 8.0 and 8.2, hyperstability model but commercial selectivity shifted by 3 and 4 mm respectively from 2007.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Southern: Spawning stock biomass generally declined from 2002 to 2007 but has been increasing up to 2009. Northern: Spawning stock biomass has been declined from 1997 until 2010
Recent Trend in Fishing Mortality or Proxy	-
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	Southern: Spawning stock biomass in 2012 is projected to be about 39% (31-50%) of B_0, or 14% (2-26%) more than current levels. The probability that the spawning stock biomass will decrease in three year's time is less than 7%. Northern: The base case model projected spawning stock biomass in 2012 to be 40% of B_0, about 3% less than current level. The probability that the spawning stock biomass will increase by 2012 is about 22%. The hyperstability model predicted a larger decline in abundance, with B_{2012} predicted to be 6% less than current state. Projections made with alternative future catches suggested that Pr{ $B_{2012} > B_{current}$ } will increase with reduced catch levels. For the base case, Pr{ $B_{2012} > B_{current}$ } will be greater than 50% if the catch is reduced by 10 t each year for the next two years; for the hyperstability model, catch shelving of up to 20 t each year is required.
Probability of Current Catch or TACC causing decline below	Soft Limit: Southern - Very Unlikely (< 10%) Northern - Unlikely (< 40%)

Limits	Hard Limit: Southern - Very Unlikely (< 10%) Northern - Very Unlikely (< 10%)

Assessment Methodology		
Assessment Type	Full quantitative stock assessment	
Assessment Method	Length-based Bayesian model	
Main data inputs	CPUE, RDSI, CSLF, RDLF, catch history	
Period of Assessment	Latest assessment: 2010	Next assessment: Unknown
Changes to Model Structure and Assumptions	- Previous assessment in 2005 was for a single QMA. The QMA was assessed as two separate areas for the 2010 assessment	
Major Sources of Uncertainty	- Potential bias in RDSI - CPUE as a reliable index of abundance - Data are not reliable - Model is homogeneous - Model assumptions may be violated	

Qualifying Comments
-

Fishery Interactions
-

6. FOR FURTHER INFORMATION

Andrew N.L., Naylor J.R., Gerring P. 1999. A modified timed-swim method for paua stock assessment. New Zealand Fisheries Assessment Report 2000/4: 23p.

Andrew N.L., Naylor J.R., Kim S.W. 2002. Fishery independent surveys of the relative abundance and size structure of paua (Haliotis iris) in PAU 5B and 5D. New Zealand Fisheries Assessment Report 2002/41.41 p.

Breen P.A., Kim S.W. 2004. The 2004 stock assessment of paua (*Haliotis iris*) in PAU 5A. New Zealand Fisheries Assessment Report 2004/40: 86p.

Breen P.A., Kim S.W. 2007. The 2006 stock assessment of paua (*Haliotis iris*) stocks PAU 5A (Fiordland) and PAU 5D (Otago). New Zealand Fisheries Assessment Report 2007/09: 164p.

Breen P.A., Kim S.W., Andrew N.L. 2003. A length-based Bayesian stock assessment model for abalone. Marine and Freshwater Research 54(5): 619-634.

Breen P.A., Smith, A.N.H. 2008. Data used in the 2007 assessment for paua (*Haliotis iris*) stock PAU 5B (Stewart Island). New Zealand Fisheries Assessment Report 2008/6. 45 p.

Cordue P.L. 2009. Analysis of PAU 5A diver survey data and PCELR catch and effort data. SeaFic and PAUMac 5 report. 45p

Chen Y., Breen P.A., Andrew N.L. 2000. Impacts of outliers and mis-specification of priors on Bayesian fish stock assessment. Canadian Journal of Fisheries and Aquatic Science. 57: 2293-2305.

Fu D., McKenzie A. 2010. The 2010 stock assessment of paua (Haliotis iris) for Chalky and South Coast in PAU 5A. New Zealand Fisheries Assessment Report 2010/36.

Fu D., McKenzie A. 2010. The 2010 stock assessment of paua (Haliotis iris) for Milford, George, Central, and Dusky in PAU 5A. New Zealand Fisheries Assessment Report 2010/46

Fu D., McKenzie A., Naylor R. 2010. Summary of input data for the 2010 PAU 5A stock assessment. New Zealand Fisheries Assessment Report 20010/35.

Gerring P.K., Andrew N.L., Naylor J.R. 2003. Incidental fishing mortality of paua (*Haliotis iris*) in the PAU 7 commercial fishery. New Zealand Fisheries Assessment Report 2003/56: 13p.

Hart A.M. 2005. Review of paua research surveys. Final Research Report to the Ministry of Fisheries for project SAP2005-02. 20 p (Unpublished report held by the Ministry of Fisheries, Wellington.).

Haist V. 2010. Paua research diver survey: review of data collected and simulation study of survey method. Draft New Zealand Fisheries Assessment Report 2010/38.

Kendrick T.H., Andrew N.L. 2000. Catch and effort statistics and a summary of standardised CPUE indices for paua (*Haliotis iris*) in PAU 5a, PAU 5B, and PAU 5D. New Zealand Fisheries Assessment Report 2000/47: 25p.

McKenzie A., Smith A.N.H. 2009. The 2008 stock assessment of paua (*Haliotis iris*) in PAU 7. New Zealand Fisheries Assessment Report 2009/34. 84 p

Naylor J. R., Andrew N.L. 2002. Determination of paua growth in PAU 2, 5A, 5B, and 5D. New Zealand Fisheries Assessment Report. 2002/34.

Naylor J. R., Breen P.A. 2008. Fine-scale growth in paua populations. Final Research Report for the Ministry of Fisheries. Project PAU2006/04. 33 p. (Unpublished report held by the Ministry for Primary Industries, Wellington.)

Pirker J.G. 1992. Growth, shell-ring deposition and mortality of paua (*Haliotis iris* Martyn) in the Kaikoura region. MSc thesis, University of Canterbury. 165p.

Sainsbury K.J. 1982. Population dynamics and fishery management of the paua, *Haliotis iris.* 1. Population structure, growth, reproduction and mortality. New Zealand Journal of Marine and Freshwater Research 16: 147-161.

Schiel D.R. 1992. The paua (abalone) fishery of New Zealand. In: Shepherd S.A., Tegner MJ., Guzman del Proo S. eds., Abalone of the World: Biology, fisheries, and culture. Blackwell Scientific, Oxford.

Schiel D.R., Breen P.A.1991. Population structure, ageing and fishing mortality of the New Zealand abalone (*Haliotis iris*). Fishery Bulletin 89: 681-691.

Vignaux M. 1993. Catch per unit effort (CPUE) analysis of the hoki fishery, 1987-92. New Zealand Fisheries Assessment Research Document 1993/14: 23p.

Will M.C., Gemmell N.J. 2008. Genetic Population Structure of Black Foot paua. New Zealand Fisheries Research Report. GEN2007A: 37p