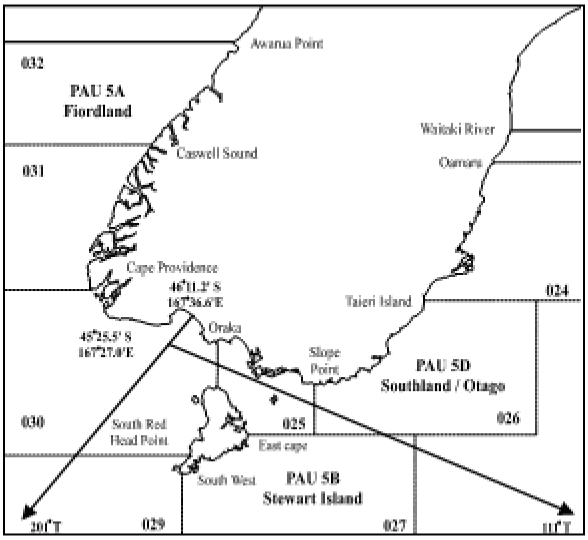
PAUA (PAU 5A) – Fiordland

(Haliotis iris)
Paua



1. FISHERY SUMMARY

1.1 Commercial fisheries

PAU 5, encompassing Southland, Otago, Stewart Island and Fiordland, was introduced into the Quota Management System on 1 October 1986 with a TACC of 445 t, which had increased to 492 t by 1992 as a result of appeals to the Quota Appeal Authority. Concerns about the status of the PAU 5 fishery led to a voluntary 10% reduction in the TACC in 1992–93. In the 1995–96 fishing year, PAU 5 was separated into three sub-stocks: PAU 5A, Fiordland; PAU 5B, Stewart Island; and PAU 5D, Southland / Otago (see figure above). The TACC was divided equally among the new stocks and the quota for PAU 5A was set at 148.98 t (Table 1). It is widely considered that this led to a large redistribution of catch from Stewart Island to Fiordland and the Catlins/Otago coast (Elvey *et al.* 1997). The exact increase in catch in the new PAU 5A caused by the subdivision cannot be determined with certainty because one statistical area used to report catch and effort straddled the new stocks (Figure above; Kendrick & Andrew 2000). The fishing year runs from 1 October to 30 September. In this report, the fishing year is referred to using the second part; *viz*, 2002–03 is termed “2003”.

Table 1: TACC and reported landings (t) of paua in PAU 5A from 1995–96 to 2007–08.

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

1.2 Recreational fisheries

The 1996 and 1999–2000 National Recreational Fishing Surveys estimated 37.1 t and 53.2 t were taken respectively from PAU 5 by recreational fisheries but with no sub-stock breakdown. The 2000–01 survey estimated a recreational harvest of 8000 paua from PAU 5A. At an average weight of 357 g, these numbers equate to a recreational harvest of 2.8 t. The Marine Recreational Fisheries Technical

Working Group considered that some harvest estimates from the 1999/2000 and 20002/001 surveys for some fish stocks were unbelievably high. The Shellfish Fisheries Working Group (SFWG) examined estimates from national recreational surveys conducted in 1996 and 1999–01. For the purpose of the stock assessment model, the SFWG agreed to assume that the 1974 recreational catch was 1 t, increasing linearly to 2 t in 2005.

On the catch and effort forms used since 2002, fishers can report paua they land as part of a recreational catch entitlement (destination code “F”). The sum of such catches for 2002 through to the partial data for 2006 was only 124 kg for PAU 5A.

1.3 Customary non-commercial fisheries

There is an important customary non-commercial use of paua by Maori for food, and the shells have been used extensively for decorations and fishing devices. Records of customary non-commercial catch taken under the authority of customary fishing permits show that only 70 paua were taken in 2000, no catches have been recorded since then. For the purpose of the stock assessment model, the SFWG agreed to assume that customary non-commercial catch has been constant at 1 t.

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.

1.5 Other sources of mortality

Sub-legal paua may be subject to handling mortality by the fishery if they are removed from the substrate to be measured. Paua may die from wounds caused by removal, desiccation or osmotic and temperature stress at the surface. Further mortality may result indirectly from paua being returned to unsuitable habitat or being lost to predators or bacterial infection. Gerring *et al.* (2003) estimated that in PAU 7, 27% of paua removed from the reef by commercial divers were undersize and were returned to the reef. Their estimate of incidental mortality associated with fishing in PAU 7 was 0.3% of the landed catch. The low estimate was attributed to improved handling behaviour by divers and their use of a benign removal tool. Incidental fishing mortality may be higher in other areas where these practices have not been adopted. Pirker (1992) reported that in some fisheries, as much as 54% of paua removed from the reef may be undersize. Of these paua, up to 13% were damaged in some way and field estimates suggest up to 80% of these may fall victim to predation by wrasses or starfishes following their return to the reef. After discussion by the SFWG, it was agreed not to incorporate this source of mortality in the stock assessment.

2. BIOLOGY

Growth, morphometrics and recruitment can vary over short distances and may be influenced by factors such as wave exposure, predation and food availability. A summary of values for biological parameters used in the PAU 5A assessment is presented in Table 2. Natural mortality was estimated in the assessment using a lognormal prior.

Table 2: Estimates of biological parameters (*H. iris*)

	Estimate		Source
1. Natural mortality (*M*)			
All	0.13		Estimated by the model
2. Weight = a (length)^b (weight in kg, shell length in mm)			
	a = 2.99E-08	b = 3.303	Schiel & Breen (1991)
3. Size at maturity (shell length)			
50% mature	97 mm (96–98)		Median (5–95% range) of posteriors estimated by the model
95% mature	108 mm (107–110)		Median (5–95% range) of posteriors estimated by the model
4. Estimated annual increments (both sexes combined			
At 75 mm	17.2 (15.7–18.7)		Median (5–95% range) of posteriors estimated by the model
At 120 mm	5.1 (4.7–5.4)		

3. STOCKS AND AREAS

PAU 5A was established in 1995–96 when PAU 5 was divided into three sub-areas, each with a TACC of 148.98 t. On 1 October 2001 it became mandatory to report catch and effort from 49 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 CELRs.

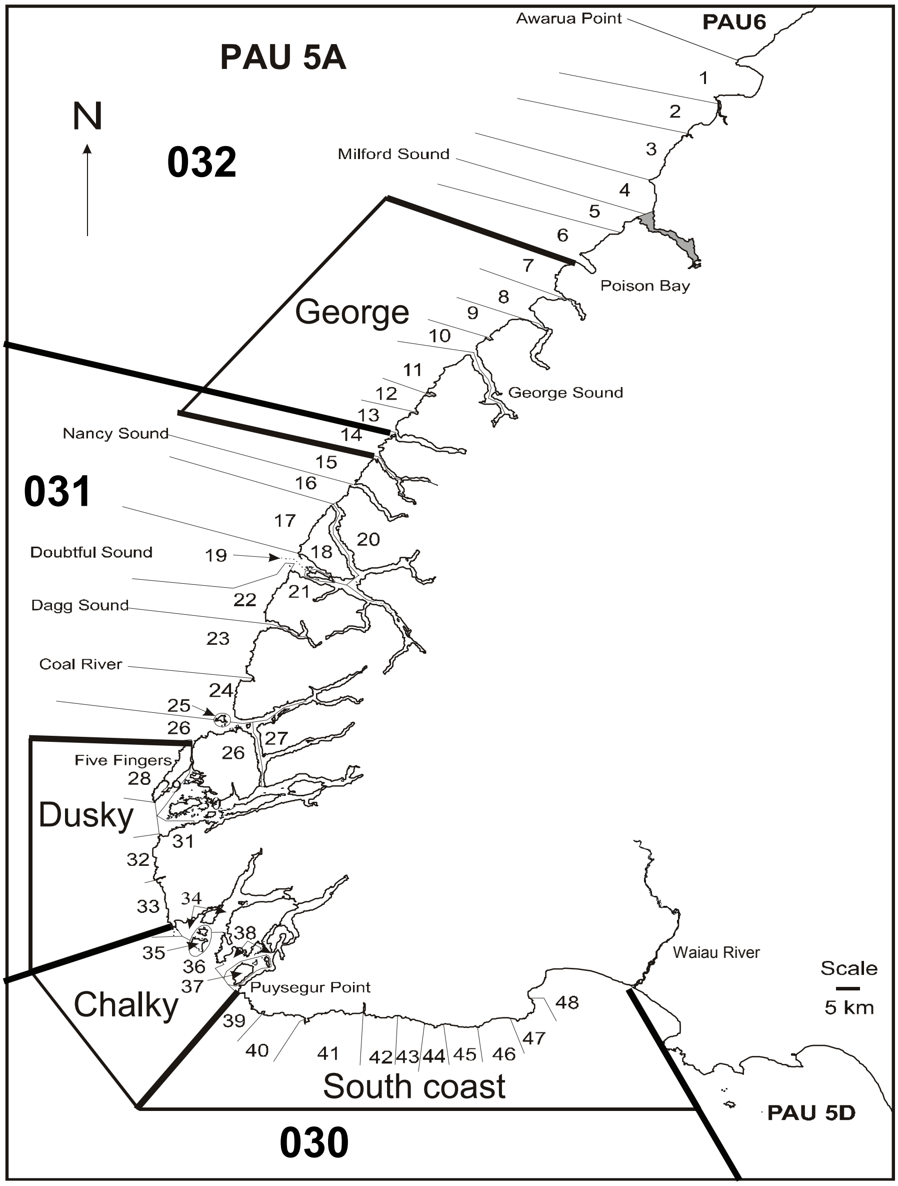


Figure 1: Map of statistical areas, fine scale statistical areas and research strata in PAU 5A.

The present Fishstock boundaries may not represent a single discrete paua stock for PAU 5A.

4. STOCK ASSESSMENT

4.1 Estimates of fishery parameters and abundance

The 2006 assessment (Breen & Kim 2007) follows an assessment undertaken by Breen & Kim (2004), and is based on estimates made by fitting a Bayesian length-based production model to fishery data. The 2004 assessment was not accepted by the Plenary.

The integrated length-based model used for the 2005 assessment of PAU 7 (Breen & Kim 2005) was used for the 2006 assessment. The model was published by Breen *et al*. (2003).

4.1.1 Model structure

The model generates a population and simulates its dynamics through 32 years of fishing, growth, natural mortality and recruitment. The predicted mid-season recruited biomass is fitted to the observed CPUE indices, and an index of numbers above 90 mm shell length is fitted to the analogous observed indices from research diver surveys. The predicted mid-season population length structure is fitted to observed length distributions from commercial catch sampling and research diver surveys. Outputs are the present and projected states of the stock. The assessment is based on the marginal posterior distributions of the parameters and derived parameters of interest. Males and females are not modeled separately.

Growth is modeled as a stochastic transition matrix calculated from the estimated growth parameters, which include parameters for variation in growth. A contribution to the total likelihood function comes from comparison of observed and expected increments in the tag-recapture data. Research diver and commercial fishery selectivity-at-size are modeled with two estimated parameters for each. Maturity-at-size is estimated with two parameters.

Exploitation rate (catch as a proportion of beginning of season biomass) is constrained to an upper bound of 0.65.

Recruitment is modeled as an estimated baseline value with estimated annual deviations. These have an assumed mean and standard deviation. No stock-recruit relationship is estimated and projections are made by re-sampling recruitment from the recent past.

Six data sets from PAU 5A were available for fitting within the model: standardised CPUE, standardised research diver survey index (RDSI), length frequencies from catch sampling and population surveys (CSLF and RDLF), tag-recapture data and maturity data. The model estimates a common error term and each dataset can be given a relative weight that does not affect the overall uncertainty. Iterative re-weighting is used to obtain standard deviations of standardized residuals equal to unity for each dataset.

The model is driven by catch. Exploitation rate is calculated from observed catch and model biomass. 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.

4.1.2 Data used in the assessment

Estimated catches for PAU 5A were based on a number of assumptions. The exact catch from PAU 5A, before 1995, cannot be determined with certainty because one statistical area used to report catch and effort straddled 5A, 5B and 5D (Kendrick & Andrew 2000). The catch vector used (Figure 2) comprises estimated PAU 5A catch from 1974 through 2005. Catches for the years 1964 to 1973 were assumed, based on linear interpolation from zero in 1962 to the level of the 1974 catch.

The Working Group agreed to assume that recreational catch was 1 t in 1974, increasing to 2 t in 2005, that customary catch was 1 t throughout, and that illegal catch was 5 t throughout.

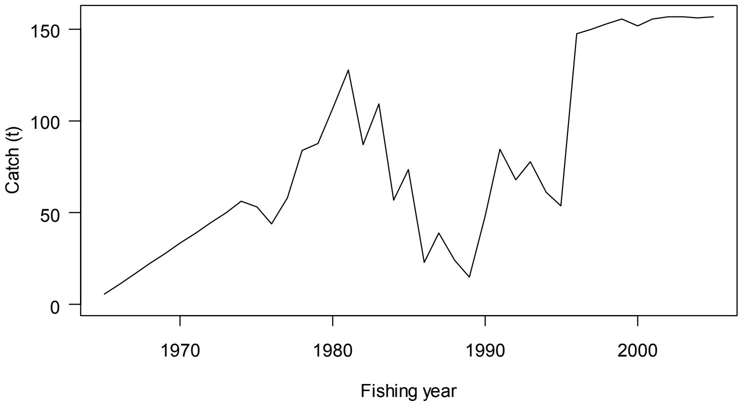


Figure 2: Catch series (t) used in the PAU 5A assessment. Catches from 1974 were estimated from the total PAU 5 catch using a number of assumptions. Catches from 1964 to 1973 were based on linear interpolation (see text). Assumed recreational, customary and illegal catches are included.

CPUE data were available from two sources: the CELR through 2001 and the newer PCELR series from 2002. The first series has coarse area and effort information: three statistical areas and effort in diver days. The second series has 49 fine-scale reporting areas and effort in diver hours. The divers are identified in the second series. The second series can be treated as a separate series by using an extra parameter for catchability, this was done in 2005 for PAU 7. For the PAU 5A assessment, after exploration of the CPUE data and discussion with the SFWG, it was agreed to standardise CPUE as a single series.

A vector of standardised CPUE was generated using the raw catch rates as catch per diver-day (Kendrick & Andrew 2000) and a multiple regression model (Vignaux 1993). The standardisation model accounted for 17.1% of the total variation in observed CPUE and deviated only slightly from the pattern of raw CPUE after 1988 (Figure 3).

Standardised catch rates from CELR records (Table 3 and Figure 3) show a sharp decrease from 1989 to 1993 and a gradual increase after 1993. Commercial CPUE may not be proportional to abundance because, in a developing fishery, it is possible to maintain relatively high catch rates of paua despite a decreasing biomass. This occurs because paua tend to aggregate and divers move among areas to maximise their catch rates. Changes in CPUE should therefore be interpreted with caution. The SFWG discarded the CPUE indices before 1989.

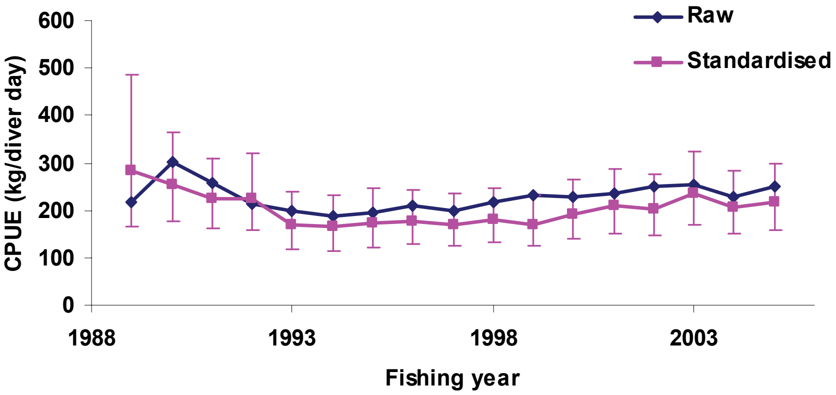


Figure 3: Raw and standardised CPUE (kg per diver-day) for PAU 5A.

Table 3: Unstandardised and standardised catch per unit effort (CPUE) in PAU 5A (kg per diver-day).

Year	Raw	Standardized	Year	Raw	Standardized
1984	232.1	245.4	2000	228.5	192.4
1985	247.3	199.7	2001	234.2	209.3
1986	399.7	403.3	2002	252.0	202.0
1987	105.8	869.9	2003	255.3	234.8
1988	90.6	103.0	2004	228.0	206.4
1989	217.0	284.9	2005	251.9	215.8
1990	303.1	254.9			
1991	259.5	223.8			
1992	212.5	224.0			
1993	198.0	168.0			
1994	187.6	163.9			
1995	195.3	173.0			
1996	211.3	177.9			
1997	199.9	170.5			
1998	216.6	179.8			
1999	232.7	171.0			

The abundance of paua in PAU 5A was also estimated from research diver surveys in 1996, 2002 and 2006. The surveys used four strata (in areas that have produced 84% of the catch in recent years) but not every stratum was surveyed in each year. Swims by stratum, and the percentages of zero-abundance swims, are shown in Table 4. The percentages of sites without paua were estimated to have increased in the Chalky stratum from 5% in 1996 to 45% in 2006, and in the Dusky stratum from 3% in 2002 to 30% in 2006. However, there was a decrease in the percentage of sites without paua in the South Coast stratum, form 24.1% in 2002 to 12.5% in 2006.

Table 4: Number of swims by fishing year and stratum in PAU 5A, and numbers and percentages of zero-abundance swims.

Fishing year	Stratum	Swims	Zero swims	%Zero	%Zero (yearly)
1996	South Coast	2	0	0	
	Chalky	42	2	4.8	4.5
2002	South Coast	29	7	24.1	
	Chalky	32	6	18.8	
	Dusky	30	1	3.3	15.4
2006	South Coast	24	3	12.5	
	Chalky	22	10	45.5	
	Dusky	24	7	29.2	
	George	28	1	3.6	20.4

The Tweedie model (Tweedie 1984), with a log link for the standardisation, was used to standardise the research diver survey index (RDSI). Results were changed into canonical form as described by Francis (1999), giving estimates that are independent of the reference year. Standardisation was based on the number of paua per 10 minute search, after correcting for search time. Variables offered to the model were fishing year, diver, stratum and visibility. Fishing year was forced to be in the model as an explanatory variable.

The standardised RDSI (Table 5 and Figure 4) decreased from 1996 through 2006. When the RDSI was standardised in a separate exercise without the George stratum (see Figure 1) surveyed in 2006 (Table 5), and the decline for 2002–06 (years in which three southern strata were all surveyed) was explored with a bootstrap analysis, the decline in that area ranged between 50–78% with 90% confidence. Therefore the recent decline is statistically significant and substantial. There was no significant area-year interaction in the standardised RDSI.

Table 5: Raw and standardised RDSI indices for PAU 5A and the standard error for standardised indices.

Fishing Year	Raw	Standardised	Index	SE
1996	51.6	91.8	1.573	0.275
2002	86.2	74.4	1.275	0.181
2006	35.1	29.1	0.499	0.183

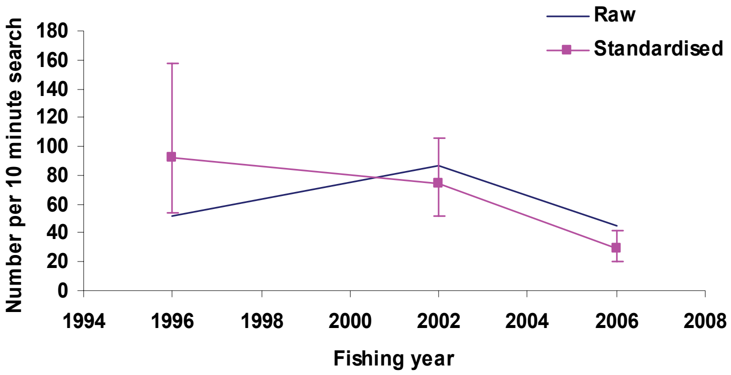


Figure 4: Raw and standardised RDSI (number per ten-minute swim) for PAU 5A.

In addition to these abundance indices, the model was fitted to ten sets of length frequency data from commercial catch sampling in 1992 to 2005, four sets of survey length frequencies from 1991 to 2006, 300 tag-recapture records, and maturity data from 217 paua examined in 2006.

Assessment model parameters and their priors and bounds are given in Table 6. The length-weight relationship is shown in Table 2.

After exploratory analysis, a single case (run 041) was chosen as a base case by the SFWG. This case excluded the CPUE series, but used all other data sets. The CPUE and RDSI series gave conflicting results, with CPUE increasing while the RDSI decreased. The CPUE series was considered to be an unreliable index of abundance because it can be confounded by hyperstability and serial depletion. In hindsight the commercial sampling length frequencies (CSLFs) should have been excluded for the same reason.

Table 6: Parameters estimated in the model and their prior distributions.

Model parameters	Definition	Priors and bounds
ln(*R0*)	Natural logarithm of base recruitment	Uniform, bounds 5, 50
M	Natural mortality	Lognormal with mean 0.10, CV 0.10, bounds 0.01, 0.50
g_{75}	Expected annual growth increment at 75 mm	Uniform, bounds 1, 50
g_{120}	Expected annual growth increment at 120 mm	Uniform, bounds 0.01, 50
α	CV of expected growth increments	Uniform, 0.001,2
σ_{MIN}	Minimum std. dev. of growth increment	Fixed to 1 in this assessment
σ_{obs}	Standard deviation of observation error for tags	Fixed to 0.25 in this assessment
T_{50}	Length at which research diver selectivity is 50%	Uniform, bounds 70, 125
T_{95-50}	Distance between lengths at which research diver selectivity is 95% and 50%	Uniform, bounds 0.001, 50
L_{50}	Length at which maturity is 50%	Uniform, bounds 70, 145
L_{95-50}	Distance between lengths at which maturity is 95% and 50%	Uniform, bounds 1, 50
D_{50}	Length at which commercial diver selectivity is 50%	Uniform, bounds 70, 145
D_{95-50}	Distance between lengths at which commercial selectivity is 95% and 50%	Uniform, bounds 0.01, 50
ln(q^J)	Scalar for the RDSI	Uniform, bounds -30 and 0
ε_t	Vector of recruitment deviations in log space	Normal, mean 0 Bounds –2.3 and 2.3, CV 0.4
$\tilde{\sigma}$	Common standard deviation of observation error	Uniform, 0.01, 2.0

4.1.3 Projections

Projections were made for both three and five years. Recruitments for projections were obtained by randomly re-sampling model estimates from 1980 through 2004. Catch projections included the 2005–06 TACC of 148.98 t and the estimates for recreational, customary and illegal harvest. The MLS was set at the current value of 125 mm. Catches were not fully taken if the corresponding exploitation rate would have exceeded the upper bound of 0.65.

4.1.4 Fishery indicators

Exploitation rates calculated were for 2005 (*U2005*) and in three- and five-year projections (*U2008*, *U2010*). The historical minimum spawning biomass (S_{MIN}) and recruited biomass (B_{MIN}) were determined from the trajectories between 1974 and 2005. Spawning biomass is the product of numbers, weight, and maturity-at-size. Recruited biomass is the product of numbers, and weight-at-size for sizes greater than or equal to the MLS. Spawning and recruited biomass were output for 2005, 2008 and 2010, thus *S2005*, *B2008* etc. All reference biomass indicators are mid-season biomass (the pre-season biomass minus half the year's catch).

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 this approach was inappropriate for this assessment. Therefore S_{AV} and B_{AV} were not used as indicators.

Additional indicators were calculated as the probability that, or percentage of runs in which:

- projected spawning biomass had decreased from 2005: *P(S08 < S05)*, *P(S10 < S05),*
- projected spawning biomass was less than the nadir: *P(S08 <* S_{MIN}*)*, *P(S08 <* S_{MIN}*)*
- projected recruited biomass had decreased from 2005: *P(B08 < B05)*, *P(B10 < B05)*
- projected recruited biomass was less than the nadir: *P(B08 <* B_{MIN}*)*, *P(B10 <* B_{MIN}*)*

4.1.5 Stock assessment results

The summaries of indicators from the base case (run 041) are shown in Table 7.

Table 7: Summaries of the marginal posterior distributions of indicators base case described in the text. Columns show the 5th and 95th quantiles and median of each distribution. Biomass is in tonnes.

Indicator	0.05	Median	0.95
U2005	0.366	0.449	0.538
S_{MIN}	270	340	430
S2005	382	482	619
B_{MIN}	125	179	242
B2005	218	276	355
$S2005/S_{MIN}$	1.140	1.421	1.782
$B2005/B_{MIN}$	1.165	1.550	2.155
U2008	0.650	0.650	0.650
S2008	200	294	645
S2008/S2005	0.455	0.593	1.356
B2008	71	96	165
B2008/B2005	0.293	0.349	0.552
U2010	0.572	0.650	0.650
S2010	191	312	726
S2010/S2005	0.406	0.634	1.482
B2010	58	84	200
B2010/B2005	0.212	0.299	0.742

The posteriors of the spawning and recruited biomass trajectories for the base case are shown in Figure 5. Despite the narrow confidence intervals, there is uncertainty about the biomass projections, particularly those prior to 1995. The estimated increases in biomass around 1997–98 are associated with a pulse in recruitment (Figure 6). Biomass decreases substantially after 1997. The posteriors of the exploitation rate and recruitment trajectories are shown in Figure 6. The exploitation trajectory shows a sharp increase after 2000, and reaches the upper bound of 0.65 after 2006.

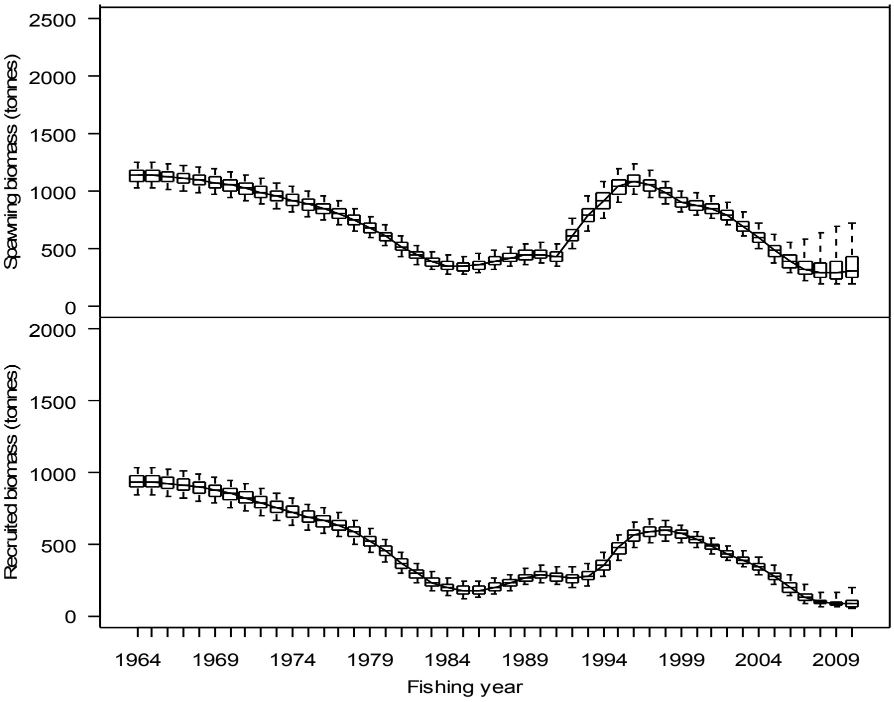


Figure 5: Posterior spawning (upper panel) and recruited (lower panel) biomass trajectories for the base case for PAU 5A. The median of the posterior (horizontal bar), the 25th and 75th percentiles (box) and 5th and 95th percentiles of the posterior are plotted for each year.

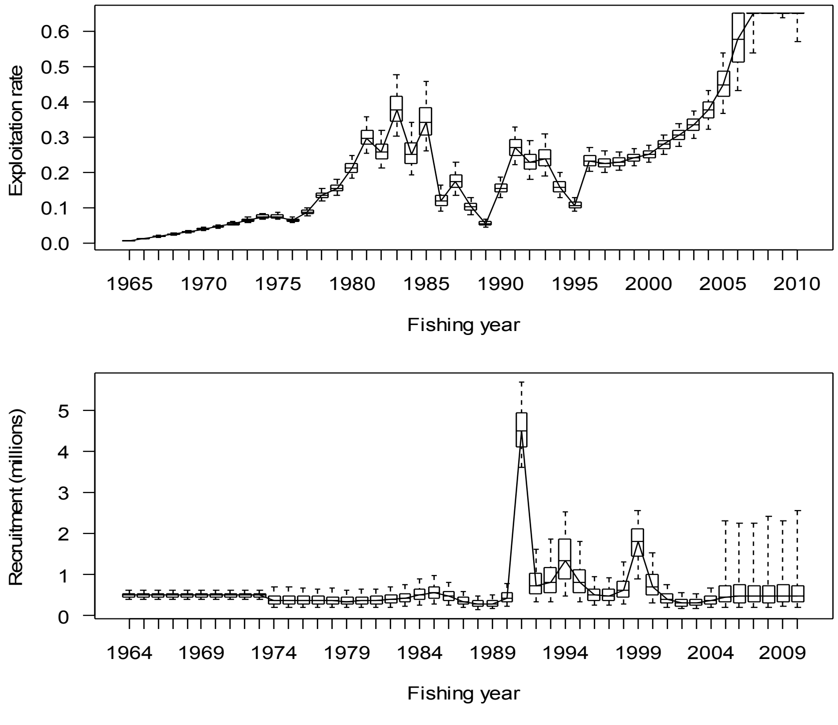


Figure 6: Posterior exploitation rates (upper panel) and recruitment (lower panel) trajectories for the base case for PAU 5A. The median of the posterior (horizontal bar), the 25th and 75th percentiles (box) and 5th and 95th percentiles of the posterior are plotted for each year.

The median biomasses in the projections to 2008 (Table 8) are less than the current biomass. By 2010, the median exploitation rate reaches the upper bound of 0.65.

The probabilities of decrease for spawning and recruited biomass in three and five year projections are shown in Table 8. All indicators show declines with probabilities greater than 50%, and many show probabilities of decrease greater than 90%. This suggests that current catch levels are unsustainable.

Table 8: Three-year (upper portion) and five-year projections (both with MLS = 125 mm) for the base case*.

P(S2008<S2005)	0.890
P(B2008<B2005)	1.000
P(S2008<S_{MIN})	0.687
P(B2008<B_{MIN})	0.959
P(S2010<S2005)	0.804
P(B2010<B2005)	0.988
P(S2010<S_{MIN})	0.591
P(B2010<B_{MIN})	0.920

*The probabilities that spawning or recruited biomass will be less than the other indicators shown are based on the MCMC.

Sensitivity trials were conducted using an alternative growth model, estimating *h*, removing the CSLF data, removing the RDLF data, removing both LF data sets and removing the tag-recapture data. Weights were left unchanged. When a length frequency data set was excluded, the selectivity parameters were also fixed.

The exponential growth model was confirmed as a good choice for these data. Many parameters were virtually unchanged in these trials. Removal of a length frequency data set from fitting always caused the fit to deteriorate, but many of the resulting fits were still “visually credible”. Removal of data sets showed no consistent pattern, suggesting that results are not highly dependent on any one data set. This, and the robustness of visual fits to the data, suggests a consistency of signals generated from the information among the various data sets.

4.2 Estimation of Maximum Constant Yield (MCY)

No estimate of MCY has been made for PAU 5A. A range of performance indicators that cover a range of management alternatives (TACCs) is presented.

4.3 Estimation of Current Annual Yield (CAY)

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

4.4 Other factors

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

4.4.1 The available data are not uniformly obtained from PAU 5A

Research diver data

The research diver surveys were not conducted in all strata during each of the three years, 1996, 2002 and 2006. Surveys were conducted mostly in the Chalky stratum in 1996, were conducted in the South coast, Chalky and Dusky strata in 2002, and all four research strata, including George, in 2006. The decline in the area comprising the southern three strata between 2002 and 2006 is both statistically significant and substantial: a decline of 50–78%. Standardised CPUE in the same area declined much less, by 4% to 17%, between 2002 and 2005. This area supported about 60% of the total catch in that period.

The assessment assumes that the RDSI indexes biomass in the whole of PAU 5A. This requires that the average decline in biomass in the surveyed southern zone (South coast, Chalky, and Dusky strata) is consistent with the average trend in biomass in the remainder of PAU 5A, or that the southern zone contains most of the PAU 5A biomass. A large proportion of the catch has been taken from the southern zone, but this does not imply that it contains (or contained) most of the PAU 5A biomass.

Tagging data

Tagging data are from only three locations (Landing Bay, Red Head and Poison Bay), and may not fully reflect the average growth and variability in growth for the PAU 5A population.

4.4.2 Potential bias in RDSI

The standardisation of the research diver data is compromised unless there is a consistent trend in biomass across years within each stratum or the number of swims within each stratum is appropriately related to the relative distribution of biomass across strata within years. The former is unlikely because of the nature of the fishery and the historical pattern of the fishing effort, which is biased in favour of the more southern strata. The latter cannot be tested without data on the area of suitable paua habitat within each stratum. However, it is unlikely that the current research diver data are appropriately weighted with regard to relative biomass. The magnitude of the bias introduced into the RDSI is unknown.

4.4.3 The data are not completely accurate

The commercial catch data show large fluctuations between 1983 and 1986, that suggests anomalies in data capture. The period before 1974 is unknown and although the effect on the overall assessment may be minor, large differences may exist between the catches assumed and what was actually taken. In addition, non-commercial catch estimates are very uncertain.

4.4.4 The model is homogeneous

In the model, the whole of PAU 5A is treated as if it were a single stock with homogeneous biology, habitat and fishing pressure. It is assumed that:

- recruitment affects all areas of PAU 5A in the same way
- natural mortality does not vary by size or year in all areas of PAU 5A
- growth has the same mean and variance in all parts of PAU 5A, 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.

4.4.5 The model assumptions are violated

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

A stock assessment of PAU 5A was undertaken in 2006. Spawning biomass was estimated to be 382–619 t. This was projected to decline to around 60% (range 40% to 150%) of its 2005 level in the following 3–5 years, at 2004–05 total catch levels of 156.95 t. The exploitation rate was estimated to be 35–55% for this period and its upper bound of 65% in the following 3–5 years.

At face value, these results suggest that the current TACC and recent catches were not sustainable. These results are dependent on the RDSI adequately indexing the biomass in the whole of PAU 5A.

This may not be the case. The Plenary could not agree on the applicability of the assessment projections to the whole of the PAU 5A stock. However, the results suggest that catches at current levels within the Dusky, Chalky and South coast areas of PAU 5A will result in further depletion within these areas.

6. FOR FURTHER INFORMATION

Andrew NL., Naylor JR., Gerring P. 1999. A modified timed–swim method for paua stock assessment. New Zealand Fisheries Assessment Report 2000/4: 23p.

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