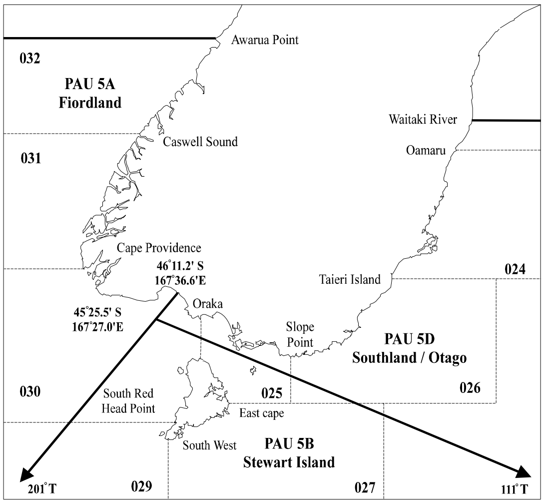
# PAUA (PAU 5B) – Stewart Island

(*Haliotis iris*)




## 1. FISHERY SUMMARY

### (a) Commercial fishery

Before 1995–96, PAU 5 was the most important QMA by number of quota holders and TACC. The TACC peaked in PAU 5 in 1991–92 at 492 t, having grown steadily from a provisional TACC of 390 t in 1985–86, as a result of the quota appeal process. Concerns about the status of the PAU 5 fishery 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. 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 reduction in catch in Stewart Island caused by subdivision cannot be determined with certainty because several Statistical Areas used to report catch and effort straddled 5B and 5D.

An assessment of the PAU 5B fishery (Breen et al., 2000a) confirmed fears of over-exploitation; the TACC was reduced by 5 t from 1 October 1999 and Industry agreed to shelve a further 25 t of quota. A subsequent assessment (Breen et al., 2000b) indicated further catch reductions were required and the TACC was reduced from 143.984 to 112.187 t from 1 October 2000, and shelving continued at the level of about 22 t. The commercial catch in 2001–02 was 89.96 t. This series of management interventions has reduced the commercial catch in PAU 5B by at least 40% since 1998–99, and probably by as much as 60% since 1994–95.

In 2002, it was decided that quota shelving would be discontinued in PAU 5B, and that the TACC would be set at 90 t within a TAC of 105 t. The TAC included a 6 t customary allowance, a 6 t recreational allowance, and a 3 t allowance for other sources of mortality (illegal catch). This decrease was based on the consideration that it was important to set a TAC that would ensure the stock would move toward the desired target level; and that sustainability concerns outweighed the socio-economic impact.

**Table 1: TACC and reported commercial landings (t) of paua in PAU 5B from 1995–96 to 2005-06. Data reported from QMR and MHR returns.**

| Year | Landings | TACC |
|---|---|---|
| 1995–96 | 144.66 | 148.98 |
| 1996–97 | 142.36 | 148.98 |
| 1997–98 | 145.34 | 148.98 |
| 1998–99 | 148.55 | 148.98 |
| 1999–00 | 118.07 | 143.98 |
| 2000–01 | 89.92 | 112.19 |
| 2001–02 | 89.96 | 112.19 |
| 2002–03 | 89.86 | 90.00 |
| 2003–04 | 90.00 | 90.00 |
| 2004–05 | 89.97 | 90.00 |
| 2005–06 | 90.47 | 90.00 |

## (b) Recreational fisheries

The 1996 national telephone diary survey estimated that 105 000 paua (27 t) were taken by recreational fishers in PAU 5. The 1999/2000 and 2000/2001 national recreational fishing surveys estimated 29 000 and 69 000 paua respectively were harvested by recreational fishers in PAU 5B. At an average weight of 357 g, these numbers equate to a recreational harvest of 10.3 t in 1999/2000 and 24.6 t in 2000/2001. The Marine Recreational Fisheries Technical Working Group (RFTWG) has reviewed the harvest estimates from the national surveys. The RFTWG concluded that the 1996 harvest estimates were unreliable due to a methodological error. Harvest estimates from the 1999/2000 and 2000/2001 surveys for some fish stocks were considered to be unbelievably high.

The Shellfish Fisheries Assessment Working Group (SFWG) agreed to assume for the 2007 assessment that recreational catch was 1 t in 1974, rising linearly to 5 t in 2006.

## (c) Maori 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. The Minister of Fisheries provided an allowance for customary harvest of 6 t beginning in 1999/2000. Estimates of recent catch have been provided as numbers of paua by the Ministry of Fisheries. The Shellfish Fisheries Assessment Working Group (SFWG) agreed to assume for the 2007 assessment that customary catch has been 1 t for the whole period modelled.

## (d) Illegal catch

Illegal catch was estimated by the Ministry of Fisheries to be 15 t, but “Compliance express extreme reservations about the accuracy of this figure.” The SFWG agreed to assume for the 2007 assessment that illegal catch was zero before 1986, then rose linearly from 5 t in 1986 to 15 t in 2006.

The total catch vector (sum of all these catch components) is shown in Figure 1.

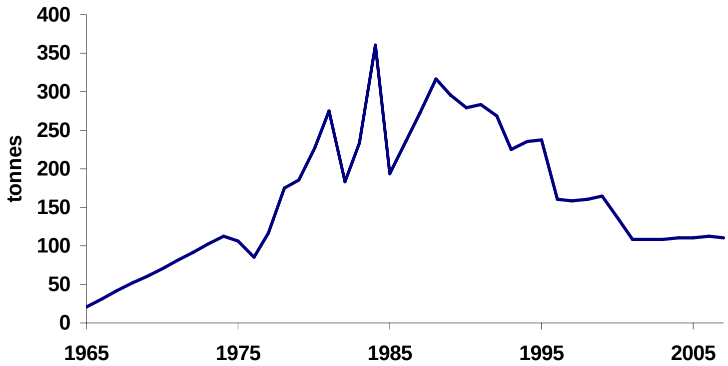



**Figure 1: Catch (t) estimates used in the assessment.**

### (e) <u>Other sources of mortality</u>

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 or indirectly from being returned to unsuitable habitat or being lost to predators or bacterial infection. 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. 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. No attempt has been made to incorporate this source of mortality in the stock assessment.

## 2. BIOLOGY

A summary of biological parameters used in the PAU 5B assessment is presented in Table 2.

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

| | Estimate | Source |
|---|---|---|
| **1. Natural mortality (M)** | | |
| | 0.10 (CV 0.10) | Assumed prior probability distribution |
| **2. Weight = a (length)$^b$** (weight in g, shell length in mm) | | |
| | $a = 2.99 \times 10^{-5}$ $b = 3.303$ | Schiel & Breen (1991) |
| **3. Size at maturity (shell length)** | | |
| | 50% maturity at 91 mm | |
| | 95% maturity at 113 mm | R. Naylor (NIWA unpub. data) |
| **4. Growth parameters (both sexes combined)** | | |
| **Growth at 75 mm** | **Growth at 120 mm** | |
| 26.1 mm (24.8 to 27.2) | 6.9 mm (6.5–7.3) | Median (5–95% range) of posteriors estimated by the model |

## 3. STOCKS AND AREAS

PAU 5B was created in 1995 when PAU 5 was divided into three sub-areas, each with a TACC of 147.66 t. From 1 November 1997 these areas were further subdivided into 17, 16 and 11 statistical areas respectively. The scale of reporting was further reduced from 1 October 2001, when it became mandatory to report catch and effort from the 96 small zones developed by the New Zealand Paua Management Company for their voluntary logbook.

## 4. STOCK ASSESSMENT

### (a) Estimates of fishery parameters and abundance

Catch rates (CPUE data from FSU, CELR and PCELR records – Table 3) appear relatively stable in recent years, although they declined between 1987 and 1996, and in 2001. In some circumstances commercial CPUE may not be proportional to abundance as it is possible to maintain catch rates of paua despite a declining biomass. This occurs because paua tend to aggregate and divers move among areas to maximise their catch rates. Apparent stability in CPUE should therefore be interpreted with caution.

**Table 3: Unstandardised and standardised catch per unit effort (CPUE) in PAU 5B (kg per diver-day) (Breen & Smith in prep.). The standardised CPUE for 1983–84 to 1994–95 includes data from statistical areas 025 and 030 assigned via the randomisation procedure described by Kendrick & Andrew (2000). As such it is subject to the additional cautions discussed below (section 4b(ii)).**

| Year | Unstandardised CPUE | Standardised CPUE |
|---|---|---|
| 1982–83 | 296.4 | 372.2 |
| 1983–84 | 303.5 | 324.5 |
| 1984–85 | 337.3 | 362.2 |
| 1985–86 | 349.2 | 366.1 |
| 1986–87 | 257.4 | 267.6 |
| 1987–88 | 233.6 | 264.3 |
| 1988–89 | 223.8 | 238.8 |
| 1989–90 | 192.8 | 217.6 |
| 1990–91 | 177.9 | 200.7 |
| 1991–92 | 174.2 | 186.7 |
| 1992–93 | 157.7 | 171.4 |
| 1993–94 | 151.0 | 155.3 |
| 1994–95 | 149.9 | 145.1 |
| 1995–96 | 142.5 | 127.2 |
| 1996–97 | 136.4 | 152.0 |
| 1997–98 | 139.8 | 142.8 |
| 1998–99 | 138.3 | 136.3 |
| 1999–00 | 143.7 | 146.2 |
| 2000–01 | 119.7 | 115.6 |
| 2001–02 | 166.2 | 154.6 |
| 2002–03 | 141.4 | 157.0 |
| 2003–04 | 152.9 | 159.9 |
| 2004–05 | 174.1 | 174.9 |
| 2005–06 | 173.2 | 194.9 |

The relative abundance of paua in PAU 5B has been estimated from research surveys (Andrew et al., 2000a, 2000b, 2002) (Table 4). Relative abundance in the research diver survey index (RDSI) increased from 1998 to 2001 and again to 2007.

**Table 4: Raw and standardised research diver survey indices (RDSI) (paua per 10-minute swim) for sites surveyed in PAU 5B. (– indicates no data collected).**

| Year | Raw | Standardised |
|---|---|---|
| 1993–94 | 54.43 | 67.55 |
| 1994–95 | 34.18 | 37.05 |
| 1995–96 | 31.94 | 26.43 |
| 1996–97 | – | – |
| 1997–98 | 20.83 | 22.12 |
| 1998–99 | – | – |
| 1999–00 | – | – |
| 2000–01 | 28.51 | 29.12 |
| 2001–02 | – | – |
| 2002–03 | – | – |
| 2003–04 | – | – |
| 2004–05 | – | – |
| 2005–06 | – | – |
| 2006-07 | 36.33 | 38.68 |

## (b) Assessment model for PAU 5B

### i) Model structure

This assessment was made with a 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).

The assessment is based on the marginal posterior distributions of the parameters and derived parameters of interest, in turn based on Markov chain Monte Carlo (MCMC) simulations.

Growth is modelled as a stochastic transition matrix calculated from the growth sub-model's estimated parameters, and the estimated relation between expected increment and its standard deviation, based on tagging data. A contribution to the total likelihood function comes from comparison of observed and expected increments in the tagging data.

Recruitment is modelled as a fixed mean with annual deviations, estimated as a vector of parameters. These have an assumed mean and standard deviation; this assumption makes the model Bayesian. No stock-recruit relation is estimated, but projections are made by re-sampling recent estimated recruitments. Commercial and research diver selectivity-at-size is modelled with two estimated parameters.

The relative weights applied to each dataset were adjusted iteratively to obtain standard deviations of normalised residuals equal to unity.

Exploitation rate was calculated from observed catch and model biomass. A point estimate of the mode of the joint posterior distribution (MPD) served as the starting point for the Bayesian estimations and as the basis for sensitivity tests. MCMC simulations were used to estimate the marginal posterior distributions of model parameters.

In addition to model parameters, derived parameters such as population size and exploitation rate were calculated and their posterior distributions summarised. In the assessment of PAU 7 in 2001, indicators using virgin recruited and spawning biomass were poorly determined (Breen et al., 2001). These indicators were replaced with those from a reference period in which the fishery appeared to be operating at a sustainable level. For this assessment, spawning and recruited biomass indicators $S_{av}$ and $B_{av}$ were also used. The period from which to take these means was chosen after examining various trajectories from preliminary results. 1985–1987 was chosen as a reference period because in these years spawning and recruited biomass had stabilised following a 'fishing down' period that started in the early 1970s, and the exploitation rate was moderate compared to later years. This period is a reference against which current and projected stock sizes can be compared; $S_{av}$ and $B_{av}$ can be considered as management targets.

We also calculate the nadir of the spawning and recruited biomass trajectories, calling these $S_{min}$ and $B_{min}$ respectively. These are references against which current and projected stock sizes can be compared; they can be considered as limit references below which the stock must not be allowed to fall.

Performance indicators were provided for the current year (2007) and for 3-year projections (2010). The indicators for current and projected recruited biomass, *B07* and *B10*, were the values for recruited biomass in those years. Spawning biomass indicators for the current and projected populations were called *S07* and *S10* and were calculated as the product of the maturity vector and numbers in each size class for each year. Exploitation rates in 2007 and 2010 were also used as indicators, and called *U07* and *U10*.

For the MCMC simulations used in projections, additional indicators were the percentages of runs in which spawning biomass decreased during projections, recruited biomass decreased during projections, spawning biomass remained less than $S_{av}$ or fell below $S_{min}$, and similarly for recruited biomass.

Sensitivity tests involved removing each of five data sets (maturity was not involved) in turn or in combination, using alternative catch series, removing CPUE before 1990, removing the 1994 RDSI datum, and changing the form of the likelihood. Retrospective analyses, in which years of data were sequentially removed and the model refitted, were also used to analyse the sensitivity of the model to data.

### ii) Data used in the assessment

This model is driven by reported commercial catch estimates from 1974 through 2007 and was fitted to six sets of data: standardised CPUE, standardised RDSI, proportion-at-length data from commercial catch sampling (CSLF) and from research diver surveys (RDLF), a set of growth increment data from tag-recapture experiments (Naylor, unpub. data), and a set of observed maturity-at-length data (Naylor, unpub. data).

Generation of a catch vector required assumptions to be made about the division of catch from statistical areas 25 and 30 to PAU 5B prior to 1995. This problem was described by Kendrick & Andrew (2000). For this purpose, the fishery was divided into three periods: pre-1984, 1984–1995, and post-1995. In this assessment we used the 2000 base case series:

| | |
|---|---|
| 1974–1983 | 52% of PAU 5 landings |
| 1984–1995 | 75% of areas 25 and 30 |
| 1996–2001 | As allocated to subdivided QMAs |

A vector of standardised CPUE was generated using the raw catch rates as catch per diver-day and a multiple regression model (Vignaux, 1993). Records from statistical areas 025 and 030 (see figure at the beginning of this report) were assigned from PAU 5 to PAU 5B using a randomisation procedure described by Kendrick & Andrew (2000). However, in 2007 the working group accepted that while the randomisation procedure retains the correct catch totals it does not retain differences in catch rate, and should technically not be used to allocate records to CPUE datasets. To assess possible bias in the CPUE series resulting from use of the randomisation procedure, a standardisation was also done with pre-1997 records from areas 025 and 030 omitted. The base case standardisation model accounted for 36% of the total variation in observed CPUE and deviated little from the pattern of decline in raw CPUE through time (Figure 2). Omission of the area 025 and 030 records caused relatively little change in standardised CPUE (Figure 2 “subset”) and the working group therefore did not consider it necessary to repeat the assessment with the subset CPUE series.

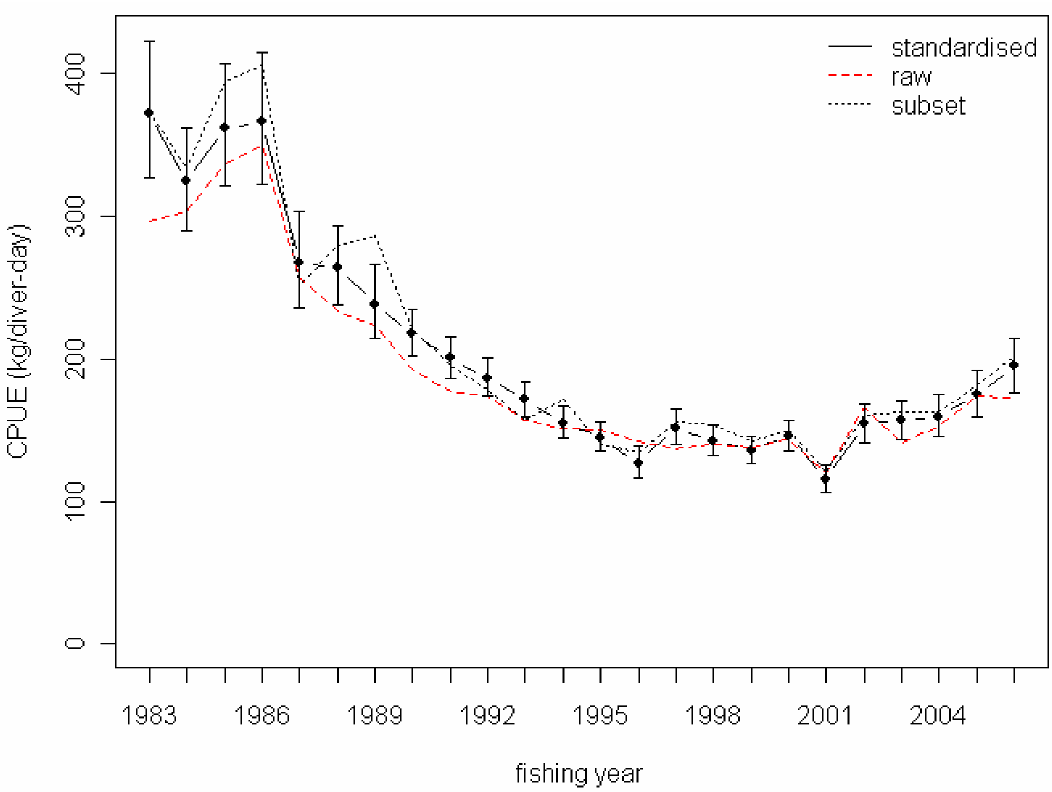



**Figure 2: Standardised and raw CPUE index, with an additional line representing the standardised CPUE index recalculated with a data subset in which all records from areas 025 and 030, randomly allocated to PAU 5B by Kendrick and Andrew (2000), were removed.**

Assessment model parameters and their priors and bounds are given in Table 5. Other biological assumptions were as follows: The length-weight relationship and growth parameters (derived from the model) are given in Table 2.

**Table 5: Parameters estimated in the model and their prior distributions.**

| Model parameters | Definition | Priors and bounds |
|---|---|---|
| ln(*R0*) | Natural log(recruitment) | Uniform, 5, 50 |
| ln(*qCPUE*) | Natural log(catchability for commercial divers) | Uniform, 5, 50 |
| ln(*qRDSI*) | Natural log(catchability for research divers) | Uniform, 5, 50 |
| *M* | Natural mortality | Log-normal, mean 0.1, CV 0.1, bounds 0.01, 0.50 |
| *galpha* | growth at 70 mm | Uniform, 1, 80 |
| *gBeta* | growth at 120 mm | Uniform, 0.01, 50 |
| *S50* | Size at 50% selectivity by research divers | Fixed at 100 |
| *S95* | Difference in size between 95% and 50% selectivity | Fixed at 19 |
| *C50* | Size at 50% selectivity by commercial divers | Uniform, 70, 145 |
| *C95* | Difference in size between 95% and 50% selectivity | Uniform, 0.01, 50 |
| *M50* | Size at 50% maturity | Uniform, 70, 145 |
| *M95* | Difference in size between 95% and 50% maturity | Uniform, 1, 50 |
| $\varepsilon_t$ | Vector of recruitment deviations in log space | Normal, mean 0, bounds –23 and 23, CV 04 |
| $\alpha$ | Growth CV | Normal, .001, 2 |
| $\tilde{\sigma}$ | Common standard deviation of observation error | Fixed at 1 |
| $\sigma_{MIN}$ | Minimum standard deviation of growth increment | Fixed at 1 mm |
| $\sigma_{OBS}$ | Standard deviation of tag observation error | Fixed at 3 mm |
| *CPUEpow* | Relation between biomass and CPUE | Normal, 0.01, 2 |

## iii) Stock assessment results

The sensitivities of model outputs to inputs and assumptions (Table 6) were explored using the MPD point estimates.

**Table 6: Results of sensitivity tests on MPD estimates to model inputs and assumptions.**

| **Sensitivity test** | **Outcomes** |
| --- | --- |
| Removing each of the five data sets in turn and in combination from the fitting procedure, | • Tag data prove to be critical<br>• One abundance index is necessary<br>• No undue influence of any other single data set.<br>• Removing CPUE or omitting early CPUE gives a more optimistic assessment of current biomass vs. the target reference. |
| Alternative catch series (the 1999 assessment base case series; Kendrick & Andrew, 2000) | • Using low-catch series gives a more optimistic assessment of current biomass vs. the target reference. |
| Removing early CPUE data | • Gave a more optimistic assessment of current biomass vs. the target reference. |

The assessment was reasonably robust in sensitivity trials. Results were not unduly sensitive to any one data set, except that the tag data set was essential to obtaining a credible fit. The procedure of iterative re-weighting the data sets to obtain standardised residuals with a standard deviation of unity worked well in this assessment, and was used for the base case.

The retrospective analyses did not suggest that bias or model mis-specification were problems with this assessment. The assessment did not change much with successive subtraction of one year's abundance and sampling data.

The model provided reasonably good fits to the tag-recapture data, proportions-at-length and CPUE, but not as good a fit to the research diver survey index.

Projections were made for three years with the current catch and MLS. The posterior summaries of indicators (Table 7) suggest that current and projected spawning and recruited biomass are both higher than the estimated minima, $S_{min}$ and $B_{min}$. Current and projected spawning biomass are less than those in the 1985-87 reference period. Current exploitation rate is in the range 8–11%. Current recruited biomass has a median less than the reference $B_{av}$, but the distribution's upper 5% tail reaches $B_{av}$. The median projected recruited biomass is also less than $B_{av}$, but more than 5% of the tail is above $B_{av}$.

There is about a 40% percentage risk that spawning biomass will decrease and about a 50% chance that recruited biomass will decrease in the next three years.

**Table 7: Performance indicators derived from posterior distributions generated from the base case assessment. B is recruited biomass (paua greater than 125 mm shell length) in tonnes, S is spawning biomass (based on numbers-at-size and maturity-at-size) in tonnes, U is exploitation rate. $S_{av}$ and $B_{av}$ are the mean biomass estimates for 1985-87. Biomass estimates in tonnes. The table shows $5^{th}$ percentile, median and $95^{th}$ percentile for the parameters indicated, taken from the distribution of 5000 samples from 5 million simulations.**

| Parameter | 0.05 | Median | 0.95 |
| --- | ---: | ---: | ---: |
| *U07* | 7.6% | 9.3% | 11.1% |
| *U10* | 7.5% | 9.3% | 11.4% |
| *Smin* | 807 | 993 | 1 277 |
| *Sav* | 1 688 | 1 982 | 2 409 |
| *S07* | 1 224 | 1 487 | 1 853 |
| *S10* | 1 196 | 1 528 | 1 954 |
| *Bmin* | 495 | 622 | 818 |
| *Bav* | 1 073 | 1 280 | 1 580 |
| *B07* | 924 | 1 120 | 1 386 |
| *B10* | 905 | 1 120 | 1 390 |
| *S07/Smin* | 133.3% | 149.3% | 168.2% |

***Table 7 continued***

| | | | |
|---|---|---|---|
| *S07/Sav* | 66.3% | 75.1% | 84.9% |
| *S10/Smin* | 126.5% | 153.0% | 184.2% |
| *S10/Sav* | 63.3% | 76.9% | 92.3% |
| *S10/S07* | 90.4% | 102.1% | 116.0% |
| *B07/Bmin* | 159.6% | 179.1% | 203.2% |
| *B07/Bav* | 76.8% | 87.3% | 99.7% |
| *B10/Bmin* | 150.3% | 178.3% | 214.3% |
| *B10/Bav* | 73.0% | 87.1% | 103.9% |
| *B10/B07* | 91.7% | 99.5% | 108.4% |
| *S10<S07* | 38.3% | | |
| *S10<Sav* | 98.9% | | |
| *S10<Smin* | 0.0% | | |
| *B10<B07* | 53.5% | | |
| *B10<Bav* | 90.2% | | |
| *B10<Bmin* | 0.0% | | |

## (d) Estimation of Maximum Constant Yield (MCY)

No estimate of MCY has been made for PAU 5B.

## (e) Estimation of Current Annual Yield (CAY)

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

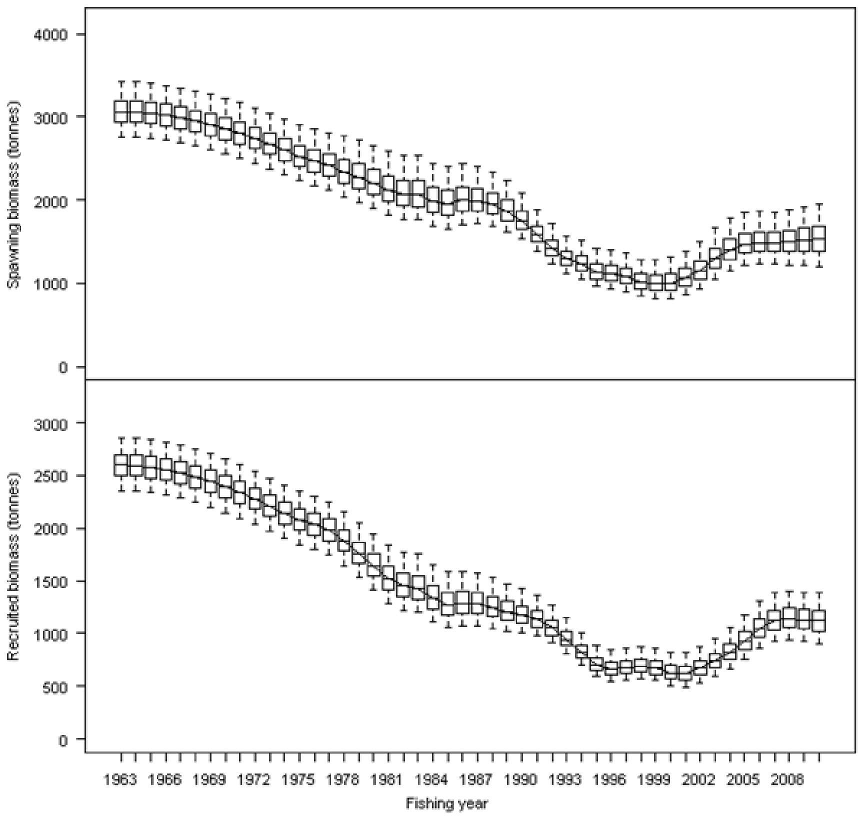



**Figure 3: The posterior biomass trajectories for recruited (upper) and spawning (lower) biomass for the base case for PAU 5B. For each year, the figure shows the median of the posterior (horizontal bar), the 25th and 75th percentiles (box) and 5th and 95th percentiles of the posterior.**

**(f) Other yield estimates and stock assessment results**

No projections of stock status under alternatives to the current TACC and Minimum legal size were done.

**(g) Other factors**

Variation in results among the various trials can be much higher than variability within a MCMC trial. The main sensitivities identified were the catch series, early CPUE data and data weighting issues, all of which affect the outcomes to some extent.

The commercial catch before 1974 is unknown, the proportion of PAU 5 catch taken from PAU 5B prior to 1995 is uncertain, and differences may exist between the catches we assume and what was taken. In addition, non-commercial catch estimates are poorly determined and could be substantially different from what was assumed by the SFWG, although non-commercial catches appear to be generally small compared with commercial catch. The illegal catch is particularly suspect.

The tagging data may not reflect fully the average growth and range of growth in this population. Length frequency data collected from the commercial catch may not represent the commercial catch with high precision.

The research diver data comprise six surveys, for some of which the standard errors are quite large, and length frequencies may not be fully representative of the population.

The model treats the paua stocks as if they were single stocks with homogeneous biology, habitat and fishing pressures. The model assumes spatial homogeneity in recruitment, spatial and temporal homogeneity in natural mortality, and assumes that growth has the same mean and variance in all places and all years.

Heterogeneity in growth can be a problem for this kind of model (Punt, 2003). Variation in growth is addressed to some extent by having a stochastic growth transition matrix based on increments observed in several different places; similarly the length frequency data are integrated across samples from many places.

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

An assumption made by the model is that CPUE is an index of abundance. There is a large abalone literature that suggests CPUE is difficult to use in abalone stock assessments because of serial depletion, which happens when fishers deplete unfished or lightly fished beds and maintain their catch rates: CPUE stays high while the biomass is actually decreasing. Even when CPUE is not fitted by the model, if serial depletion is occurring, the model does not model serial depletion.

Another source of uncertainty is that fishing may cause spatial contraction of populations (e.g., Shepherd & Partington, 1995), or that some populations become relatively unproductive after initial fishing (Gorfine & Dixon, 2000). If this happens, the model will overestimate productivity in the population as a whole. Past recruitments estimated by the model might instead have been the result of serial depletion.

## 5. STATUS OF THE STOCK

The stock assessment was updated in 2007. A Bayesian length-based stock assessment model was applied to PAU 5B to estimate stock status and yield. The agreed reference points used were the average spawning and recruited biomass, $S_{\mathbf{av}}$ and $B_{\mathbf{av}}$ respectively, from a reference period of 1985 to 1987. This period was chosen because in these years spawning and recruited biomass had stabilised following a 'fishing down' period that started in the early 1970s. The assessment also used the minimum spawning and recruited biomass observed in the model's reconstruction: $S_{min}$ and $B_{min}$.

The assessment suggests that current biomass estimates (*S07* and *B07*) are well above the minimum reference levels $S_{min}$ and $B_{min}$. This was true in all MPD sensitivity trials and in the MCMC. Projected biomass (*S10* and *B10*) is highly likely to remain above these reference levels; in the MCMC projection, biomass never fell below $B_{min}$ or $S_{min}$.

The assessment suggests that both spawning and recruited biomass are below the target levels $S_{av}$ and $B_{av}$. Spawning biomass was estimated at 75% of $S_{av}$, (5th to 95th quantiles 66% to 85%) while recruited biomass was estimated as 87% of $B_{av}$ (77% to 100%).

MCMC projections suggest that spawning biomass was more likely, (61%), to increase than decrease under current levels of total catch, and is likely to remain below $S_{av}$ for the next three years. In contrast, recruited biomass shows a tendency to decrease, (64% probability), and remain below $B_{av}$. For recruited biomass, however, it cannot be concluded strongly that current biomass is less than the $B_{av}$ reference level. The posterior touches 100% at the 95% confidence level. MPD sensitivity trials showed estimates of $B07/B_{av}$ near 100% in several situations: when the CPUE dataset was removed, when the pre-1990 CPUE data were removed and when the lower-catch alternative series were used.

TACCs and reported landings are summarized in Table 8.

**Table 8: Summary of TACC (t) and reported landings (t) of paua 5B for the 2005-06 fishing year.**

| QMA | Actual TACC | Reported commercial landings |
|---|---|---|
| PAU 5B | 89.97 | 90.47 |

## 6. FOR FURTHER INFORMATION

Andrew, N.L.; Naylor, J.R.; Gerring, P.; Notman, P.R. (2000a). Fishery independent surveys of paua (*Haliotis iris*) in PAU 5B and 5D. *New Zealand Fisheries Assessment Report 2000/3*. 21 p.

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

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Bradford, E. (1998). Harvest estimates from the 1996 national recreational fishing surveys. *New Zealand Fisheries Assessment Research Document. 98/16*. 27 p.

Breen, P.A.; Andrew, N.L.; Kendrick, T.H. (2000a). Stock assessment of paua (*Haliotis iris*) in PAU 5B and PAU 5D using a new length-based model. *New Zealand Fisheries Assessment Report 2000/33*. 37 p.

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