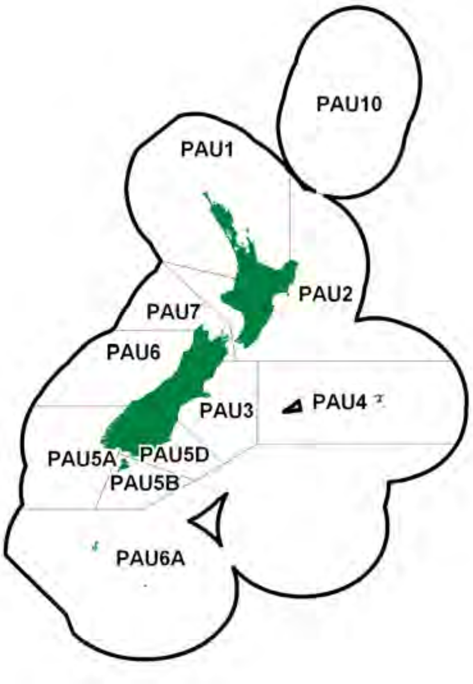
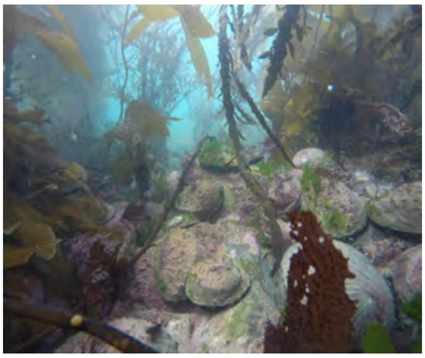
# INTRODUCTION – PĀUA (PAU)

(*Haliotis iris*, *Haliotis australis*)



## 1. INTRODUCTION

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

### 1.1 Commercial fisheries

The commercial fishery for pāua dates from the mid-1940s. In the early years of this commercial fishery the meat was generally discarded and only the shell was marketed, however by the late 1950s both meat and shell were being sold. Since the 1986–87 fishing season, the Quota Management Areas have been managed with an individual transferable quota system and a total allowable catch (TAC) that is made up of total allowed commercial catch (TACC), recreational and customary catch, and other sources of mortality.

Fishers gather pāua by hand while free diving. The use of underwater breathing apparatus (UBA) is not permitted except in the PAU 4 fishery. Due to safety concerns of great white shark interactions, the use of UBAs has been permitted in the Chatham Island pāua fishery (PAU 4) since 2012. Most of the catch is from the Wairarapa coast southwards: the major fishing areas are in the Chatham Islands (PAU 4) and the South Island, Marlborough (PAU 7), Stewart Island (PAU 5B) and Fiordland (PAU 5A). Virtually the entire commercial fishery is for the black-foot pāua, *Haliotis iris*, with a minimum legal size for harvesting of 125 mm shell length. The yellow-foot pāua, *H. australis* is less abundant than *H. iris* and is caught only in small quantities; it has a minimum legal size of 80 mm. Catch statistics include both *H. iris* and *H. australis*.

Concerns about the status of some stocks led to the commercial fishers agreeing to voluntarily reduce their Annual Catch Entitlement (ACE). This management tool is still in place in some QMAs.

Up until the 2002 fishing year, catch was reported by general statistical areas, however from 2002 onwards, a finer scale system of pāua specific statistical areas was put in place throughout each QMA (refer to the QMA specific Plenary chapters). Figure 1 shows the historical landings for the main PAU stocks. On 1 October 1995 PAU 5 was divided into three separate QMAs: PAU 5A, PAU 5B, and PAU 5D. On 1 October 2021 PAU 3 was divided into two separate QMAs: PAU 3A and PAU 3B.

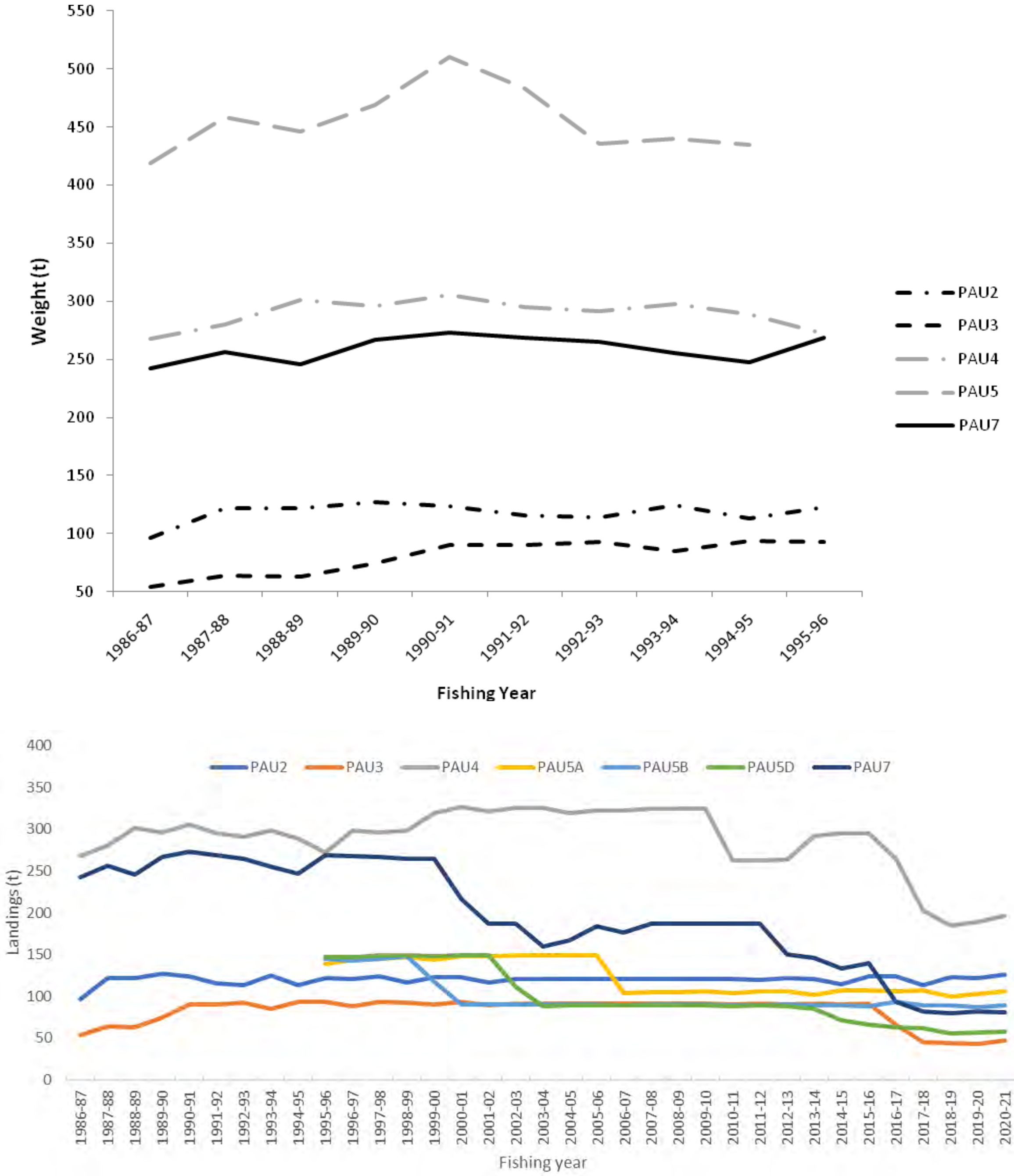



**Figure 1: Historic landings for the major pāua QMAs from 1986–87 to 1995–96 (top) and from 1986–87 to present (lower).**

Landings for PAU 1, PAU 6, PAU 10, and PAU 5 (prior to 1995) are shown in Table 1. PAU 1 landings have been below the TACC since its introduction to the QMS in 1986–87 with an average of 0.58 t caught per year and with no landings recorded for 2017–18. Landings increased to 1.36 t in 2019–20, close to the TACC of 1.93 t and at a level not seen since 1992–93. In contrast PAU 6 landings have been close to the TACC since the fishing year 2006–07. For information on landings specific to other pāua QMAs refer to the specific chapters.

**Table 1: TACCs and reported landings (t) of pāua by Fishstock from 1983–84 to present.**

| Fishstock | PAU 1 | | PAU 5 | | PAU 6 | | PAU 10 | |
|---|---|---|---|---|---|---|---|---|
| | Landings | TACC | Landings | TACC | Landings | TACC | Landings | TACC |
| 1983–84* | 1 | – | 550 | – | 0.00 | – | 0.00 | – |
| 1984–85* | 0 | – | 353 | – | 3.00 | – | 0.00 | – |
| 1985–86* | 0 | – | 228 | – | 0.00 | – | 0.00 | – |
| 1986–87* | 0.01 | 1.00 | 418.9 | 445 | 0.00 | 1.00 | 0.00 | 1.00 |
| 1987–88* | 0.98 | 1.00 | 465 | 448.98 | 0.00 | 1.00 | 0.00 | 1.00 |
| 1988–89* | 0.05 | 1.93 | 427.97 | 449.64 | 0.00 | 1.00 | 0.00 | 1.00 |
| 1989–90 | 0.28 | 1.93 | 459.46 | 459.48 | 0.00 | 1.00 | 0.00 | 1.00 |
| 1990–91 | 0.16 | 1.93 | 528.16 | 484.94 | 0.23 | 1.00 | 0.00 | 1.00 |
| 1991–92 | 0.27 | 1.93 | 486.76 | 492.06 | 0.00 | 1.00 | 0.00 | 1.00 |
| 1992–93 | 1.37 | 1.93 | 440.15 | 442.85 | 0.88 | 1.00 | 0.00 | 1.00 |
| 1993–94 | 1.05 | 1.93 | 440.39 | 442.85 | 0.10 | 1.00 | 0.00 | 1.00 |
| 1994–95 | 0.26 | 1.93 | 436.13 | 442.85 | 18.21H | 1.00 | 0.00 | 1.00 |
| 1995–96 | 0.99 | 1.93 | – | – | 28.62H | 1.00 | 0.00 | 1.00 |
| 1996–97 | 1.28 | 1.93 | – | – | 0.11 | 1.00 | 0.00 | 1.00 |
| 1997–98 | 1.28 | 1.93 | – | – | 0.00 | 1.00 | 0.00 | 1.00 |
| 1998–99 | 1.13 | 1.93 | – | – | 0.00 | 1.00 | 0.00 | 1.00 |
| 1999–00 | 0.69 | 1.93 | – | – | 1.04 | 1.00 | 0.00 | 1.00 |
| 2000–01 | 1.00 | 1.93 | – | – | 0.00 | 1.00 | 0.00 | 1.00 |
| 2001–02 | 0.32 | 1.93 | – | – | 0.00 | 1.00 | 0.00 | 1.00 |
| 2002–03 | 0.00 | 1.93 | – | – | 0.00 | 1.00 | 0.00 | 1.00 |
| 2003–04 | 0.05 | 1.93 | – | – | 0.00 | 1.00 | 0.00 | 1.00 |
| 2004–05 | 0.27 | 1.93 | – | – | 0.00 | 1.00 | 0.00 | 1.00 |
| 2005–06 | 0.45 | 1.93 | – | – | 0.00 | 1.00 | 0.00 | 1.00 |
| 2006–07 | 0.76 | 1.93 | – | – | 1.00 | 1.00 | 0.00 | 1.00 |
| 2007–08 | 1.14 | 1.93 | – | – | 1.00 | 1.00 | 0.00 | 1.00 |
| 2008–09 | 0.47 | 1.93 | – | – | 1.00 | 1.00 | 0.00 | 1.00 |
| 2009–10 | 0.20 | 1.93 | – | – | 1.00 | 1.00 | 0.00 | 1.00 |
| 2010–11 | 0.12 | 1.93 | – | – | 1.00 | 1.00 | 0.00 | 1.00 |
| 2011–12 | 0.77 | 1.93 | – | – | 1.00 | 1.00 | 0.00 | 1.00 |
| 2012–13 | 1.06 | 1.93 | – | – | 1.00 | 1.00 | 0.00 | 1.00 |
| 2013–14 | 0.71 | 1.93 | – | – | 1.00 | 1.00 | 0.00 | 1.00 |
| 2014–15 | 0.47 | 1.93 | – | – | 1.00 | 1.00 | 0.00 | 1.00 |
| 2015–16 | 0.13 | 1.93 | – | – | 0.84 | 1.00 | 0.00 | 1.00 |
| 2016–17 | 0.25 | 1.93 | – | – | 1.06 | 1.00 | 0.00 | 1.00 |
| 2017–18 | 0.00 | 1.93 | – | – | 1.04 | 1.00 | 0.00 | 1.00 |
| 2018–19 | 0.22 | 1.93 | – | – | 1.00 | 1.00 | 0.00 | 1.00 |
| 2019–20 | 1.36 | 1.93 | – | – | 1.00 | 1.00 | 0.00 | 1.00 |
| 2020–21 | 0.64 | 1.93 | – | – | 1.00 | 1.00 | 0.00 | 1.00 |

H experimental landings
* FSU data

## 1.2 Recreational fisheries

There is a large recreational fishery for pāua. Estimated catches from telephone and diary surveys of recreational fishers (Teirney et al 1997, Bradford 1998, Boyd & Reilly 2002, Boyd et al 2004) are shown in Table 2.

**Table 2: Estimated annual harvest of pāua (t) by recreational fishers from telephone-diary surveys*.**

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

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

The harvest estimates provided by telephone-diary surveys between 1993 and 2001 are no longer considered reliable for various reasons. A Recreational Technical Working Group concluded that these harvest estimates should be used only with the following qualifications: a) they may be very inaccurate; b) the 1996 and earlier surveys contain a methodological error; and c) the 2000 and 2001 estimates are implausibly high for many important fisheries. In response to these problems and the cost and scale challenges associated with onsite methods, a national panel survey was conducted for the first time throughout the 2011–12 fishing year. The panel survey used face-to-face interviews of a random sample of 30 390 New Zealand households to recruit a panel of fishers and non-fishers for a full year. The panel members were contacted regularly about their fishing activities and harvest information collected in standardised phone interviews. The panel survey was repeated in 2017–18 (Wynne-Jones et al 2019). Harvest estimates for pāua are given in Table 3 (from Wynne-Jones et al 2014 using mean weights from Hartill & Davey 2015 and from Wynne-Jones et al 2019).

**Table 3: Recreational harvest estimates for pāua stocks from the national panel survey in 2011–12 (Wynne-Jones et al 2014) and 2017–18 (Wynne-Jones et al 2019). Mean fish weights were obtained from boat ramp surveys (Hartill & Davey 2015).**

| Stock | Fishers | Events | Number of pāua | CV | Total weight (t) | CV |
|---|---|---|---|---|---|---|
| 2011–12 (national panel survey) | | | | | | |
| PAU 1 | 39 | 63 | 43 480 | | 12.16 | 0.27 |
| PAU 2 | 158 | 378 | 286 182 | | 81.85 | 0.15 |
| PAU 3 | 35 | 67 | 60 717 | | 16.98 | 0.31 |
| PAU 5A | 2 | 3 | 1 487 | | 0.42 | 0.76 |
| PAU 5B | 5 | 5 | 2 945 | | 0.82 | 0.50 |
| PAU 5D | 41 | 84 | 80 290 | | 22.45 | 0.30 |
| PAU 7 | 19 | 41 | 50 534 | | 14.13 | 0.34 |
| PAU total | 299 | 641 | 525 635 | | 148.82 | 0.11 |
| 2017–18 (national panel survey) | | | | | | |
| PAU 1 | 27 | 41 | 27 707 | 0.34 | 8.74 | 0.34 |
| PAU 2 | 151 | 367 | 283 240 | 0.15 | 83.22 | 0.15 |
| PAU 3 | 21 | 46 | 28 140 | 0.35 | 8.79 | 0.35 |
| PAU 5A | 3 | 4 | 2 419 | 0.76 | 0.85 | 0.76 |
| PAU 5B | 10 | 21 | 15 361 | 0.45 | 9.85 | 0.45 |
| PAU 5D | 48 | 88 | 55 | 0.21 | 19.28 | 0.21 |
| PAU 6 | E | e | 3 076 | 0.60 | 0.95 | 0.61 |
| PAU 7 | 11 | 16 | 10 576 | 0.36 | 3.02 | 0.36 |
| PAU total | 274 | 590 | 425 661 | | 134.70 | |

## 1.3 Customary fisheries

Pāua is a taonga species and as such there is an important customary use of pāua by Maori for food, and the shells have been used extensively for decorations and fishing devices. Pāua forms an important fishery for customary non-commercial, but the total annual catch is not known.

Māori customary fishers utilise the provisions under both the recreational fishing regulations and the various customary regulations. Many tangata whenua harvest pāua under their recreational allowance and these are not included in records of customary catch. Customary reporting requirements vary around the country. Customary fishing authorisations issued in the South Island and Stewart Island would be under the Fisheries (South Island Customary Fishing) Regulations 1999. Many rohe moana / areas of the coastline in the North Island and Chatham Islands are gazetted under the Fisheries (Kaimoana Customary Fishing) Regulations 1998 which require reporting on authorisations. In the areas not gazetted, customary fishing permits would be issued would be under the Fisheries (Amateur Fishing) Regulations 2013, where there is no requirement to report catch.

The information on Māori customary harvest under the provisions made for customary fishing can be limited (Table 4). These numbers are likely to be an underestimate of customary harvest as only the catch approved and harvested in kilograms and numbers are reported in the table.

## 1.4 Illegal catch

There are qualitative data to suggest significant illegal, unreported, unregulated (IUU) activity in this fishery. Current quantitative levels of illegal harvests are not known. In the past, annual estimates of illegal harvest for some Fishstocks were provided by MFish Compliance based on seizures. In the current pāua stock assessments, nominal illegal catches are used.

**Table 4: Fisheries New Zealand records of customary harvest of pāua (approved and reported as weight (kg) and in numbers), since 1998-99. – no data. [Continued on next page]**

| | PAU 1 | | | | PAU 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | Weight (kg) | | Numbers | | Weight (kg) | | Numbers | |
| Fishing year | Approved | Harvested | Approved | Harvested | Approved | Harvested | Approved | Harvested |
| 1998–99 | – | – | – | – | 40 | 40 | – | – |
| 1999–00 | – | – | – | – | – | – | 1 400 | 820 |
| 2000–01 | – | – | – | – | – | – | – | – |
| 2001–02 | – | – | – | – | – | – | – | – |
| 2002–03 | – | – | 30 | 30 | – | – | – | – |
| 2003–04 | – | – | 184 | 146 | – | – | 4 805 | 4 685 |
| 2004–05 | – | – | 240 | 220 | – | – | 2 780 | 2 440 |
| 2005–06 | 125 | 100 | 40 | 40 | – | – | 5 349 | 4 385 |
| 2006–07 | 705 | 581 | 2 175 | 1 925 | – | – | 7 088 | 3 446 |
| 2007–08 | 460 | 413 | 2 155 | 1 618 | – | – | 11 298 | 6 164 |
| 2008–09 | 491 | 191 | 2 915 | 2 228 | – | – | 30 312 | 24 155 |
| 2009–10 | 184 | 43 | 2 825 | 2 225 | – | – | 5 505 | 4 087 |
| 2010–11 | 154 | 129 | 5 915 | 3 952 | – | – | 20 570 | 17 062 |
| 2011–12 | 25 | 8 | 470 | 470 | 243 | 243 | 29 759 | 23 932 |
| 2012–13 | 20 | 20 | 1 305 | 1 193 | 10 | 6 | 51 275 | 27 653 |
| 2013–14 | – | – | – | – | – | – | 61 486 | 30 129 |
| 2014–15 | 45 | 33 | 700 | 536 | – | – | 25 215 | 16 449 |
| 2015–16 | 50 | 9 | 1 425 | 756 | – | – | 11 540 | 6 383 |
| 2016–17 | – | – | 2 190 | 618 | 100 | 100 | 13 698 | 6 877 |
| 2017–18 | 15 | 15 | 4 632 | 3 162 | – | – | 6 960 | 1 942 |
| 2018–19 | – | – | 1 368 | 710 | – | – | 8 585 | 3 209 |
| 2019–20 | 60 | 20 | 120 | 115 | – | – | – | – |
| 2020–21 | 40 | 0 | 66 | 8 | – | – | – | – |

| | PAU 3* | | | | PAU 4 | | | |
|---|---|---|---|---|---|---|---|---|
| | Weight (kg) | | Numbers | | Weight (kg) | | Numbers | |
| Fishing year | Approved | Harvested | Approved | Harvested | Approved | Harvested | Approved | Harvested |
| 1998–99 | – | – | – | – | – | – | – | – |
| 1999–00 | – | – | – | – | – | – | – | – |
| 2000–01 | – | – | 300 | 230 | – | – | – | – |
| 2001–02 | – | – | 6 239 | 4 832 | – | – | – | – |
| 2002–03 | – | – | 3 422 | 2 449 | – | – | – | – |
| 2003–04 | – | – | – | – | – | – | – | – |
| 2004–05 | – | – | – | – | – | – | – | – |
| 2005–06 | – | – | 1 580 | 1 220 | – | – | – | – |
| 2006–07 | – | – | 5 274 | 4 561 | – | – | – | – |
| 2007–08 | – | – | 7 515 | 5 790 | – | – | – | – |
| 2008–09 | – | – | 10 848 | 8 232 | – | – | – | – |
| 2009–10 | – | – | 8 490 | 6 467 | – | – | 635 | 635 |
| 2010–11 | – | – | 8 360 | 7 449 | – | – | – | – |
| 2011–12 | – | – | 5 675 | 4 242 | – | – | – | – |
| 2012–13 | – | – | 15 036 | 12 874 | – | – | – | – |
| 2013–14 | – | – | 10 259 | 7 566 | – | – | 110 | 110 |
| 2014–15 | – | – | 8 761 | 7 035 | – | – | 150 | 150 |
| 2015–16 | – | – | 14 801 | 11 808 | – | – | 320 | 120 |
| 2016–17 | – | – | 11 374 | 9 217 | – | – | 366 | 366 |
| 2017–18 | – | – | 2 708 | 1 725 | 50 | 50 | 820 | 764 |
| 2018–19 | – | – | 480 | 278 | 330 | 330 | – | – |
| 2019–20 | – | – | 30 288 | 21 527 | – | – | – | – |
| 2020–21 | – | – | 4 960 | 3 242 | – | – | – | – |

| | PAU 5A | | | | PAU 5B | | | |
|---|---|---|---|---|---|---|---|---|
| | Weight (kg) | | Numbers | | Weight (kg) | | Numbers | |
| Fishing year | Approved | Harvested | Approved | Harvested | Approved | Harvested | Approved | Harvested |
| 1998–99 | – | – | – | – | – | – | – | – |
| 1999–00 | – | – | – | – | – | – | – | – |
| 2000–01 | – | – | – | – | – | – | 50 | 50 |
| 2001–02 | – | – | 80 | 70 | – | – | 610 | 590 |
| 2002–03 | – | – | – | – | – | – | – | – |
| 2003–04 | – | – | – | – | – | – | – | – |
| 2004–05 | – | – | – | – | – | – | – | – |
| 2005–06 | – | – | – | – | – | – | 140 | 90 |
| 2006–07 | – | – | – | – | – | – | 485 | 483 |
| 2007–08 | – | – | 100 | 100 | – | – | 2 685 | 2 684 |
| 2008–09 | – | – | 100 | 100 | – | – | 3 520 | 3 444 |
| 2009–10 | – | – | 150 | 150 | – | – | 2 680 | 2 043 |
| 2010–11 | – | – | 150 | 150 | – | – | 2 053 | 1 978 |
| 2011–12 | – | – | 512 | 462 | – | – | 495 | 495 |
| 2012–13 | – | – | 590 | 527 | – | – | 1 875 | 1 828 |
| 2013–14 | – | – | – | – | – | – | 130 | 130 |
| 2014–15 | – | – | – | – | – | – | – | – |
| 2015–16 | – | – | 255 | 50 | – | – | 2 195 | 2 003 |

**Table 4 [continued]**

| | PAU 5A | | | | PAU 5B | | | |
|---|---|---|---|---|---|---|---|---|
| | Weight (kg) | | Numbers | | Weight (kg) | | Numbers | |
| Fishing year | Approved | Harvested | Approved | Harvested | Approved | Harvested | Approved | Harvested |
| 2016–17 | – | – | – | – | – | – | 75 | 75 |
| 2017–18 | – | – | 200 | 200 | – | – | 2 245 | 2 245 |
| 2018–19 | – | – | – | – | – | – | 1 405 | 1 337 |
| 2019–20 | – | – | – | – | – | – | 835 | 815 |
| 2020–21 | – | – | 850 | 820 | – | – | 2 080 | 1 930 |

| | PAU 5D | | | | PAU 6 | | | |
|---|---|---|---|---|---|---|---|---|
| | Weight (kg) | | Numbers | | Weight (kg) | | Numbers | |
| Fishing year | Approved | Harvested | Approved | Harvested | Approved | Harvested | Approved | Harvested |
| 1998–99 | – | – | – | – | – | – | – | – |
| 1999–00 | – | – | – | – | – | – | – | – |
| 2000–01 | – | – | 665 | 417 | – | – | – | – |
| 2001–02 | – | – | 5 530 | 3 553 | – | – | – | – |
| 2002–03 | – | – | 2 435 | 1 351 | – | – | – | – |
| 2003–04 | – | – | – | – | – | – | – | – |
| 2004–05 | – | – | – | – | – | – | – | – |
| 2005–06 | – | – | 1 560 | 1 560 | – | – | – | – |
| 2006–07 | – | – | 2 845 | 2 126 | – | – | 100 | 100 |
| 2007–08 | – | – | 5 600 | 5 327 | – | – | 60 | 60 |
| 2008–09 | – | – | 6 646 | 6 094 | – | – | – | – |
| 2009–10 | – | – | 4 840 | 4 150 | – | – | – | – |
| 2010–11 | – | – | 15 806 | 15 291 | – | – | 230 | 130 |
| 2011–12 | – | – | 7 935 | 7 835 | – | – | – | – |
| 2012–13 | – | – | 10 254 | 8 782 | – | – | – | – |
| 2013–14 | – | – | 5 720 | 5 358 | – | – | – | – |
| 2014–15 | – | – | – | – | – | – | – | – |
| 2015–16 | – | – | 15 922 | 13 110 | – | – | 50 | 50 |
| 2016–17 | – | – | 3 676 | 3 576 | – | – | 80 | 80 |
| 2017–18 | – | – | 3 588 | 3 310 | – | – | – | – |
| 2018–19 | – | – | 950 | 894 | – | – | – | – |
| 2019–20 | – | – | 6 905 | 6 439 | – | – | – | – |
| 2020–21 | – | – | 9 247 | 9 020 | – | – | – | – |

| | PAU 7 | | | |
|---|---|---|---|---|
| | Weight (kg) | | Numbers | |
| Fishing year | Approved | Harvested | Approved | Harvested |
| 1998–99 | – | – | – | – |
| 1999–00 | – | – | – | – |
| 2000–01 | – | – | – | – |
| 2001–02 | – | – | – | – |
| 2002–03 | – | – | – | – |
| 2003–04 | – | – | – | – |
| 2004–05 | – | – | – | – |
| 2005–06 | – | – | – | – |
| 2006–07 | – | – | – | – |
| 2007–08 | – | – | 1 110 | 808 |
| 2008–09 | – | – | 1 270 | 1 014 |
| 2009–10 | – | – | 1 085 | 936 |
| 2010–11 | – | – | 60 | 31 |
| 2011–12 | – | – | 20 | 20 |
| 2012–13 | – | – | – | – |
| 2013–14 | – | – | – | – |
| 2014–15 | – | – | – | – |
| 2015–16 | – | – | – | – |
| 2016–17 | – | – | – | – |
| 2017–18 | – | – | – | – |
| 2018–19 | – | – | – | – |
| 2019–20 | – | – | – | – |
| 2020–21 | – | – | – | – |

* Data before 2010–11 exclude the area between the Hurunui River and the South Shore (just north of Banks Peninsula), as Tangata Tiaki were not appointed there until November 2009.

## 1.5 Other sources of mortality

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

## 2. BIOLOGY

Pāua are herbivores which can form large aggregations on reefs in shallow subtidal coastal habitats. Movement is over a sufficiently small spatial scale that the species may be considered sedentary. Pāua are broadcast spawners and spawning is usually annual. Habitat related factors are an important source of variation in the post-settlement survival of pāua. Growth, morphometrics, and recruitment can vary over short distances and may be influenced by factors such as water temperature, wave exposure, habitat structure and the availability of food. Naylor et al (2016) analysed demographic variation in pāua in New Zealand. They concluded that there were large differences in the growth rates and maximum size over a large latitudinal range. Their analysis indicated that water temperature, as indicated by sea surface temperature, was an important determinant of these. Pāua become sexually mature when they are about 70–90 mm long, or 3–5 years old. A summary of generic estimates for biological parameters for pāua is presented in Table 5. Parameters specific to individual pāua QMAs are reported in the specific Working Group reports.

**Table 5: Estimates of biological parameters for pāua (*H. iris*).**

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

## 3. STOCKS AND AREAS

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

## 4. ENVIRONMENTAL AND ECOSYSTEM CONSIDERATIONS

This section was updated for the 2021 Fishery Assessment Plenary. A more detailed summary from an issue-by-issue perspective is available in the Aquatic Environment and Biodiversity Annual Review 2021 (Fisheries New Zealand 2021), online at https://www.mpi.govt.nz/dmsdocument/51472-Aquatic-Environment-and-Biodiversity-Annual-Review-AEBAR-2021-A-summary-of-environmental-interactions-between-the-seafood-sector-and-the-aquatic-environment.

### 4.1 Ecosystem role

Pāua are eaten by a range of predators, and smaller pāua are generally more vulnerable to predation. Smaller pāua are consumed by blue cod (Carbines & Beentjes 2003), snapper (Francis 2003), banded wrasse (Russell 1983), spotties (McCardle 1983), triplefins (McCardle 1983) and octopus (Andrew & Naylor 2003). Large pāua are generally well protected by their strong shells but are still vulnerable to rock lobsters (McCardle 1983) and the large predatory starfishes *Astrostole scabra* and *Coscinasterias muricata* (Andrew & Naylor 2003). Large pāua are also vulnerable to predation by eagle rays (McCardle 1983), but Ayling & Cox (1982) suggested that eagle rays feed almost exclusively on Cook's turban. There are no known predators that feed exclusively on pāua.

Pāua feed preferentially on drift algae but at high densities they also feed by grazing attached algae. They are not generally considered to have a large structural impact upon algal communities but at high densities they may reduce the abundance of algae. There are no recognised interactions with pāua abundance and the abundance or distribution of other species, except for kina which, at very high densities, appear to exclude pāua (Naylor & Gerring 2001). Research at D'Urville Island and on Wellington's south coast suggests that there is some negative association between pāua and kina (Andrew & MacDiarmid 1999).

### 4.2 Fish and invertebrate bycatch

Because pāua are harvested by hand gathering, incidental bycatch is limited to epibiota attached to, or within the shell. The most common epibiont on pāua shell is non-geniculate coralline algae, which, along with most other plants and animals which settle and grow on the shell, such as barnacles, oysters, sponges, bryozoans, and algae, appears to have general habitat requirements (i.e., these organisms are not restricted to the shells of pāua). Several boring and spiral-shelled polychaete worms are commonly found in and on the shells of pāua. Most of these are found on several shellfish species, although within New Zealand's shellfish, the onuphid polychaete *Brevibrachium maculatum* has been found only in pāua shell (Read 2004). This species, however, has also been reported to burrow into limestone, or attach its tube to the holdfasts of algae (Read 2004). It is also not uncommon for pāua harvesters to collect predators of pāua (mainly large predatory starfish) while fishing and to effectively remove these from the ecosystem. The levels of these removals are unlikely to have a significant effect on starfish populations (nor, in fact, on the mortality of pāua caused by predation).

### 4.3 Incidental catch (seabirds, mammals, and protected fish)

There is no known bycatch of threatened, endangered, or protected species associated with the hand gathering of pāua.

### 4.4 Benthic interactions

The environmental impact of pāua harvesting is likely to be minimal because pāua are selectively hand gathered by free divers. Habitat contact by divers at the time of harvest is limited to the area of pāua foot attachment, and pāua are usually removed with a blunt tool to minimise damage to the flesh. The diver's body is also seldom in full contact with the benthos. Vessels anchoring during or after fishing have the potential to cause damage to the reef depending on the type of diving operation (in many cases, vessels do not anchor during fishing). Damage from anchoring is likely to be greater in areas with fragile species such as corals than it is on shallow temperate rocky reefs. Corals are relatively abundant at shallow depths within Fiordland, but there are seven areas within the sounds with significant populations of fragile species where anchoring is prohibited.

## 4.5 Other considerations

### 4.5.1 Genetic effects

Fishing, and environmental changes, including those caused by climate change or pollution, could alter the genetic composition or diversity of a species and there is some evidence to suggest that genetic changes may occur in response to fishing of abalones. Miller et al (2009) suggested that, in *Haliotis rubra* in Tasmania, localised depletion will lead to reduced local reproductive output which may, in turn, lead to an increase in genetic diversity because migrant larval recruitment will contribute more to total larval recruitment. Enhancement of pāua stocks with artificially-reared juveniles has the potential to lead to genetic effects if inappropriate broodstocks are used.

### 4.5.2 Biosecurity issues

*Undaria pinnatifida* is a highly invasive opportunistic kelp which spreads mainly via fouling on boat hulls. It can form dense stands underwater, potentially resulting in competition for light and space which may lead to the exclusion or displacement of native plant and animal species. *Undaria* may be transported on the hulls of pāua dive tenders to unaffected areas. Bluff Harbour, for example, supports a large population of *Undaria*, and is one of the main ports of departure for fishing vessels harvesting pāua in Fiordland, which appears to be devoid of *Undaria* (R. Naylor pers. comm.). In 2010, a small population of *Undaria* was found in Sunday Cove in Breaksea Sound, and attempts to eradicate it appear to have been successful (see https://www.mpi.govt.nz/biosecurity/marine-pest-disease-management/fiordland-marine-biosecurity-programme/).

### 4.5.3 Kaikōura Earthquake

Research was undertaken to investigate the influence of the November 2016 Kaikōura earthquake on pāua stocks along the Kaikōura coastline. The results estimated that the seabed uplift led to a loss of up to 50% of the pre-earthquake fished area across PAU 3 statistical areas. Annual biomass surveys have showed a recovery of the stock which has led to the reopening of the fishery in 2021-22 for 3 months. More details can be found in the PAU 3 Working Group report.

### 4.5.4 Marine heatwave

A baseline report summarising trends in climatic and oceanographic conditions in New Zealand that are of potential relevance for fisheries and marine ecosystem resource management in the New Zealand region was completed by Hurst et al (2012). There is also an updated chapter on oceanic trends in the Aquatic Environment and Biodiversity Annual Review 2021 (Fisheries New Zealand 2021). Any effects of recent warmer temperatures (such as the high surface temperatures off the WCSI during the 2016 and 2017 spawning seasons, marine heatwaves, and general warming of the Tasman Sea (Sutton & Bowen 2019) on fish distribution, growth, or spawning success have yet to be determined.

Shellfish fisheries have been identified as likely to be vulnerable to ocean acidification (Capson & Guinotte 2014). A recent project that has just reached completion describes the state of knowledge of climate change-associated predictions for components of New Zealand's marine environment that are most relevant to fisheries (Cummings et al 2021). Past and future projected changes in coastal and ocean properties, including temperature, salinity, stratification and water masses, circulation, oxygen, ocean productivity, detrital flux, ocean acidification, coastal erosion and sediment loading, wind and waves are reviewed. Responses to climate change for these coastal and ocean properties are discussed, as well as their likely impact on the fisheries sector, where known.

A range of decision support tools in use overseas were evaluated with respect to their applicability for dissemination of the state of knowledge on climate change and fisheries. Three species, for which there was a relatively large amount of information available were chosen from the main fisheries sectors for further analysis. These were pāua, snapper, and hoki (shellfish, inshore, and middle-depths/deepwater fisheries, respectively). An evaluation of the sensitivity and exposure of pāua to climate change-associated threats, based on currently available published literature and expert opinion, assessed pāua vulnerability to climate change effects as 'low' (Cummings et al 2021).

# 5. STOCK ASSESSMENT

The dates of the most recent survey or stock assessment for each QMA are listed in Table 6.

**Table 6: Recent survey and stock assessment information for each pāua QMA.**

| QMA | Type of survey or assessment | Date | Comments |
|---|---|---|---|
| PAU 1 | No surveys or assessments have been undertaken | | |
| PAU 2 | Base case: length-based Bayesian stock assessment | 2021 | A large proportion of PAU 2, including the Wellington south coast and west of Turakirae, is either a Marine Reserve or voluntarily closed to commercial fishing. This means that the data collected from the commercial fishery are exclusive of this large area and therefore the assessment only applies to the south east component of PAU 2 (Wairarapa). Lack of contrast in catch, CPUE, and length frequency makes estimation of stock status and biomass trajectories difficult.<br>The 2019–20 year was excluded from the PCELR CPUE series because of concerns about the comparability with previous years due to the effects of COVID-19 on export markets, and ERS reporting issues. This may continue into the future. |
| PAU 3A | Biomass survey | 2021 | Biomass surveys have been conducted since the 2016 Kaikōura earthquakes. They have showed a recovery of the stock and led to the reopening of the fishery in 2021-22 for a duration of 3 months only. There are not enough data to attempt a stock assessment at this stage. |
| PAU 3B | CPUE Standardisation | 2022 | A stock assessment for the PAU 3B area was attempted in 2021–22, based on estimates of historical catches, CPUE trends and commercial length frequency data. CPUE trends were found to be stable despite steady increases in catch over the past decades. |
| PAU 4 | CPUE Standardisation | 2016 | In February 2010 the Shellfish Working Group (SFWG) agreed that, due to the lack of data of adequate quality to use in the Bayesian length-based model, a stock assessment for PAU 4 using this model was not appropriate. In 2016 an analysis of the last 14 years of CPUE data was done. This report showed a potential decline in the fishery since the early 2000s, however the poor data quality is causing considerable uncertainty about the real trend in the fishery. |
| PAU 5A | Quantitative assessment using a Bayesian length-based model | 2020 | The 2020 stock assessment was implemented as a single area model together with a three-area spatial model to corroborate findings from the single area model. The status of the stock was estimated to be 51% $B_0$. At current levels of catch spawning stock biomass is projected to remain nearly unchanged at 51% $B_0$ after 3 years, with an equilibrium value of 50% of $B_0$. |
| PAU 5B | Quantitative assessment using a Bayesian length-based model | 2018 | The 2018 Plenary accepted this assessment as best scientific information. The status of the stock was estimated to be 47% $B_0$. |
| PAU 5D | Quantitative assessment using a Bayesian length-based model | 2019 | The reference case model estimated that the unfished spawning stock biomass ($B_0$) was about 2029 t (1673–2535 t) and the spawning stock population in 2018 ($B_{2018}$) was about 40% (25–65%) of $B_0$. The model projection made for three years assuming 2018 catch levels (which includes commercial catch) and using recruitment re-sampled from the recent model estimates, suggested that the spawning stock abundance would remain at 42% (28–52%) $B_0$ over the following three years. The projection also indicated that the probability of the spawning stock biomass being above the target (40% $B_0$) will decrease from about 52% in 2018 to 49% by 2021. |
| PAU 6 | Biomass estimate | 1996 | This fishery has a TACC of 1 t. |
| PAU 7 | Quantitative assessment using a Bayesian length-based model | 2022 | The SFWG agreed that the stock assessment was reliable for Cook Strait based on the available data. Currently, spawning stock biomass is estimated to be 33% $B_0$ and is Unlikely to be at or above the target. It is also Very Unlikely to be below the soft and hard limits. Overfishing is About as Likely as Not to be occurring. |
| PAU 10 | No surveys or assessments have been undertaken | | |

### 5.1 Estimates of fishery parameters and abundance

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

In QMAs where quantitative stock assessments have been undertaken, standardised CPUE is used as input data for the Bayesian length-based stock assessment model. There is however a large amount of literature on abalone which suggests that any apparent stability in CPUE should be interpreted with caution and CPUE may not be proportional to abundance because it is possible to maintain high catch rates despite a falling biomass. This occurs because pāua tend to aggregate and, to maximise their catch rates, divers move from areas that have been depleted of pāua to areas with higher density. The consequence of this fishing behaviour is that overall abundance is decreasing while CPUE is remaining stable. This process of hyperstability is believed to be of less concern in most commercial areas because fishing in these QMAs is consistent across all fishable areas. An exception are the D'Urville Island and Northern Faces areas of PAU 7, where catches have declined substantially, and CPUE now only reflects a few remaining areas. Other areas may be highly depleted but fishery dependent CPUE does not reflect abundance in these areas any longer.

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

- Due to inappropriate survey design the RDS data appear to be of very limited use for constructing relative abundance indices.
- There was clear non-linearity in the RDS index, the form of which is unclear and could be potentially complex.
- CVs of RDS index 'year' effects are likely to be underestimated, especially at low densities.
- Different abundance trends among strata reduces the reliability of RDS indices, and the CVs are likely to be uninformative about this.
- It is unlikely that the assessment model can determine the true non-linearity of the RDS index-abundance relationship because of the high variability in the RDS indices.
- The non-linearity observed in the RDS indices is likely to be more extreme at low densities, so the RDSI is likely to mask trends when it is most critical to observe them.
- Existing RDS data is likely to be most useful at the research stratum level.

For these reasons, RDS data are not used in any recent PAU stock assessments.

### 5.2 Biomass estimates

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

Biomass has been estimated, as part of the stock assessments, for PAU 2, 5A, 5B, 5D, and 7 (Table 6). For further information on biomass estimates specific to each pāua QMA refer to the specific Working Group report.

### 5.3 Yield Estimates and Projections

Yield estimates and projections are estimated as part of the stock assessment process. Both are available for PAU 2, PAU 5A, PAU 5B, PAU 5D, and PAU 7. For further information on yield estimates and projections specific to each pāua QMA refer to the specific Working Group report.

### 5.4 Other factors

In the last few years, the commercial fisheries have been implementing voluntary management actions in the main QMAs. These management actions include raising the minimum harvest size, subdividing QMAs into smaller management areas, and capping catch in the different areas and in some QMAs, not catching the full Annual Catch Entitlement (ACE) in a particular fishing year.

## 6. STATUS OF THE STOCKS

The status of pāua stocks PAU 2, PAU 3A, PAU3B, PAU 4, PAU 5A, PAU 5B, PAU 5D, and PAU 7 are given in the relevant Working Group reports.

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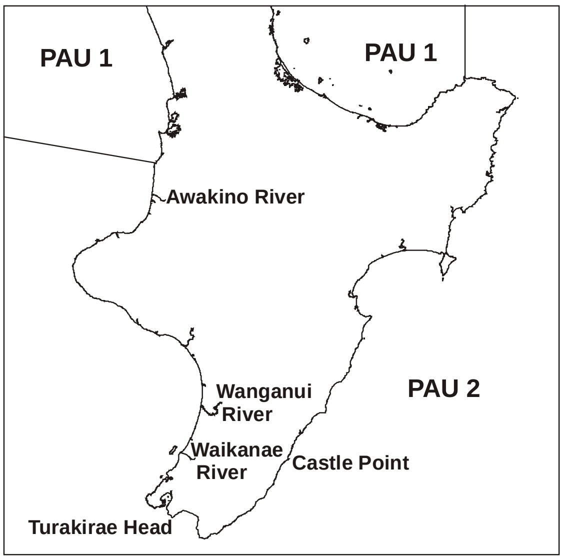
# PĀUA (PAU 2) – Wairarapa / Wellington / Taranaki

(*Haliotis iris*)
Pāua




## 1. FISHERY SUMMARY

PAU 2 was introduced into the Quota Management System in 1986–87 with a TACC of 100 t. As a result of appeals to the Quota Appeal Authority, the TACC was increased to 121.19 t in 1989 and has remained unchanged to the current fishing year (Table 1). There is no TAC for this QMA; 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.

**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 2 since introduction to the Quota Management System (QMS).**

| Year | TAC | Customary | Recreational | Other mortality | TACC |
|---|---|---|---|---|---|
| 1986–1989 | – | – | – | – | 100 |
| 1989–present | – | – | – | – | 121.19 |

### 1.1 Commercial fisheries

The fishing year runs from 1 October to 30 September. Most of the commercial catch comes from the Wairarapa and Wellington South coasts between Castlepoint and Turakirae Head. The western area between Turakirae Head and the Waikanae River is closed to commercial fishing.

On 1 October 2001 it became mandatory to report catch and effort on PCELRs using the fine-scale reporting areas that had been developed by the New Zealand Pāua Management Company for their voluntary logbook programme (Figure 1). Landings for PAU 2 are shown in Table 2 and Figure 2. Landings have been at or very close to the TACC since 1988–89.

### 1.2 Recreational fisheries

The most recent recreational fishery survey "The National Panel Survey of Marine Recreational Fishers 2017–18: Harvest Estimates" Wynne-Jones et al (2019), estimated that about 83 t of pāua were harvested by recreational fishers in PAU 2 in 2017–18.

Because pāua around Taranaki are naturally small and never reach the minimum legal size (MLS) of 125 mm, a new MLS of 85 mm was introduced for recreational fishers from 1 October 2009. The new length was on a trial basis for five years and now applies between the Awakino and Wanganui rivers.

For further information on recreational fisheries refer to the Introduction – Pāua chapter.

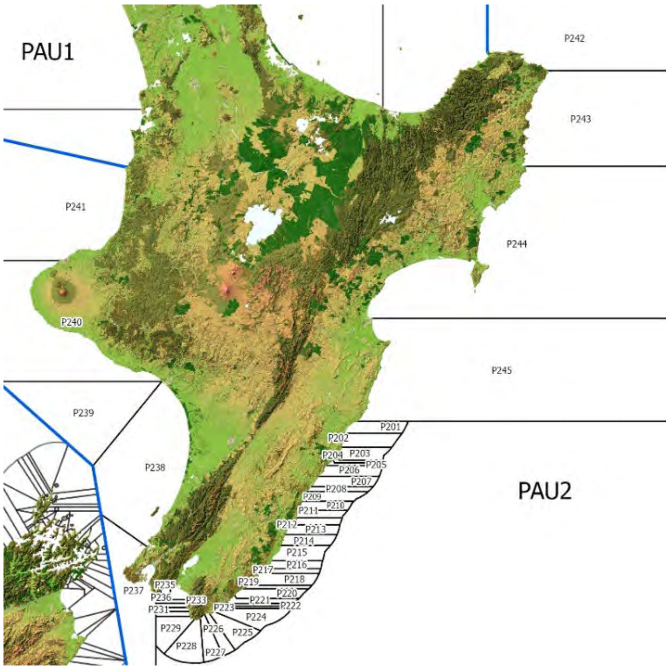



**Figure 1:Map of fine-scale statistical reporting areas for PAU 2.**

**Table 2: TACC and reported landings (t) of pāua in PAU 2 from 1983–84 to the present.**

| Fishing year | Landings | TACC | Fishing year | Landings | TACC |
|---|---|---|---|---|---|
| 1983–84* | 110 | – | 2002–03 | 121.19 | 121.19 |
| 1984–85* | 154 | – | 2003–04 | 121.06 | 121.19 |
| 1985–86* | 92 | – | 2004–05 | 121.19 | 121.19 |
| 1986–87* | 96.2 | 100 | 2005–06 | 121.14 | 121.19 |
| 1987–88* | 122.11 | 111.33 | 2006–07 | 121.20 | 121.19 |
| 1988–89* | 121.5 | 120.12 | 2007–08 | 121.06 | 121.19 |
| 1989–90 | 127.28 | 121.19 | 2008–09 | 121.18 | 121.19 |
| 1990–91 | 125.82 | 121.19 | 2009–10 | 121.13 | 121.19 |
| 1991–92 | 116.66 | 121.19 | 2010–11 | 121.18 | 121.19 |
| 1992–93 | 119.13 | 121.19 | 2011–12 | 120.01 | 121.19 |
| 1993–94 | 125.22 | 121.19 | 2012–13 | 122.00 | 121.19 |
| 1994–95 | 113.28 | 121.19 | 2013–14 | 120.00 | 121.19 |
| 1995–96 | 119.75 | 121.19 | 2014–15 | 115.00 | 121.19 |
| 1996–97 | 118.86 | 121.19 | 2015–16 | 123.74 | 121.19 |
| 1997–98 | 122.41 | 121.19 | 2016–17 | 123.69 | 121.19 |
| 1998–99 | 115.22 | 121.19 | 2017–18 | 113.87 | 121.19 |
| 1999–00 | 122.48 | 121.19 | 2018–19 | 122.89 | 121.19 |
| 2000–01 | 122.92 | 121.19 | 2019–20 | 122.28 | 121.19 |
| 2001–02 | 116.87 | 121.19 | 2020–21 | 126.26 | 121.19 |

* FSU data.

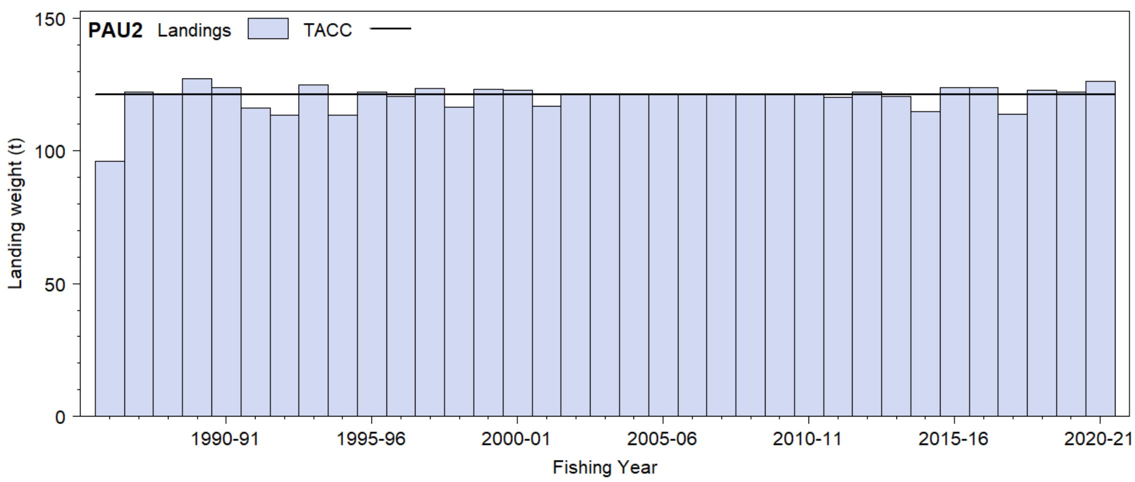



**Figure 2:Historical landings and TACC for PAU 2 from 1983–84 to the present. QMS data from 1986 to present.**

### 1.3 Customary fisheries

Pāua is a taonga species and as such there is an important customary use of pāua by Maori for food, and the shells have been used extensively for decorations and fishing devices.

For information on customary catch regulations and reporting refer to the Introduction – Pāua chapter.

Estimates of customary catch for PAU 2 are given in Table 3. These numbers are likely to be an underestimate of customary harvest because only the catch in kilograms and numbers are reported in the table. In addition, many tangata whenua also harvest pāua under their recreational allowance and these are not included in records of customary catch.

**Table 3: Fisheries New Zealand records of customary harvest of pāua (approved and reported as weight (kg) and in numbers) in PAU 2 since 1998-99. – no data.**

| | Weight (kg) | | Numbers | |
|---|---|---|---|---|
| Fishing year | Approved | Harvested | Approved | Harvested |
| 1998–99 | 40 | 40 | – | – |
| 1999–00 | – | – | 1 400 | 820 |
| 2000–01 | – | – | – | – |
| 2001–02 | – | – | – | – |
| 2002–03 | – | – | – | – |
| 2003–04 | – | – | 4 805 | 4 685 |
| 2004–05 | – | – | 2 780 | 2 440 |
| 2005–06 | – | – | 5 349 | 4 385 |
| 2006–07 | – | – | 7 088 | 3 446 |
| 2007–08 | – | – | 11 298 | 6 164 |
| 2008–09 | – | – | 30 312 | 24 155 |
| 2009–10 | – | – | 5 505 | 4 087 |
| 2010–11 | – | – | 20 570 | 17 062 |
| 2011–12 | 243 | 243 | 29 759 | 23 932 |
| 2012–13 | 10 | 6 | 51 275 | 27 653 |
| 2013–14 | – | – | 61 486 | 30 129 |
| 2014–15 | – | – | 25 215 | 16 449 |
| 2015–16 | – | – | 11 540 | 6 383 |
| 2016–17 | 100 | 100 | 13 698 | 6 877 |
| 2017–18 | – | – | 6 960 | 1 942 |
| 2018–19 | – | – | 8 585 | 3 209 |

### 1.4 Illegal catch

It is widely believed that the level of illegal harvesting is high around Wellington and on the Wairarapa coast. For further information on illegal catch refer to the Introduction – Pāua chapter.

### 1.5 Other sources of mortality

For further information on other sources of mortality refer to the Introduction – Pāua chapter.

## 2. BIOLOGY

For further information on pāua biology refer to the Introduction – Pāua chapter. A summary of published estimates of biological parameters for PAU 2 is presented in Table 4.

**Table 4: Estimates of biological parameters (*H. iris*)**

| Area | | | Estimate | Source |
|---|---|---|---|---|
| 1. Size at maturity (shell length) | | | | |
| Wellington | 50% mature | | 71.7 mm | Naylor et al (2006) |
| Taranaki | 50% mature | | 58.9 mm | Naylor & Andrew (2000) |
| Meta-analysis for fished areas (all QMAs) | 50% mature | | 90.5 mm | Neubauer & Tremblay-Boyer (2019a) |
| 2. Fecundity = $a$ (length)$^b$ (eggs, shell length in mm) | | | | |
| Taranaki | | $a$ = 43.98 | $b$ = 2.07 | Naylor & Andrew (2000) |
| 3. Exponential growth parameters (both sexes combined) | | | | |
| Wellington | $g_{50}$ | | 30.58 mm | Naylor et al (2006) |
| | $g_{100}$ | | 14.8 mm | |
| Taranaki | $G_{25}$ | | 18.4 mm | Naylor & Andrew (2000) |
| | $G_{75}$ | | 2.8 mm | |
| Assessment fit for commercially fished area | $G_{75}$ | | 14.01 mm (SE 1.36mm) | Neubauer (in press) |
| | $G_{125}$ | | 2.00 mm (SE 0.30 mm) | |

## 3. STOCKS AND AREAS

For further information on stocks and areas refer to the Introduction – Pāua chapter.

## 4. STOCK ASSESSMENT

In 2020, the Shellfish Fisheries Assessment Working Group evaluated the overall CPUE trend and concluded (given experience with other QMAs) that the data were potentially sufficient to conduct a full length-based stock assessment in line with those run for other QMAs (e.g., Neubauer & Tremblay-Boyer 2019b, Neubauer 2020a). However, the Fisheries Assessment Plenary considered the stock assessment results to be insufficiently robust given concerns about the choice of the base-case scenario and sensitivities, and issues with use of the early CPUE data (i.e., FSU and CELR data). Concerns were also raised about the validity of region-wide CPUE and Catch Sampling Length-Frequency (CSLF) trends given the fine-scale stock structure of pāua. An updated model addressing concerns raised in the 2020 plenary was presented to plenary in May 2021, including updated data to the 2020 fishing year.

### 4.1 Relative abundance estimates from standardised CPUE analyses

A combined series of standardised CPUE indices CELR (1990–2001) data and PCELR (2002–2020) data was considered for the 2021 stock assessment. However, the Plenary concluded that the CELR analysis was unlikely to represent biomass trends and also that the 2019–2020 PCELR data were likely to be inconsistent with earlier years in the series, because of COVID-19 effects on export markets and Electronic Reporting System (ERS) reporting issues, and should therefore be excluded.

There was little evidence in the data for serial depletion at statutory reporting scales; all main areas (i.e., excluding sporadically fished northern areas) were fished consistently throughout the time series (Figure 3).

CPUE standardisation was carried out using Bayesian Generalised Linear Mixed Models (GLMM) which partitioned variation among fixed (research strata) and random variables. CPUE was defined as the log of daily catch within a statistical area. Variables in the model were fishing year, estimated fishing effort, client number, research stratum, dive condition, diver ID (PCELR), and fine-scale statistical area.

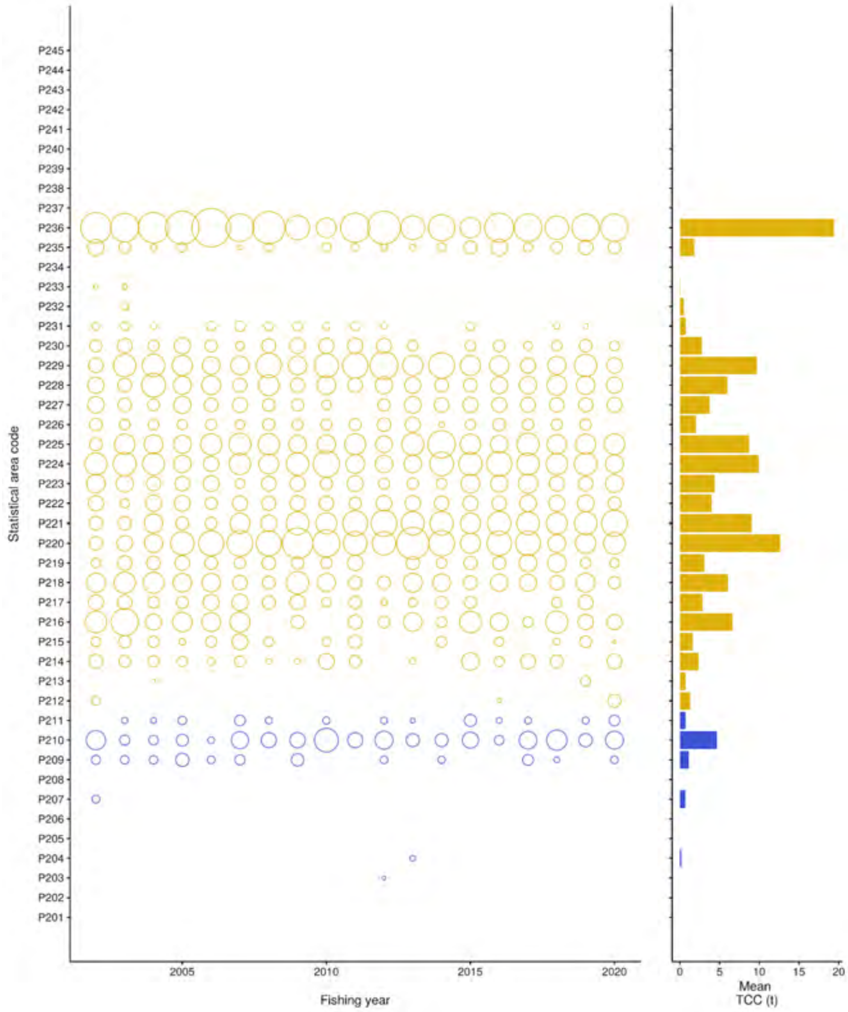



**Figure 3: Relative trend in pāua catch (kg) over time by statistical areas in quota management area PAU 2 for the period from 2002 to 2020, with mean commercial catch over the same time period (right-hand side). Statistical areas used for the stock assessment within PAU 2 are colour-coded as gold for Statistical Areas 015 & 016 and blue for the northern Statistical Area 014; the latter area is small and less consistently fished, and was excluded from the stock assessment (but included in CPUE analyses).**

Following recommendations from the 2020 plenary, the 2021 CPUE analysis introduced a client experience effect, estimated as a smoothing spline across years that individual clients (usually referring to ACE-holders/boat-owners) had been active in the fishery. The latter was determined across CELR and PCELR data. This effect was found to have a large influence on the CPUE index for CELR data, and the plenary chose not to retain this index because it is unclear to what degree changes in abundance and changes in the fishery at the time are confounded, and in how far the standardisation model can correct for the latter, even in the presence of an experience effect (this effect may itself be confounded with trends in biomass).

For the retained PCELR index, changes over time in ACE-holders present in the fishery had the strongest influence on CPUE (Figure 4). An initial decline was evident from the early part of the PCELR time series, with relatively stable but fluctuating CPUE since 2007 (Figure 5). In some circumstances, commercial CPUE may not be proportional to abundance because it is possible to maintain catch rates of pāua despite a declining biomass. This occurs because pāua tend to aggregate and divers move between areas to maximise their catch rates. The apparent stability in the CPUE should therefore be interpreted with caution.

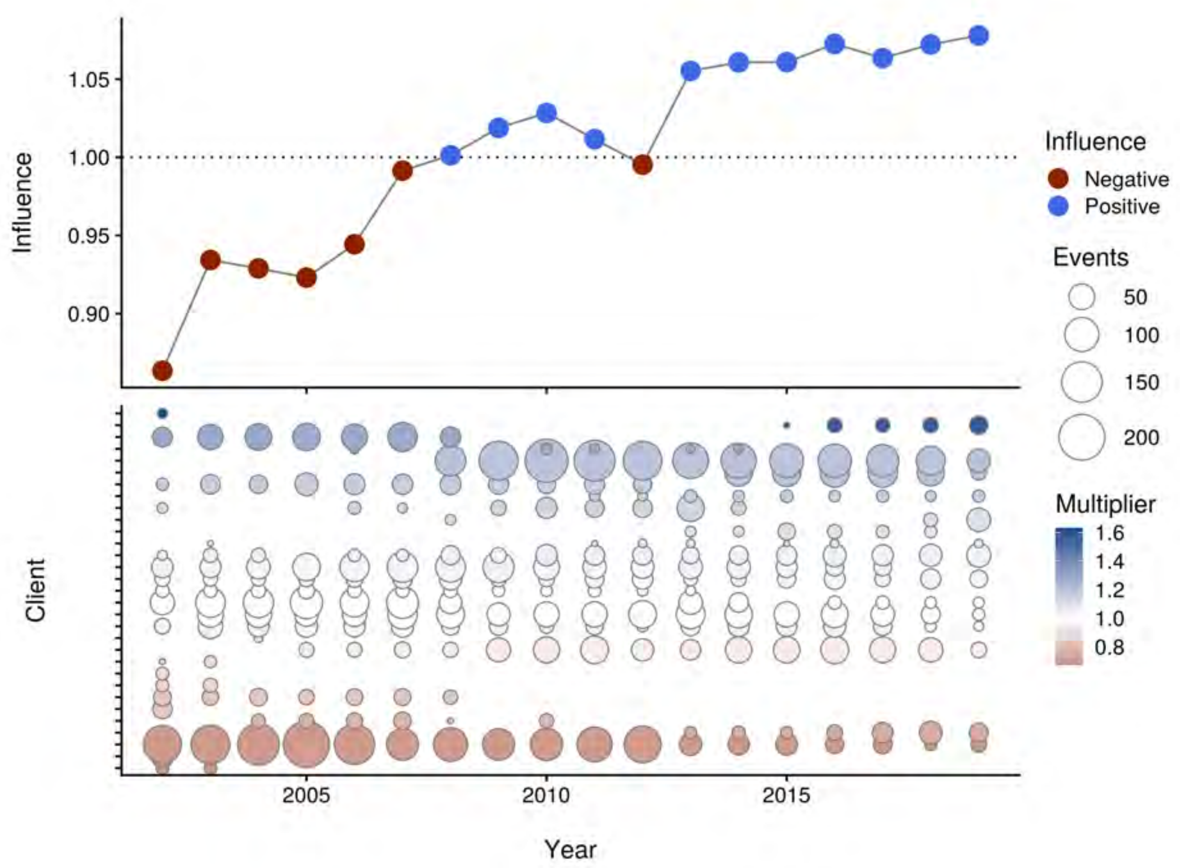



**Figure 4: Influence of client number (usually ACE holders) turnover on the PCELR CPUE index through time. A positive influence for any given year suggests that the raw CPUE is inflated because most effort came from clients with higher catch rates in the fishery.**

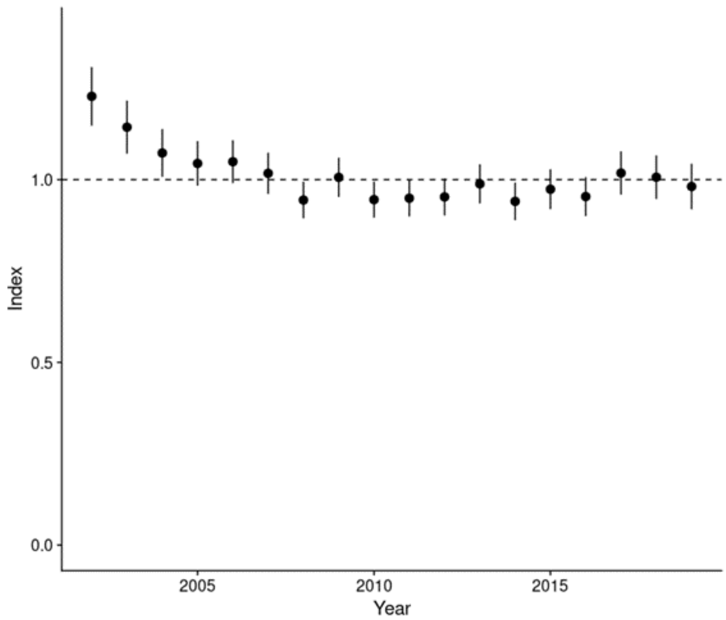



**Figure 5: Standardised CPUE index for PCELR data, with posterior mean and standard errors.**

## 4.2 Stock assessment methods

The 2021 stock assessment for PAU 2 used an updated version of the length-based population dynamics model described by Breen et al (2003), catch and commercial length-frequency data up to the 2019–20 fishing year, as well as the above-mentioned CPUE index for fishing years 2002–2019 (Neubauer 2020b). Although the overall population dynamics model remained unchanged from Breen et al (2003), the PAU 2 stock assessment incorporates changes to the previous methodology first introduced in the 2018 assessment of PAU 5D (Neubauer & Tremblay-Boyer 2019b). In addition, illegal and recreational catch were, for the first time, split from commercial catch, and illegal catch was modeled as taking pāua in proportion to abundance rather than according to commercial selectivity.

The model structure assumed a single-sex population residing in a single homogeneous area, with length classes from 70 mm to 170 mm in groups of 2 mm, although a spatial version of the assessment model (Neubauer 2020a) was also tried in 2019. The latter provided near identical results to the non-spatial model and was not pursued in 2021.

Growth was length-based, without reference to age, mediated through an estimated growth transition matrix that describes the probability of each length class to change at each time step. A growth prior was formulated from a meta-analysis of pāua growth across fished areas in New Zealand (Neubauer & Tremblay-Boyer 2019a), and the functional form of the resulting growth was encoded in a multivariate normal (Gaussian process) prior on the growth transition matrix. Pāua entered the partition following recruitment and were removed by natural mortality and fishing mortality.

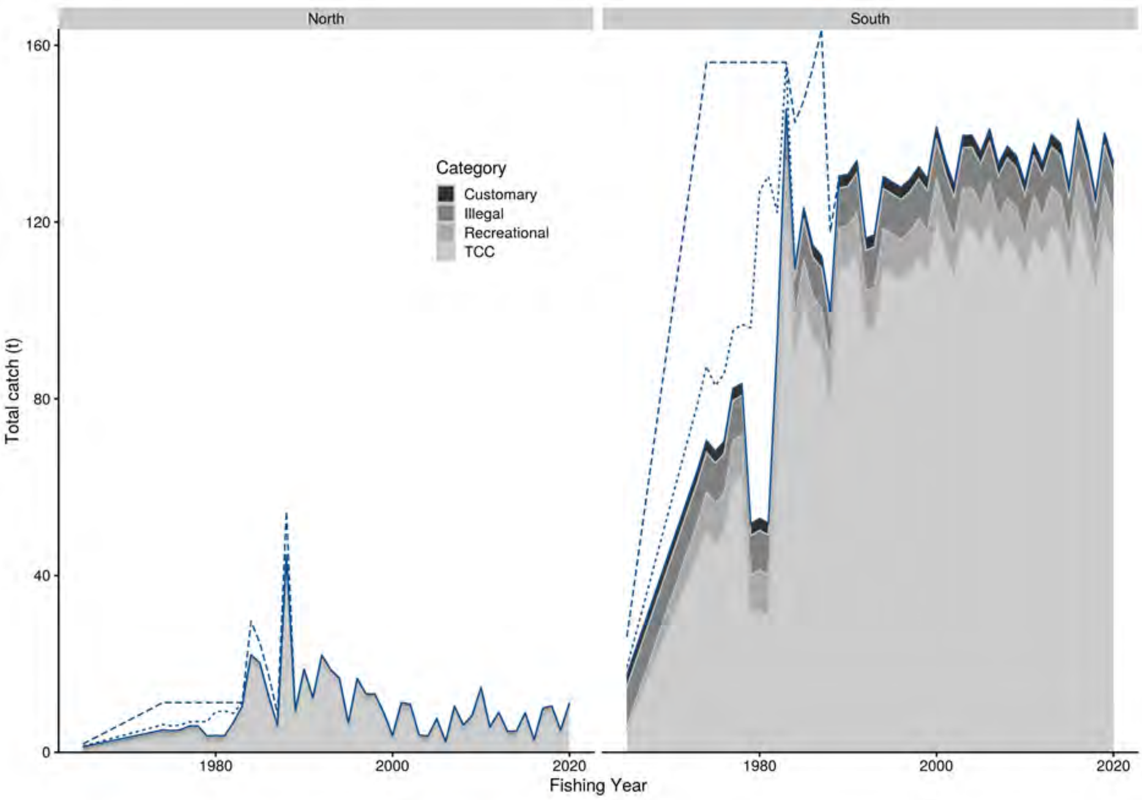



**Figure 6: Assumed catch histories for southern (gold circles in Figure 3) and northern (blue circles in Figure 3) statistical areas. Grey shading indicates components of the total catch, with the dotted line showing the base case assumption of total catch, including unreported catches prior to QMS entry of PAU 2, and the dashed line showing a sensitivity with high assumed pre-QMS catches. The reported catches (grey area only) were taken as a second sensitivity.**

The model simulates the population from 1965 to 2020. Catches were available for 1974–2020, though catches before 1990 are considered highly uncertain. Interviews with divers at the time suggested that misreporting was prevalent in early years preceding the Quota Management System (i.e., before 1986), and that a considerable amount of catch was unreported at the time. Three different catch levels were tried to account for this uncertainty in the assessment, and catches were assumed to increase linearly from 0 in 1965 to the 1974 catch level (Figure 6). Catches included commercial, recreational, customary, and illegal catch, and all catches occurred within the same time step. Illegal catch was assumed to be constant at 10 t for the commercially fished area (South Wairarapa), whereas recreational catch increased from the start of the fishery to 1974 and remained at 10 t for the remainder of the time series.

Recruitment was assumed to take place at the beginning of the annual cycle, with recruitment deviates estimated from 2000 to 2017, and length-at-recruitment was defined by a uniform distribution with a range between 70 and 80 mm. Natural mortality was fixed at 0.11, with sensitivities at 0.06 and 0.16 bracketing *a priori* assumptions about natural mortality. The model estimated the commercial fishing selectivity, assumed to follow a logistic curve, with increases in recent years due to changes in the minimum harvest size in some areas. Models with variable (random effect) selectivity were also tried, and though they improved fits to commercial length frequency data, they did not markedly change the overall assessment of biomass trends. The model was initiated with likelihood weights that were found to lead to subjectively appropriate fits to both CPUE and CSLF inputs in other areas (PAU 5, PAU 7), and relative fits for CPUE and CSLF data were examined, based on model fits and residuals.

The assessment calculates the following quantities from the marginal posterior distributions of various partitions of the biomass: the equilibrium (unfished) spawning stock biomass ($SSB_0$) assuming that recruitment is equal to the average recruitment, and the relative spawning and available biomass for 2019 ($SSB_{2019}$ and $B^{Avail}_{Proj}$) and for the projection ($Proj$) period ($SSB_{Proj}$ and $B^{Avail}_{proj}$). This assessment also reports the following fishery indicators:

| | |
|---|---|
| Relative $SSB$ | Estimated spawning stock biomass in the final year relative to unfished spawning stock biomass |
| Relative $B^{Avail}$ | Estimated available biomass in the final year relative to unfished available stock biomass |
| P($SSB_{2019}$ > 40% $SSB_0$) | Probability that the spawning stock biomass in 2019 was greater than 40% of the unfished spawning stock |
| P($SSB_{2019}$ > 20% $SSB_0$) | Probability that the spawning stock biomass in 2019 was greater than 20% of the unfished spawning stock (soft limit) |
| P($SSB_{Proj}$ > 40% $SSB_0$) | Probability that projected future spawning stock biomass will be greater than 40% of the unfished spawning stock given assumed future catches |
| P($SSB_{Proj}$ > 20% $SSB_0$) | Probability that projected future spawning stock biomass will be greater than 20% of the unfished spawning stock given assumed future catches |
| P($B_{Proj}$ > $B_{2018}$) | Probability that projected future biomass (spawning stock or available biomass) is greater than estimated biomass for the 2018 fishing year given assumed future catches |

### 4.2.1 Estimated parameters

Parameters estimated in the assessment model and their assumed Bayesian priors are summarized in Table 4.

**Table 4: A summary of key model parameters, lower bound, upper bound, type of prior, (U, uniform; N, normal; LN = lognormal; Beta = beta distribution), and mean and standard deviation of the prior.**

| | | | | Bounds | |
|---|---|---|---|---|---|
| **Parameter** | **Prior** | **$\mu$** | **sd** | **Lower** | **Upper** |
| ln($R_0$) | LN | 14 | 10 | | |
| ln($q$) | LN | -14 | 100 | | |
| M | fixed | 0.11 | | 0.06 | 0.16 |
| Steepness ($h$) | Beta | 0.8 | 0.17 | 0 | 1 |
| Growth | MVN | From Neubauer & Tremblay-Boyer (2019) | | | |
| $D_{50}$ (Length at 50% selectivity for recreational and commercial catch before adjustments for commercial minimum harvest size) | LN | 125 | 6.25 | 100 | 145 |
| $D_{95-50}$ (Length between 50% and 95% selectivity the commercial catch) | LN | 5.6 | 3 | 0.01 | 50 |
| $ln(\epsilon)$ (Recruitment deviations; 2000-2017) | LN | 0 | 0.4 | | - |

The observational data were:

- A standardised CPUE series covering 2002–2019 based on PCELR data.
- Commercial catch sampling length frequency from 2006 to 2020
- Catches were assumed known at three levels

## 4.3 Stock assessment results

The base model with *M*=0.11 and estimated growth gave a relatively good fit to CPUE and CSLF data, although the first year of PCELR CPUE was not fitted well by this model or any sensitivities. This lack of fit is due to constraints on recruitment deviations that were estimated from 2000, given LF data are available in sufficient numbers since 2006. Since recruitment into the model occurs between 70 and 80 mm (assumed to be 3 year olds), these individuals would only appear in the commercial data as about 6 year olds, and recruitment would likely need to be freed up back to 1996 to fit these points. Fits to recent CSLF data (2019, 2020) were also slightly worse than for other years, potentially due to changes in markets and resulting selectivity. Model sensitivities with low *M* (0.06) fitted CSLF data poorly, and estimated very slow growth, indicating that this assumption is not consistent with data and assumptions about growth in fished areas.

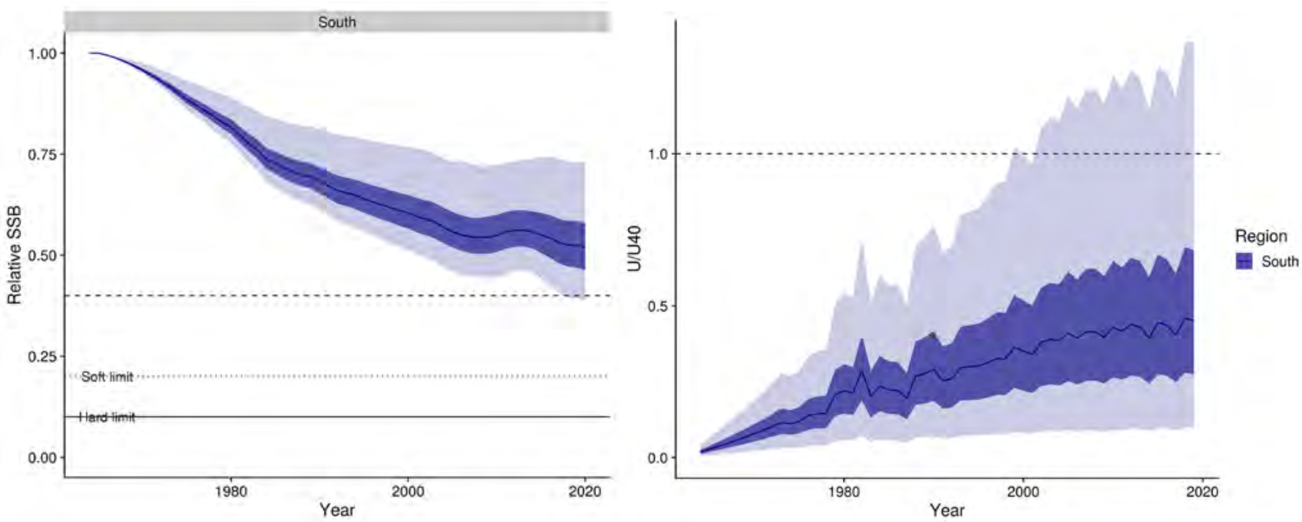



**Figure 7: Posterior distributions of relative spawning stock biomass (*SSB*, left panel) and trends in relative commercial exploitation rate (right panel) in the base case model. Exploitation rate (*U*) is relative to the exploitation rate that would result in a stock depletion to 40% of unfished spawning biomass ($U_{40}$). The dark purple line shows the median of the posterior distribution, the 25$^{th}$ and 75th percentiles are shown as dark ribbons, with light ribbons representing the 95% confidence range of the distribution.**

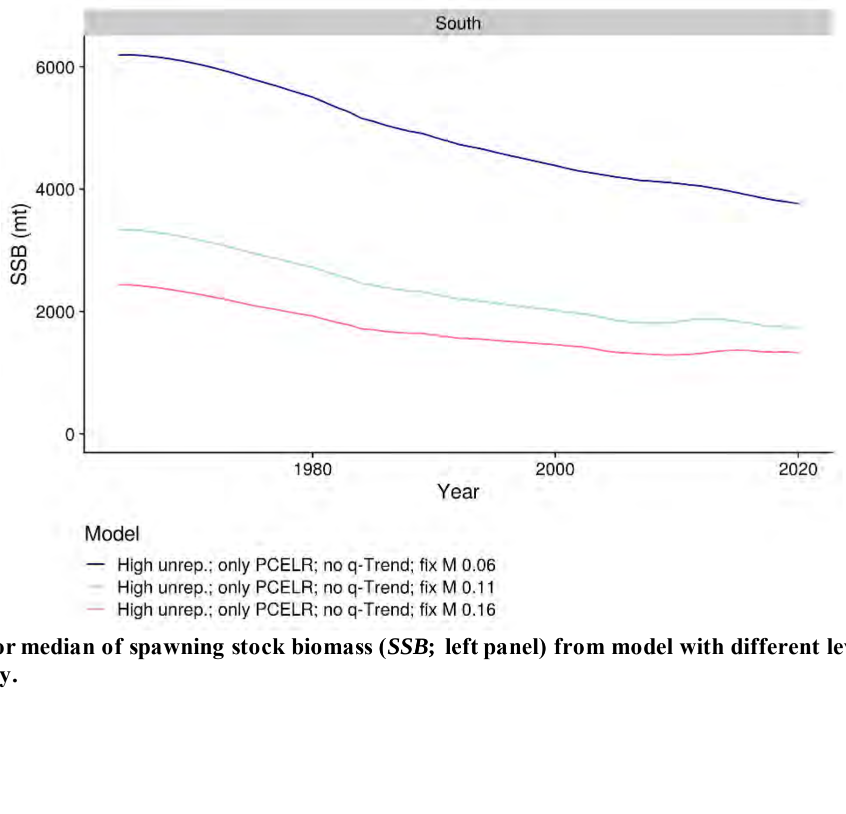



**Figure 8: Posterior median of spawning stock biomass (*SSB*; left panel) from model with different levels of natural mortality.**

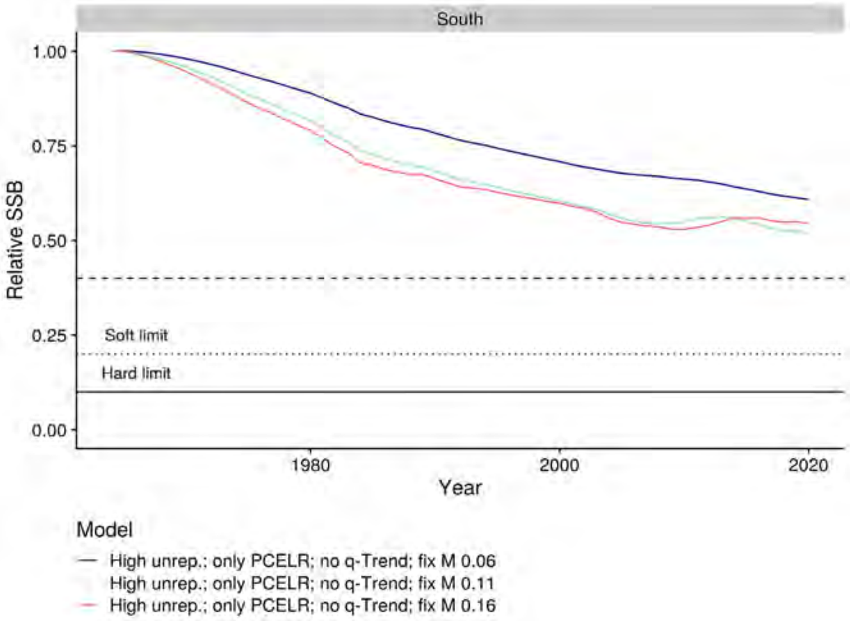



**Figure 9: Posterior median of relative spawning stock biomass (SSB; left panel) from model with different levels of natural mortality.**

**Table 5: Projections for key fishery indicators from the base case model: probabilities of being above 40% and 20% of unfished spawning biomass (*SSB*) [P($SSB_{Proj}$ > 40% $SSB_0$) and P($SSB_{Proj}$ > 20% $SSB_0$)], the probability that *SSB* in the projection year is above current *SSB*, the posterior mean relative to *SSB*, the posterior mean relative available spawning biomass $B^{Avail}_{Proj}$, and the probability that the exploitation rate (*U*) in the projection year is above $U_{40\%\ SSB0}$, the exploitation rate that leads to 40% $SSB_0$. The total commercial catch (TCC) marked with * corresponds to current commercial catch (TACC at 121 t). Other projection scenarios show 20% catch reduction to 97 t and a 20% TACC increase (145 t).**

| TACC (t) | Year | P($SSB_{Proj}$ > 40% $SSB_0$) | P($SSB_{Proj}$ > 20% $SSB_0$) | P($SSB_{Proj}$ > $SSB_{2020}$) | Median rel. $SSB_{Proj}$ | Median rel. $B^{Avail}_{Proj}$ | P($U$ > $U_{40\%\ SSB0}$) |
|---|---|---|---|---|---|---|---|
| 97 | 2021 | 0.96 | 1 | 0.04 | 0.53 | 0.37 | 0.04 |
| | 2022 | 0.96 | 1 | 0.27 | 0.53 | 0.37 | 0.04 |
| | 2023 | 0.96 | 1 | 0.44 | 0.54 | 0.38 | 0.04 |
| | 2024 | 0.96 | 1 | 0.54 | 0.54 | 0.38 | 0.03 |
| | 2025 | 0.96 | 1 | 0.57 | 0.55 | 0.39 | 0.03 |
| 121 | 2021 | 0.96 | 1 | 0.04 | 0.53 | 0.37 | 0.08 |
| | 2022 | 0.95 | 1 | 0.13 | 0.53 | 0.37 | 0.08 |
| | 2023 | 0.94 | 1 | 0.22 | 0.53 | 0.36 | 0.09 |
| | 2024 | 0.93 | 1 | 0.28 | 0.53 | 0.36 | 0.09 |
| | 2025 | 0.92 | 1 | 0.32 | 0.53 | 0.36 | 0.09 |
| 145 | 2021 | 0.96 | 1 | 0.04 | 0.53 | 0.37 | 0.14 |
| | 2022 | 0.94 | 1 | 0.05 | 0.52 | 0.36 | 0.16 |
| | 2023 | 0.92 | 1 | 0.11 | 0.52 | 0.35 | 0.19 |
| | 2024 | 0.89 | 1 | 0.14 | 0.51 | 0.34 | 0.21 |
| | 2025 | 0.86 | 1 | 0.15 | 0.5 | 0.33 | 0.23 |

The base model estimated a steady reduction in spawning biomass from the beginning of the fishing history (assumed to be 1965) to the mid-2000s (Figure 7), with a relatively steady biomass since, reflecting the relatively stable CPUE (Figure 5) and catch (Figure 6) since then. The model estimates that the stock stabilised near 50% of the unfished spawning biomass, with a relatively stable recent exploitation rate (Figure 8).

Alternative models investigated uncertainty in *M*. These models differed in the estimated growth, with the low-*M* model estimating very slow growth to fit commercial length frequency data. As a consequence, the model estimates much higher biomass than at higher *M* to sustain observed catches at stable CPUE. Despite these differences, all models suggest that current stock status is above the target of 40% of unfished biomass. Projections for the base case model suggest unchanged biomass at current exploitation levels (121 t of commercial catch, Table 5).

## 4.4 Other factors

To run the stock assessment model, a number of assumptions must be made, one of these being that CPUE is a reliable index of abundance. The literature on abalone fisheries suggests that this assumption is questionable and that CPUE is difficult to use in abalone stock assessments due to the serial depletion behaviour of fishers along with the aggregating behaviour of abalone. Serial depletion is when fishers consecutively fish-down beds of pāua but maintain their catch rates by moving to new unfished beds; thus CPUE stays high while the overall population biomass is actually decreasing. The aggregating behaviour of pāua results in the timely re-colonisation of areas that have been fished down, as the cryptic pāua, that were unavailable at the first fishing event, move to and aggregate within the recently depleted area. Both serial depletion and aggregation behaviour cause CPUE to have a hyperstable relationship with abundance (i.e., abundance is decreasing at a faster rate than CPUE) thus potentially making CPUE a poor proxy for abundance. The strength of the effect that serial depletion and aggregating behaviour have on the relationship between CPUE and abundance in PAU 2 is difficult to determine. However, because fishing has been consistent in for a number of years and effort has been reasonably well spread, it could be assumed that CPUE is not as strongly influenced by these factors, relative to the early CPUE series.

The assumption of CPUE being a reliable index of abundance in PAU 2 can also be upset by exploitation of spatially segregated populations of differing productivity. This can conversely cause non-linearity and hyper-depletion in the CPUE-abundance relationship, making it difficult to accurately track changes in abundance by using changes in CPUE as a proxy.

Another source of uncertainty is the data. The commercial catch is unknown before 1974 and is estimated with uncertainty before 1990. The model assumes that catches were higher than those reported for the early period of the fishery (1980s) to account for large discrepancy between export and reported catch by QMA. Major differences may exist between the catches assumed in the model and what was actually taken. Non-commercial catch trends, including illegal catch, are also very poorly determined and could be substantially different from what was assumed.

The model treats the whole of the assessed area of PAU 2 as if it were a single stock with homogeneous biology, habitat, and fishing pressure. The model assumes homogeneity in recruitment and natural mortality. Heterogeneity in growth can be a problem for this kind of model (Punt 2003). Nevertheless, the spatial three area model trialed in 2019 showed near identical trends to the single area model, and variation in growth is likely addressed to some extent by having a stochastic growth transition matrix; similarly the length frequency data are integrated across samples from many places. Nevertheless, length frequency data collected from the commercial catch may not represent the available biomass represented in the model with high precision.

The effect of these factors is likely to make model results imprecise at a local scale. 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 the dispersal of larvae is unknown and may be limited. Recruitment failure is a common observation in overseas abalone fisheries, and the current model does not account for such local processes that may decrease recruitment.

## 4.5 Future research considerations

The Plenary considered that the stock assessment model was promising, but that it needed extra work before it could be accepted. Accordingly, the following research considerations are split into those that should be implemented using existing data, and those related to longer term considerations (most of which are also applicable to other PAU stocks).

<u>Short term</u>

- Investigation of alternative non-informative priors in CPUE analysis
- Explore changes in fisher catachability over time (including changing fisher experience, new technology, increasing professionalism) across all PAU fisheries

- Describe effective scaling, and how it's used to estimate size composition of removals (relevant for all PAU assessments). Explore the potential of incorporating seasonal effects into the standardisation model for length compositions.
- More tagging is needed in a larger number of representative strata/areas to estimate growth.
- It is unclear whether a single area model (and an aggregate CPUE index) can adequately represent biomass trends for the many sub-populations in PAU stocks. Spatial use trends and variability in biomass trends can induce both positive and negative bias in CPUE, and more sophisticated models may be needed to counter these biases (e.g., spatio-temporal models, Neubauer 2017). Similarly, finer-scale assessment models should be considered to account for potentially different trends within small-scale populations components, although this is difficult when there are inadequate data to support spatial assessments.
- Re-investigation of value of fishery-independent data (timed swim surveys) for PAU, with view to develop series for PAU 2. This might include sub legal population surveys/sampling.
- Explore sensitivity to alternative growth assumptions and growth rates.
- Investigate implications of non-stationary selectivity

<u>Longer term</u>

- It is unclear to what degree large scale aggregate statistics of commercial length frequency distributions represent changes in the overall length composition of the fishery. Although standardisation of CSLF was carried out for the attempted stock assessment, systematic deviations from stock assessment model expectations point to potential problems with the use of aggregate CSLF data.
- Paua growth is known to be temperature dependent. With warming and increasing heat waves linked to global warming, pāua fisheries could see reductions in long-term productivity linked with direct (physiological) and indirect (bottom-up) changes in the environment. The extent of these changes and potential fishery interactions should be investigated.

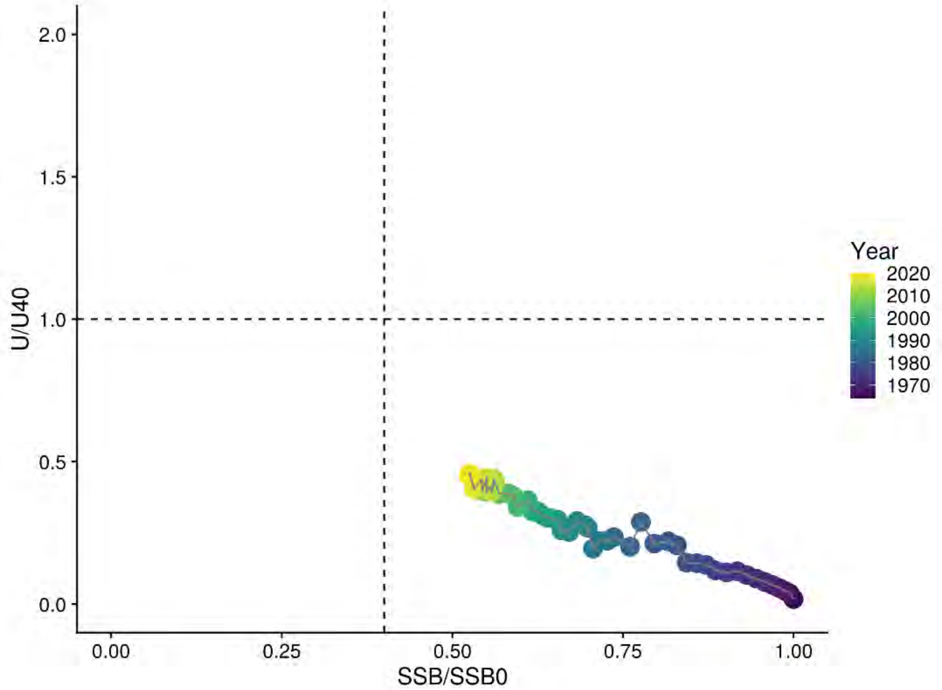
## 5. STATUS OF THE STOCKS

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

The PAU 2 assessment described here applies to the south east component of the region (Wairarapa coast), encompassed by the region between pāua statistical reporting areas P212–P236.

- **PAU 2 -** *Haliotis iris*

| **Stock Status** | |
|---|---|
| Year of Most Recent Assessment | 2021 |
| Assessment Runs Presented | Base case: length-based Bayesian stock assessment |
| Reference Points | Target: 40% $B_0$ (Default as per HSS)<br>Soft Limit: 20% $B_0$ (Default as per HSS)<br>Hard Limit: 10% $B_0$ (Default as per HSS)<br>Overfishing threshold: $U_{40\%B0}$ |
| Status in relation to Target | Likely (> 60%) to be at or above |
| Status in relation to Limits | $B_{2020}$ is Very Unlikely (< 10%) to be below the soft and hard limits |
| Status in relation to Overfishing | Overfishing is Very Unlikely (< 10%) to be occurring |

| **Historical Stock Status Trajectory and Current Status** |
|---|
|   |
| **Posterior medians of relative stock status (spawning stock biomass (*SSB*) depletion level relative to unfished biomass (*$SSB_0$*)) and exploitation rate (*U*), relative to the exploitation rate that would result in a stock depletion to 40% of unfished biomass (*$U_{40}$*).** |

| **Fishery and Stock Trends** | |
|---|---|
| Recent Trend in Biomass or Proxy | Spawning stock biomass has fluctuated without a long-term trend since the early 2000s. |
| Recent Trend in Fishing Mortality or proxy | Fluctuating without trend |
| Other Abundance Indices | - |
| Trends in Other Relevant Indicators or Variables | Commercial length frequency data (CSLF) have shown stable length frequency distributions since the early 2000s, with slight increases in recent CSLF lengths possibly due to market demands and catch-spreading arrangements. |

| **Projections and Prognosis** | |
|---|---|
| Stock Projections or Prognosis | At current catch levels and given the recent trend, the stock would continue to fluctuate without trend. |
| Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits | Soft Limit: Very Unlikely (< 10%)<br>Hard Limit: Very Unlikely (< 10%) |
| Probability of Current Catch or TACC causing Overfishing to continue or commence | Very Unlikely (< 10%) |

| **Assessment Methodology** | | |
|---|---|---|
| Assessment Type | Level 1 - Full Quantitative Stock Assessment | |
| Assessment Method | Bayesian length-based stock assessment | |
| Period of Assessment | Latest assessment: 2021 | Next assessment: 2025 |
| Overall assessment quality rank | 1 – High Quality | |
| Main data inputs (rank) | - CPUE indices PCELR series<br>- Commercial sampling length frequencies | 1 – High Quality<br>1 – High Quality |

| | | |
|---|---|---|
| Data not used (rank) | CELR CPUE series<br><br>FSU CPUE series | 3 – Low Quality: variable catchability and changes in technology<br><br>3 – Low Quality: poor recording |
| Changes to Model Structure and Assumptions | This represents the first accepted assessment model for PAU 2 | |
| Major Sources of Uncertainty | Growth is known to vary spatially over small scales, and it is unclear how representative the available samples are of the PAU 2 fishery area.<br>Recruitment: length composition data available to the stock assessment provide little information about relative year class strengths.<br>The assessment model is sensitive to natural mortality, which is poorly quantified.<br>Early catch history: Pre QMS pāua exports exceeded catches reported to FMAs, and it is unclear which areas these catches came from.<br>Selectivity in the commercial fishery has varied spatially and over time as voluntarily agreed Minimum Harvest Size (MHS) has changed. Different MHSs have been applied to different statistical areas within the assessed area in the same year. | |

| **Qualifying Comments** |
|---|
| A large proportion of PAU 2, including the Wellington south coast and west of Turakirae, is either a marine reserve or voluntarily closed to commercial fishing. This means that the data collected from the commercial fishery are exclusive of this large area and therefore the assessment only applies to the south east component of PAU 2 (Wairarapa).<br>Lack of contrast in catch, CPUE, and length frequency makes estimation of stock status and biomass trajectories difficult.<br>The 2019–20 year was excluded from the PCELR CPUE series owing to concerns about the comparability with previous years due to the effects of COVID-19 on export markets, and ERS reporting issues. This may continue into the future. |

| **Fishery Interactions** |
|---|
| - |

## 6. FOR FURTHER INFORMATION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