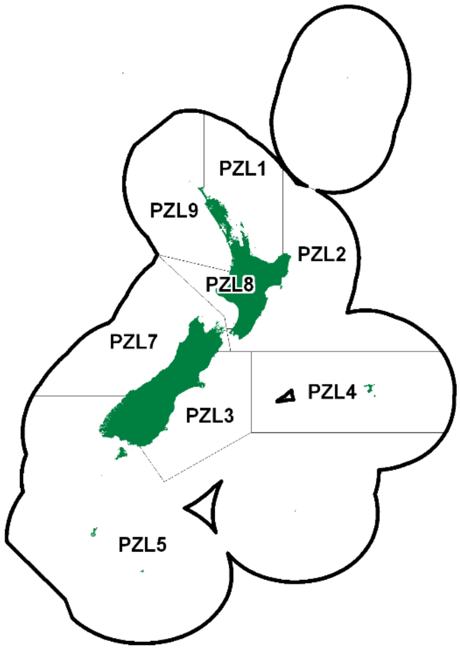
DEEPWATER (KING) CLAM (PZL)

(*Panopea zelandica*)
Hohehohe



1. FISHERY SUMMARY

Deepwater clams (*Panopea zelandica*), commonly referred to as geoducs, geoducks, or New Zealand king clams, were introduced into the Quota Management System on 1 October 2006 with a total TAC of 40.5 t, consisting of 31.5 t TACC and a 9 t allowance for other sources of mortality (Table 1). Most TACs have remained unchanged since entering the QMS, however, the TAC for PZL 7 was increased on 1 October 2020. The fishing year is from 1 October to 30 September and commercial catches are measured in greenweight. Deepwater clams are harvested by divers using underwater breathing apparatus and a hydraulic probe.

Table 1: Current TAC, TACC, and allowances for other sources of mortality for *Panopea zelandica.*

Fishstock	Description	TAC (t)	TACC (t)	Other sources of mortality
PZL 1	Auckland	1.5	1.2	0.3
PZL 2	Central (East)	1.5	1.2	0.3
PZL 3	South East (Coast)	1.5	1.2	0.3
PZL 4	South East (Chatham Rise)	1.5	1.2	0.3
PZL 5	Southland	1.5	1.2	0.3
PZL 7	Challenger	114.0	80.0	32.0
PZL 8	Central (West)	1.5	1.2	0.3
PZL 9	Auckland (West)	1.5	1.2	0.3
Total		124.5	88.4	9.0

1.1 Commercial fisheries

The large landings reported between 1989 and 1992 (Table 2), were almost all taken in the Nelson-Marlborough region under a special permit for investigative research. Targeted fishing was also carried out under a special permit in PZL 7 between 2004 and 2005. Rare catches have also been made by trawlers. Annual catches averaged about 5 t between 2008–08 and 2018–19, but increased to almost 50 t by 2021–22, taken from the Nelson-Marlborough region (Table 2). Nationally, the deepwater clam fishery is undeveloped but is recognised as having significant potential.

The TAC increase for PZL 7 (30 to 114 t) was the outcome of a biomass survey conducted in 2017 under a further special permit. Current quota holders for PZL 7, including Te Tau Ihu iwi and Te Ohu Kaimoana, are progressing a fisheries development research plan to ensure co-ordinated, sustainable and well researched growth of the fishery. PZL 7 commercial fishers have agreed not to fish within the Marlborough Sounds.

Table 2: TACCs and reported landings (t) of deepwater clam by Fishstock from 1989–90 to present, taken from CELR and CLR data. There have never been any reported landings in PZL 2, 4, 5, 8, or 9.

	PZL 1		PZL 3		PZL 7		Total	
Fishing year	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1989–90	0.315	–	0	–	95.232	–	95.547	–
1990–91	0	–	0	–	29.293	–	29.293	–
1991–92	0	–	0.725	–	31.394	–	32.119	–
1992–93	0	–	0.053	–	0	–	0.053	–
1993–94	0	–	0	–	0	–	0	–
1994–95	0	–	0	–	0	–	0	–
1995–96	0	–	0	–	0	–	0	–
1996–97	0	–	0	–	0	–	0	–
1997–98	0	–	0	–	0	–	0	–
1998–99	0	–	0	–	0	–	0	–
1999–00	0	–	0	–	0	–	0	–
2000–01	0	–	0.146	–	0	–	0.146	–
2001–02	0.003	–	0.068	–	0	–	0.071	–
2002–03	0	–	0.001	–	0	–	0.001	–
2003–04	0	–	0	–	1.444	–	1.444	–
2004–05	0	–	0	–	2.944	–	2.944	–
2005–06	0	–	0	–	0	–	0	–
2006–07	0	1.2	0	1.2	0	23.1	0	31.5
2007–08	0	1.2	0.132	1.2	0.320	23.1	0.450	31.5
2008–09	0	1.2	0.016	1.2	5.100	23.1	5.116	31.5
2009–10	0	1.2	0	1.2	4.578	23.1	4.578	31.5
2010–11	0	1.2	0.076	1.2	7.880	23.1	7.956	31.5
2011–12	0	1.2	0.036	1.2	10.849	23.1	10.885	31.5
2012–13	0	1.2	0	1.2	1.746	23.1	1.746	31.5
2013–14	0	1.2	0	1.2	6.072	23.1	6.072	31.5
2014–15	0	1.2	0.003	1.2	3.927	23.1	3.93	31.5
2015–16	0	1.2	0	1.2	4.686	23.1	4.686	31.5
2016–17	0	1.2	0	1.2	3.260	23.1	3.260	31.5
2017–18	0	1.2	0	1.2	6.720	23.1	6.720	31.5
2018–19	0	1.2	0	1.2	6.294	23.1	6.294	31.5
2019–20	0.21	1.2	0	1.2	13.357	23.1	13.567	31.5
2020–21	0	1.2	0	1.2	38.708	80.0	38.708	88.4
2021–22	0	1.2	0.001	1.2	49.479	80.0	49.48	88.4

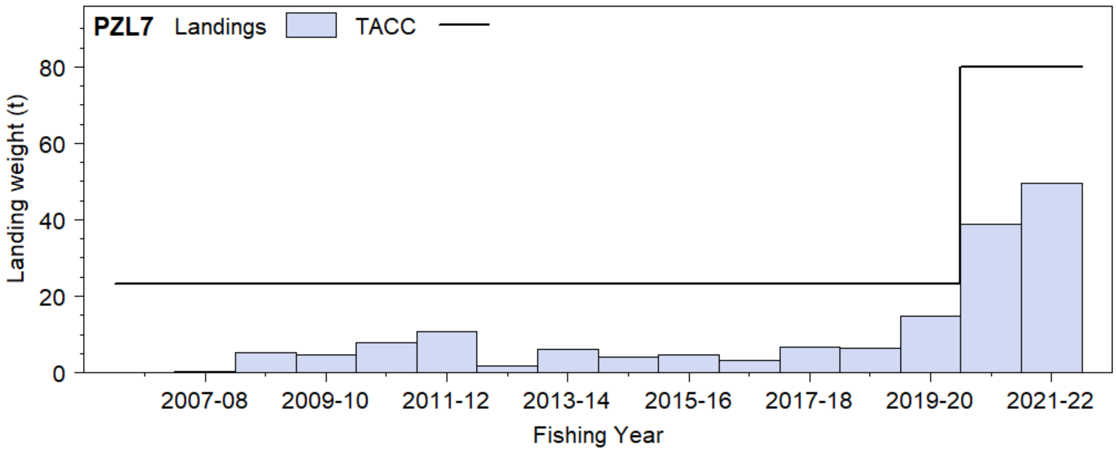


Figure 1: Reported commercial landings and TACCs for the main PZL stock: PZL 7 (Challenger).

1.2 Recreational fisheries

There are no estimates of recreational take for this clam. Recreational take is likely to be very small or non-existent however, some recreational take is recorded as section 111 landings.

1.3 Customary fisheries

This clam is harvested for customary use when washed ashore after storms but there are no estimates of this use of this clam. Customary take is likely to be very small or non-existent.

1.4 Illegal catch

There is no documented illegal catch of this clam.

1.5 Other sources of mortality

While there is little hard information on other sources of mortality, the clam has on rare occasions been captured during trawling operations.

Deepwater clams are extracted from the sediment using a hand-held water probe to liquefy the substrate, freeing the clam to be gathered. International research suggests the environment impacts of this method are similar to a storm event and disappear relatively quickly. However, damage to juvenile clams from this method is unknown and even adults show poor reburial after being dug out (Gribben & Creese 2005). Being cautious, the *other sources of mortality* allowance is set at 40% of the TACC.

2. BIOLOGY

There are two similar *Panopea* species in New Zealand: *P. zelandica*, also referred as geoduc, geoduck, and king clam; and *P. smithae*. Both are endemic and occur around the North, South, and Stewart islands. *P. smithae* has also been reported from the Chatham Islands. *P. smithae* is reported under the Fishstock code PSM and is not included in this Working Group report. Their distributions overlap, but *P. zelandica* occurs mainly in shallow waters (5–25 m) in sand and mud off sandy ocean beaches, whereas *P. smithae* lives mainly at greater depths (110–130 m) on coarse shell bottoms and is also thought to burrow deeper into the substrate. In samples of commercial and exploratory catches, *P. zelandica* is more abundant than *P. smithae*, and it comprises virtually all of the catch.

Deepwater clams are broadcast spawners with separate sexes. Protandric development (where an organism begins life as a male and then becomes a female) is considered likely for a proportion of the population (Gribben & Creese 2003). Fifty percent sexual maturity was calculated at 55 and 57 mm length for populations in Wellington and on the Coromandel Peninsula, respectively. Samples taken from three locations between the Coromandel Peninsula and Nelson showed spawning between spring and late summer (Gribben et al 2004a). Spawning may be controlled by temperature because it occurred at both the Coromandel and Wellington sites when water temperature reached approximately 15 °C (Gribben et al 2004a). The larval life is thought to be about two to three weeks (Gribben & Hay 2003), and there is evidence of significant recruitment variation between years.

The oldest *P. zelandica* based on annual ring counts in Golden Bay, Shelly Bay (Wellington), and Kennedy Bay (Coromandel) were 34, 34, and 85 years respectively (Breen 1991, Gribben & Creese 2005); ring counts were validated from Shelly Bay only. Growth in shell length appeared to be rapid for the first 10–12 years in these populations and total weight increased rapidly until at least 12–13 years of age. Differences in growth rates were seen between the Kennedy Bay and Shelly Bay populations: estimates of K varied between 0.16 and 0.29, t_0 between 1.67 and 3.8, and L_∞ between 103.6 mm and 116.5 mm, respectively (Breen 1991, Gribben & Creese 2005)[1]. The most recent estimate of K in Golden Bay was 0.11 (SE 0.027), L_∞ was 127.5 mm (SE 4.8 mm), and age-at-length-zero was -4.24 years (SE 2.15) (Slater et al 2017).

Estimates of M (instantaneous natural mortality) from catch curve analysis, estimates of maximum age, and the Chapman-Robson estimator from Kennedy Bay and Shelly Bay populations were all between 0.02 and 0.12 (Gribben & Creese 2005). The estimate by Breen (1991) for Golden Bay was 0.15, but in modelling this parameter was varied between 0.1 and 0.2.

3. STOCKS AND AREAS

For management purposes stock boundaries are based on FMAs, however, there is little information on stock structure, recruitment patterns, or other biological characteristics to determine fishstock boundaries.

[1] No confidence intervals were available for these estimates.

4. STOCK ASSESSMENT

4.1 Estimates of fishery parameters and abundance

Estimates of total mortality (*Z*) for deepwater clam using Millar's method (2015) in a small part of Golden Bay (PZL 7) were obtained from a biomass survey conducted in 2014 (Slater et al 2017). In this analysis the first 8 age classes were removed because there is age-based selectivity bias. Estimated annual mortality was 0.189 (SE 0.042). The estimated instantaneous mortality *Z* (inclusive of both natural mortality and fishing mortality) was 0.209 (SE 0.047). This *Z* was similar to the upper value of instantaneous mortality *M* (0.20) estimated by Breen (1991) and higher than the *M* estimated for Kennedy Bay (0.05–0.07) and Shelly Bay (0.02–0.04) (Gribben & Creese 2005); the key difference being that the 2017 *Z* estimates were determined from both natural causes and fishing. The catch-curve analyses used by Breen (1991) and Gribben & Creese (2005) operate under two assumptions: firstly, recruitment rates are approximately constant during the time that aged deepwater clam were recruited; and secondly, mortality is similar for all age classes. Gribben & Creese (2005) concluded that catch-curve analyses may not be appropriate for estimating natural mortality in deepwater clam, and Millar (2015) suggested that general linear mixed modelling (GLMM) is superior in predicting mortality, due to the inclusion of recruitment involving annual variation and the substantial variability known to exist in population dynamics (Myers et al 1995).

The size and age data have been used for comparison with the age-weight growth curve and natural mortality values used in the study of deepwater clam sustainability by Breen (1994). When estimating recruitment, Breen (1994) used animals 8 years or older for recruited biomass, as did Slater et al (2017) because there appeared to be an age-based selectivity bias. The maximum realistic exploitation rate of 0.35 was based on Goodwin's (1977) show-factor and the disturbances created by the fishing method causing nearby individuals to retract their siphons. The upper bound of the 95% confidence interval for show-factor was 31%.

Slater et al (2017) fitted a von Bertalanffy growth curve to the aged individuals and estimated a L_{inf} of 127.5 mm (SE 4.8 mm), a growth rate (*K*) of 0.11 y^{-1} (SE 0.027), and an age-at-length-zero of -4.24 years (SE 2.15). These results were not dissimilar to earlier studies: a maximum theoretical length of 116.5 mm, $K = 0.16\ y^{-1}$, and t_0 of –3.80 years (Breen 1991) and estimated asymptotes of 111.5 mm (Kennedy Bay) and 103.6 mm (Shelly Bay) (Gribben & Creese 2005).

4.2 Biomass estimates

Biomass has not been estimated for any deepwater clam stocks. Slater et al. (2017) estimated the biomass for a small area in Golden Bay (PZL 7).

Deepwater clam densities in North America are calculated by the use of established methods that include counting the siphon holes through which deepwater clam filter feed. Problematically, not all deepwater clam "show" their siphon holes at the same time and thus this method could lead to an erroneous population estimate (Hand & Dovey 1999).

This is solved by the use of a "show–factor" which is the number of deepwater clam siphons that are visible, or can be felt, versus the total number of individuals present in a given area. In North America, the number of deepwater clam that "show" their siphon holes is variable depending on different environmental and physiological factors; with more showing during the summer months during periods of feeding and breeding (Campbell et al 1998), and when local water currents are not overly severe with no mechanical disturbances of the bottom due to events such as storm activity (Goodwin 1977).

Gribben et al (2004b) investigated whether the North American methodology used for determining population abundance estimates is transferrable to New Zealand's *P. zelandica*. Experiments were conducted to determine how many deepwater clam were visible at a given point in time (show/no-show factors). Analysis of sediment samples indicated that *P. zelandica* were found in similar habitats to the American species *P. generosa.* There was no significant difference in the show-factor with regard to season or tidal height. A mean show-factor of 0.914 was used to adjust the density estimates from both populations which gave mean densities of 0.058 deepwater clam m^{-2} in Kennedy Bay and 0.489 deepwater clam m^{-2} in Wellington Harbour, with coefficients of variation generally less than 0.2. The density estimates for *P. zelandica* were much lower than those reported for *P. generosa.* But the authors suggested that the North American methodology for estimating deepwater clam populations was transferrable to *Panopea zelandica*.

Gribben & Creese (2005) reported mean maximum drained wet weights of 275.5 g in Kennedy Bay and 223.1 g in Shelly Bay. This would give 0.016 kg m^{-2} average density for Kennedy Bay and 0.109 kg m^{-2} for Shelly Bay. Slater et al (2017) calculated an average density of 0.0619 kg m^{-2} for the area surveyed in Golden Bay. Even accounting for water lost in draining, the Golden Bay area appears to have higher density than Kennedy Bay but not Shelly Bay. However, any difference in density could be explained by different measuring techniques or local environmental and productivity factors. Extrapolating this density to the area delineated in the study yields an estimate of total parent biomass of 1,334 t. By employing the very conservative upper confidence interval of 30.8% efficiency of the survey effort as a multiplier to the parent biomass in the surveyed area, a mean density of 0.201 kg m^{-2} and a parent biomass of 4,331.17 t would be estimated (Slater et al 2017).

4.3 Yield estimates and projections

MCY has not been estimated for any deepwater clam stocks. However, an age–structured stochastic model suggested that sustainable yields for this species, with realistic management constraints, appear to be on the order of 2% to 4% of virgin biomass (Breen 1994).

CAY has not been estimated for any deepwater clam stocks.

4.4 Future research considerations

Research should be conducted on:
- diver variability on counts of deepwater clam;
- the role that deepwater clam occurring deeper than 17 m perform; and
- the effect of geoduc density on fertilisation success.

5. STATUS OF THE STOCKS

PZL 7 – Challenger

Stock Status	
Year of Most Recent Assessment	A small area was surveyed in 2017 in Golden Bay
Assessment Runs Presented	–
Reference Points	Target: Not defined, but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: –
Status in relation to Target	Because of the relatively low levels of exploitation of *P. zelandica* until 2018-19, it is likely that this stock is still effectively in a virgin state, therefore it is Very Likely (> 90%) to be at or above the target.
Status in relation to Limits	Because of the relatively low levels of exploitation of *P. zelandica* until 2018-19, it is likely that this stock is still effectively in a virgin state, therefore it is Very Unlikely (< 10%) to be below the soft or hard limits
Status in relation to Overfishing	Very Unlikely (<10%)

Historical Stock Status Trajectory and Current Status
Unknown

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Unknown
Recent Trend in Fishing Mortality or Proxy	In 1989–92 the landings for PZL 7 averaged 52 t; however, since that time fishing has been light in all

	QMAs with a maximum of only 37.927 t taken across all QMAs in the 2020-21 fishing year.
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	-
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Current catches are Very Unlikely (< 10%) to cause declines below soft or hard limits.
Probability of Current Catch causing Overfishing to continue or to commence	Very Unlikely (<10%)

Assessment Methodology and Evaluation		
Assessment Type	Level 2: partial quantitative stock assessment	
Assessment Method	Biomass estimate from transects survey	
Assessment Dates	Latest assessment: 2014	Next assessment: unknown
Overall assessment quality rank	-	
Main data inputs (rank)	- Abundance survey - Length frequency	
Data not used (rank)	-	
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	-	

Qualifying Comments
Early surveys show that density is generally low compared with North American species but that productivity is higher.

Fishery Interactions
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6. FOR FURTHER INFORMATION

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