2018 SMALL BIVALVE FISHERY ASSESSMENT
Ostrea angasi - Georges Bay
Katelysia scalarina - Ansons Bay
Venerupis largillierti - Northern Zone, Georges Bay

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Executive Summary

In 2018, stock assessments with total allowable commercial catch recommendations (TACC) ware conducted for the Georges Bay flat oyster, *Ostrea angasi*, fishery and the Ansons Bay Vongole, *Katelysia scalarina,* fishery. The size structure of the Georges Bay Northern Zone Venus Clam, *Venerupis largillierti,* fishery was also assessed.

Native Flat Oyster, *Ostrea angasi - Georges Bay*

The *O. angasi* survey recorded an estimate (50th quantile of the mean) of total biomass of 364.9 tonnes (± s.e. 324.8 – 404.8). Best estimates of total abundances from survey data across the fishing area suggested that there was a 90% chance the total abundance exceeded 3.5 million oysters. The current harvest fraction for O. angasi is set at 10% of the estimated total biomass. TACC recommendations are provided in the form of probability tables calculated from estimated total biomass and converted to counts per dozen at the 50th, 20th and 10th quantile of the estimated total biomass mean. The TACC allocations presented in the probability table provide a choice in certainty that the estimation of total biomass is greater than the probability value. All three levels of estimates are above the biological limit reference point (B_{LIM}) of 134.1 t recommended by IMAS (Jones and Gardner, 2016). The 10^{th} percentile estimates returned a total biomass of 315.7 tonnes (± s.e. 275.6 – 355.7), equating to a TACC of 21,420 (± s.e. 18,706 – 24,133) dozen. Samples taken outside the fished area used returned high densities, but do not form part of the estimated total biomass available meaning biomass and TACC calculations are conservative. These populations are also likely to contribute to the reproductive capacity of the bay. The low proportion of annual catch to TACC recorded in the *O. angasi* fishery since 2008 would suggest that the current level of fishing pressure is unlikely to cause the stock to become recruitment overfished. In accordance with national stock status definitions, this fishery is assessed as sustainable.

Vongole, *Katelysia scalarina* - Ansons Bay

A survey conducted in Ansons Bay in 2018 resulted in a biomass estimate of 23.42 tonnes of Vongole in the fished area, with lower and upper 95% confidence limits of 19.31 – 27.52 t. An estimated 98.7% (23.1 t) of the biomass was above the legal size limit of 32 mm. A TAC of 10% of total biomass would therefore be 2.3 t. However, the estimated biomass is below the Biomass limit reference point (B_{LIM}) of 40 t recommended by IMAS (Tarbath and Gardner, 2015). The 2018 biomass estimate is lower than the 2017 survey of 30.73 (26.17 – 35.28) t, but greatly reduced compared with the 2012 estimate of 133.32 (106.62 – 161.03) t. The size structure of the fishery indicates aging stocks with minimal recruitment. Given the fishery was closed following this stock decline, minimal evidence of stock recovery and the apparent aging of the population, we recommend that this stock remains closed.

Venus Clam, *Venerupis largillierti* - Georges Bay Northern Zone

Length frequency distribution of Venus clam indicate three consecutive years of recruitment to the population. In the absence of a high mortality event, fishable biomass of the population should increase in the coming years. We recommended the TACC should be maintained at 4.9 t for the 2018/19 season, with a full biomass survey conducted in 2019.

Stock status – small bivalves

The four commercial small bivalve fisheries in Georges Bay and Ansons Bay are surveyed every two to three years for the purposes of estimating total biomass and assessing fishery status in order to assist with the allocation of quota for the forthcoming fishing years.

The status of Tasmania's small bivalve's fisheries have been assessed in terms of the lower acceptable limit of the stock, which is the point where recruitment overfishing occurs. Recruitment overfishing implies that the mature adult (spawning biomass) is depleted to a level where the future productivity of the stock is diminished. Recruitment overfished stocks have not necessarily collapsed, but do have fewer recruits than a healthy stock.

It's important to note that fishery management generally includes both limit reference points that define the lower acceptable point for the stock plus target reference points, which are the ideal level for the stock. In this report we assess bivalve fisheries against only the limit reference point, which is also the process used nationally for stock status reporting.

Stock status of these bivalve fisheries was based on density and size composition data from the most recent surveys, plus consideration of trends in catch and CPUE data.

Species	Status	Comments
Georges Bay – **Native Flat Oyster** ***Ostrea angasi***	**SUSTAINABLE**	Biomass in the Flat Oyster fishery is estimated from diver quadrat counts which are extrapolated across the area of the oyster beds to provide an estimate of overall biomass. Total biomass was estimated in 2018 as 364.9 tonnes, which is above reference points of historical lows. This means the fishery is not overfished. The allocated total allowable commercial catch was 10% of the stock which is a level that implies low risk of overfishing. The combination of biomass that is not overfished and fishing mortality that has low risk of overfishing results in a classification for this stock of sustainable.
Ansons Bay - Vongol **Katelysia scalarina**	**ENVIRONMENTALLY LIMITED**	Biomass in the Vongol Clam fishery is estimated at 23.42 t, 12 % of its peak, based on quadrat counts that are extrapolated across the defined fishable beds. This stock was classified in 2015 as environmentally limited on the basis of severe declines in biomass associated with a flood event (Tarbath and Gardner 2015). This fishery is currently closed to commercial catch.
Northern Zone Georges Bay - **Venus Clam** **Venerupis largillierti**	**RECOVERING**	Biomass in the Venus Clam fishery was estimated at 76.2 t in 2017 based on quadrat counts that are extrapolated across the defined fishable beds. The stock extends beyond the boundaries of the fished beds so the fishery

		biomass is less than the total biomass of clams in Georges Bay. The current low biomass combined with declines in CPUE in 2015 and 2016 provides evidence that the stock is at an unusually low level. Fishing has been low with less than 8% of the estimated biomass taken as catch from 2015 to 2017. This is evidence that the stock has not been reduced by excess fishing mortality. Information on length frequency distribution indicate that multiple settlement pulses have occurred and are likely to translate to significant recruitment to the fishery in coming years. On the basis of low estimated biomass, low fishing mortality patterns in length frequency data, and the, the stock is classed as recovering.
Southern Zone Georges Bay - Venus Clam **Venerupis largillierti** **(NOT ASSESSED IN THIS DOCUMENT)**	**ENVIRONMENTALLY LIMITED**	This stock was last surveyed in 2013 (Tarbath and Gardner 2013). It was classified as environmentally limited on the basis of severe declines in biomass that appeared unrelated to fishing mortality. This fishery is currently closed to commercial catch.

Native Flat Oyster, Ostrea angasi - Georges Bay

Background

In Georges Bay, north-east Tasmania, a commercial dive fishery has operated for the native flat oyster (*Ostrea angasi*) since approximately 1985. The fishery operates on mixed species shellfish beds with the area harvested varying between years (Figure 1). Until 2007 the fishery was managed principally through the allocation of half yearly or yearly permits. From the start of fishing year 2007 a formal TACC structure was introduced with two associated commercial licences. TACC allocation is based on fishery dependent surveys of estimated total biomass conducted every two or three years with the TACC set as equal to 10% of the estimated total biomass. Legal minimum length of *O. angasi* has been set at 70 mm shell length on the basis of market demand. In recent years' market demand for *O. angasi* has been weak, and consequently harvest levels are typically less than the available TACC. Total catch and catch per unit effort data are available for this fishery from 2007 onwards, with the fishing year running from 1st September to 31st August.

Figure 1. Example of mixed species shellfish bed in Georges Bay, St Helens.

Objectives

This is the 4th report on the status of the *O. angasi* fishery since the introduction of TACC in 2007. Its objectives are; 1. Provide an estimate of the total biomass of *O. angasi* in Georges Bay. 2. Use this information to provide a probability table of TACC allocations for 2016-2017 fishing year. 3. Assess previous years CPUE and catch trends with reference to the allotted TACC.

Methods

The survey design for 2018 is consistent with methods used in other small bivalve fisheries in Australia (Dent et al. 2014), and is replicate of the 2016 Angasi survey where the total area used to estimate biomass only includes areas considered to be active fishing grounds (82,540 m^2; Fig. 2; Jones and Gardner, 2016). Within the identified clam beds, transects of 100 m in length were laid randomly from the vessel. Samples (0.25 m^2 quadrats) were collected by a commercial diver and IMAS researcher at 0 m and every 20 m along the transect (i.e. 6 samples per 100 m transect). A total of 14 transects and 82 quadrats were sampled within the active fishing grounds. From each quadrat all *O. angasi* present were harvested, returned to the vessel and measured across the longest axis (± 1mm) using electronic measuring boards. Weight estimates for each oyster were calculated from length-weight relationships previously established for this species in Georges Bay (Fig. 3).

$w = 0.0002*l^{2.8924}$

where *w* is the estimated total weight of *O. angasi*, and *l* is the shell length at longest axis.

Estimation of total biomass of *O. angasi* across the survey area was calculated as the mean biomass per m^2 multiplied by the survey area. A non-parametric bootstrap method (100,000 iterations with repeats) as for total abundance estimation was employed to extract the 50th, 20th and 10th quantiles of the bootstrapped mean with standard errors. Estimates of total survey area biomass are reported together with confidence levels and standard errors. TACC recommendations at each confidence level are provided as 10% of the estimated total biomass in tonnes and as counts of dozens to provide a risk assessment framework for determining the TACC. Conversion of TACC in tonnes to counts in dozens was calculated as the biomass in kilograms divided by the estimated weight of harvestable sized oysters. In the absence of information on the size structure of the catch, the estimated weight of harvestable sized oysters was calculated from the 80% percentile (upper) of the legal size structure at the time of the survey.

Estimation of total abundance of *O. angasi* across the survey area were calculated as the mean density per m^2 multiplied by the survey area. The same non-parametric bootstrap method (100,000 iterations with repeats) was employed to extract the 50th, 20th and 10th quantiles of the bootstrapped mean with standard errors. Estimates of total survey area abundance are reported together with the estimated abundance as dozens (total abundance/12).

CPUE and catch data were extracted from the Department of Primary Industries, Parks, Water and Environment (DPIPWE) database to include all data from 01/09/2007 to 31/08/2017. CPUE data is presented as the fishing year (1st Sept – 31st August) mean (dozensHr^{-1}) with catch recorded in dozens. Years refers to the end of each fishing year e.g. 01/09/07 to 31/08/08 is year 2008.

This survey also recorded mean density in historically fished *O. angasi* beds; Bed 1, Bed 2 and bed 4 (Fig. 3) to determine the extent of biomass outside currently fished area. Densities were determined by six quadrats sampled along a single transect laid along the centreline of each bed.

Figure 2. Map of Georges Bay *O. angasi* beds surveyed between 2008 to 2018. Total O. angasi area for 2016 / 2018 (green polygon) is estimated at 82,540 m^2 (Jones and Gardner 2016). The 2003 O. angasi beds were surveyed by DPIPWE and reproduced by Tarbath and Gardner (2013).

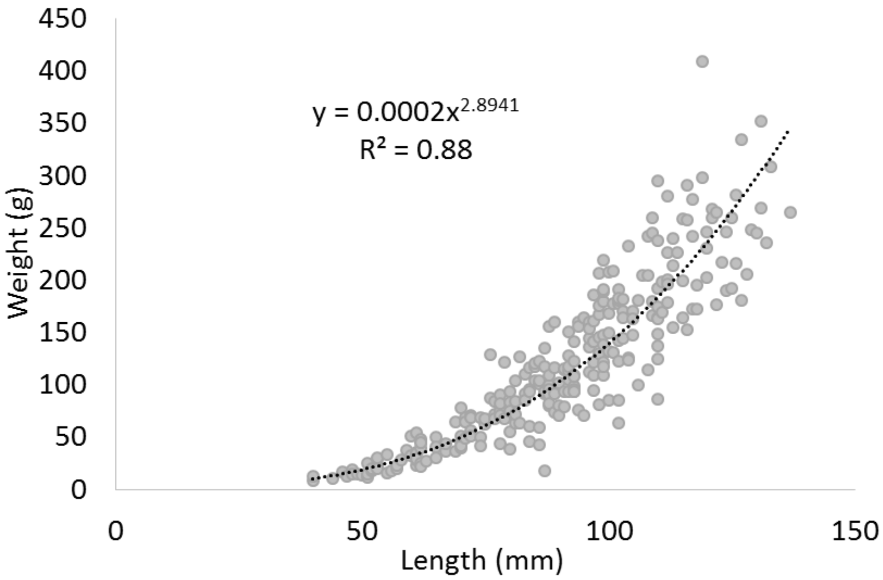

Figure 3. Length-weight relationship of O. angasi from Georges Bay (data from TAFI 2008, Tarbath 2010).

Results

A total of 1048 *O. angasi* were collected from the 82 quadrats across the fished area with a mean shell length of 87.9 mm (± s.d = 14.0) and an estimated mean weight of 90.5 g (± s.d.= 41.7 g) (Fig. 4). Of all animals sampled 90.8% were greater than the LML which represents 97.0% of the estimated total weight sampled. Estimated mean weight of legal sized animals from the 2018 survey was 95.8 (± s.e. = 1.3) therefore a dozen is estimated to weigh 1.15 Kg. The 80% percentile (upper) of the legal size structure was 100 mm, equating to an estimated weight of harvested animals to be 1.47 Kg. The density of *O. angasi* per quadrat in 2018 ranged from 0 to 60 with a mean of 12.3 (± s.d. = 12.8). The mean biomass per metre square of *O. angasi was* estimated at 4.43 Kg (± s.d. = 1.11).

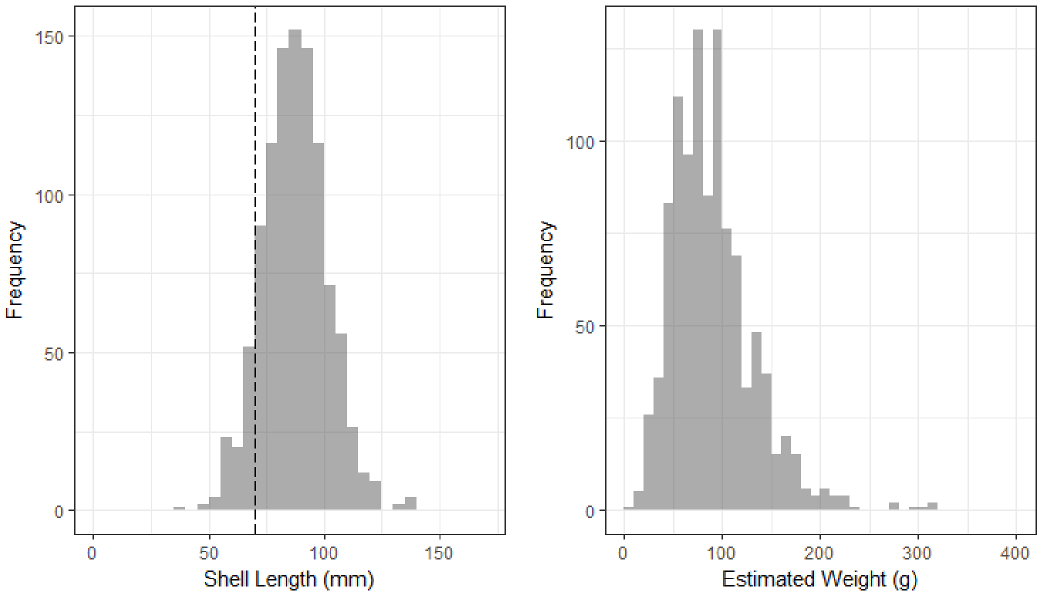

Figure 4. Frequency histograms of shell length and estimated weight of O. angasi from Georges Bay 2016. Dashed vertical line represents the legal minimum length (70 mm).

Total biomass estimates for the fishable reef area ranged from 364.9 tonnes (50th quantile of the mean) to 315.7 t (10th quantile) (Tab. 1). TACC estimations for each probability estimate for total biomass and counts in dozens are given in Table 1. Probability estimates of density ranged from 48.9 m^2 (50th quantile) to 42.0 m^2 (10th quantile), with the estimated total abundances across the fishing area surveyed ranging from 4.0 million (50th quantile) to 3.5 million (10th quantile) (Tab. 2). Maximum biomass under the proposed harvest strategy (321.9 t) equates to a TACC of 21,842 dozen.

Total catch of *O. angasi* in 2015 - 2017 period was the lowest since the introduction of TACC's in September 2007 and was associated with a reduced CPUE (Fig. 5). Mean catch, since introduction of the TACC in 2007, is 1453 dozen (± s.d. = 968). The maximum annual catch was 3240 dozen in 2008 which equates to 7.8% of the allocated TACC in that year which is also the maximum percentage of TACC caught in any year (Tab. 3).

Mean densities of *O. angasi* in beds outside the fished area ranged from 59.2 to 283.2 /m2 equating to 2.8 to 22.7 kgm-2, respectively (Tab. 5). Large quantities of juvenile *O. angasi* < 25mm were observed to have settled on oyster shell throughout much of the fished area, but were not quantified in this survey (Fig 5.).

Table 1. Biomass estimates and TACC recommendations as biomass and number of dozens. Probability estimates are calculated from bootstrapped (100,000 iterations) of O. angasi from the 2016 fishery survey with 50th, 20th and 10th quantile of the bootstrapped mean biomass with standard errors in parenthesis. TACC estimates are provided in tonnes as 10% of total biomass estimates and counts in dozens based on a mean weight of harvestable sized oysters per dozen of 1.15 Kg.

Probability estimate	Biomass (Kg m^2)	Total Biomass (tonnes)	Biomass TACC (tonnes)	TACC Recommendation (dozens)
50th Quantile	4.4	364.8	36.5	24,755
	(3.9 – 4.9)	(324.7– 404.8)	(32.5- 40.5)	(22,041 – 27,486)
20th Quantile	4.0	331.9	33.2	22,535
	(3.5 – 4.5)	(291.8 – 372.0)	(29.2 – 37.2)	(19,822 – 25,249)
10th Quantile	3.8	315.7	31.6	21,420
	(3.3– 4.3)	(275.6 – 355.7)	(27.6 – 35.6)	(18,706– 24,133)

Table 2. Density estimates calculated from bootstrapped (100,000 iterations) of *O. angasi* densities from the 2016 fishery survey in Georges Bay. 50th, 20th and 10th quantile of the bootstrapped mean density with standard errors in parenthesis.

Probability estimate	Density (m^2)	Total abundance estimate (millions)	Total number of dozens estimated for survey area
50th Quantile	48.9	4.0	336,538
	(43.2 - 54.5)	(3.6 – 4.5)	(298,038 - 375037)
20th Quantile	44.3	3.7	461,405
	(38.7 – 49.9)	(3.2 – 4.1)	(412,568 - 510,242)
10th Quantile	42.0	3.5	289,563
	(36.3 – 47.6)	(3.0 – 3.9)	(251,064 – 328,063)

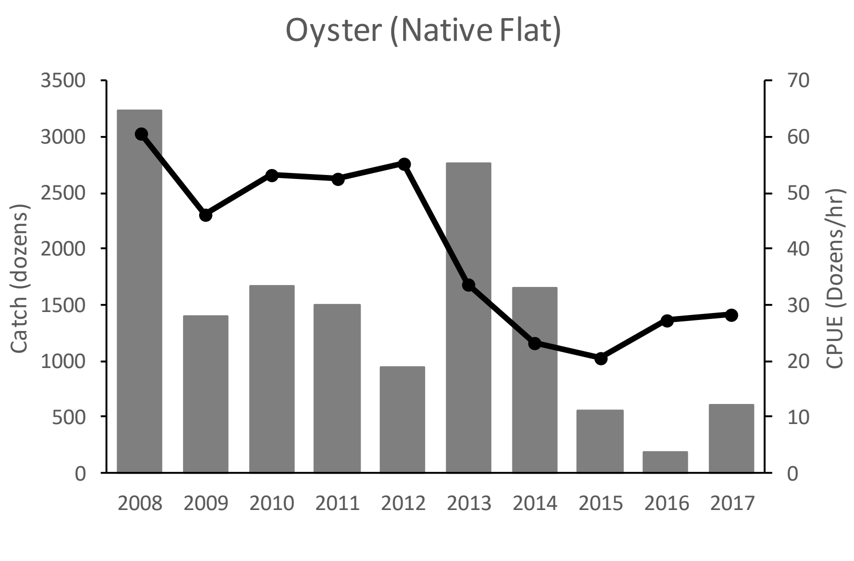

Figure 5. Catch (dozens) and mean catch per unit effort (CPUE) ($DozensHr^{-1}$) for O. angasi in Georges Bay from fish year ending 2008 to fish year end 2017. Fishing year runs from 01 September to 31st August.

Table 3. Catch (dozens), TACC (dozens) and percentage of TACC caught for O. angasi in Georges Bay St Helens since 2008.

Year	Catch	TACC	% TACC
2008	3240	41369	7.83
2009	1395	41369	3.37
2010	1677	39025	4.30
2011	1507	39025	3.86
2012	940	39025	2.41
2013	2770	39796	6.96
2014	1656	39796	4.16
2015	550	39796	1.38
2016	180	39796	0.45
2017	615	21400	2.87

Table 4. Estimates of area, biomass and TACC from fishery assessments of *O. angasi* in Georges Bay. St Helens since 2007. * 50th quantile of bootstrapped mean.

	2008	2010	2013	2016	2018
Est. area of fishery (m^2)	55,036	69,895	52,104	82,540	82,540
Est. mean biomass (Kg/m^2)	12.2	8.2	11.1	4.7*	4.4*
Est. total biomass (t)	670.6	569.5	618.4	391.5*	364.8*
Est. total number in fishery (millions)	5.0	4.7	4.8	6.0*	4.0*
TACC (dozens)	41,369	39,025	39,796	25,906*	24,755*

Table 5. Mean length, density and biomass of *O. angasi* in Georges Bay outside the current fished area in previously defined beds, Bed 1, Bed 2 and Bed 4 (see Fig. 3).

	length (mm)			**Density No. / m2**			**Biomass kg / m2**		
	Bed 1	**Bed 2**	**Bed 4**	**Bed 1**	**Bed 2**	**Bed 4**	**Bed 1**	**Bed 2**	**Bed 4**
Mean	84.5	91.2	71.1	283.2	197.3	59.2	22.7	18.9	2.8
95% CI (Lower)	77.5	81.8	50.2	196.8	138.2	15.4	18.0	15.6	1.0
95% CI (Upper)	91.5	100.5	91.9	369.6	256.5	103.0	27.4	22.1	4.5

Figure 6. Juvenile *O. angasi* < 25 mm settled on oyster shell.

Discussion and Recommendations

The 2018 survey area replicated that of the 2016 survey which recognised a single large bed of *O. angasi* within Georges Bay. Surveys prior to 2016 have included part of the area identified in 2016 as small individual beds but the presence of *O. angasi* from samples across this entire area suggested this may have been previously underrepresented (Jones and Gardner 2016). Three of the smaller *O. angasi* beds identified in earlier surveys to the east and north of the bay were surveyed but not form part of the estimated total biomass available, with results indicating they hold substantial biomass which is likely to contribute to the reproductive capacity of the bay. The 2013 *O. angasi* survey (Tarbath and Gardner 2013) indicated a similar spatial trend away from the former fishing beds to the north and east of the bay with preference to the area identified in 2016. The current method provides a level of precision with regard to the abundance and biomass of *O. angasi* for the area sampled without making assumptions on the biomass available more widely within the bay. Calculation of TACC based on the estimated total biomass of *O. angasi* across the entire bay area assumes that the TACC will be taken across the entire area, not just the active fishing grounds. By basing abundance and total biomass calculations only to the extent of the active fishing areas, the estimates of total biomass and abundance are less than the overall total of *O. angasi* present within the Georges Bay catchment and as such provide a level conservatism within the TACC allocation. This method of biomass estimation is considered a robust technique for providing information for TACC estimations in shellfish fisheries as it targets only productive fishing grounds and excludes animals in non-sampled areas (Dent et al. 2014).

The TACC is the primary tool used to ensure biological sustainability within the *O. angasi* fishery and is determined as 10% of the total biomass estimate. The TACC is set typically set for a period of two to three quota years. This document provides a probability estimate of total estimated biomass and TACC and subsequent TACC in dozens for assessment by management. The estimated biomass is presented at three levels of confidence based on the mean biomass per m^2 from the survey and total fished area examined in the survey. Each estimate provides a biomass with standard errors together with the level of confidence that the true biomass within the fishery is greater than the estimated biomass. The resultant

TACC is derived from the estimated biomass in dozens for each confidence level and allows management to determine the level of risk that is associated with each TACC allocation. All three levels of estimates are above the biological limit reference point (B_{LIM}) of 134.1 t recommended by Jones and Gardner (2016)

Increased precision in the estimation of the area occupied by both the resource and the fishery is seen at the best way to reducing uncertainty in the estimate of biomass. Resource boundaries are currently defined by fishers approximating bed boundaries, however could be spatially mapped by towed video and diver swims with increased accuracy. The use of GPS and depth/time loggers (spatial data) has proven useful in assisting management decisions in Australian abalone fisheries where it has become mandatory in some states (Mundy 2011), and could be applied to the *O. angasi* fishery.

This survey used the 80% percentile (upper) of the legal size structure as the estimated weight of harvested oysters for the conversion of biomass to dozens for the TACC setting, as opposed to mean weight used in previous surveys. This robust and conservative measure reduces potential catch bias to the larger size classes theoretically allowing the TACC, in terms of biomass, to be exceeded. Increasing precision in this estimate could be achieved by assessing by the size structure of the catch compared to the population. Alternatively, adapting the harvest strategy to an abundance based measure would eliminate biomass to dozens conversion uncertainty. The observation of large numbers of juvenile *O. angasi* < 25 mm throughout the fished area should result in recruitment to the fishery in coming years. Juveniles were observed to have settled on dead shell throughout the fished area, but not in the high-density areas of Bed 1 and 2.

Vongole - Ansons Bay

Background

The commercial fishery for Vongole (*Katelysia scalarina*) clams takes place on an inter-tidal sandbar in Ansons Bay, North East Tasmania. The current management strategy includes limited entry (three licences), a LML of 32 mm, a TACC set at 10% of the most recent total biomass estimate and a resurvey of biomass every two to three years. Since 2007, fishing has been restricted to a defined zone within Ansons Bay as a further measure to protect the clam stocks, and birdlife from indirect effects of fishing (Maguire, 2005). Formerly, fishing occurred to the north of this zone along the bayhead spit to Shark Bay, and eastwards in the channel towards the sea. Apart from daily bag limits, there is no limit to the annual recreational catch, but it is understood that the recreational catch is insignificant in the context of the total catch. Anecdotally, concerns about recent severe harmful algal blooms in the region has deterred harvesting.

A rapid and extreme decline in abundance of Vongole at Ansons Bay was apparent in 2014, with the 2015 biomass estimate of 27 t being 13% of the peak recorded biomass of 202 t in 2002. The most probable cause for the population collapse appeared related to both the low levels of pre-recruits observed in the 2006 – 2017 surveys, exacerbated by sporadic events of high natural mortality and cumulative fishing mortality of recruited Vongole (Tarbath and Gardner, 2015). It was noted during the 2015 survey that the density of non-commercial bivalve species (e.g. *Katelysia rhytiphora*, *Paphies sp.*, *Callista sp.*) was remarkably low compared with previous years, indicating that an environmental factor had increased mortality of Vongole and other bivalves, rather than fishing mortality (Tarbath and Gardner, 2015). The fishery was closed in 2015 following the stock decline (Fig. 7).

2018 Assessment

The survey was conducted by sampling from quadrats placed randomly at regular (approx. 35 m) intervals over the previously fished area (149,049 m^2) on 23rd May 2018. The tide was low, and the entire area of the fishery was surveyed. Unlike previous surveys, the 2018 survey utilised a 5mm sieve to sift sediments to ensure small size classes were not missed. 119 quadrats of area 0.25 m^2 (i.e. a square sided 500 mm) were sampled, from which a total of 225 clams were recovered. The clams were measured to the nearest 1 mm and weights estimated using the length-weight relationship (weight = a*length^b, where a = 0.00012, b = 3.27794). It was estimated the biomass of clams in the area was 23.42 tonnes (95% confidence limits of 19.31 – 27.52 tonnes).

The results from the current and past surveys are presented below for comparison (Tab. 6). The 2018 estimate is lower than all previous estimates and represents 18% of the biomass recorded in the 2012 survey, and is an abrupt departure from the range of biomass estimates from between 1997 and 2012. The current density of clams at 8.6/m^2 is < 15% of that estimated between 1997 and 2012 (Fig. 8).

A small cohort of pre-recruits of modal length 9mm were observed in 22% of quadrats sampled, the first recording of individuals < 20 mm since 2002. (Fig. 9). The 2002 survey contained two distinct groups of pre-recruits with modal at 10 mm and 26 mm. The 2009 distribution also shows one group of pre-recruits, modal at 27 mm. Pre-recruits were poorly represented in the 2006, 2012 and 2017 distributions and entirely absent in the 2015 sample distribution. The modal length of 39 mm recorded in the 2018 survey was slightly smaller than that recorded in the 2017 survey (42 mm), indicative of natural mortality in larger individuals and the cause of decreasing biomass.

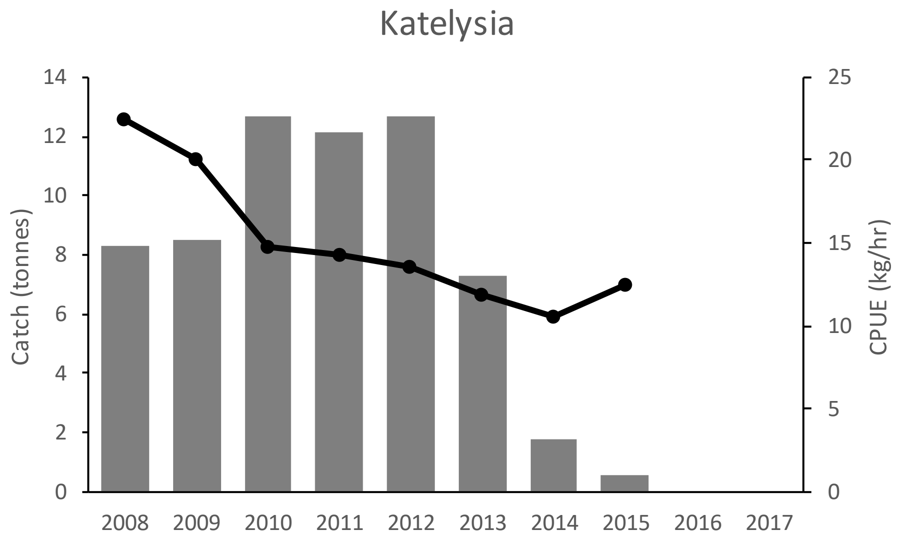

Figure 7. Catch (tonnes) and mean catch per unit effort (CPUE) (Kg/Hr) for *K. scalarina* in Ansons Bay from fish year 2008 to fish year 2017. Fishing year runs from 01 September to 31st August, fish year 2016 comprises of partial year data complete to 23/05/2016.

Table 6. Comparison of results obtained from biomass surveys of Vongole beds at Ansons Bay: 1997 to 2018, coupled with commercial fishery data. The fished area was remeasured in 2008, causing a reduction. Between 1997 and 2006, the TACC was derived by summing the weights specified on each fisher's permit. In 2007 and 2008, the TACC was assumed to be 10% of biomass, as it was thereafter. Estimated catches between 2001 and 2005 were reported in the fishery's policy document (DPIPWE, 2007), and between 2008 and 2014 were supplied by DPIPWE. Prior to 2001, catch weights are unknown.

Year	Total area of fishery (m^2)	Population size ('000s)	Density (no./m2)	Biomass (tonnes)	TACC (Tonnes)	Estimated catch (Tonnes)
1997	185,800	6,671	35.9	75.8	9.36	?
1998	185,800	11,890	64.0	98.7	9.36	?
1999					9.36	?
2000	185,800	11,261	60.6	148.6	9.36	?
2001	185,800	14,811	79.7	202.25	9.36	9.72
2002	185,800	10,598	57.0	159.87	9.36	8.77
2003					9.36	8.31
2004					9.36	5.71
2005					9.36	4.18
2006	185,500	9,483	51.1	157.64	9.36	3.01
2007					15.76	2.30
2008					15.76	8.27
2009	149,049	7,783	52.2	127.07	12.71	8.47
2010					12.71	12.58
2011					12.71	11.94
2012	149,049	7,196	48.3	133.32	13.33	12.90
2013					13.33	9.17
2014	149,049	1,391	9.3	27.15	13.33	0.46
2015					0	0
2016					0	0
2017	149,049	1,442	10.6	30.73	0	0
2018	149,049	1,278	8.5	23.42	0	0

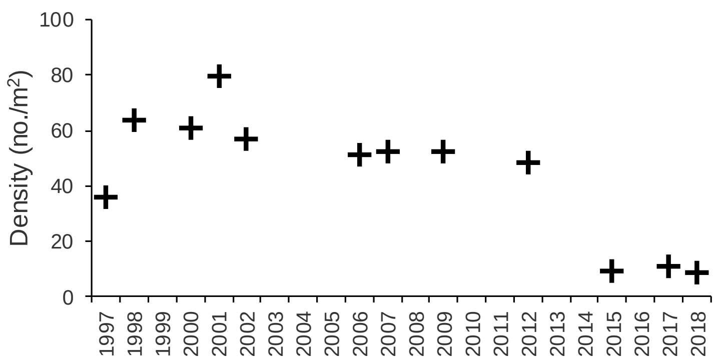

Figure 8. Estimated density (number per square metre) of Vongole collected from Ansons Bay in surveys between 1997 and 2017.

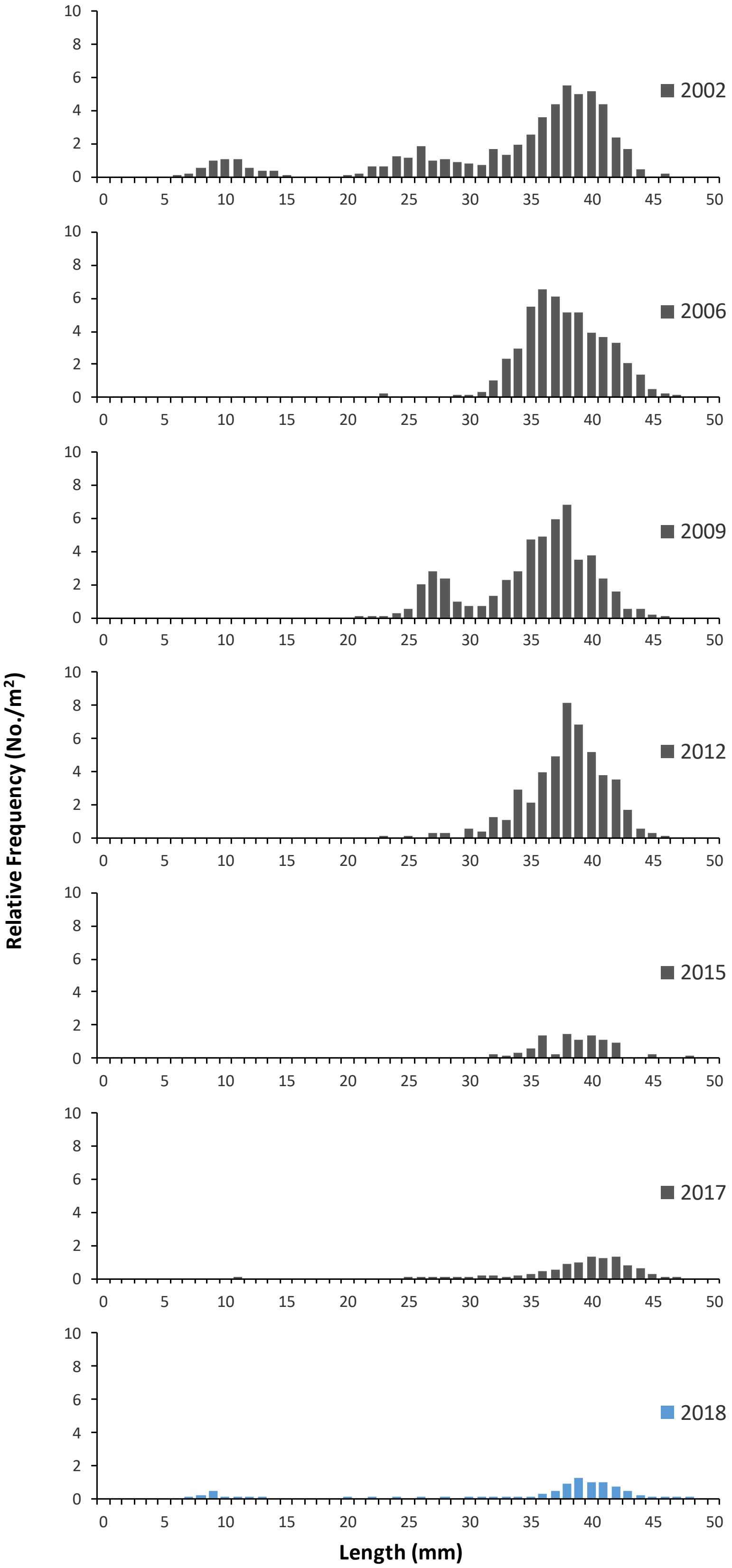

Figure 9. Relative length frequency (no./m^2) distribution of Vongole collected from Ansons Bay in surveys between 2002 and 2018.

Discussion and recommendations

The abundance of Vongole at Ansons Bay remains low, with the current biomass of 23.42 t at 12% of 2002 levels and below the limit reference point of 40 t recommended by Tarbath and Gardner (2015). The length frequency distribution indicates an aging of the population. Natural mortality occurring in the large (older) size classes is resulting in a decreasing biomass, as predicted by Keane and Gardner (2017). Further natural mortality of the larger size classes may continue to reduce total biomass in the short term. While evidence of some spawning and recruitment has occurred, levels are low and unlikely to recover biomass to fishable levels without further recruitment. Given that the fishery was closed following stock decline, and there is low levels of stock recovery, we recommend that this stock remains closed.

The initial population collapse and sustained low biomass levels appears to caused by several factors including low levels of pre-recruits, as observed in surveys post 2006, sporadic events of high natural mortality, and fishing mortality of recruited Vongole in 2012 and 2013 (Tarbath and Gardner 2015).

The harvest strategy for this fishery does not include a limit reference point for biomass at which fishing should operate. In the absence of a limit reference point, we recommend closing the fishery to harvests and developing an agreed limit reference point for biomass, above which the stock would be considered to have recovered.

Venus Clam - Northern Zone Georges Bay

Background

A commercial dive fishery has operated for the Venus Clam, (also known as Venerupis; *Venerupis largillierti*) in Georges Bay, north-east Tasmania since approximately 1985. The Venus Clam is endemic to New Zealand but was found in Tasmania in 1963. It remains indistinguishable from New Zealand populations, on the basis of allozyme analysis (Macguire, 2005). Venus Clams grows to a length of 70 mm and are found in the intertidal zone and subtidally in both muddy and sandy substrates in shallow estuarine waters on parts of Tasmania's east and south-east coasts (Grove, 2011). Experimental estimation of growth rates indicate growth increments at 1.3 $mm.month^{-1}$ at 27 mm and 0.5 $mm.month^{-1}$ at 43.5 mm (Kent et al., 2005; Maguire, 2005). Sexual maturity is estimated to occur below 27 mm (Maguire, 2005). Georges Bay is the only commercial fishery for this species in Tasmania, where the species forms beds on both intertidal sandbars and in subtidal deeper channels subjected to tidal flow. The Georges Bay Venus Clam Fishery is subdivided into two zones (Northern and Southern) with two licences in the Northern Zone and one in the Southern Zone (DPIPWE, 2007).

The Northern Zone fishery operates on mixed species shellfish beds in the bay with the area harvested varying between years. Until 2007 the fishery was managed principally through the allocation of half yearly or yearly permits. From 2007 a formal TACC structure was introduced with two associated commercial licences (DPIPWE 2007). TACC allocation is based on fishery dependent surveys of estimated available biomass conducted every two or three years with the TACC set as equal to 10% of the estimated biomass. Legal minimum length of *V. largillierti* is set at 40 mm shell length on the basis of market demand (DPIPWE 2007). Total catch and catch per unit effort data are available for this fishery from 1st September 2007 onwards, with the fishing year operating from 1st September to 31st August.

For the 2015-2016 fishing year, the two licensees implemented a voluntary reduction in TACC to 3 t as a consequence of low biomass. Due to continued low biomass and catch, an independent biomass survey was not requested by DPIPWE for 2016. A full assessment was conducted in 2017 and estimated the total biomass in the fished area to be 76.2 t, substantially lower than that of the three prior surveys: 284.7 t in 2009, 537.4 t in 2012 and 463.0 t in 2014. Length frequency distributions showed high levels of stock recruitment, with 69% of the population in terms of abundance, equating to 35% of the biomass, is under the LML of 40 mm. Two of the cohorts observed had modal lengths at or below the LML, giving confidence that stock levels have the potential to rebuild in the short term.

The objective of this survey was to estimate length frequency distributions of Venus Clams within Georges Bay to assess if continued spawning and recruitment was occurring.

2018 assessment

A total of 20 quadrats of 0.25 m^2 were sampled by a commercial diver and IMAS researcher randomly within commercially fished clam bed in Georges Bay. A total 417 clams were collected and measured to the nearest 1 mm using electronic measuring boards before being returned to the fishing grounds.

Two clear cohorts of clams were recorded in 2018, with modal peaks in abundance observed at 20 and 42 mm which appear to be consecutive year classes given estimates of growth rates at 1.3 $mm.month^{-1}$ at 27 mm and 0.5 $mm.month^{-1}$ at 43.5 mm (Fig. 3; Kent et al., 2005, Maguire and Paturusi 2005). It is estimated that 55% per cent of clams were under the legal size of 40 mm. This compares to 2012 when the modal peak was 52 mm and only 11% of clams were < 40 mm.

Discussion and recommendations.

A cohort of clams with modal length of 20 mm indicates additional spawning and recruitment to the population since the 2017 biomass estimate. This data represents the third consecutive year where cohorts of clams < 25 mm were observed, indicating sustained recruitment to the population over at least the last 3 years. If high levels of survival occur, biomass of the population should increase in the coming years. Based on this data the TACC should be maintained at 4.9 t for the 2018/19 season, with a full biomass survey conducted in 2019.

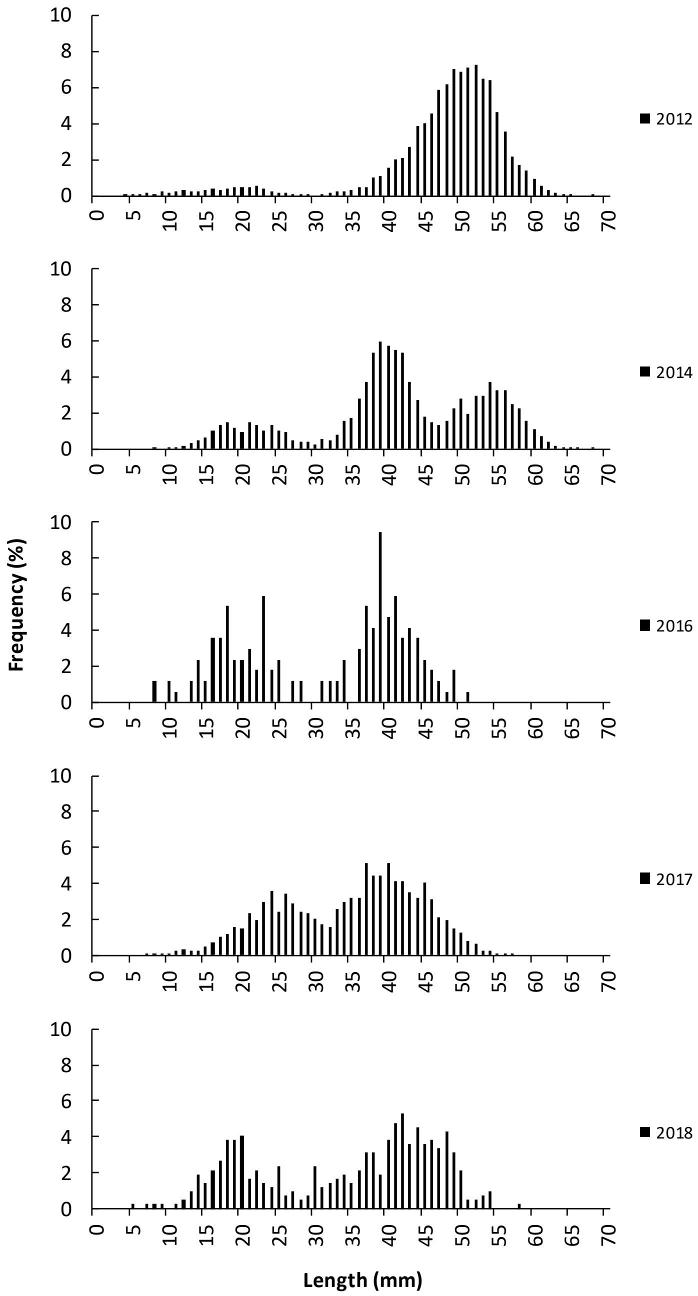

Figure 10. Length frequency (no./m^2) distribution of Venus Clams from the fished beds within Georges Bay Northern Zone between 2012 and 2018.

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