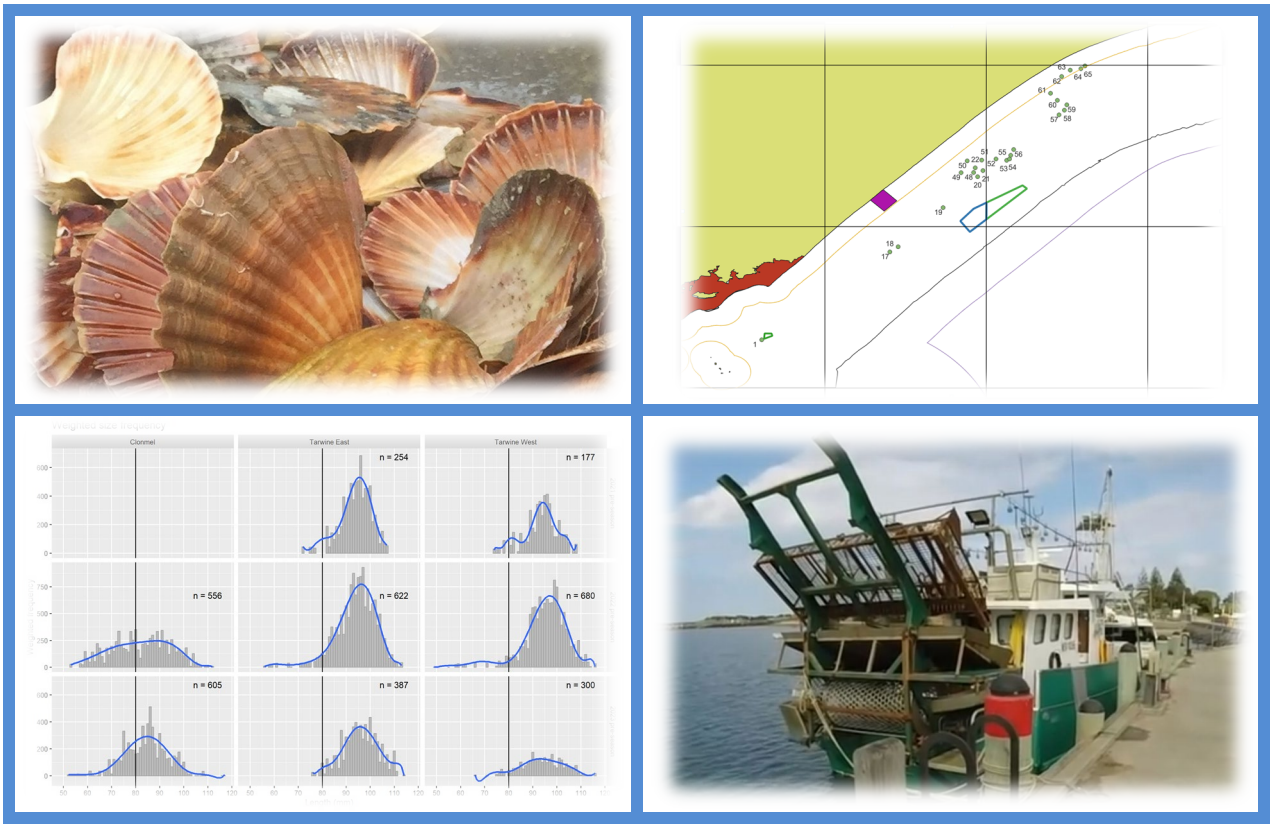
VFA Project 2021-23 0104

Eastern Victorian Ocean Scallop Fishery

2023 Pre-season Abundance Survey



Matt Koopman, Ian Knuckey and Russell Hudson

2023

fishwell CONSULTING

Victorian Fisheries AUTHORITY

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ISBN 978-0-6453571-6-5

Title: Eastern Victorian Ocean Scallop Fishery 2023 Pre-season Abundance Survey

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Koopman, M., Knuckey, I. and Hudson, R. (2023). Eastern Victorian Ocean Scallop Fishery 2023 Pre-season Abundance Survey. Report to the Victorian Fisheries Authority. Fishwell Consulting. 28pp.

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In submitting this report, the researcher has agreed to VFA publishing this material in its edited form.

Executive Summary

The main target species in the Victorian (Ocean) Scallop Fishery is the Commercial Scallop, *Pecten fumatus*, taken by dredging. The scallop fishery is managed using a statutory consultation process that involves fishers, fishery scientists and fishery managers. Information from a range of sources including scientific research, stock assessments and data from other Bass Strait scallop fisheries is considered in setting the annual total allowable commercial catch (TACC) which is divided equally between each licence holder.

Since the commercial fishery began in the 1970s, catches have varied greatly from year to year, with catches between 50 t and 2500 t occurring during the 1980s and 1990s, mainly taken in Port Phillip Bay and beds off Lakes Entrance. Scallop dredging was closed in Port Phillip Bay during 1998 at a time when catches were very low across the state. Continued low abundances of (Ocean) scallops off Lakes Entrance during the mid- to late-2000's prompted a fishery independent survey during 2009 that showed there were no commercially viable scallop beds remaining in the fishery and a zero TACC was set for the subsequent three fishing seasons to 2012/13 inclusive. Numerous subsequent fishery independent surveys suggested only extremely low levels of abundance and despite setting a low TACC (~135 t) subsequent to 2013, virtually no catches were taken in the fishery for the decade following the 2009/10 season.

During 2019 and 2020, industry members identified a bed that appeared to be recovering off Ninety Mile Beach near the Tarwhine oil and gas field. This "Tarwhine bed" was the focus of an industry-initiated survey conducted during December 2020. The results of this survey provided an estimated biomass of 7,876 t legal (≥80mm wide) Commercial Scallop on the Tarwhine bed with a density of 1.15 individuals per m^2. This result prompted an increase in the TACC from 135 t to 979 t (about 12% of available biomass) for the 2021/22 season, but the eastern half of that bed (east of Longitude 147° 30' E) was closed to fishing. A total of 663 t (meat weight) of Commercial Scallop was landed during that season (VFA - Wenner pers. com.).

Based on these results, the Victorian Fisheries Authority (VFA) committed to fund the 2022 and 2023 pre-season surveys to inform management of the fishery. Conducted during December 2021, the 2022 pre-season survey separated the western (open) and eastern (closed) areas of Tarwhine bed and also surveyed the small Clonmel bed located off Port Albert. Biomass of legal sized (≥80mm) Commercial Scallops was estimated to be 4867 t at Tarwhine East, 3892 t at Tarwhine West and 146 t at Clonmel. The percent of legal-sized Commercial Scallops was over 98% at the two Tarwhine beds and 73% at Clonmel. The TACC remained at 979 t during the 2022/23 season with the closure from the previous season remaining in place over east Tarwhine. As at 4 January 2023, less than 80 t of Commercial Scallop from the Victorian Ocean Scallop Fishery had been landed during the 2022/23 season (VFA - Wenner pers. comm.).

This report contains results of the second of the VFA-funded surveys, conducted during December 2022 to inform the 2023/24 season TACC and management.

Survey beds were identified through examination of previous surveys, analysis of last season's catch and effort data, information provided by Industry and exploratory fishing. Based on this, only the three beds previously identified were formally surveyed:

- the Tarwhine East bed (closed over the last two seasons) with a western boundary at longitude 147˚ 30'E;
- the Tarwhine West bed is the remaining part of the Tarwhine bed clipped in the west to exclude an area with low densities of scallops
- the small Clonmel bed located off Port Albert that was defined last year through exploratory fishing.

The 2023 pre-season survey was successfully completed between 18-20 December 2022. Forty tows were conducted as random stratified surveys of the three beds and 25 exploratory tows were undertaken at various locations.

The biomass of legal-sized (≥80 mm) Commercial Scallops was estimated to be 2770 t in Tarwhine East stratum, and 1510 t in Tarwhine West stratum. This represents a marked reduction (~50%) in biomass of Commercial Scallops on the Tarwhine bed this year (4280 t) compared to the previous year (8759 t). This level of reduction occurred in both the area of the bed that had been closed to commercial fishing (Tarwhine East) and the area that was open (Tarwhine West). Very little catch was taken from the Victorian (Ocean) Scallop fishery during the 2022/23 season, so the reduction can not be attributed solely to removals by fishing; it appears that many of the scallops died during 2022.

The biomass of legal-sized Commercial Scallops on the Clonmel bed increased from 146 t last year to 264 t this year. The percent of scallops ≥80 mm increased from 72% to 78%. As no new recruitment to the bed was evident, this increase in biomass is attributed to somatic growth of the animals during the intervening year. Although a much smaller bed than Tarwhine, the mean density of scallops on Clonmel (125.7 kg/1000^2) has increased and is approaching those that were evident on Tarwhine during the 2022 pre-season survey.

The implications of the survey results for the Victorian (Ocean) Scallop Fishery Harvest Strategy is discussed. Overall, there has been a marked drop in the biomass available to the fishery compared to last year and no signs of new recruitment or developing beds elsewhere in the fishery. Despite a closure that protected more than half of the only known commercially viable bed—Tarwhine, the biomass on both the open and closed areas halved during the 2022/23 fishing season, despite very low levels of fishing. We recommend that highly precautionary management is essential until more widespread evidence of recovery across the spatial extent of the Victorian fishery is observed.

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Acknowledgements

Thanks for the support of Mr John Cull and "Dusty" Cull and the crew of the Rachel Maree in preparing for the survey, but unfortunately a case of COVID-19 rendered the vessel unavailable at the time of the survey. We would like to thank Mr Andy Watts, Mr Jake Watts and the crew of the Northern Star for making their vessel available at short notice and for their assistance and hard work in undertaking the survey. We appreciate the contributions made by other industry members in identifying potential survey areas.

We appreciate the assistance of the Victorian Fisheries Authority staff: Mrs Michelle Wenner, Mr Toby Jeavons, Mrs Paula Baker and Mrs Monique Nelis (VFA).

Introduction

The main target species in the Victorian (Ocean) Scallop Fishery is the Commercial Scallop, *Pecten fumatus*. Commercial Scallops in wild populations live for between five and nine years, but have been observed to die-off rapidly after only three to five years in some situations (Haddon *et al.*, 2006). They are generally subject to high spatial and temporal variability in recruitment and abundance, variable growth and mortality, and rapidly changing meat yield and reproductive condition. This variability means that management of Commercial Scallops can be difficult due to the spatial and temporal patchiness of the resource. Although the Victorian (Ocean) Scallop Fishery extends twenty nautical miles out from the Victorian coastline, large portions of these waters are not suitable for Commercial Scallop fishing. Most commercial fishing is targeted towards high density scallop aggregations in spatially distinct 'beds' in eastern Victoria.

Commercial Scallops are taken using a dredge towed along the ocean floor with a tooth-bar to deflect scallops from the seabed into the dredge basket. The fishery is managed using a statutory consultation process that involves fishers, fishery scientists and fishery managers. Information from a range of sources including scientific research, stock assessments and data from other Bass Strait scallop fisheries is considered in setting the annual total allowable commercial catch (TACC). Although only 10–15 boats operate in the fishery, the number of commercial access licences is capped at 89 and each licence holder is given an equal share of the TACC. Transfer of quota between licence holders occurs during the season, under a system of "individual transferable quotas" (ITQs), facilitated by the Victorian Fisheries Authority (VFA) under the Department of Transport (DoT) (Victorian Fisheries Authority, 2021).

Since the beginning of the commercial fishery in the 1970's, catches have varied from tens of tonnes to thousands of tonnes (meat weight). Catches (and presumably stock abundance) declined in the mid- to late-2000s (Figure 1) and a lack of recovery prompted a fishery independent survey to be undertaken during 2009 by the Tasmanian Aquaculture and Fisheries Institute (TAFI) for the then Victorian Department of Primary Industries (DPI) (Harrington *et al.*, 2010). This survey determined that there were no commercially viable scallop beds available and as a result, DPI and the scallop industry made a joint decision to set the TACC at zero for the 2010/11, 2011/12 and 2012/13 fishing seasons. A further survey conducted in 2012 (Semmens and Jones, 2012) showed little improvement in the status of the stocks, although there was some indication of recent recruitment of juvenile scallops that should have reached commercial size by 2014. The TACC was subsequently set at 136.5 t in 2013/14 and 2014/15 and 135 t for the period 2015/16 to 2020/21.

Anecdotal information from Danish seine fishermen working off Victoria's east coast during 2017 suggested that there had been some level of recovery of the stock and commercially viable beds may be available for fishing. Based on this, and significant scallop beds being found recently in Bass Strait (Knuckey *et al.*, 2015, 2016, 2017, 2018, see also Koopman e*t al,*. 2019 and 2021a), VFA considered that there was merit in conducting a 2018 pre-season biomass survey of the Victorian Scallop Fishery to inform management arrangements for the following season. A broad-area survey was designed and conducted based on depth limitations of scallop fishing, GIS habitat layers, past fishing effort and results of past surveys in areas from Point Hicks in the east to Wilsons Promontory in the west. Total biomass in the broad-area stratum was estimated to be 5,107 t (95% confidence limits (CLs) ranged 2,226 t–14,372 t), and with 89% of these scallop of a legal size (≥80mm width),

estimated biomass ≥80 mm was 4,545 t (95% CI 1,980 t–12,791 t). The overall density was 1.1 kg per 1000 m^2, or 0.06 individuals per m^2 (Koopman *et al*. 2018).

In response to additional information from industry members, an industry-initiated 2021 pre-season survey was undertaken during December 2020 at what is now known as the "Tarwhine bed" (Koopman *et al*. 2021b). Results from this survey revealed a total biomass of 8,018 t (95% CIs ranged 4,706 t–12,020 t) of which 98.2% were ≥80 mm. The density was 1.2 individuals per m^2. These results prompted the VFA to increase the 2021/22 TACC from 135 t to 979 t (about 12% of the available biomass) but close half to the Tarwhine bed to fishing (east of Longitude 147° 30' E) to protect spawning potential.

A VFA-funded biomass survey was undertaken during December 2021 to inform the 2022/23 season management of the fishery. For that survey, the Tarwhine bed was split into east (closed to fishing) and west (open) strata, and a new bed located off Port Albert, Clonmel, was mapped out and surveyed (Koopman *et al*. 2021). Biomass estimated at the Tarwhine East, Tarwhine West and Clonmel beds were 4,966 t (3,203 t–6,729 t), 3,955 t (2,630 t–5,281 t) and 200 t (136 t–265 t) respectively. Nearly all scallops (>94%) measured at the Tarwhine beds were ≥80 mm, while 72.8% were ≥80 mm at the Clonmel bed. Densities ranged 1.13 individuals per m^2 at Clonmel to 1.53 individuals per m^2 at Tarwhine East. The TACC remained at 979 t during the 2022/23 season with the closure from the previous season remaining in place over east Tarwhine. Catches this year, however, were considerably lower than the previous year.

This report contains results from the 2023 pre-season survey conducted during December 2022.

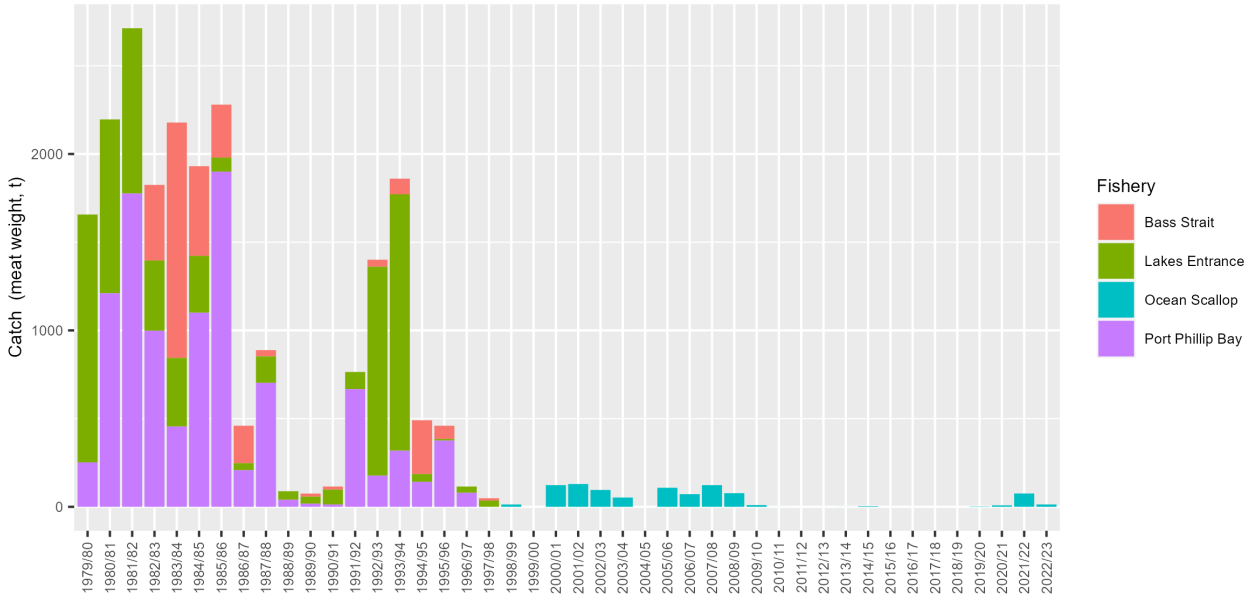

Figure 1. Time series of catch (meat weight, tonnes) in the Victorian Scallop Fishery. Minimum number of vessel contributing to any data point since 2000/01 is five or more. Note that 2022/23 catch is not shown because it comprises less than five vessels. Historical data (prior to 2000/01) from https://vfa.vic.gov.au/commercial-fishing/scallop (accessed January, 2023)

Objectives

1. Estimate the available (≥80 mm) scallop biomass in the area of the Victorian (Ocean) Scallop Fishery.
2. Measure the size frequency distribution of scallops in each area to calculate discard rates.
3. Measure a range of biological information from the catch.
4. Report results to VFA to inform setting the 2023/24 Total Allowable Commercial Catch.

Methods

Design on the 2023 Pre-season Survey

Koopman *et al.* (2022) undertook analysis of catch and effort data up to October 2021 in planning the 2022 pre-season survey. For the design the 2023 pre-season survey, these analyses were updated to include 2022 catch and effort data up to October 2022. Those additional data did not include any information that warranted a change from the 2022 pre-season survey design. For this reason, and because the new data comprised less than five fishing vessels (the minimum required by VFA to publish catch levels), those catches are not included in this report.

Thus, the three beds from the 2022 pre-season survey (Tarwhine East, Tarwhine West and Clonmel) were retained and their boundaries remained unchanged for the 2023 pre-season survey.

Industry members provided only two marks considered to potentially contain commercially viable beds to explore during the 2023 pre-season survey, both were inside the Tarwhine beds and reportedly contained small scallops during 2021.

Sampling methods

Survey methods follow those of Knuckey *et al.* (2015), modified from those described in Harrington *et al.* (2009).

The survey vessel was selected from respondents to an expression of interest sent out the previous year. Criteria used to evaluate vessel included safety, history of cooperation with management of the fishery, skipper experience in the fishery and in undertaking surveys, workspace and accommodation facilities and availability.

For each tow, estimates were made of weight of: total live scallop catch, dead shell and all bycatch by species / species group. Dead shell was separated into:

- Clappers (both valves still connected at the hinge)
- Old single (single valve – inside appears old and overgrown with epiphytes / epifauna)
- New single (single valve – inside appears new without any epiphytes / epifauna)

A random sample of at least 35 scallops (where available) was collected from each tow before they went through the tumbler (a device used to remove small bycatch and scallops from the sorted catch). The observer measured the length of those scallops using a Scielex ™ electronic measuring board. Either the first or last (or both) scallop from each tow measured using the measuring board was also measured by hand using digital callipers or a metal ruler. This was done to ensure accuracy

and consistency of the measuring board throughout the survey. The sample weight of scallops measured was also recorded.

From every fifth tow, an additional 10 random scallops were taken before passing through the tumbler to collect biological information. First, the whole scallop was weighed, then split and the gonad condition staged according to the scale based on Semmens, *et al.* (2019) (Table 8). Adductor meat and gonad were removed from the shell and weighed together to calculate number of meats per kg. Shell height and width were also measured for morphometric analyses.

Data analysis

All data processing and analysis was undertaken in R (R Core Team, 2022), and density plots were created using the package QGIS (version 3.22.5). Estimates of biomass followed the methods of Semmens and Jones (2014).

Biomass

The internal widths of the dredges used during the survey were measured in accordance with Semmens and Jones (2014). Dredge width used by the Northern Star was 4.02 m. A dredge efficiency of 33% was assumed (see Harrington *et al*. 2008 for origin of the 33%).

Swept area (S) of each tow was calculated as follows:

$$S=L \times W$$

Where L is the tow distance (m) and W is the width of the dredge (m). Tow distance was calculated from the straight-line distance between start and end tow positions for most tows. In two cases the GPS fix was lost, and so distance was calculated from the vessel speed and tow duration.

Scallop catch in each tow ($C^{standardised}$ in kg/1000 m^2) was calculated as follows:

$$C^{standardised} = (C/S) \times 1000$$

Where C is the estimated catch in a tow (kg).

Assuming a 33% dredge efficiency, biomass (B) in tonnes and 95% confidence limits (CL) were estimated for each stratum (bed) as follows:

$$B = meanD \times A \times 3.03 / 1000$$

$$\text{Upper 95\% CL} = ((meanD + (t_{n-1} \times SE_{meanD})) \times A) \times 3.03 / 1000$$

$$\text{Lower 95\% CL} = ((meanD - (t_{n-1} \times SE_{meanD})) \times A) \times 3.03 / 1000$$

Where meanD is the mean density (kg) of scallops per m^2 swept, t_{n-1} is the t –value for the number of tows (n) -1, SE_{meanD} is the standard error of meanD and A is the total stratum area (m^2). The area of each bed was calculated using the package QGIS (version 3.10.10).

Biomass and upper and lower 95% CL of scallops ≥80 mm were calculated as follows:

$$B_{>80mm} = B \times (1\text{-discard rate})$$

$$\text{Upper 95\% CL}_{>80mm} = \text{Upper 95\% CL} \times (1\text{-discard rate})$$

$$\text{Lower 95\% CL}_{>80mm} = \text{Lower 95\% CL} \times (1\text{-discard rate})$$

where the discard rate was calculated using catch weighted length frequencies converted to weight.

An estimate of density in individuals per square metre (*I*) was obtained as follows

$$I = \sum_{len} WLf \; / \; S$$

Where *WLf* is the weighted length frequency for each length class *len*, and *S* is the swept area (m^2).

All densities (kg / m^2 and individuals per m^2) reported have been adjusted for the 33% assumed dredge efficiency.

Biological measurements

Length-weight relationships were calculated for each stratum separately, and the parameters of the relationship are provided in the results. The length-weight relationship was applied to catch-weighted size frequencies to calculate the discard rate at 80 mm. The discard rate was used in calculations of biomass of scallops ≥80 mm. Number of meats per kg was calculated separately for each bed by dividing 1000 by the mean meat and gonad weight in grams.

Quality Assurance

The survey was undertaken following Standard Operating Procedures. All tow and scallop catch data were recorded in ORLAC Dynamic Data Logger (DDL), which contains quality assurance protocols including automatic data capture (time, date and position), field restrictions, range checks, mandatory fields and lookup tables. These data are maintained in the ORLAC Dynamic Data Manager (DDM) database on a cloud-based server from which data are extracted for analyses. Data were manually error-checked against data sheets. Analyses were undertaken using R (R Core Team, 2022), and a subset of outputs were reproduced and compared using an alternative software package. Scallops were measured using Scielex™ electronic measuring boards, or callipers in the event of measuring board failure. The first or last (or both) scallop from each tow was measured by both the measuring board and by hand using either digital callipers or a metal ruler. This was done to ensure accuracy and consistency of the measuring board throughout the survey.

Results and their interpretations and conclusions were discussed amongst the research team, and draft reports were reviewed by co-authors and VFA managers. Where required, comments were addressed in preparation of the final report.

Results

Initially the survey was to be undertaken on the Rachel Maree, one of the vessels selected from the previous Expression of Interest, but a case of COVID-19 on board just prior to departure required an alternative vessel to be sought at short notice. The survey was undertaken on the fishing vessel Northern Star (that conducted the pre-2022 survey), departing Lakes Entrance at 19:56 on 18/12/2022 and returning to Lakes Entrance at 15:22 on 20/12/2022.

Exploratory tows

Exploratory tows were undertaken at different areas on each day of the trip. A total of 25 exploratory tows were undertaken, mostly around historic fishing marks (Figure 2). Few Commercial Scallops were caught in exploratory tows, with only up to 1 kg recorded per tow. Scallops in good condition were found in tow 58. Dead shell and Eleven-armed Sea Stars were commonly recorded in the exploratory tows. Details of each of the exploratory tows is provided at Appendix 5, Table 12.

Biomass estimates of survey beds

The location of the three survey beds is shown by the blue and green polygons in Figure 2 and the detailed position of each tow is provided at Appendix 5, Table 11 and Table 10.

Clonmel

The small, southernmost Clonmel bed has a total area of 2.69 km^2 (Figure 2, Table 1). A total of 15 survey tows were undertaken there on 18 December 2022 (Table 2). Mean densities of Commercial Scallops in survey tows were 125.7 kg/1000 km^2 and 1.76 individuals per m^2 and an estimated biomass of 338 t (95% confidence intervals CIs; 245–431 t). With 78.1% of Commercial Scallops ≥80 mm length, estimated biomass legal-sized scallops was 264 t (95%CL; 191–337 t) (Table 3). Medium to high densities of Commercial Scallops were found throughout the bed (Figure 3).

Tarwhine East

A total of 15 valid tows were undertaken in the Tarwhine East stratum, which has an area of 40.23 km^2 (Table 1, Table 2). Commercial Scallops in survey tows had mean densities of 69.3 kg/1000 km^2 and 1.01 individuals per m^2 and a biomass of 2,789 t (95%CL; 1081–4496 t). Using the 99.3% of Commercial Scallops ≥80 mm, estimated biomass of legal-sized scallops was 2,770 (95%CL; 1073–4465 t) (Table 3). Four tows undertaken in the Tarwhine East stratum contained no Commercial Scallops. High, medium and low densities were observed throughout the area surveyed (Figure 3).

Tarwhine West

Twenty tows were undertaken in the 37.66 km^2 Tarwhine West bed (Table 1, Table 2). Densities of Commercial Scallops were 41.1 kg/1000 km^2 and 0.51 individuals per m^2. More than 97.5% of Commercial Scallops were ≥80 mm length resulting in an estimated legal-sized biomass of 1510 t (95%CL; 541–2479 t) (Table 3). One tow had no Commercial Scallops, while medium and low densities were observed throughout the area surveyed.

Length frequencies

Mean length of Commercial Scallops at Clonmel was 85.0 mm compared to 96.0 mm at Tarwhine East and 95.3 mm at Tarwhine West (Table 4). A wide range of scallop sizes were measured at Clonmel, with a mode of 86 mm and good signs of recruitment (Figure 4). Length frequencies from the two Tarwhine strata were similar to each other, differing slightly in that scallops from Tarwhine East were generally larger than at Tarwhine West. Mean number of meats per kg were 85.1, 85.4 and 88.5 per 1 kg at Clonmel, Tarwhine East and Tarwhine West and respectively (Table 4). Distribution of meat and gonad weights is shown in Figure 5.

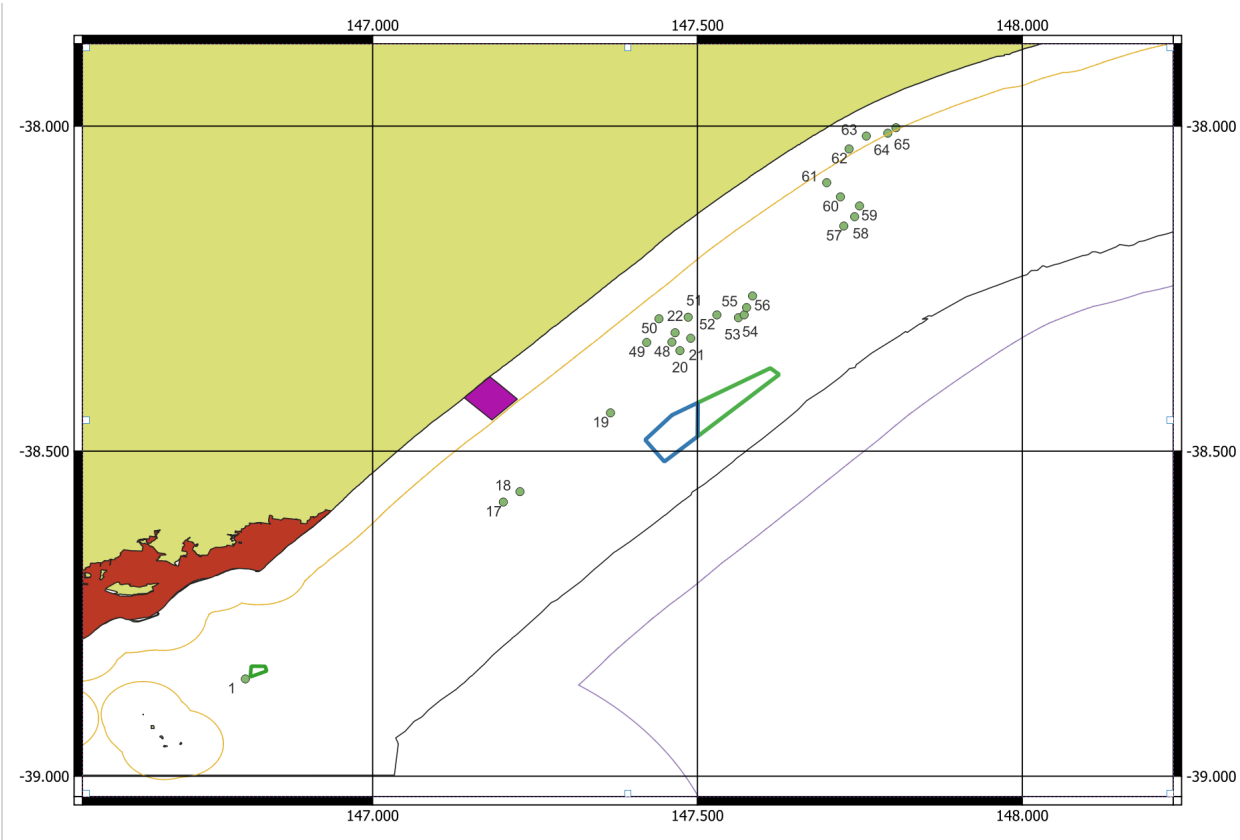

Figure 2. Survey beds (▭) and exploratory tows (●) undertaken during the survey.

Table 1. Total area of each survey bed.

Bed	Total Area (km^2)
Clonmel	2.69
Tarwhine East	40.23
Tarwhine West	37.66

Table 2. Biomass estimates, 95% confidence limits and number of tows included in analyses. Note that both densities have been adjusted for a 33% assumed dredge efficiency.

	Clonmel	Tarwhine East	Tarwhine West		Total
Number of tows	15	15	10		40
Mean density (kg/1000 m^2)	125.7	69.3	41.1		
Standard deviation (kg/1000 m^2)	62.3	76.6	36.9		
Lower 95% CL (t)	245	1081	555		1882
Estimated biomass (t)	338	2789	1549		4676
Upper 95% CL (t)	431	4496	2543		7470
Density (ind/m^2)	1.76	1.01	0.51		

Table 3. Percent weight of scallops ≥80 mm (catch weighted by weight), and biomass estimates 95% confidence limits for scallops ≥80 mm.

	Clonmel	Tarwhine East	Tarwhine West		Total
% weight ≥80 mm	81.0	99.3	97.5		
Lower 95% CL (t)	198.5	1073.4	541.1		1813.0
Estimated biomass (t) ≥80 mm	273.8	2769.5	1510.3		4553.6
Upper 95% CL (t)	349.1	4464.5	2479.4		7293.0

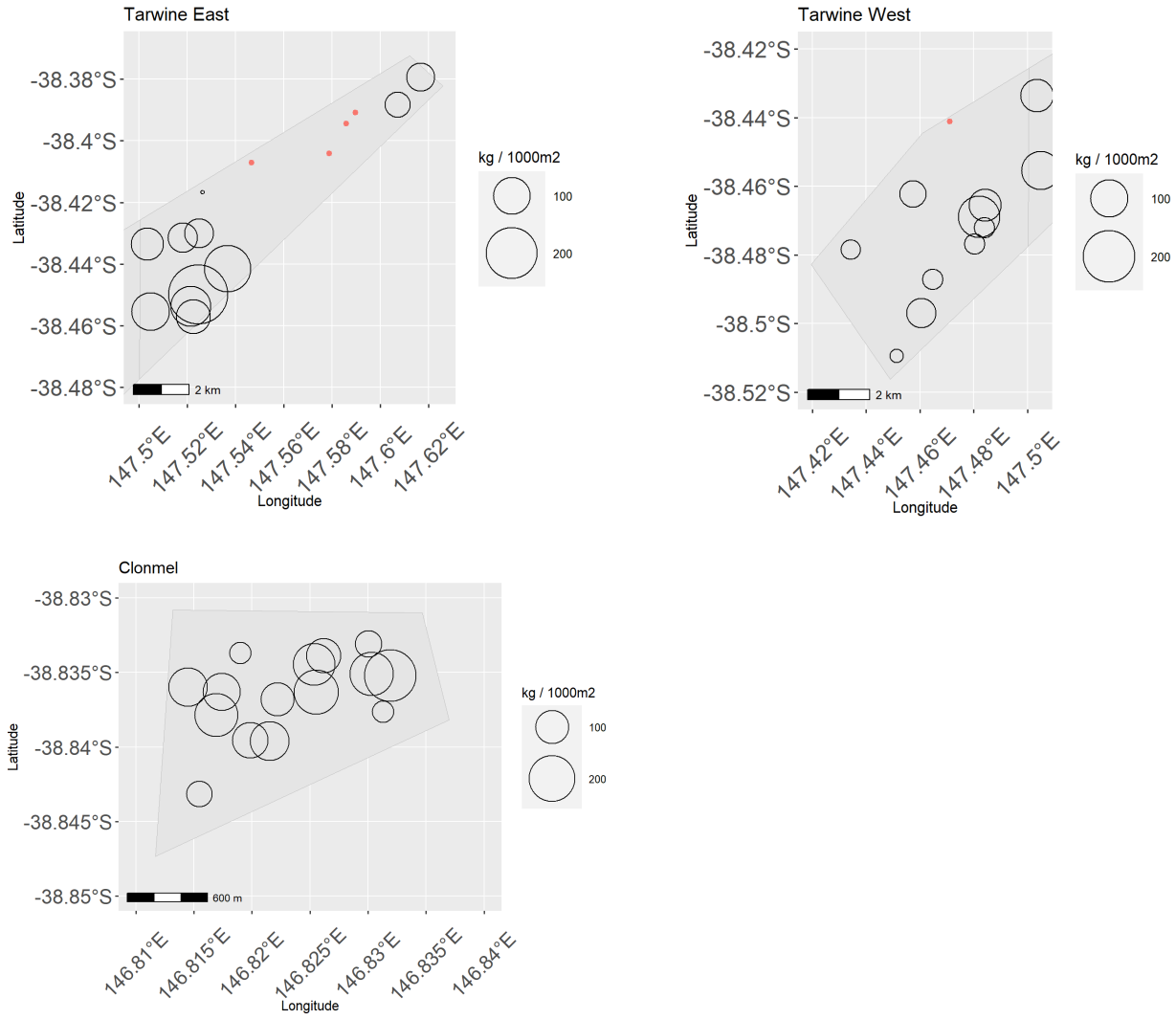

Figure 3. Scallop density (kg / 1000 m^2) within each bed. The right-hand scale bubbles reflect the estimated scallop density of each tow assuming a dredge efficiency of 33%. Red dots denote zero catches.

Table 4. Number of length measurements (N), median, mean and standard error (SE) of scallops measured, and % of scallops measured (catch weighted by weight) <80 and ≥80 mm and mean number of meats per kg of scallops ≥80 mm from each bed.

Trip	Clonmel	Tarwhine East	Tarwhine West
N	605	387	300
Median length (mm)	85.3	96.1	95.5
Mean length (mm)	85.0	96.0	95.3
SE length (mm)	0.4	0.4	0.5
% <80 mm	21.9	0.7	2.5
% ≥80 mm	78.1	99.3	97.5
Mean meats per kg	85.1	85.4	88.5

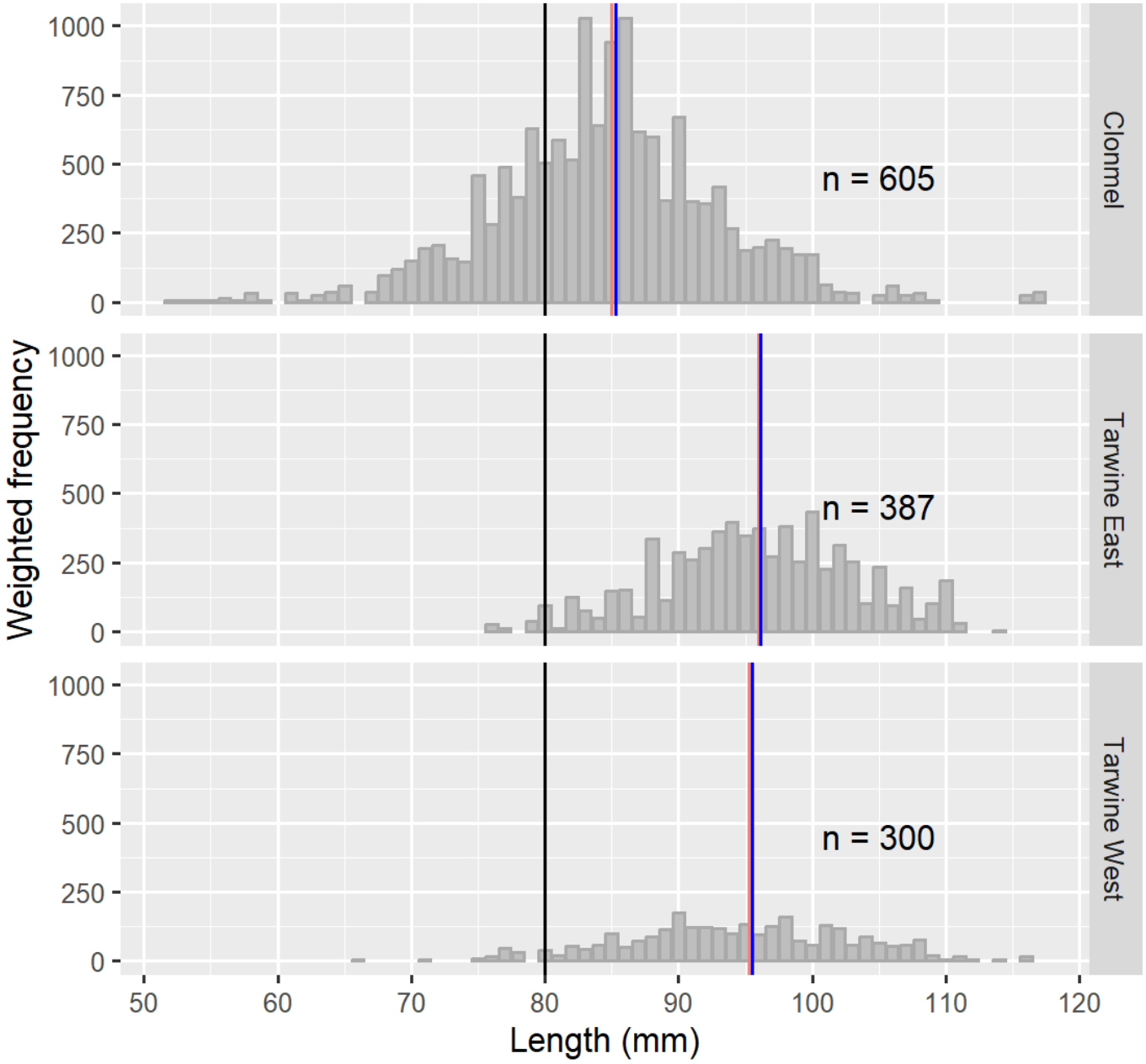

Figure 4. Catch weighted size frequency from tows included in biomass estimates from each bed. The black vertical line is at 80 mm, blue line shows median length and orange line is the mean length.

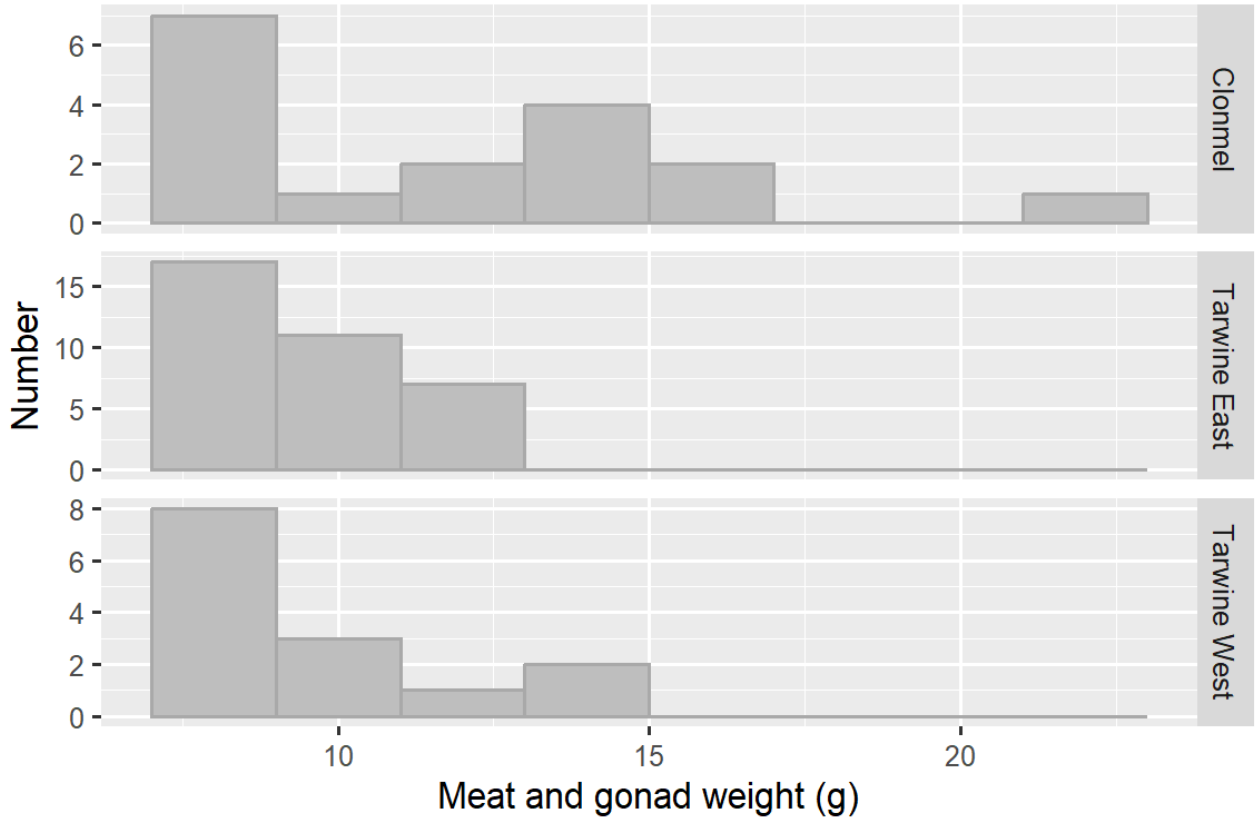

Figure 5. Frequency of combined meat and gonad weights of scallops ≥80 mm measured from each bed, binned into 2 g weight categories.

Biological measurements

Comparison of length-weight regressions revealed that the interaction term was not significant ($p>0.05$), indicating that there was no detectable difference in slopes in the length-weight relationship between beds (Figure 6A and Table 5). The p-value for the indicator variable ($p<0.0001$) suggests that there is a difference in intercepts, and that there are differences in length-weight relationships between beds. However, because of the small sample size, data from beds were pooled in further calculations. Parameters of the length-weight relationships are shown in Table 5.

Morphometric measurements are plotted in Figure 6. Data from the different beds mostly overlap with the exception that scallops from Clonmel were consistently heavier for a given length than the other two beds. Despite that, none of the combinations of measurements had statistically different slopes between beds.

The majority of scallops sampled were at stage 1 at Clonmel and Tarwhine West, while more than 50% of scallops were at stage 2 at Tarwhine East (Figure 7).

Table 5. Number of scallops retained for biological sampling, and parameter estimates for length-weight relationships.

Stratum	N	a	b	Adjusted R^2
Tarwhine East	39	-5.721	2.189	0.740
Tarwhine West	15	-8.048	2.685	0.844
Clonmel	30	-8.389	2.812	0.923
Combined	84	-6.1037	2.2797	0.808

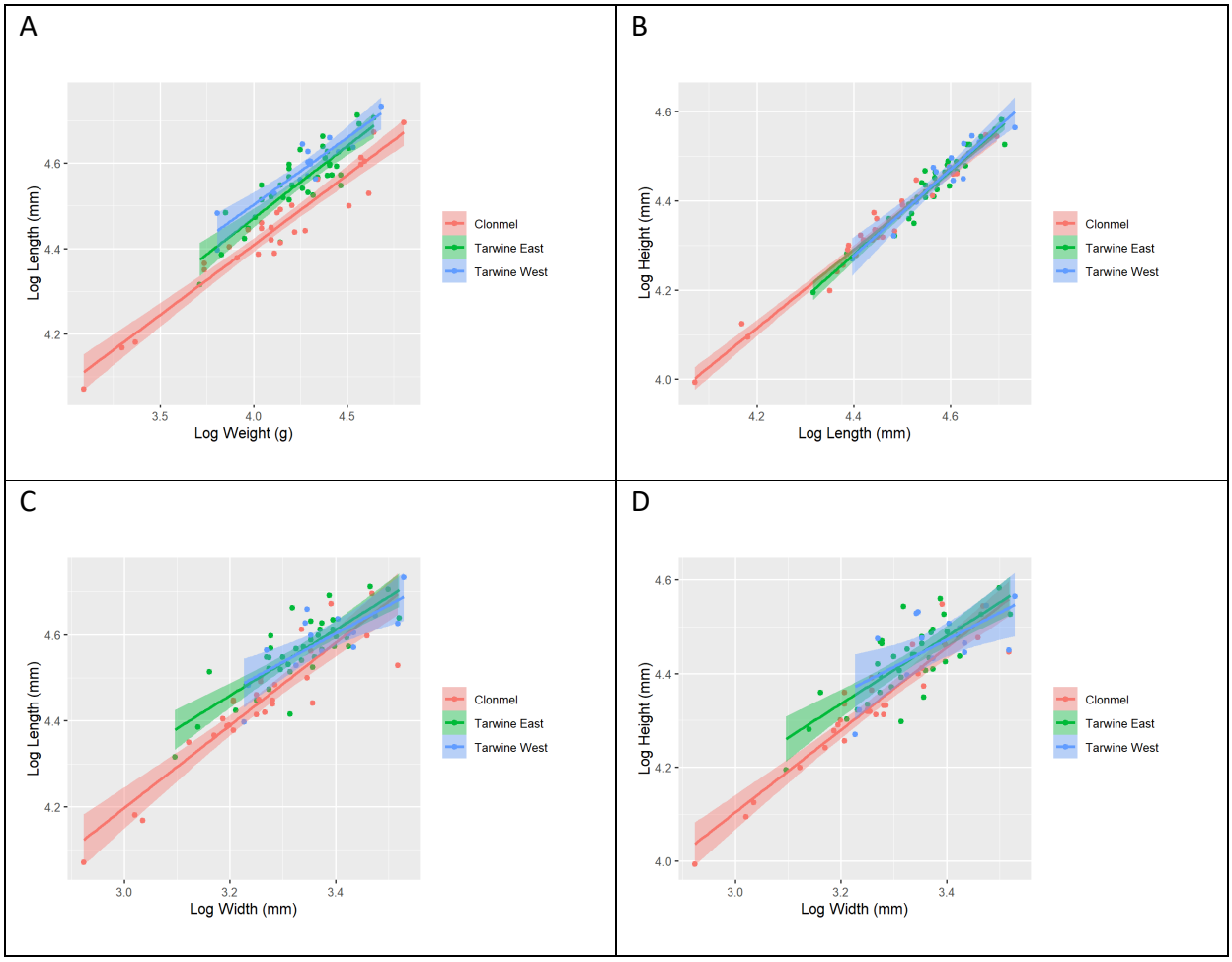

Figure 6. Log transformed A) length vs weight, B) length vs height, C) length vs width and D) height vs width from each bed.

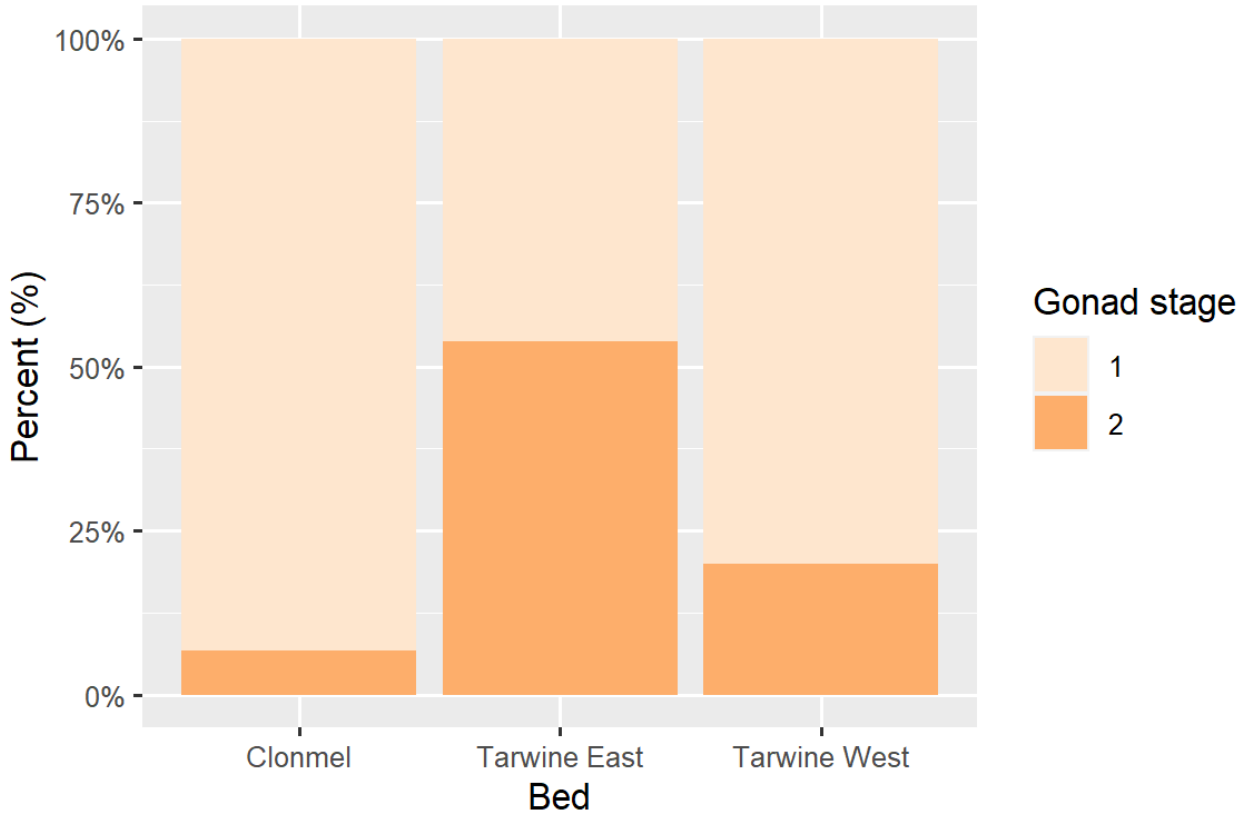

Figure 7. Percent of scallops at each stage from each bed based on macroscopic staging criteria shown in Appendix 2.

Survey catch composition

Species composition of the main species is shown in Table 6 and all survey catches are shown in Table 9. Survey catches at Tarwhine East and Tarwhine West were dominated by Old Single Shell (2460 kg and 1520 kg) followed by live Commercial Scallops at Tarwhine East (623 kg) and other shell Tarwhine West (247 kg) (Table 6). Catch composition was very different at Clonmel, dominated by benthos (1275 kg), sponge (1235 kg) and Commercial Scallops (1005 kg). Percent composition of scallops and scallop shell also reveals higher proportions of old single shell at the two Tarwhine beds than at Clonmel (Figure 8).

The survey caught no species of conservation interest.

Table 6. Survey catch (kg) of scallops and other main species by stratum. "U" denotes undifferentiated species. Catch of all species shown in Table 9.

Species	Clonmel	Tarwhine East	Tarwhine West		Total
Commercial Scallop	1004.6	623.0	247.2		1874.8
New Single	55.5	70.0	44.0		169.5
Old Single	97.0	2460.0	1520.0		4077.0
Clappers	5.3	38.0	28.0		71.3
Sponge (U)	1235.0	215.0	170.0		1620.0
Benthos	1275.0	0.0	150.0		1425.0
Shell	42.0	530.0	420.0		992.0
Ascidian (U)	440.0	19.0	2.0		461.0
Doughboy Scallop	12.8	14.5	9.5		36.8
Other species	96.5	37.4	54.3		188.2
Total	4263.7	4006.9	2645		10915.6

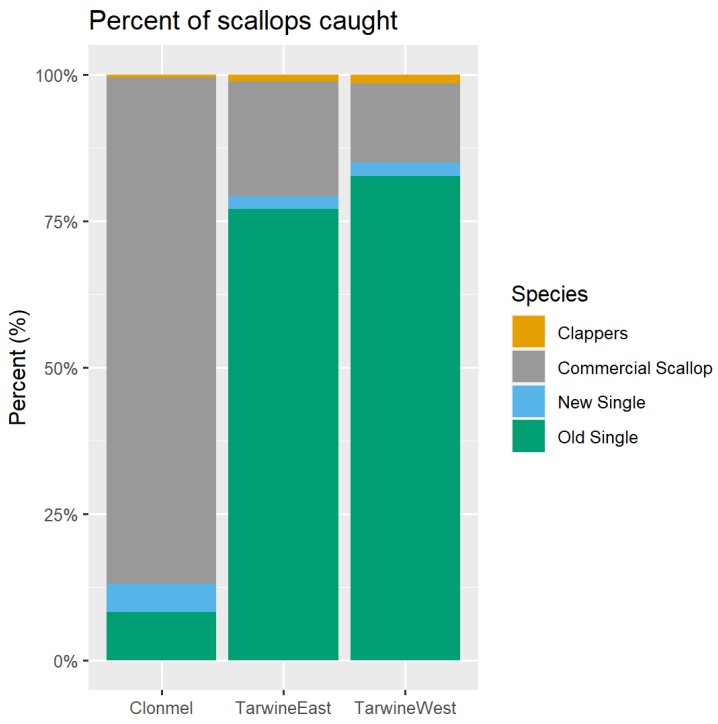

Figure 8. Percent composition of clappers, live scallop, new single and old single shell from each strata from the 2023 pre-season survey.

Comparison of the 2021, 2022 and 2023 pre-season survey results

To aid in the management decisions for the 2023/24 season, we provide a comparison of the results of the current 2023 pre-season survey to those of the previous 2021 and 2022 pre-season surveys.

Scallop density, proportion of legal-sized scallops and biomass estimates from the time-series of three surveys are shown in (Table 7). Length frequencies from the Tarwhine beds from the 2021 pre-season (retrospectively assigned to Tarwhine East and Tarwhine West) and 2022 pre-season surveys (combined East and West) are shown in Figure 9. The catch composition of live scallop, clappers, new single and old single shell is provided in Figure 10.

Although the bed is relatively small, density and biomass of scallops on the Clonmel bed increased, as did the size range of scallops on the bed, with a great proportion now over the legal size. In comparison, the 2023 pre-season survey biomass estimate on the Tarwhine bed (combined East and West Tarwhine strata) has roughly halved, from over 8000 t in the previous two years to around 4300 t in the current survey. This is reflected in the marked reduction in densities and in the increase in the proportion of old (dead) single shells to over 75%. The size range of the scallops did not change greatly, but it is evident that the proportion of individuals in the 85-105mm range was much reduced in the Tarwhine West stratum compared to Tarwhine East, which was closed to fishing.

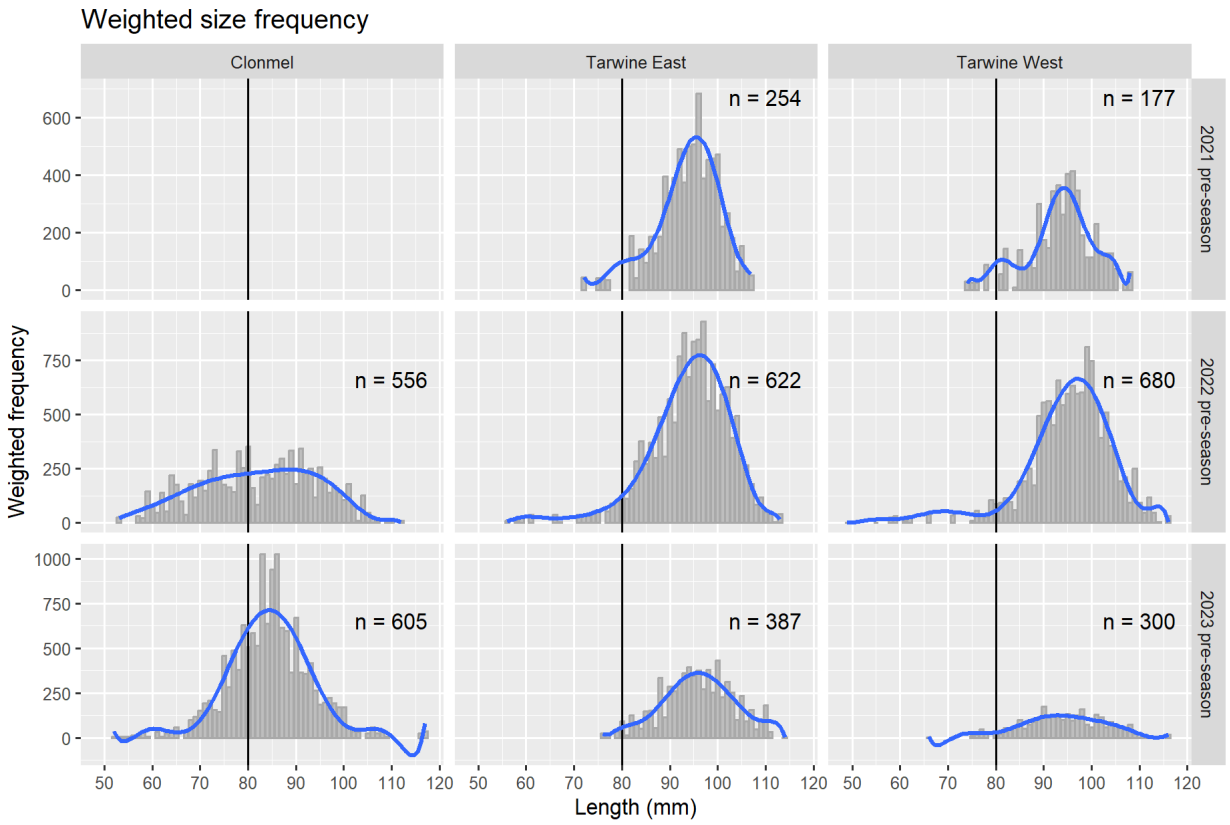

Figure 9. Comparison of the length frequency distributions from each bed from the 2021, 2022 and 2023 pre-season surveys. Note that the 2021 pre-survey length frequencies were retrospectively assigned to Tarwhine East and Tarwhine West, and that data from three tows in the south-west did not fall within the boundaries of the 2022 pre-season survey stratum and were omitted.

Figure 10. Percent composition of clappers, live scallop, new single and old single shell from each bed from the 2021, 2022 and 2023 pre-season surveys (note that Clonmel was not surveyed during 2021).

Table 7. Summary of main results from the 2021 pre-season survey, 2022 pre-season survey and 2023 pre-season survey with the two Tarwhine strata combined. Where results could not be combined, both are shown.

Indicator	2023 pre-season survey		2022 pre-season survey		2021 pre-season survey
	Clonmel	Tarwhine East and West combined	Clonmel	Tarwhine East and West combined	Tarwhine
Number of tows	15	25	14	39	20
Mean density (kg/1000 m^2)	125.7	69.3 and 41.1	74.5	123.4 and 105	91.0
Density (ind/m^2)	1.76	1.01 and 0.51	1.13	1.53 and 1.14	1.2
% weight ≥80 mm	78.1	99.3 and 97.5	72.8	98 and 98.4	98.2
Estimated biomass (t) (95%CL)	338 (245–431)	4338 (1636–7039)	200 (136–265)	8921 (5833–12010)	8010 (4706-12020)
Estimated biomass (t) ≥80 mm (95%CL)	264 (191.3–336.6)	4279.8 (1614.5–6943.9)	146 (99–193)	8759 (5727–11791)	7876 (4326-11807)

Discussion

The 2023 pre-season survey was successfully completed between 18-20 December 2022. Forty tows were conducted as random stratified surveys of three beds: 15 on Clonmel, 15 on Tarwhine East and 10 on Tarwhine West. With an obvious reduction of scallop density on Tarwhine, it was decided during the survey to spend extra time exploring outside the known beds. Twenty five exploratory tows were undertaken at various locations, but revealed no areas worth further surveying.

The biomass of Commercial Scallops ≥80 mm was estimated to be 2770 t in Tarwhine East stratum, 1510 t in Tarwhine West stratum and 264 t Clonmel (Table 3). Total average biomass ≥80 mm at all strata combined was 4544 t, about half of the estimate from the previous year. The percent of Commercial Scallops ≥80 mm remained at around 98% at the two Tarwhine strata and 78% at Clonmel.

The most notable aspect of the 2023 pre-season survey was the marked reduction (~50%) in biomass of Commercial Scallops on the Tarwhine bed this year (4676 t) compared to the previous year (9121 t). This level of reduction occurred in both the area of the bed that had been closed to commercial fishing (Tarwhine East reduced from 4,966 t to 2767 t) and the area that was open (Tarwhine West reduced from 3955 t to 1510 t).

Given that very little catch (<80 t) was taken from the Victorian (Ocean) Scallop fishery during the 2022/23 season, and that none was removed from the closed area, the reduction across both areas of the bed can not be attributed solely to removals by fishing. Compared to the previous year, both the East and West areas of the Tarwhine bed saw an increase in the proportion of old (dead) single shells compared to live scallops and new (dead) single shells, suggesting many of the scallops had died during 2022. It was also clearly apparent from the Tarwhine length frequency distributions that whilst there had been some growth of sub-legal animals up to a legal size, this was a only very small fraction of the population and no further recruitment to the bed had occurred.

Previously noted last year, the proportion of old single shell recorded at both Tarwhine strata increased markedly again this year (Figure 10). Large increases in the proportion of dead shell in beds of the Bass Strait Central Zone Scallop Fishery (BSCZSF) are usually (but not always) associated with a decrease in biomass. Examples from Flinders Island, KI-BDE, KI-7 and KI-9 demonstrate this (see Appendix 2 of Koopman et al. 2021a). A large decline in biomass, however, does not necessarily lead to a large increase in the proportion of dead shell (e.g. the AB2-E bed in Koopman et al. 2021a).

The generally reducing trends in both biomass and density were similar in both Tarwhine East and Tarwhine West. The size range of scallops were also similar, but one notable difference was that the proportion of individuals in the 85-105mm range was much reduced in the Tarwhine West stratum (open to fishing) compared to Tarwhine East (closed). This may be a result of the of the significant commercial catch (663 t meat weight) that occurred in Tarwhine West during the 2021/22 fishing season.

In contrast to the Tarwhine bed, biomass estimates for Clonmel from the 2023 pre-season survey (338 t) increased compared to the previous year (200 t). The wide size range of scallops evidenced last year was attributed to ongoing recruitment over numerous years, but there was no evidence of further recruitment this year. With no evidence of recruitment to the bed, the increase in biomass is attributed to the growth in size and weight of the scallops during 2022, reflected in the increased

proportion of scallops larger than the legal limit. Although a much smaller bed than Tarwhine, the mean density of scallops on Clonmel (125.7 kg/1000^2) has increased and is approaching those that were evident on Tarwhine during the 2022 pre-season survey. A tow on Clonmel undertaken during the 2017/18 survey revealed a mean density of 70.1 kg/1000 m^2 and a mean density of 74.5 kg/1000 m^2 was calculated from the 2022 pre-season survey.

Although the low catches taken by commercial fishing during the 2022/23 season may have been influenced by the lower densities of legal-sized scallops on the Tarwhine bed, it is likely not the only reason. Many Victorian scallop fishers also have licences in the Commonwealth's Bass Strait and Central Zone Scallop Fishery (BSCZSF) and the Tasmanian scallop fishery. High costs of diesel fuel during 2022 influenced many fishers to seek fishing grounds that were near to ports of landing. In the case of scallops, high density, nearshore beds of good quality Commercial Scallops were found in Tasmania and many multi-licenced fishers opted to work the Tasmanian scallop beds during 2022 rather than the Victorian or BSCZSF fisheries. Certainly, despite many high-density, commercially viable scallop beds being available in the BSCZSF, catches were significantly lower during 2022 than in previous years.

Application of survey results to harvest strategy

The Victorian (Ocean) Scallop Fishery Harvest Strategy guides annual TACC-setting based on whether or not a fishery independent biomass survey is conducted, and the biomass and density of scallops in surveyed beds. Applying the results from the 2023 pre-season survey to the harvest strategy, the TACC could be set above the 135 t default TACC because a biomass survey was undertaken and a "viable scallop bed" was located. Each of the east and west strata of the Tarwhine Bed could be considered a "viable scallop bed" under the Harvest Strategy with each "containing at least 1500 tonnes biomass (assuming 33% dredge efficiency) of high-density scallops above the minimum legal size". Whether the current densities of scallops on the Tarwhine bed (which have dropped to 69.3 and 41.1 kg/1000m^2 for Tarwhine East and West respectively), classify as "high-density" is worth careful consideration. There is high density of scallops on Clonmel (125.7 kg/1000m^2) but the legal-sized biomass, at 264 t, is well below the 1500 t minimum that defines a "viable scallop bed".

Overall, based on the survey of currently known scallop beds, there has been a marked drop in the biomass available to the Victorian (Ocean) Scallop fishery compared to last year and no signs of new recruitment or developing beds elsewhere in the fishery. Despite a closure that protected more than half of the only known commercially viable bed—Tarwhine, the biomass on both the open and closed areas halved during the 2022/23 fishing season, despite very low levels of fishing. We recommend that highly precautionary management is essential until more widespread evidence of recovery across the spatial extent of the Victorian fishery is observed.

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Appendix 1 – Valid survey tow

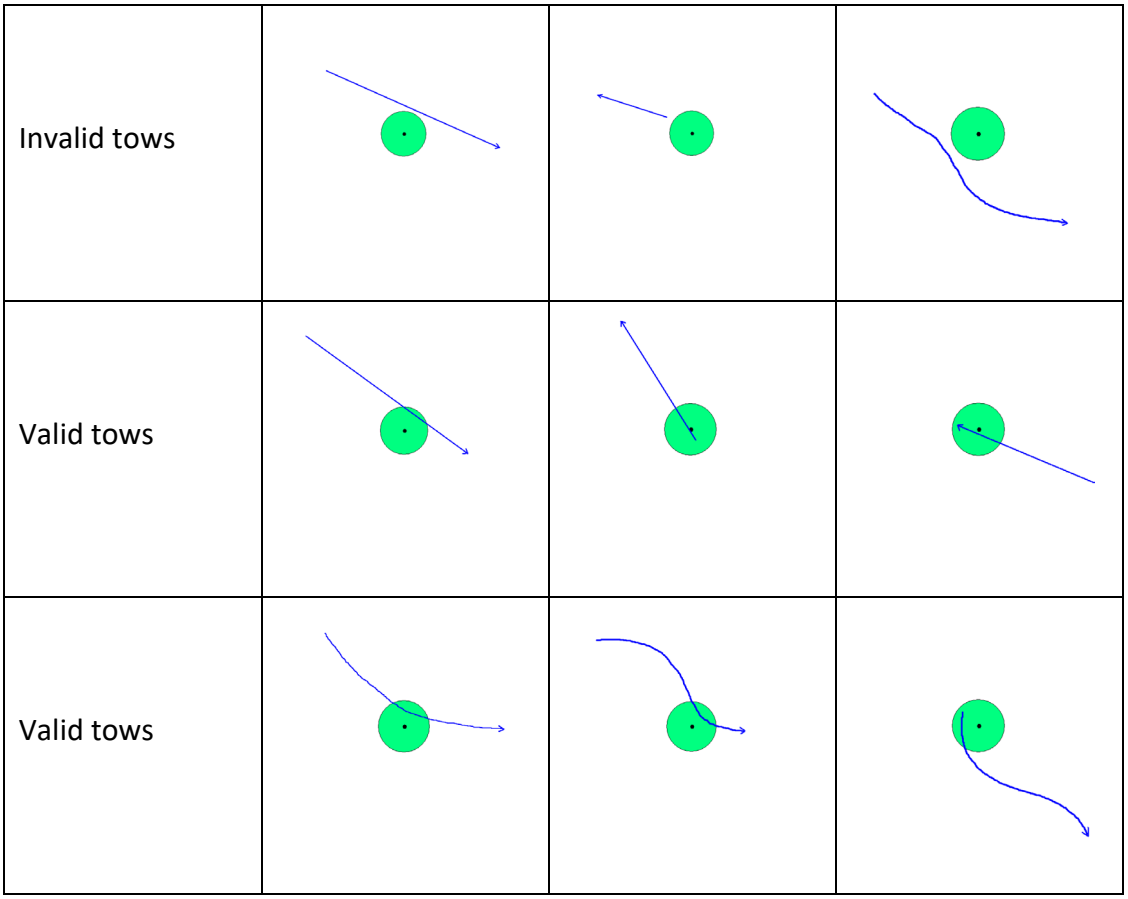
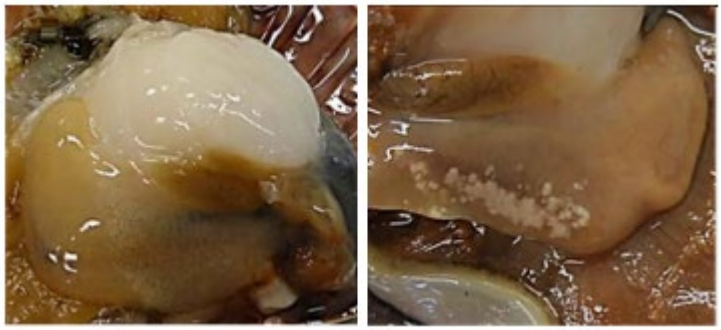


Figure 11. How to conduct a valid survey tow. Green circle is 100 m radius.

Appendix 2 – Gonad staging

Table 8. Gonad maturation scheme for macroscopic field staging of scallops (modified from Semmens et al., 2019).[1]

Stages	Description
1 Developing or spent	Gonad is small, thin, translucent, brownish colour. Intestinal loop usually visible. Ovarian and testicular tissues difficult to differentiate. 
2 Maturing or atretic (reabsorbing eggs as spawning is delayed)	Separate acini clearly visible, male (white) and female (orange) part of gonad distinguishable. Gonad increases in turgor (rigidity) and becomes less granular in appearance as acini begin to fill until ovarian tissue appears uniform in colour. 
3 Partially spawned	Gonad reduced in size compared to previous stage. Ovary appears mottled, presumably due to some acini being voided. Intestinal loop usually visible, ovarian tissue uniform in colour, but interspersed with isolated specs of translucent (void) acini. Testicular tissues turn paler in colour. 

[1] Semmens, J.M., Mendo, Jones, Keane, Leon, Ewing, Hartmann., Institute for Marine and Antarctic Studies, 2019. Determining when and where to fish: Linking scallop spawning, settlement, size and condition to collaborative spatial harvest and industry in-season management strategies, University of Tasmania, Hobart, June. CC BY 3.0

Appendix 3 – Shell measurements

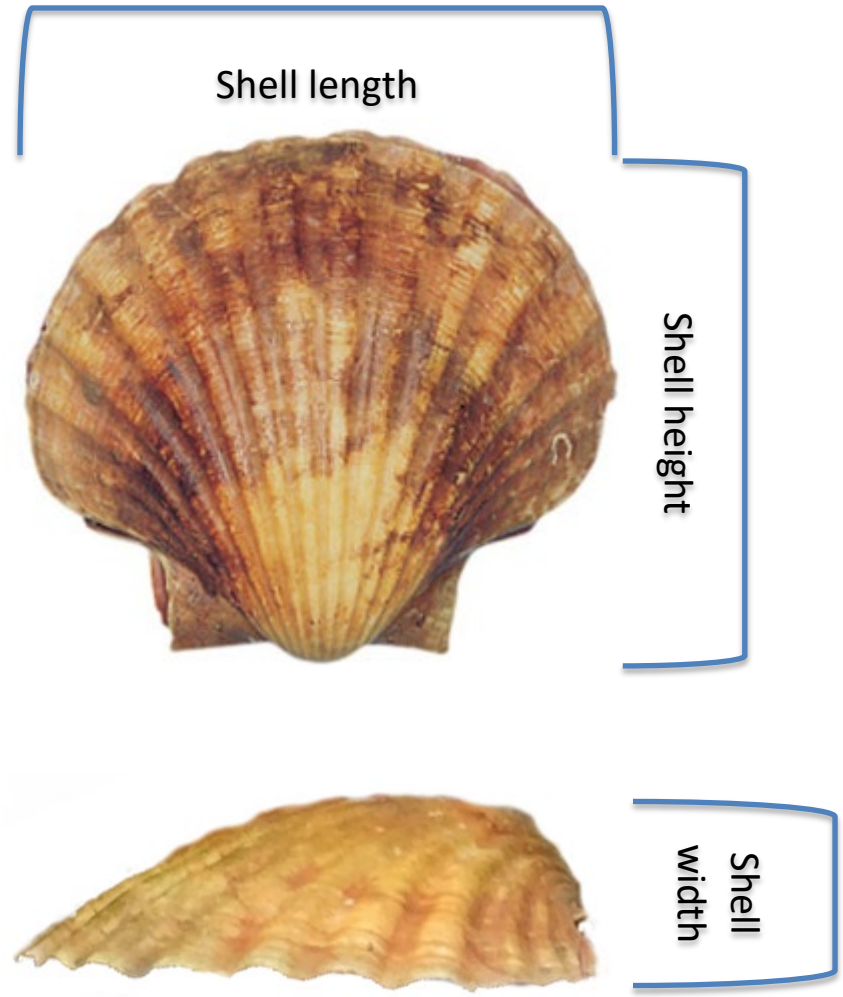


Figure 12. Shell diagram showing measurement of length, height and width used in this report.

Appendix 4 – Catch composition

Table 9. Catch (kg) of each species by stratum. "U" denoted undifferentiated species.

Species / Group	Clonmel	Tarwhine East	Tarwhine West		Total
Commercial Scallop	1004.6	623	247.2		1874.8
New Single	55.5	70	44		169.5
Old Single	97	2460	1520		4077
Clappers	5.3	38	28		71.3
Ascidian (U)	440	19	2		461
Australian Tulip Shell	1.4	13.3	10.5		25.2
Benthos	1275		150		1425
Brittlestars (U)	0.6				0.6
Cockle (U)			0.5		0.5
Common Gurnard Perch			0.5		0.5
Doughboy Scallop	12.8	14.5	9.5		36.8
Eastern Balmain Bug	0.4				0.4
Eleven-Arm Seastar	23				23
Hard Coral		2	4.5		6.5
Hermit Crabs - (U)		7.5	6		13.5
King Island Thickshell-Clam	0.6	0.1	0.5		1.2
Octopus (U)	3.6	1.8			5.4
Oysters	9.5	1	12		22.5
Pen Shell	5.5	7	0.8		13.3
Sea Urchin (U)	0.2	3.2	16.5		19.9
Seastar (U)	9		1		10
Shell	42	530	420		992
Southern Red Scorpionfish	0.1				0.1
Spider Crab (U)	27.7				27.7
Sponge (U)	1235	215	170		1620
Tiger Flathead			1		1
Triggerfish & Leatherjacket (U)	0.2				0.2
Volute (U)	0.4		0.5		0.9
Whelks - (U)	14.3	1.5			15.8
Total	**4263.7**	**4006.9**	**2645**		**10915.6**

Appendix 5 – Survey and exploratory tow details

Table 10. Survey tows for the Clonmel bed

Tow ID	Bed	Priority	Longitude	Latitude
1	Clonmel	Primary	146°49.9970 E	38°50.3401 S
2	Clonmel	Primary	146°48.9041 E	38°50.4307 S
3	Clonmel	Primary	146°48.9748 E	38°49.9908 S
4	Clonmel	Primary	146°49.2868 E	38°50.4858 S
5	Clonmel	Primary	146°49.4513 E	38°50.0446 S
6	Clonmel	Primary	146°48.8519 E	38°50.6615 S
7	Clonmel	Primary	146°48.7612 E	38°50.2014 S
8	Clonmel	Primary	146°49.1062 E	38°50.4727 S
9	Clonmel	Primary	146°49.7069 E	38°49.9347 S
10	Clonmel	Primary	146°49.9097 E	38°50.1629 S
11	Clonmel	Primary	146°49.4752 E	38°50.1817 S
12	Clonmel	Primary	146°49.5134 E	38°50.0276 S
13	Clonmel	Primary	146°49.9983 E	38°50.1527 S
14	Clonmel	Primary	146°48.9297 E	38°50.2381 S
15	Clonmel	Primary	146°49.1612 E	38°50.2074 S
16	Clonmel	Secondary	146°49.3920 E	38°50.4890 S
17	Clonmel	Secondary	146°49.0999 E	38°50.5862 S
18	Clonmel	Secondary	146°48.8227 E	38°50.4357 S
19	Clonmel	Secondary	146°48.9131 E	38°49.9375 S
20	Clonmel	Secondary	146°49.5664 E	38°50.5262 S

Table 11. Survey tows for the Tarwhine beds

Tow ID	Bed	Priority	Longitude	Latitude
1	Tarwhine East	Primary	147°37.0450 W	38°22.7318 S
2	Tarwhine East	Primary	147°31.4201 W	38°27.0744 S
3	Tarwhine East	Primary	147°31.1678 W	38°25.7904 S
4	Tarwhine East	Primary	147°35.2897 W	38°23.3781 S
5	Tarwhine East	Primary	147°31.5366 W	38°24.9796 S
6	Tarwhine East	Primary	147°31.5217 W	38°25.9129 S
7	Tarwhine East	Primary	147°35.0426 W	38°23.6156 S
8	Tarwhine East	Primary	147°30.1991 W	38°27.3722 S
9	Tarwhine East	Primary	147°34.6146 W	38°24.1890 S
10	Tarwhine East	Primary	147°32.7326 W	38°24.3992 S
11	Tarwhine East	Primary	147°30.2136 W	38°25.9704 S
12	Tarwhine East	Primary	147°31.3712 W	38°27.4900 S
13	Tarwhine East	Primary	147°32.2226 W	38°26.4567 S
14	Tarwhine East	Primary	147°31.2291 W	38°27.3211 S
15	Tarwhine East	Primary	147°36.4643 W	38°23.2987 S
16	Tarwhine East	Primary	147°32.4375 W	38°25.8659 S
17	Tarwhine East	Primary	147°33.9566 W	38°24.5072 S
18	Tarwhine East	Primary	147°36.8217 W	38°23.1914 S
19	Tarwhine East	Primary	147°33.9059 W	38°24.4074 S
20	Tarwhine East	Primary	147°33.9806 W	38°25.1116 S
21	Tarwhine East	Secondary	147°30.9329 W	38°25.9335 S
22	Tarwhine East	Secondary	147°31.6592 E	38°26.2909 S
23	Tarwhine East	Secondary	147°35.2244 E	38°23.0643 S
24	Tarwhine East	Secondary	147°30.3453 E	38°28.1045 S
25	Tarwhine East	Secondary	147°35.0193 E	38°23.2442 S
1	Tarwhine West	Primary	147°28.9258 E	38°28.3758 S
2	Tarwhine West	Primary	147°28.8791 E	38°28.1331 S
3	Tarwhine West	Primary	147°25.9122 E	38°28.6577 S
4	Tarwhine West	Primary	147°27.9731 E	38°29.0937 S
5	Tarwhine West	Primary	147°28.8173 E	38°28.0790 S
6	Tarwhine West	Primary	147°27.3258 E	38°27.7873 S
7	Tarwhine West	Primary	147°27.1104 E	38°30.5108 S
8	Tarwhine West	Primary	147°28.1623 E	38°26.5125 S
9	Tarwhine West	Primary	147°28.8576 E	38°28.5882 S
10	Tarwhine West	Primary	147°27.6855 E	38°29.7545 S
11	Tarwhine West	Primary	147°29.8221 E	38°28.5973 S
12	Tarwhine West	Primary	147°26.3608 E	38°29.8397 S
13	Tarwhine West	Primary	147°29.4491 E	38°25.9193 S
14	Tarwhine West	Primary	147°27.9101 E	38°29.2635 S
15	Tarwhine West	Primary	147°28.2764 E	38°28.8635 S
16	Tarwhine West	Primary	147°27.9456 E	38°27.5021 S
17	Tarwhine West	Primary	147°26.7069 E	38°29.2437 S
18	Tarwhine West	Primary	147°29.7322 E	38°27.3026 S
19	Tarwhine West	Primary	147°29.6506 E	38°28.6990 S
20	Tarwhine West	Primary	147°27.2980 E	38°29.9001 S
21	Tarwhine West	Secondary	147°27.6883 E	38°27.0161 S
22	Tarwhine West	Secondary	147°29.8631 E	38°28.2811 S
23	Tarwhine West	Secondary	147°27.6816 E	38°28.0619 S
24	Tarwhine West	Secondary	147°29.3406 E	38°26.9186 S
25	Tarwhine West	Secondary	147°27.1339 E	38°29.6753 S

Table 12. Exploratory tow details.

Tow	Area	Date	Start Time	Start Lat	Start Long	Notes
1	S Clonmel	18/12/2022	6:32:58	-38.8505	146.8042	1 kg scallops
17	90 Mile MNP	18/12/2022	14:08:33	-38.5784	147.2012	0.5 kg scallops
18	90 Mile MNP	18/12/2022	14:32:21	-38.5623	147.2268	0.5 kg scallops
19	90 Mile MNP	18/12/2022	16:13:19	-38.4411	147.3662	0 kg scallops
20	N Tarwhine	18/12/2022	17:29:45	-38.3454	147.473	0 kg scallops, lots of Eleven-armed Sea Stars
21	N Tarwhine	18/12/2022	17:52:13	-38.3265	147.4896	0.5 kg scallops, lots of Eleven-armed Sea Stars
22	N Tarwhine	18/12/2022	18:13:01	-38.3179	147.4656	0 kg scallops
48	N Tarwhine	19/12/2022	15:33:35	-38.3324	147.4606	0 kg scallops
49	N Tarwhine	19/12/2022	15:53:19	-38.3329	147.4218	0 kg scallops
50	N Tarwhine	19/12/2022	16:27:36	-38.2964	147.4408	0 kg scallops
51	N Tarwhine	19/12/2022	16:56:57	-38.294	147.4857	0 kg scallops
52	N Tarwhine	19/12/2022	17:25:13	-38.2905	147.5299	0.3 kg scallops
53	N Tarwhine	19/12/2022	17:49:50	-38.2947	147.563	Some scallops
54	N Tarwhine	19/12/2022	18:10:08	-38.2904	147.5719	0 kg scallops
55	N Tarwhine	20/12/2022	7:15:43	-38.2792	147.5756	Some scallops, lots of Eleven-armed Sea Stars
56	N Tarwhine	20/12/2022	7:34:46	-38.2613	147.5847	0 kg scallops
57	S Lakes	20/12/2022	9:02:43	-38.1538	147.7253	0 kg scallops
58	S Lakes	20/12/2022	9:22:07	-38.1394	147.7419	Some scallops, good quality
59	S Lakes	20/12/2022	9:47:30	-38.1229	147.7494	One scallop
60	S Lakes	20/12/2022	10:09:05	-38.1089	147.7201	Eleven-armed Sea Stars
61	S Lakes	20/12/2022	10:30:28	-38.087	147.699	0 kg scallops, lots of Eleven-armed Sea Stars
62	S Lakes	20/12/2022	11:11:39	-38.0352	147.7334	0 kg scallops, lots of Eleven-armed Sea Stars, Dead shell
63	S Lakes	20/12/2022	11:32:04	-38.0153	147.7599	Dead shell
64	S Lakes	20/12/2022	11:54:36	-38.0109	147.793	Dead shell
65	S Lakes	20/12/2022	12:09:04	-38.0025	147.8056	Dead shell

Table 13. Catch of Commercial Scallop in survey tows, tow details and stratum.

Bed	Tow ID	Start Date	Start Time	Tow duration (mins)	Start latitude	Start longitude	Depth (m)	Tow distance (m)	Area swept (m^2)	Weight (kg)
Clonmel	1	18/12/2022	7:12:06	5.0	-38.839	146.8331	29	442.6783	1682.178	20.8
Clonmel	10	18/12/2022	7:26:31	4.6	-38.8363	146.832	30	387.3063	1471.764	86.4
Clonmel	9	18/12/2022	7:36:59	5.1	-38.8319	146.8278	30	466.6099	1773.118	35
Clonmel	13	18/12/2022	7:49:21	4.3	-38.8360	146.8336	29	342.0659	1299.85	111.2
Clonmel	12	18/12/2022	8:04:23	4.4	-38.8336	146.8241	30	361.7467	1374.637	49.2
Clonmel	5	18/12/2022	8:26:48	4.8	-38.8339	146.823	30	433.9812	1649.128	89.2
Clonmel	15	18/12/2022	8:46:21	5.1	-38.8366	146.8193	29	507.1992	1927.357	62.4
Clonmel	11	18/12/2022	9:01:39	4.7	-38.8364	146.8231	29	416.2518	1581.757	97.2
Clonmel	3	18/12/2022	9:19:48	5.0	-38.8333	146.8162	26	493.4644	1875.165	23.6
Clonmel	7	18/12/2022	9:38:38	4.4	-38.8367	146.8121	28	446.103	1695.191	76.4
Clonmel	14	18/12/2022	9:52:19	5.0	-38.8374	146.8152	28	455.8835	1732.357	73.6
Clonmel	2	18/12/2022	10:08:37	4.5	-38.8391	146.8148	30	448.8181	1705.509	98.4
Clonmel	6	18/12/2022	10:25:23	4.8	-38.8447	146.8136	30	483.5960	1837.665	34
Clonmel	8	18/12/2022	10:40:18	4.8	-38.8413	146.8183	31	475.7377	1807.803	70
Clonmel	4	18/12/2022	10:55:55	4.4	-38.8416	146.8215	28	431.9628	1641.459	77.2
Tarwhine West	5	19/12/2022	7:38:40	5.3	-38.4639	147.4867	41	569.7663	2165.112	51.2
Tarwhine West	2	19/12/2022	8:00:34	4.5	-38.4698	147.4802	40	378.2996	1437.539	60
Tarwhine West	1	19/12/2022	8:17:15	5.0	-38.4734	147.4818	41	469.3938	1783.697	15.2
Tarwhine West	9	19/12/2022	8:31:53	4.5	-38.4751	147.4822	42	506.6251	1925.175	16.4
Tarwhine West	4	19/12/2022	8:44:39	6.0	-38.4847	147.4666	41	632.7359	2404.396	20.4
Tarwhine West	10	19/12/2022	8:55:09	5.1	-38.4948	147.4612	42	506.0560	1923.013	36.4
Tarwhine West	7	19/12/2022	9:06:29	4.2	-38.5078	147.4526	42	426.1664	1619.432	4.8
Tarwhine West	3	19/12/2022	9:34:39	4.2	-38.4778	147.4323	40	357.8629	1359.879	10.4
Tarwhine West	6	19/12/2022	9:52:51	6.0	-38.4635	147.4547	40	557.5363	2118.638	32.4
Tarwhine West	8	19/12/2022	10:09:46	4.1	-38.4421	147.4692	38	410.5814	1560.209	0
Tarwhine East	8	19/12/2022	10:32:54	4.3	-38.4565	147.5031	42	406.0628	1543.039	54
Tarwhine East	2	19/12/2022	10:47:56	5.1	-38.4518	147.5233	42	480.4212	1825.6	168
Tarwhine East	6	19/12/2022	11:06:02	5.8	-38.4325	147.5255	42	550.0979	2090.372	40
Tarwhine East	3	19/12/2022	11:16:00	5.6	-38.4297	147.5202	42	524.0999	1991.58	39.6
Tarwhine East	11	19/12/2022	11:29:10	5.7	-38.4325	147.5023	40	529.3633	2011.581	48.8
Tarwhine East	14	19/12/2022	11:50:23	4.7	-38.4559	147.5205	41	508.4930	1932.273	76.8
Tarwhine East	12	19/12/2022	12:04:18	5.1	-38.4591	147.523	43	482.2153	1832.418	50.4
Tarwhine East	5	19/12/2022	12:19:11	4.9	-38.4438	147.5367	41	496.6815	1887.39	102
Tarwhine East	9	19/12/2022	12:47:25	5.3	-38.4148	147.5241	42	559.7701	2127.126	0.2
Tarwhine East	10	19/12/2022	13:06:58	4.2	-38.4059	147.5447	44	439.6014	1670.485	0
Tarwhine East	11	19/12/2022	13:24:08	5.2	-38.4027	147.5767	44	485.5850	1845.223	0
Tarwhine East	7	19/12/2022	13:40:48	5.3	-38.3930	147.5838	44	484.9507	1842.813	0
Tarwhine East	4	19/12/2022	13:53:10	5.0	-38.3892	147.5881	43	454.4038	1726.734	0
Tarwhine East	15	19/12/2022	14:05:39	4.9	-38.3889	147.6054	45	455.2833	1730.077	24
Tarwhine East	1	19/12/2022	14:17:54	4.2	-38.3804	147.6157	45	287.6141	1092.933	19.2