



Australian Government

Australian Fisheries Management Authority

Bass Strait Central Zone Scallop Fishery — 2023 Survey

AFMA Project 2021-0802

June 2023

Matt Koopman and Ian Knuckey



Vessel	Head	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th
Scallop composition																					
Date	Day	Month	Year	Total catch	Number of scallops	Weight (kg)	Mean length (mm)	Standard deviation	Minimum length (mm)	Maximum length (mm)	Number of scallops < 100mm	Number of scallops > 100mm	Number of scallops > 150mm	Number of scallops > 200mm	Number of scallops > 250mm	Number of scallops > 300mm	Number of scallops > 350mm	Number of scallops > 400mm	Number of scallops > 450mm	Number of scallops > 500mm	Number of scallops > 550mm

Scallop	Date	Time	Sample #	Length mm	Length mm
First					
Last					

Sample weight measured (kg)
10 scallops retained for biologicals

Contents

About this document	3
Executive Summary	4
List of Tables	5
List of Figures	5
Acknowledgements	7
1 Introduction	8
1.1 Objectives	9
2 Methods	9
2.1 Survey History	9
2.2 Survey Design	15
3 Results	17
3.1 Survey order	17
3.2 Biomass, size and potential commercial catch rates	17
3.3 Biologicals	18
3.4 Bycatch	18
4 Discussion	31
5 References	32
6 Appendix 1 – Methods	33
6.1 Gonad Staging	33
6.2 Shell measurements	34
7 Appendix 2 - Time series data	35
8 Appendix 3 - 2023 Survey bed vertices	39

About this document

© 2023 Fishwell Consulting.

All rights reserved.

ISBN

Title: Bass Strait and Central Zone Scallop Fishery - 2023 Survey

AFMA Project 2021-0802

2023

Ownership of Intellectual Property Rights

Unless otherwise noted, copyright (and any other intellectual property rights, if any) in this publication is owned by the Fishwell Consulting and the Australian Fisheries Management Authority.

This publication (and any information sourced from it) should be attributed to:

Koopman, M., and Knuckey, I. (2023). Bass Strait and Central Zone Scallop Fishery - 2023 Survey. AFMA Project 2021-0802. Fishwell Consulting. 39 pp.

Creative Commons Licence

All material in this publication is licensed under a Creative Commons Attribution 3.0 Australia Licence, save for content supplied by third parties, logos and the Commonwealth Coat of Arms.



Creative Commons Attribution 3.0 Australia Licence is a standard form licence agreement that allows you to copy, distribute, transmit and adapt this publication provided you attribute the work. A summary of the licence terms is available from creativecommons.org/licenses/by/3.0/au/deed.en. The full licence terms are available from

creativecommons.org/licenses/by/3.0/au/legalcode.

Inquiries regarding the licence and any use of this document should be sent to: ian@fishwell.com.au

Cover photo: Jess Kube

Disclaimer

The authors do not warrant that the information in this document is free from errors or omissions. The authors do not accept any form of liability, be it contractual, tortious, or otherwise, for the contents of this document or for any consequences arising from its use or any reliance placed upon it. The information, opinions and advice contained in this document may not relate, or be relevant, to a reader's particular circumstances. Opinions expressed by the authors are the individual opinions expressed by those persons and are not necessarily those of the publisher, research provider or the AFMA.

Researcher Contact Details

Name: Ian Knuckey
Address: Fishwell Consulting
27A Hesse St Queenscliff, VIC 3225
Phone: +61 3 5258 4399
Web: www.fishwell.com.au



Executive Summary

At the start of each Bass Strait and Central Zone Scallop Fishery (BSCZSF) fishing season, the Australian Fisheries Management Authority (AFMA) provides a 150 t research catch allowance to enable fishers to search for commercially viable scallop (*Pecten fumatus*) beds. Industry members must then undertake research surveys to determine if the fishery can remain open under a Tier 1 (catches \leq 2,000 t) or Tier 2 (catches $>$ 2,000 t) management arrangement. Research surveys must carry an independent observer or electronic monitoring that is able to verify catch quantity, shell size and any other scientific data required to determine biomass estimates. This report provides the results of the 2023 research surveys.

Five commercial fishing vessels were selected by an independent panel to conduct the 2023 scallop surveys: the *Shandara*, *Northern Star*, *Rachel Maree*, *Odette C* and the *Dell Richey II*. During May/June 2023, stratified random surveys were conducted using these vessels on six beds in the Flinders Island (FI) region (including the new bed: FI – The Sisters East), five beds in the King Island (KI) region including two new beds (Three Hummocks East and Three Hummocks West), and one bed in the Apollo Bay (AB) region. Choice and prioritisation of these beds was based on previous surveys, commercial catches from 2022, and input from the Scallop Resource Assessment Group (ScallopRAG) and the Industry Co-Management Committee. Conduct of surveys was frustrated by lengthy periods of very poor weather. Biomass estimates were calculated for each bed using area swept calculated from the straight-line distance between the start and end tow points and the measured internal width of dredges. Based on previous experimental work, an assumption of 30% dredge efficiency was used for the biomass estimates.

Biomass of Commercial Scallops \geq 85 mm length (the commercial minimum legal size) was estimated to be 1,861 t at the AB bed, 42,256 t combined at the five KI beds and 4,927 t combined at the six FI beds. Total biomass greater than 85 mm at all sites combined was 49,044 t. The percent of Commercial Scallops greater than 85 mm was more than 80% at only one of the KI and AB beds (KI – 10), while it was greater than 80% at all FI beds except for FI (76.2%). Densities in individuals per m^2 ranged 0.02 at FI - South - North of Babel to 2.86 at KI - Three Hummock East.

Catch composition varied greatly between beds. Overall, live Commercial Scallops comprised 24% of the catch, while Brocken Shell (17%), Old Single Shell (29%), and New Single Shell (13%) comprised the largest other components of the catch. The other 17% of the catch comprised a total of 63 different bycatch species / groups with significant amounts of sponges and ascidians. Several high-risk species were recorded. One Southern Blue-Ringed Octopus was recorded from a tow at each at FI – The Wreck B. Black and White Seastars were recorded from FI – The Wreck B and FI – South – North of Babel. King Island Thickshell-Clams were caught at KI – BDSE, KI – 10, KI – 9, FI – South – North of Babel, FI – The Wreck B and AB – The Hill North. A number of gastropod mollusc species were present in catches, but given the large number of species within each family, and the lack of time available to observers, these were generally only identified to the family or genus level and included Volutidae, Cassidae, Cypraeidae, Buccinidae and Fascioliidae. Pebble crabs were caught at KI – 10.

These results were presented at the ScallopRAG meeting on 7 June 2023 and at the Scallop Management Advisory Committee (ScallopMAC) meeting on 8 June 2023.

List of Tables

Table 1. Description of beds surveyed since 2015 and beds new to 2023. See Figure 1, Figure 2 and Figure 3 for maps of beds.	12
Table 2. Names, nicknames (used in this report) surveyed in 2023 and area of polygons (km ²).	19
Table 3. Total commercial catch (t) and the number of vessels that fished within each 2023 survey bed during the 2022 fishing season based on logbook data. Records coloured red are confidential – they were used in the analyses but removed for final report. *Note: While 9 different vessels fished outside of the 2022 beds, the catch can not be reported because it allow the catch from FI – The Wreck A and FI – The Wreck to be derived from the total catch.....	19
Table 4. Biomass estimates, 95% confidence intervals and number of tows included in analyses. Note that both densities have been adjusted for a 33% assumed dredge efficiency.	21
Table 5. Percent weight of scallops > 85 mm (catch weighted by weight), and biomass estimates 95% confidence intervals for scallops greater than 85 mm.	22
Table 6. Number of length measurements (N), median, mean and standard error (SE) of scallops measured, and % of scallops measured (catch weighted by weight) less than and greater than 85 mm and mean number of meats per kg of scallops greater than 85 mm from each bed.	22
Table 7. Number of scallops retained for biological sampling, and parameter estimates for length weight relationships.	23
Table 8. Catch of each species in each bed. (u) refers to undifferentiated species recorded at a higher taxonomic level.	23
Table 9. Summary of biomass, density and size data.....	31
Table 10. Gonad maturation scheme for macroscopic field staging of scallops (modified from Semmens <i>et al.</i> , 2019).....	33

List of Figures

Figure 1. History of beds surveyed off Flinders Island from 2015 to 2022.	10
Figure 2. History of beds surveyed off King Island from 2015 to 2022.	10
Figure 3 History of beds surveyed off Apollo Bay and King Island from 2015 to 2022.	11
Figure 4. New beds surveyed in 2023 off King Island (Three Hummocks West and Three Hummocks East) in relation to historical beds. One metre incremental bathymetry is show in orange.	14
Figure 5. New beds surveyed in 2023 off Flinders Island – The Sisters East (with survey sites indicated) and Flinders Island – North – The Sisters (grey polygon). The FI historical survey bed is also shown. The black polygon in the north shows a bed that was proposed during the survey design based on incorrect logbook data that was subsequently moved to create the Flinders Island – The Sisters East bed	14
Figure 6. Family and genus of gastropod molluscs found in catches during the survey.	25

Figure 6. Scallop density (kg / 1000 m²) within the AB – The Hill. The top right scale bubbles reflect the estimated scallop density of each tow assuming a dredge efficiency of 33%. Red circles denote zero catches. ... 26

Figure 7. Scallop density (kg / 1000 m²) within the KI – BDSE, KI – 10, KI – 9 beds, KI – Three Hummocks East and KI – Three Hummocks West. The scale bubbles on the right reflect the estimated scallop density of each tow assuming a dredge efficiency of 33%. Red circles denote zero catches..... 26

Figure 8. Scallop density (kg / 1000 m²) within the FI – The Wreck A, FI – The Wreck B, FI – South – North of Babel, FI – North – The Sisters, FI – The Sisters East and FI beds near Flinders Island. The scale bubbles on the right reflect the estimated scallop density of each tow assuming a dredge efficiency of 33%. Red circles denote zero catches..... 27

Figure 9. Log transformed A) length and weight, B) length and height, C) length and width and D) height and width from each area bed..... 28

Figure 10. Catch weighted size frequency from tows included in biomass estimates from each bed. The vertical line is at 85 mm..... 28

Figure 11. Frequency of combined meat and gonad weights of scallops >85 mm measured from each bed binned into 2 g weight categories. 29

Figure 12. Percent of scallops at each stage from each bed based on macroscopic staging criteria shown in Table 10. 29

Figure 13. Percent catch composition by weight from all beds. 30

Figure 14. Percent composition of clappers, live scallop, new single and old single shell from each Bed. 30

Figure 15. Scallop width, length and height to be measured..... 34

Figure 16. Time series of biomass estimate, size frequency and percent of scallop (live/shell type) at the FI – The Wreck A bed. 35

Figure 17. Time series of biomass estimate, size frequency and percent of scallop (live/shell type) at the FI – The Wreck B bed. 35

Figure 18. Time series of biomass estimate, size frequency and percent of scallop (live/shell type) at the FI – South – North of Babel bed..... 36

Figure 19. Time series of biomass estimate, size frequency and percent of scallop (live/shell type) at the FI bed. 36

Figure 20. Time series of biomass estimate, size frequency and percent of scallop (live/shell type) at the KI – BDSE. 37

Figure 21. Time series of biomass estimate, size frequency and percent of scallop (live/shell type) at the KI – 10 bed..... 37

Figure 22. Time series of biomass estimate, size frequency and percent of scallop (live/shell type) at the KI – 9 bed..... 38

Figure 23. Time series of biomass estimate, size frequency and percent of scallop (live/shell type) at the AB – The Hill bed..... 38

Acknowledgements

We would like to thank Glen Wisby and the crew of the *Odetta C*, John and Johnno Hammond and crew of the *Shandara*, John, Graham and Dusty Cull and crew of the *Rachel Maree*, Andy and Jake Watts and the crew of the *Northern Star*, John and Stuart Richey and the crew of the *Dell-Richey II* for all of their assistance and hard work in undertaking the 2023 survey. Dusty Cull and Jake Watts provided valuable information used to define the new Flinders Island beds, while John and Stuart Richey provided information to inform the boundaries of the Three Hummocks beds. The observers Russell Hudson, Graeme Ewing and Ian Knuckey worked very hard to collect all data required to a high-quality standard. Daniel Corrie (AFMA), provided the logbook data used to guide the survey design. Steve Hall (AFMA), together with ScallopRAG, ScallopMAC and the BSCZSF Co-Management Committee provided valuable input into the survey logistics and design.

1 Introduction

The main target species in the Bass Strait Central Zone Scallop Fishery (BSCZSF) 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). The species is 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 must adapt to short-term changes in distribution and abundance of scallops, yet still ensure protection of the resource in line with the *Commonwealth Fisheries Harvest Strategy Policy 2018* (HSP).

Under the original HSP, the initial harvest strategy for the BSCZSF was developed during 2007. It was revised during the 2012 season and in response to industry concerns about the cost-effectiveness and flexibility, was further reviewed during 2014. The BSCZSF Harvest Strategy (the Harvest Strategy) has two primary objectives. To:

1. keep stocks within the BSCZSF at ecologically sustainable levels and, within that context, maximise the economic returns to the Australian community; and,
2. pursue efficient and cost-effective management in attaining (1) above.

The Harvest Strategy uses a tiered approach designed to apply different levels of management and research input depending on the state of the resource. Underpinning the tiered approach is the need to balance the risk of over exploitation with obtaining initial knowledge on the status of the stock at the commencement of the season through pre-season surveys.

At the start of each fishing season, the Australian Fisheries Management Authority (AFMA) provides a 150 t research catch allowance to enable fishers to search for commercially-viable scallop beds, defined as “...an area or scallop bed containing no greater than 20 per cent of scallops of a size less than 85 mm”. To increase the catch allowance above 150 t, industry members must undertake research surveys to determine if the fishery can remain open under Tier 1 or Tier 2 level management arrangements (as defined below).

- **Tier 1 management arrangements** require initial closure of an area/s (not more than 2 scallop beds) that contain a total biomass of $\geq 1,500$ tonnes of high-density scallops of a minimum size of 85 mm. The season begins with a 1,000 t total allowable catch (TAC) that can be increased to 2,000 t if good catches are achieved.
- **Tier 2 management arrangements** require initial closure of an area/s (not more than 2 scallop beds) that contain a total biomass of $\geq 3,000$ tonnes of high-density scallops of a minimum size limit of 85 mm. The season begins with a 2,000 t TAC that can be increased if good catches are achieved.

Research surveys must carry an independent observer or electronic monitoring that is able to verify catch quantity, shell size and any other scientific data required to determine biomass estimates. This report provides the results of the 2023 stratified random surveys.

1.1 Objectives

1. Estimate the scallop biomass and potential commercial catch rates in three different areas of the BSCZSF.
2. Measure the size frequency distribution of scallops in each area to calculate discard rates.
3. Report results to AFMA, the Scallop Resource Assessment Group (ScallopRAG) and the Scallop Management Advisory Committee (ScallopMAC).

2 Methods

2.1 Survey History

The 2015 survey covered three beds in the King Island (KI) region and one bed in the Flinders Island (FI) region (Figure 1, Figure 2, Figure 3, Table 1). To provide greater flexibility in management arrangements regarding closures, the pre-season survey was expanded in 2016 with the addition of an extra four beds in the KI region and another bed in the FI region. In addition to the extra sites, the boundaries of some of the 2015 beds were modified (for example northern and southern boundaries of the bed known as KI-Main in Knuckey *et al.* (2015) were brought in slightly, and the eastern and western boundaries moved east slightly to form a bed titled KI-2 in Knuckey *et al.* (2016). The beds surveyed during 2017 were based on advice from the Scallop Research Workshop and input from ScallopRAG and the BSCZSF Co-Management Committee. They comprised previously surveyed beds, modified beds and new exploratory beds. In 2018 two beds were added off King Island, while Apollo Bay (AB) – 3, AB – 4, FI – 3 and FI – 4 were not surveyed. In 2019 as well as the FI bed, AB 1 and 2 were surveyed, and two new beds (one stretching south-east of KI Bluedot Extended (BDE) and another called the KI – JH bed comprising high density of juvenile scallops) were added. To protect the juveniles at KI – JH, sampling intensity was reduced, and a fine mesh cover was placed over half of the dredge to better sample small scallops. No survey was undertaken in 2020 because of concerns regarding the Covid-19 outbreak. Twelve beds were surveyed in 2021 when the FI – North - The Sisters and FI – North of Babel (NB) beds were added in the FI region, the KI – JH site was extended to the southeast, AB – 2 was extended to the north and AB – The Hill and AB – Five Hours sites were added in the AB region.

Significant catches were taken from an area to the north-west of the FI South – North of Babel site during 2021. Accordingly, new beds were surveyed in 2022 (FI – Wreck A together with FI – The Wreck B) reflect that catch.

New beds introduced in 2023 included: KI – Three Hummocks East, KI – Three Hummocks West and FI – The Sisters East. The Three Hummocks beds were based on results of an FRDC funded industry survey in December 2021 that showed high densities of undersized scallops. Similarly, VMS data showed high fishing effort in a new bed east of the Sisters and so a new bed (FI – The Sisters East) was surveyed there in 2023.

More generally, the beds surveyed in 2023 were based on previous surveys, analysis of 2022 catch and effort data and advice from the ScallopRAG and the BSCZSF Co-Management Committee.

Changes to the beds surveyed since 2015 are outlined in Table 1.

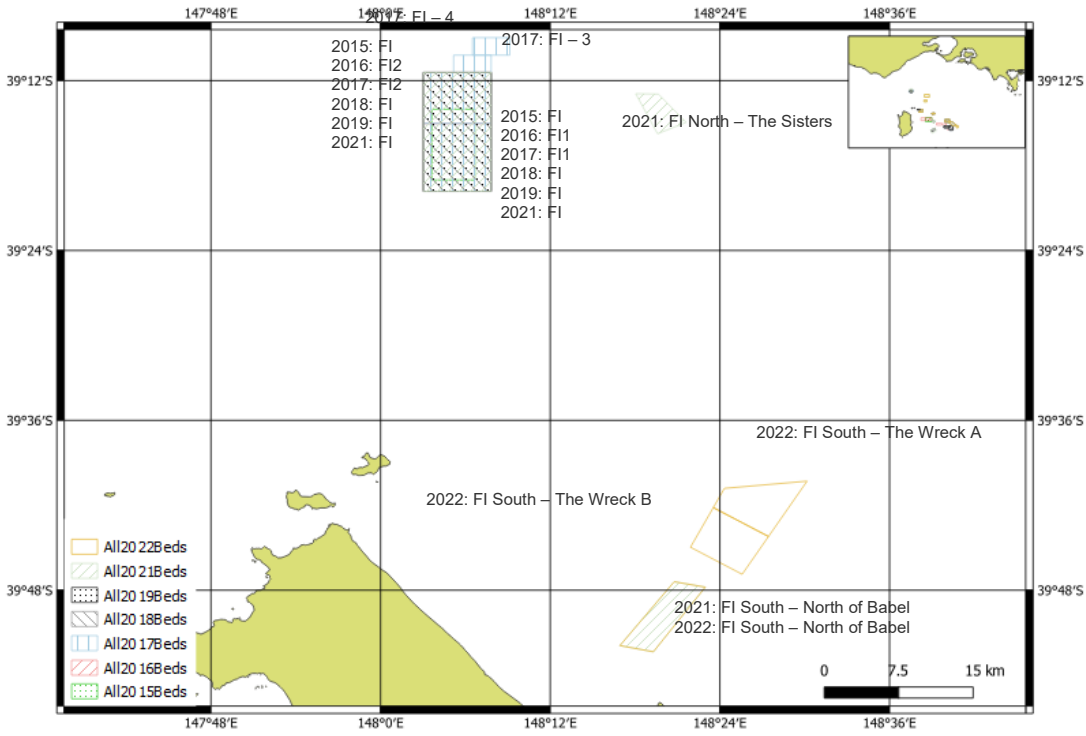


Figure 1. History of beds surveyed off Flinders Island from 2015 to 2022.

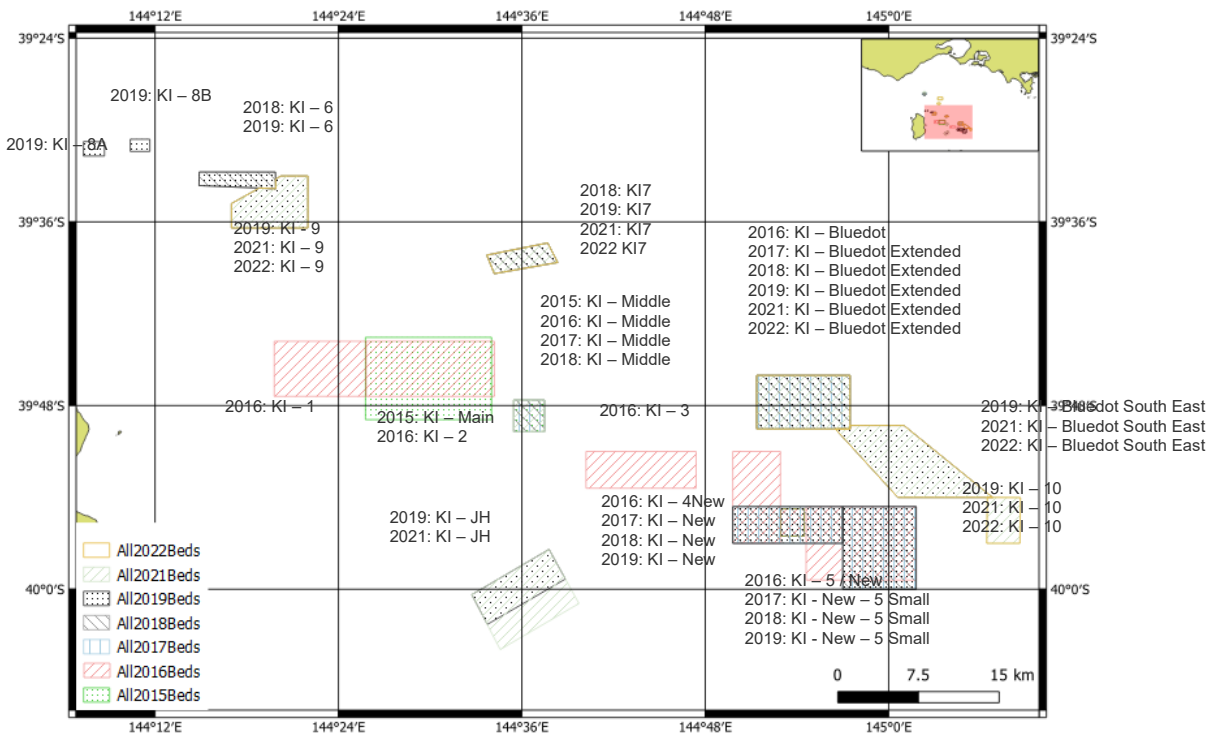


Figure 2. History of beds surveyed off King Island from 2015 to 2022.

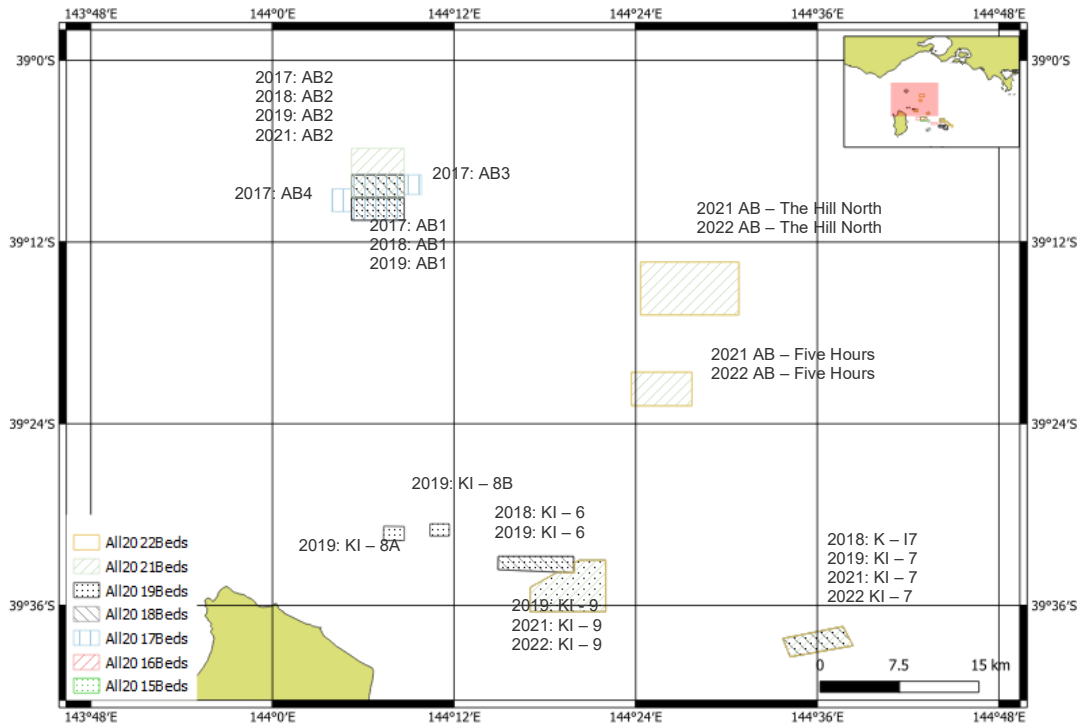


Figure 3 History of beds surveyed off Apollo Bay and King Island from 2015 to 2022.

For the 2023 survey, ScallopRAG recommended including the following beds:

1. King Island– Three hummocks (west)
2. King Island– Three hummocks (east)
3. King Island Blue Dot South East
4. King Island 10
5. King Island 9
6. Apollo Bay– The Hill North
7. Flinders Island – FI
8. Flinders Island South – North of Babel
9. Flinders Island – The Wreck A
10. Flinders Island – The Wreck B
11. Flinders Island – The Sisters East
12. Flinders Island – North – The Sisters

New beds surveyed off King Island (Three Hummocks East and Three Hummocks West) and Flinders Island (the Sisters East) in 2023 are highlighted in Table 1 and shown in Figure 4 and Figure 5. Surveyed beds and their size are shown in Table 2.

Table 1. Description of beds surveyed since 2015 and beds new to 2023. See Figure 1, Figure 2 and Figure 3 for maps of beds.

Name	Description
KI – 5S	Originally a larger area that was surveyed in 2016, KI – 5S was formed by extending the eastern boundary of KI-New south to -40°S, and including the area of KI – 5 to the east of that. This bed remained unchanged from the 2017 to 2019 when it was last surveyed.
KI – New	KI-New was a bed that was defined for management proposes (it formed the initial closure) after the 2016 survey, covering at least parts of three different beds surveyed in 2016. It comprised parts of a bed called KIEast which was surveyed during 2015, and again in 2016, along with two new adjacent beds, KI – 4 and KI – 5. KI – New remained unchanged from the 2017 to 2019 when it was last surveyed.
KI – BDE	During the TAC setting by the MAC for the 2016 season, industry provided information regarding a dense bed of small scallops that would be more suitable for closure than the KI – New bed. This bed titled King Island Blue Dot was mapped out and then surveyed during August of 2016. The area was expanded north and west to form an area closure that replaced the closure of KI – New. The boundaries of this expanded area are shown in Figure 2. This bed remained unchanged from the 2017 to 2022 surveys.
AB – 1 and AB – 2	Seven exploratory marks in the KI region were provided by industry in 2017 to be explored and considered for additional survey beds. Only one of those showed enough promise to survey, and the skippers mapped out area, splitting it into two beds. Two additional smaller beds were added to each of the western and eastern boundaries, however these contained low densities of scallops and were dropped from the 2018 and future surveys. The AB-1 and AB – 2 bed boundaries remained unchanged during the 2018 and 2019 surveys. For the 2021 survey, only AB – 2 was surveyed, and the northern boundary was moved north to cover relatively high levels of commercial effort in that area. Neither were surveyed in 2022
KI – 6	Examination of 2018 commercial catch and effort data revealed significant catches in a large area at approximately longitude 144° 17', latitude 39° 32'. The vessels mapped out this area to provide a smaller area with high density scallops with the boundaries shown in Figure 2. The bed boundaries remained unchanged from the 2018 survey, was resurveyed in 2019, but dropped for the 2021 survey.
KI – 7	Examination of 2018 commercial catch and effort data revealed significant catches in a large area at approximately longitude 144° 36', latitude 39° 38'. The vessels mapped out this area to provide a smaller area with high density scallops with the boundaries shown in Figure 2. The bed boundaries remained unchanged from the 2018 survey, was resurveyed in 2019 and was surveyed in 2021 as a replacement for KI – Mid (in accordance with ScallopRAG recommendations
FI	FI-1 was called the “Flinders Island” bed during the 2015 survey. For the 2016 and 2017 surveys, the area was expanded and spilt into the two beds (FI – 1 and FI – 2). Two additional smaller beds were added to the northern boundary of FI-2 in 2017, however because of low densities, these were dropped for the 2018 survey. For the 2018 survey, FI – 1 and FI – 2 were combined into a single large bed (Figure 1). The bed boundaries remained unchanged from the 2018 survey and was resurveyed in 2019, 2021 and 2023, but not in 2022.
KI – 8a and KI – 8b	Examination of 2019 commercial catch and effort data revealed significant catches in a large area at approximately longitude 144° 10', latitude 39° 31'. Within the general area of this effort, there were three main patches of densely populated scallop beds separated by areas of low density and an underwater cable. The two largest of these small areas were selected to survey in that year. They were not surveyed in 2021 or 2022.
KI – 9	Examination of 2019 commercial catch and effort data revealed significant catches in a large area at approximately longitude 144° 21', latitude 39° 35'. The final boundaries were set based

Name	Description
	on a combination of fishing effort by the survey vessel in the previous year and exploratory fishing. This bed was resurveyed in 2021 and 2022.
KI – JH	An industry member provided two marks that bound a line of exploratory tows that contained relatively high densities of juvenile scallops (~50 mm). Being the most recent sign of significant recruitment there was interest in tracking the growth of this bed, however there was some sensitivity around the potential to disturb the bed by surveying it. As a compromise, a relatively small survey area was set with only 20 sampling sites. Based on advice from industry, the bed was extended to the south-east for the 2021 survey. This bed was not surveyed in 2022
KI – BDSE	Examination of 2019 commercial catch and effort data revealed significant catches in a large area at approximately longitude 145° 00, latitude 39° 49. The final boundaries were set based on a combination of fishing effort by the survey vessel in the previous year and exploratory fishing. This bed was resurveyed in 2021 and 2022.
KI – Mid	This bed remained unchanged from 2015, 2016, 2017 and 2018. In accordance with RAG recommendations, five exploratory tows were conducted at this bed during 2021 revealing low densities (no scallops were caught), and so KI – 7 was surveyed instead. This bed was not surveyed in 2022
KI – 10	Significant catches were taken from an area to the south-east of the KI-BDSE site during 2020. KI – 10 is that surrounds that catch and was surveyed in 2021 and 2022.
AB – The Hill North	Industry members provided marks about 17 nm to the south-east of Apollo 2 where significant amounts of scallops were caught in 2020. Based on commercial effort reported from the area, and notes made on a fishing vessel’s plotter, a bed was defined and surveyed in 2021 and 2022.
AB – Five hours	Industry members provided marks about 19 nm to the south-east of AB – Apollo 2 where significant amounts of scallops were caught in 2020. Based on commercial effort reported from the area, and notes made on a fishing vessel’s plotter, a bed was defined and surveyed in 2021 and 2022.
FI – North - The Sisters	Significant catches were taken from an area about 11 nm to the east of the FI site. Based on commercial effort reported from the area, and notes made on a fishing vessel’s plotter, a bed was defined. This bed was surveyed in 2021, but not in 2022.
FI – South – North of Babel	Significant catches were taken from an area about 31 nm to the south-south-east of the FI site. Based on commercial effort reported from the area, and notes made on a fishing vessel’s plotter, a bed was defined and surveyed in 2021 and 2022.
FI – The Wreck A	Significant catches were taken from an area to the north-west of the FI South – North of Babel site during 2021. FI – The Wreck A was a new bed in 2022 that together with FI – The Wreck B, surrounds that catch.
FI – The Wreck B	Significant catches were taken from an area to the north-west of the FI South – North of Babel site during 2021. FI – The Wreck B was a new bed in 2022 that together with FI – The Wreck A, surrounds that catch.
KI – Three Hummocks West	An industry led survey in December 2021 (as part of a FRDC project) revealed high densities of undersized scallops. The bed was not surveyed in 2022 as many scallops remained undersized.
KI – Three Hummocks East	An industry led survey in December 2021 (as part of a FRDC project) revealed high densities of undersized scallops. The bed was not surveyed in 2022 as many scallops remained undersized. The division between the two beds of the Three Hummocks (Figure 4) reflects a difference in depth (and size composition of scallops).

Name	Description
FI – The Sisters East	For the 2023 survey, the previously agreed FI – North bed was replaced with an eastern extension to FI – North - The Sisters. This new bed is based on VMS data and commercial fisher input (Figure 5).

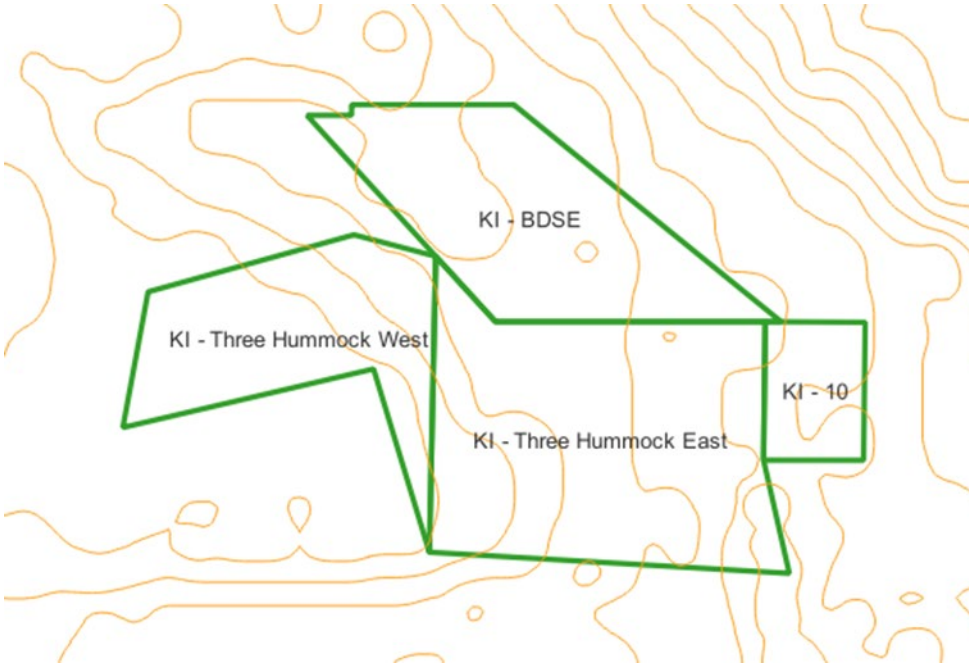


Figure 4. New beds surveyed in 2023 off King Island (Three Hummocks West and Three Hummocks East) in relation to historical beds. One metre incremental bathymetry is show in orange.

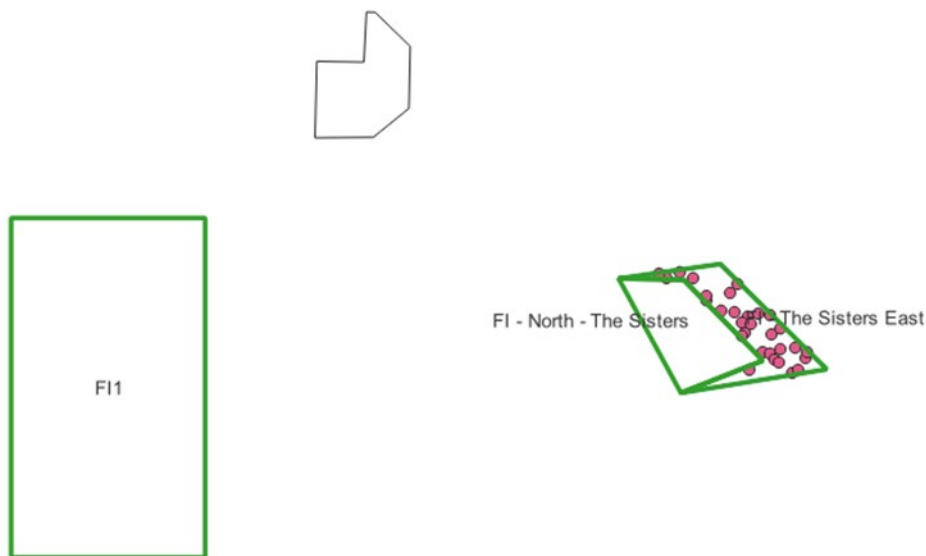


Figure 5. New beds surveyed in 2023 off Flinders Island – The Sisters East (with survey sites indicated) and Flinders Island – North – The Sisters (grey polygon). The FI historical survey bed is also shown. The black polygon in the north shows a bed that was proposed during the survey design based on incorrect logbook data that was subsequently moved to create the Flinders Island – The Sisters East bed

2.2 Survey Design

Survey methods follow those of Knuckey *et al.* (2015, 2016, 2017, 2018) and Koopman *et al.* (2019, 2021, 2022), modified from those described in Harrington *et al.* (2008). Five vessels were selected to undertake the survey. A procedures manual (Fishwell 2023) guided vessel-based conduct of the survey.

The number of survey points allocated to each bed was largely guided by sampling effort during past surveys, with consideration given to the maximum number of tows that can be achieved in a 12-hour sampling block¹. Primary sampling sites within each bed were randomly allocated using the QGIS Random Points in Polygons Tool. Additional survey points were allocated to each bed as “backup sites”, to be used where “primary sites” were unfishable.

During 2023, surveys were conducted onboard the fishing vessels *Rachel Maree* (Scientific Permit# 1005312), *Shandara* (Scientific Permit# 1005313), *Odette C* (Scientific Permit# 1005309), *Dell Richey II* (Scientific Permit# 1005662) and the *Northern Star* (Scientific Permit# 1005308), which were selected by an independent panel. To be considered a valid tow, the vessel must dredge within 100 m of the tow location provided. Lotek LAT1400-64kb temperature-depth loggers were attached to the dredge on some vessels at the start of the first tow for each trip. They were set to record an observation at regular intervals so that multiple records would be obtained for each trip.

2.2.1 Sampling methods

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. The observer measured the length of those scallops using an 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 in based on Semmens, *et al.* (2018) (Table 10). 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 (Fishwell 2023).

2.2.2 Data analysis

All data processing and analysis was undertaken in R (R Core Team, 2023). Estimates of biomass and potential commercial catch rates followed the methods of Semmens and Jones (2014).

¹ For OHS reasons, observers are restricted to a maximum of 12 hours of sampling in a 24-hour period.

2.2.3 Biomass estimates

The internal widths of the dredges used during the survey were measured in accordance with Semmens and Jones (2014). Dredge widths used by the *Shandara*, *Odette C*, *Northern Star*, *Del-Richey II* and *Rachel Maree* were 4.87 m, 3.905 m, 3.583 m, 3.930 m and 3.875 m (Table 2). A dredge efficiency of 33% was assumed.

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.

Scallop catch in each tow ($C^{\text{standardised}}$ in kg/1000 m²) was calculated as follows:

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

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

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

$$B = \text{meanD} * A * 3.03 / 1000$$

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

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

Where meanD is the mean density (kg) of scallops per m² 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 (m²). The area of each bed was calculated using the R package “Simple Features” (Pebesma, 2018).

Biomass and upper and lower 95% confidence intervals (CI) of scallops greater than 85 mm were calculated as follows:

$$B_{>85 \text{ mm}} = B * (1 - \text{discard rate})$$

$$\text{Upper 95\% CI}_{>85 \text{ mm}} = \text{Upper 95\% CI} * (1 - \text{discard rate})$$

$$\text{Lower 95\% CI}_{>85 \text{ mm}} = \text{Lower 95\% CI} * (1 - \text{discard rate})$$

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

$$I = \sum_{len} W L f / S$$

Where W L f is the weighted length frequency for each length class len, and S is the swept area (m²).

All densities (kg / m² and individuals per m²) reported have been adjusted for the 33% assumed dredge efficiency (see Harrington *et al.* (2008) for origin of the 33%).

2.2.4 Biologicals

The length-weight relationship was calculated for each area separately, and the parameters of the relationship are provided in the results. Length-weight relationship was applied to catch-weighted size frequencies to calculate the discard rate at 85 mm. The discard rate was used in calculations of biomass of

scallops greater than 85 mm. Number of meats per kg was calculated separately for each bed by dividing 1000 by the mean meat and gonad weight in grams.

2.2.5 Quality Assurance

The survey was undertaken following Standard Operating Procedures (Fishwell 2023). 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, 2023), and a subset of outputs were reproduced and compared using an alternative software package. Scallops were measured using 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 AFMA managers. Where required, comments were addressed in preparation of the final report.

3 Results

3.1 Survey order

The 2023 BSCZSF survey was undertaken during May and early June of 2023. Commencing May 16, the *Dell Richey II* surveyed the Three Hummock areas off King Island, the *Shandara* surveyed KI – BDSE and KI – 10 commencing May 18. Commencing 1 June, the *Odette C* surveyed the FI – The Wreck A, FI – The Wreck B and FI – South – North of Babel. Commencing 1 June, the *Rachel Maree* surveyed KI – 9 and AB – the Hill. Commencing, 1 June, the *Northern Star* surveyed FI-the sisters (see Table 2 for bed nicknames). The total area of each bed is shown in Table 2.

3.2 Biomass, size and potential commercial catch rates

Mean biomass estimates for AB – The Hill was 2,436 t (95%CI 1,335 t – 3537 t) (Table 4). The percentage of scallops >85mm at each of that bed was 76.4% (Table 5), and consequently the mean biomass of scallops > 85 mm was 1,861 t (Table 5).

Mean biomass estimates for KI – 10, KI – 9, KI-BDSE, KI – Three Hummock East and KI – Three Hummock West were 1,464 t (95%CI 745 t – 2,182 t), 3,293 t (95%CI 2,294 t – 4,293 t) and 1,714 t (95%CI 953 t – 2,474 t) respectively (Table 4). The percentage of scallops >85mm was only greater than 80% at KI – 10 (80.6%) and was low as 43.9% at KI – Three Hummock East (Table 5), and consequently mean biomasses of scallops > 85 mm were much lower than total biomass estimates: 1,180 t, 2,330 t, 950 t, 27,274 t and 10,522 t respectively (Table 5).

Mean biomass estimates for FI – North – The Sisters, FI – South – North of Babel, FI – The Sisters East, FI – The Wreck A, FI – The Wreck B and FI were 880 t (95%CI 585 t – 1,175 t), 122 t (95%CI 22 t – 223 t), 345 t (95%CI 260 t – 430 t), 249 t (95%CI 60 t – 439 t), 284 t (95%CI 127 t – 442 t) and 4,229 (95%CI 1,592 t – 6,866 t) respectively (Table 4). Apart from at FI (76.2%), the percentage of scallops >85 mm were all above

80% (Table 5), resulting in mean biomasses of scallops > 85 mm of 780 t, 107 t, 315 t, 239 t, 262 t and 3,224 t respectively (Table 5).

Low to medium density (kg/1000 m²) tows were also recorded throughout AB – The Hill, with the highest densities in the south (Figure 7). Tows in the northern half of KI – BDSE contained either no scallops or low densities, with medium densities in the south (Figure 8). Densities at KI – 10 were also lowest in the north. Very high densities were recorded throughout KI – Three Hummock East, but decreasing towards the west and into KI – Three Hummock West. KI – 9 had low densities in the north and medium densities in the south. At FI – North of Babel, FI – The Wreck A and FI – The Wreck B low densities were recorded with many zero catches, particularly in the west (Figure 9). Densities at FI – North – The Sisters and FI – The Sisters East were generally lowest in the south-east and increasing to the north-west. Some zero catches were recorded in the south-west. Densities at FI were lowest in the north and south.

Estimated densities in numbers of Commercial Scallops >85 mm ranged 0.02 individuals per m² at FI – South – North of Babel to 2.86 individuals per m² at KI – Three Hummock East (Table 4).

Comparisons of biomass estimates, percent catch composition and size distributions of beds that have been repeatedly surveyed and surveyed in 2023 are shown in Appendix 2. While the sampling methods have been consistent, the areas of the beds have changed considerably. Care should be taken when interpreting those results, and consideration of changes in bed areas over time should be made.

3.3 Biologicals

Mean length of scallops measured ranged 82 mm at KI – Three Hummock East to 101 mm at FI – The Wreck A (Table 6). Length frequency distributions from all sites are shown in Figure 11. Some recruitment was observed at KI – 7 and FI – South – North of Babel. Scallop meats were much smaller at the KI and AB beds compared to FI (Table 6, Figure 12). Overall, most meats were less than 20 g, and meats per kg ranged 61 at FI – The Wreck A to 145 at AB – The Hill North and KI – Three Hummock East. The larger meat weights at the Flinders beds are reflected in the maturity stages (Figure 13, Table 10), with the highest proportion of stage 2 gonads at FI – The Wreck A, FI – The Wreck B and FI – The Sisters East. Stage 3 gonads were only recorded from FI – The Wreck B.

Comparison of length-weight regressions between beds revealed that the interaction term was significant ($p < 0.001$), suggesting that there is a difference in slopes in the length-weight relationship between beds. The p -value for the indicator variable was also significant ($p < 0.001$) suggesting that there is also a difference in intercepts, and it appears that there are differences in length-weight relationships between beds. Similar results ($p < 0.001$ to $p < 0.05$) were obtained when beds were grouped into the areas FI, KI and AB and for most beds within each group and for beds within sub areas (i.e KI – BDSE and KI – 10, the northern FI beds and the southern FI beds) with the exception of the two Three Hummocks beds for which there was no difference ($p > 0.05$).

Separate length-weight relationships were calculated for each bed except for the two Three Hummocks beds which were combined (Table 7). Scatterplots of each combination of size measurements (including total weight) shown in Figure 10.

3.4 Bycatch

A total of 67 different species / groups were identified during the survey (Table 8), and catch composition varied greatly between beds (Figure 14). Overall, live Commercial Scallops comprised 24% of the catch, while Broken Shell (17%), Old Single Shell (29%), and New Single Shell (13%) comprised the largest other components of the catch. Sponge comprised relatively high proportions of the catch at AB – The Hill North and KI – 9, while ascidians and oysters comprised large components of the catch at FI – South – North of

Babel, FI – The Wreck A and FI – The Wreck B. A number of different species of gastropod molluscs were caught but given the large number of species within each family, and the lack of time available to observers, these were generally only identified to the family or genus level and included Volutidae, Cassidae, Cypraeidae, Buccinidae and Fasciolaridae. Examples of some of these specimens are provided at Figure 6.

Several high-risk species were recorded. One Southern Blue-Ringed Octopus was recorded from a tow at FI – The Wreck B. Black and White Seastars were recorded from FI – The Wreck B and FI – South – North of Babel. Suspected King Island Thickshell Clams were caught at KI – BDSE, KI – 10, KI – 9, FI – South – North of Babel, FI – The Wreck B and AB – The Hill North. The large number of mollusc species present in catches, lack of obvious identifying features and lack of time inhibits the observers’ ability to accurately identify that species. Pebble crabs were caught at KI – 10.

Considering only the four different scallop “groups” (Commercial Scallops, old single, new single, and clappers), FI – South – North of Babel, FI – The Wreck A, FI – The Wreck B and FI had a much higher percentage of old single shell (more than 75%) than other beds (Figure 15). KI – Three Hummock East, KI – Three Hummock West and KI – 9 had the highest proportion of live Commercial Scallop (>60%). Only small amounts of clappers were recorded from some beds.

Table 2. Names, nicknames (used in this report) surveyed in 2023 and area of polygons (km2).

Bed	Nickname	Total Area (km2)
Flinders Island – FI	FI	107
Flinders Island – The Wreck A	FI – The Wreck A	37.51
Flinders Island – The Wreck B	FI – The Wreck B	36.41
Flinders Island South – North of Babel	FI – NB	31.43
Apollo Bay – The Hill North	AB – The Hill	60.47
King Island – 10	KI – 10	17.11
King Island – Blue Dot South East	KI – BDSE	66.88
King Island – 9	KI – 9	36.36
Flinders Island – The Sisters East	FI – The Sisters East	11.29
Flinders Island – The Sisters West	FI – The Sisters West	13.49
King Island – Three Hummocks East	KI – Three hummocks East	55.50
King Island – Three Hummocks West	KI – Three hummocks west	103.23

Table 3. Total commercial catch (t) and the number of vessels that fished within each 2023 survey bed during the 2022 fishing season based on logbook data. Records coloured red are confidential – they were used in the analyses but removed for final report. *Note: While 9 different vessels fished outside of the 2022 beds, the catch can not be reported because it allow the catch from FI – The Wreck A and FI – The Wreck to be derived from the total catch.

Bed	Catch (t)	Number of vessels
Apollo 2	0	0
KI – 10	0	0
The Hill North	0	0

Bed	Catch (t)	Number of vessels
KI – BDSE	0	0
Five Hours	0	0
FI – The Wreck A	Confidential	<5
FI – The Wreck B	Confidential	<5
Outside of beds	Confidential*	9
Total	495	10

BSCZSF – 2023 Scallop Survey

Table 4. Biomass estimates, 95% confidence intervals and number of tows included in analyses. Note that both densities have been adjusted for a 33% assumed dredge efficiency.

Area	Bed	Number of tows	Mean density (kg/1000 m2)	Standard deviation (kg/1000 m2)	Lower 95% CI (t)	Estimated biomass (t)	Upper 95% CI (t)	Potential catch rate (kg/hr)	Density (ind/m2 >85mm)
Apollo	AB–The Hill	24	40.3	43.1	1,335	2,436	3,537	160	0.22
Sub-total		24				2,436			
King	KI – 10	25	85.5	101.7	745	1,464	2,182	339	0.61
	KI – 9	25	90.6	66.6	2,294	3,293	4,293	359	0.71
	KI – BDSE	25	25.6	27.5	953	1,714	2,474	101	0.14
	KI – Three Hummock East	25	601.9	313.5	48,732	62,075	75,418	2,384	2.86
	KI – Three Hummock West	25	261.2	177.3	10,421	14,479	18,537	1,034	2.40
Sub-total		125				83,025			
Flinders	FI – North – The Sisters	25	65.3	53.0	585	880	1,175	259	0.57
	FI – South – North of Babel	25	3.9	7.8	22	122	223	15	0.02
	FI – The Sisters East	25	30.6	18.3	260	345	430	121	0.27
	FI – The Wreck A	25	6.6	12.3	60	249	439	26	0.06
	FI – The Wreck B	25	7.8	10.5	127	284	442	31	0.06
	FI	25	39.4	59.6	1,592	4,229	6,866	156	0.31
Sub-total		150				6,109			
Total		299				91,570			

Table 5. Percent weight of scallops > 85 mm (catch weighted by weight), and biomass estimates 95% confidence intervals for scallops greater than 85 mm.

Area	Bed	% weight > 85 mm	Lower 95% CI (t)	Estimated Biomass (t)	Upper 95% CI (t)
Apollo	AB–The Hill	76.4	1,020	1,861	2,701
Sub-total				1,861	
King	KI – 10	80.6	601	1,180	1,759
	KI – 9	70.7	1,623	2,330	3,037
	KI–BDSE	55.5	529	950	1,372
	KI – Three Hummock East	43.9	21,412	27,274	33,137
	KI – Three Hummock West	72.7	7,573	10,522	13,471
	Sub-total				42,256
Flinders	FI – North – The Sisters	88.6	518	780	1,041
	FI – South – North of Babel	87.4	19	107	195
	FI – The Sisters East	91.2	237	315	393
	FI – The Wreck A	95.9	57	239	422
	FI – The Wreck B	92.0	117	262	407
	FI	76.2	1,214	3,224	5,234
	Sub-total				4,927
Total				49,044	

Table 6. Number of length measurements (N), median, mean and standard error (SE) of scallops measured, and % of scallops measured (catch weighted by weight) less than and greater than 85 mm and mean number of meats per kg of scallops greater than 85 mm from each bed.

Bed	N	Length (mm)			85 mm		Meats / kg
		Median	Mean	SE	%<	%>	Mean
AB – The Hill North	676	90	91	0.4	76.4	23.6	145
KI – 10	1286	91	90	0.2	80.6	19.4	128
KI – 9	692	88	87	0.4	70.7	29.3	107
KI – BDSE	939	85	84	0.2	55.5	44.5	143
KI – Three Hummock East	954	82	82	0.2	43.9	56.1	145
KI – Three Hummock West	973	87	87	0.2	72.7	27.3	135
FI	710	90	89	0.4	76.2	23.8	121
FI – North – The Sisters	825	93	93	0.3	88.6	11.4	95
FI – South – North of Babel	339	96	98	0.7	87.4	12.6	73
FI – The Sisters East	938	94	94	0.3	91.2	8.8	81
FI – The Wreck A	391	100	101	0.5	95.9	4.1	61
FI – The Wreck B	574	97	99	0.4	92.0	8.0	64

Table 7. Number of scallops retained for biological sampling, and parameter estimates for length weight relationships.

Sub Area	N	a	b	Adjusted R ²
AB – The Hill North	72	-5.2298	2.0789	0.7783
KI – 10	50	-7.8618	2.6768	0.8348
KI – 9	79	-7.0101	2.4626	0.8224
KI – BDSE	50	-7.9002	2.669	0.7611
KI – Three Hummock East and west	84	-7.6576	2.6009	0.7989
FI	49	-7.2829	2.5217	0.8532
FI – North – The Sisters	50	-7.7154	2.6269	0.8928
FI – South – North of Babel	36	-6.7940	2.4635	0.737
FI – The Sisters East	51	-9.9020	3.1233	0.8885
FI – The Wreck A	52	-9.0961	2.9704	0.8909
FI – The Wreck B	49	-8.8857	2.9136	0.8426

Table 8. Catch of each species in each bed. (u) refers to undifferentiated species recorded at a higher taxonomic level.

Species	Catch (kg)											
	AB – The Hill North	KI – 10	KI – 9	KI – BDSE	KI – Three Hummock East	KI – Three Hummock West	FI	FI – North – The Sisters	FI – South – North of Babel	FI – The Sisters East	FI – The Wreck A	FI – The Wreck B
Commercial scallop	647.2	1980	1527.64	566	8379.6	3867.6	556.5	914.9	69.4	411.8	121.4	137.2
Clappers	56.65	250	84.1	760	125.7	62.4	11.84	23.1	20	9.02	110	120
New Single	1056.1	1180	654	1475	2504.4	1829.5	401.4	482.7	215	191	325	310
Old Single	1741.7	2705	1008.8	3705	1111.7	550.8	3079.6	2333.3	990	561.4	2570	3010
Ascidian (u)				2					167		895	320
Banded stingaree		0.15		0.2							1	0.6
Black and White Seastar									0.8			0.2
Boxfish (u)			0.1									
Brittlestars (u)							0.6					
Bug		0.1						1.5				
Bulldog stargazer						0.8	2.5					
Butterfly gurnard				2.1			0.4					
Cockle							54.4	3.3		0.45		
Common gurnard perch				0.43					0.3			
Common Silverbidy									0.1			
Common stargazer						0.6	8		0.5			0.3
Crab (u)							1					
Cucumberfish, greeneye & flathead lizardfish (u)										0.3		
Cuttlefish (u)							0.3					
Deepwater bug							8.4					
Dog cockles		0.11										
Doughboy scallop			625.7				465.5	100.1		37.8	0.5	
Doughboy Scallop shell			738.9									
Draughtboard shark			0.8									
Eleven-arm seastar		26		37	31	32		77.7	44.5	2.7	81.5	94.5
Flathead (u)												0.3
Hard Coral								219.1		0.5		
Hermit crab		0.1	1.1	0.1		0.3	16.7	173.1	18.32	153.3	10.6	11.4
John dory												0.3
King Island Thickshell-Clam	1.1	0.1	1.6	0.05					36			1.5
Longsnout flounder		0.2		0.25								
Mollusc (u)				0.8								
Octopus (u)	0.1	0.6	5		0.4	0.5	2.1			4.2		
Oysters						0.8	2.7	24.1	160	8	265	890
Pale octopus		10.7		0.7					0.8		1	2.6
Pebble Crab		0.06										
Polychaete worm (u)	22.8								0.2			
Porcupinefish (u)			0.2									
Razorfish (u)							6.6	13.3		1.7	1	0.5
Salp (u)										0.4		
Sandyback stingaree							0.8	1.2		0.8		
Scorpionfish											0.3	0.5
Sculptured seamoth				0.01								

BSCZSF – 2023 Scallop Survey

Species	Catch (kg)											
	AB – The Hill North	KI – 10	KI – 9	KI – BDSE	KI – Three Hummock East	KI – Three Hummock West	FI	FI – North – The Sisters	FI – South – North of Babel	FI – The Sisters East	FI – The Wreck A	FI – The Wreck B
Sea urchin (u)							22.6	12.6		1.3		
Seapen (u)							2.1					
Searobin & armour gurnard (u)			4.35									
Seastar (u)							2.2	3.7		2		
Shark egg (u)										0.1		
Skate (u)		35	0.7									
Southern blue-ringed octopus												0.2
Southern red scorpionfish								1.3				
Southern sand flathead		0.4			0.7		0.2		0.5			
Sparsely-spotted stingaree				0.65	0.3	0.3		1.3	0.5	3.6	0.5	
Spider crab (u)	21.7	18.3	34.5	4.5	37.8	46.7	2.5	0.7	12.5	2.2	27.5	28.5
Spiny gurnard		0.4		0.3					0.2			
Sponge	892.3	155	1743	111	21	14		17.3	90	9.6	207	67
Stingaree & giant stingaree (u)	1.1		0.5									
Substrate								16.9				
Substrate - Broken Shell	1959.3		2629.99		181.2	1133.7	4845.6	2194.9		581		
Substrate - Rock	851.7		1.3		1			13				
Tasmanian numbfish		0.4		0.3				0.2		2.7	0.3	0.7
Temperate bass & rockcod (u)	0.3		5									
Triton shells		5.2		4.65					8.3		19.9	12.7
Venus shells							4.6	3.2	44.5	1	0.7	0.7
Volute (u)		0.15					1.3		0.9			0.2
Whelk					4.6	4.5	35.3	32.1		11		
Whitespotted skate												137.2
							0.8			1		



Volutidae, *Amoria undulata*?



Cassidae, *Semicassis* spp.



Cypraeidae, *Cypraea* spp.



Buccinidae, *Penion* spp.



Fascioliariidae, *Fusinus* spp.

Figure 6. Family and genus of gastropod molluscs found in catches during the survey.

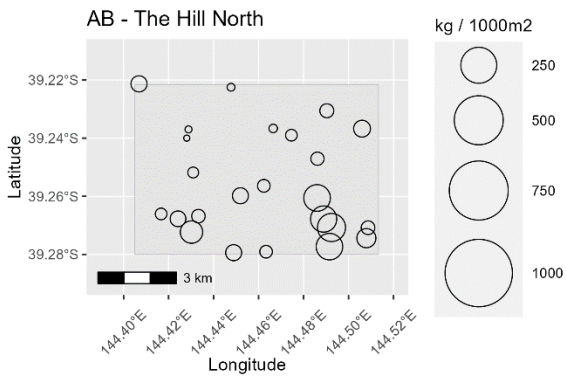


Figure 7. Scallop density (kg / 1000 m²) within the AB – The Hill. The top right scale bubbles reflect the estimated scallop density of each tow assuming a dredge efficiency of 33%. Red circles denote zero catches.

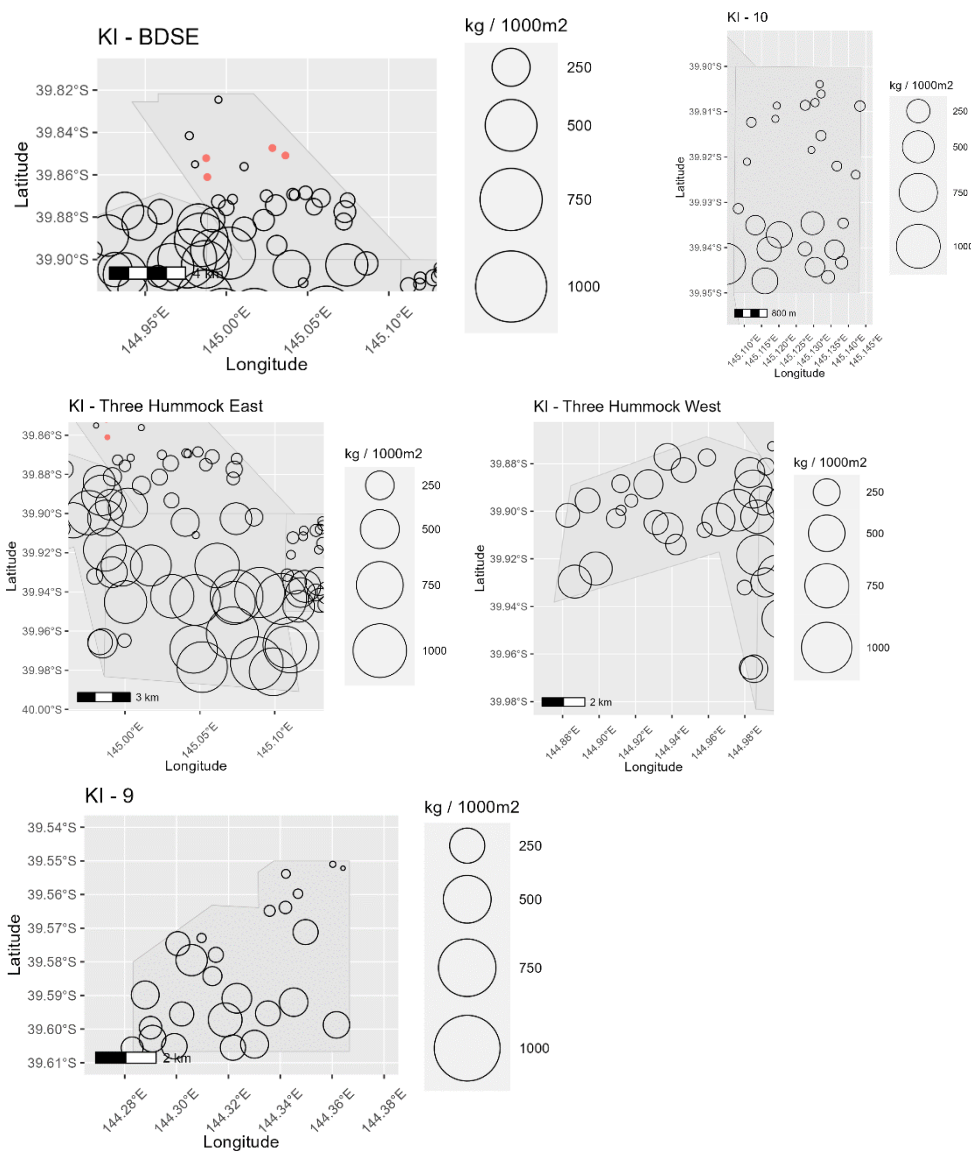


Figure 8. Scallop density (kg / 1000 m²) within the KI – BDSE, KI – 10, KI – 9 beds, KI – Three Hummocks East and KI – Three Hummocks West. The scale bubbles on the right reflect the estimated scallop density of each tow assuming a dredge efficiency of 33%. Red circles denote zero catches.

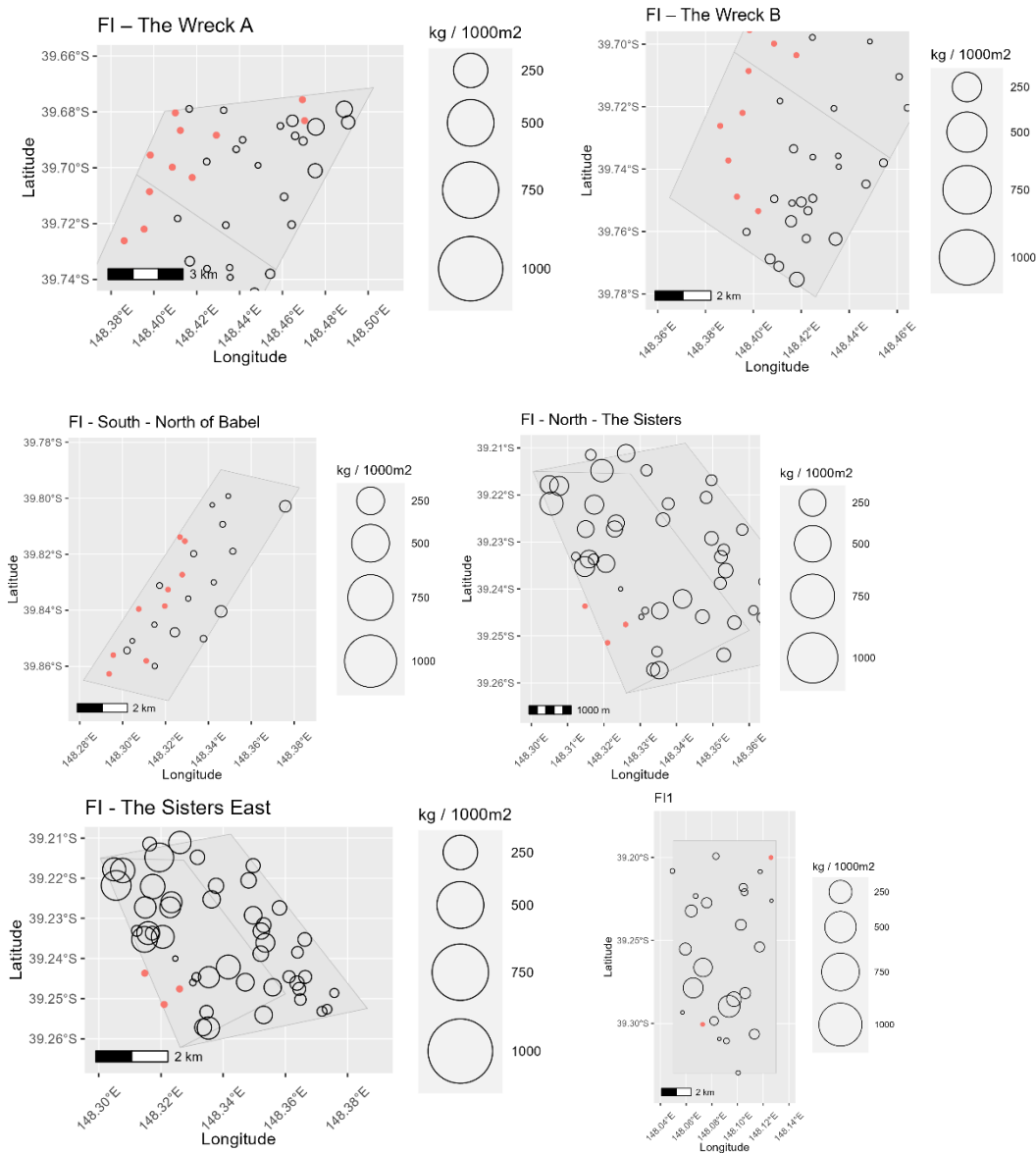


Figure 9. Scallop density (kg / 1000 m²) within the FI – The Wreck A, FI – The Wreck B, FI – South – North of Babel, FI – North – The Sisters, FI – The Sisters East and FI beds near Flinders Island. The scale bubbles on the right reflect the estimated scallop density of each tow assuming a dredge efficiency of 33%. Red circles denote zero catches.

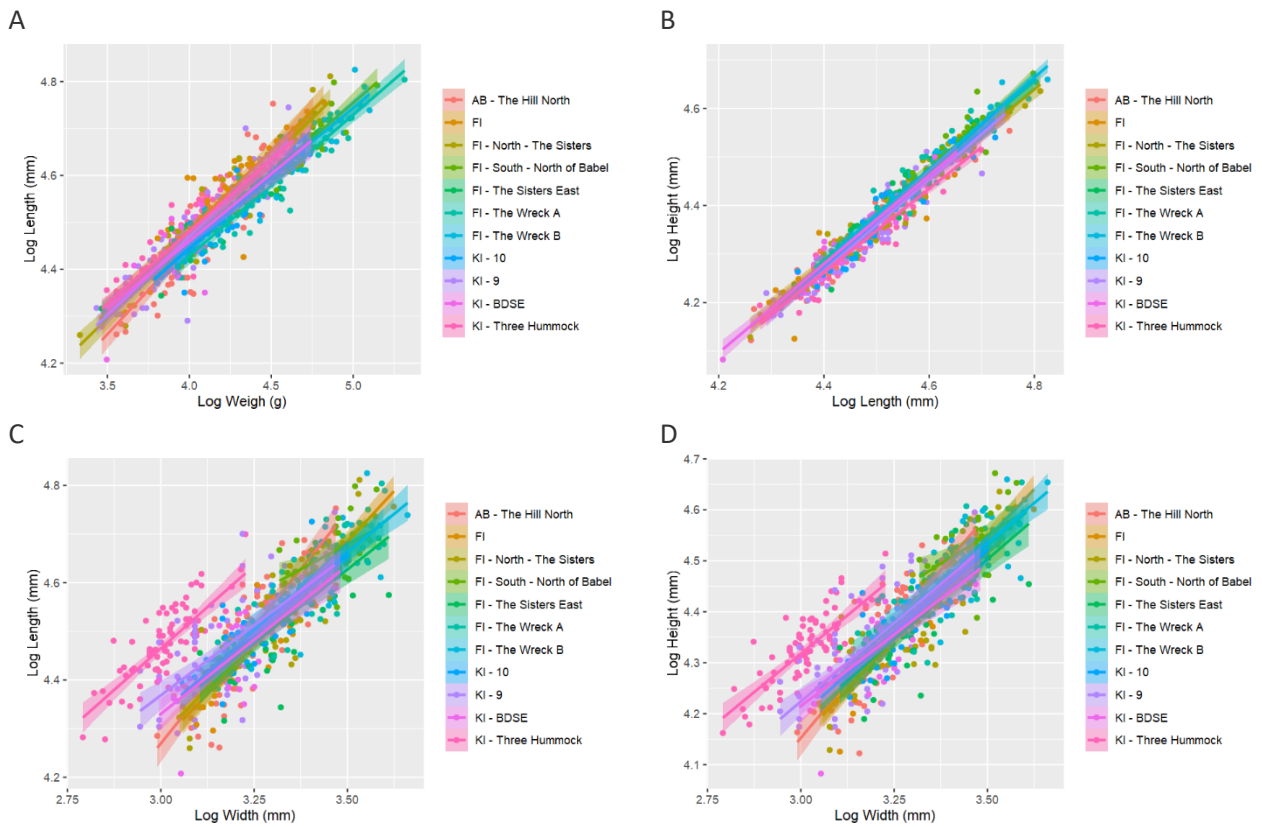


Figure 10. Log transformed A) length and weight, B) length and height, C) length and width and D) height and width from each area bed.

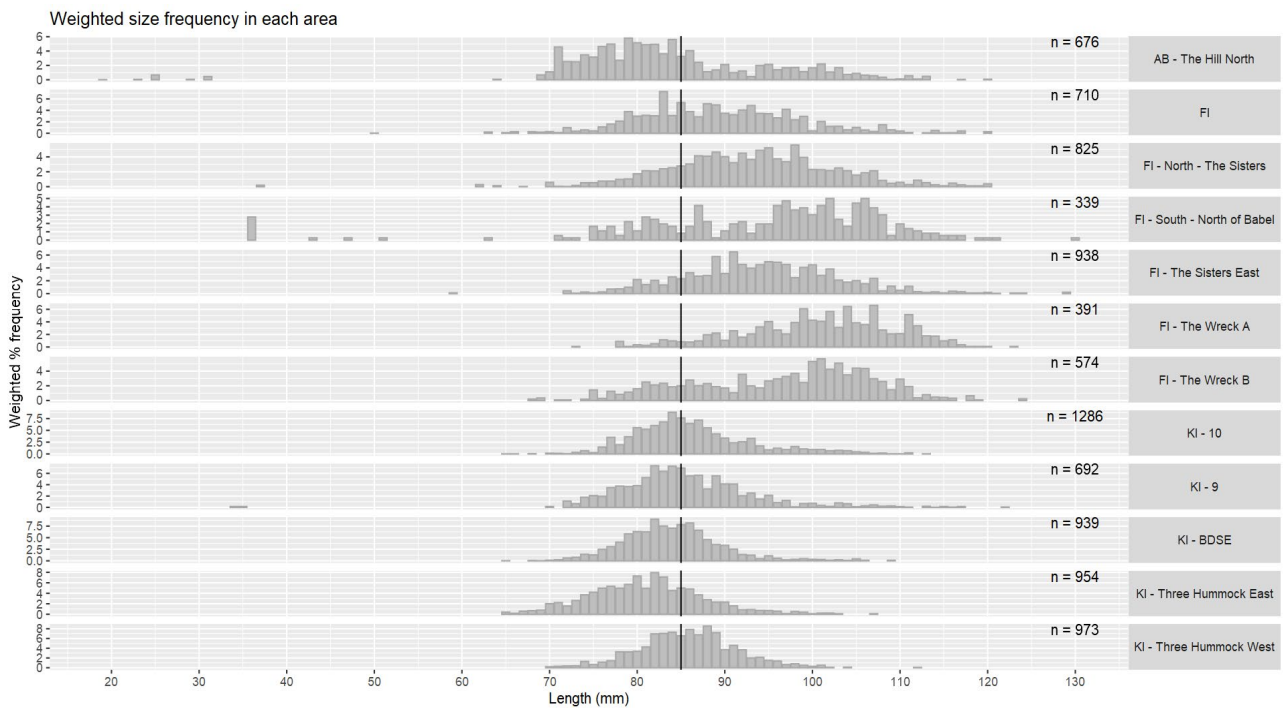


Figure 11. Catch weighted size frequency from tows included in biomass estimates from each bed. The vertical line is at 85 mm.

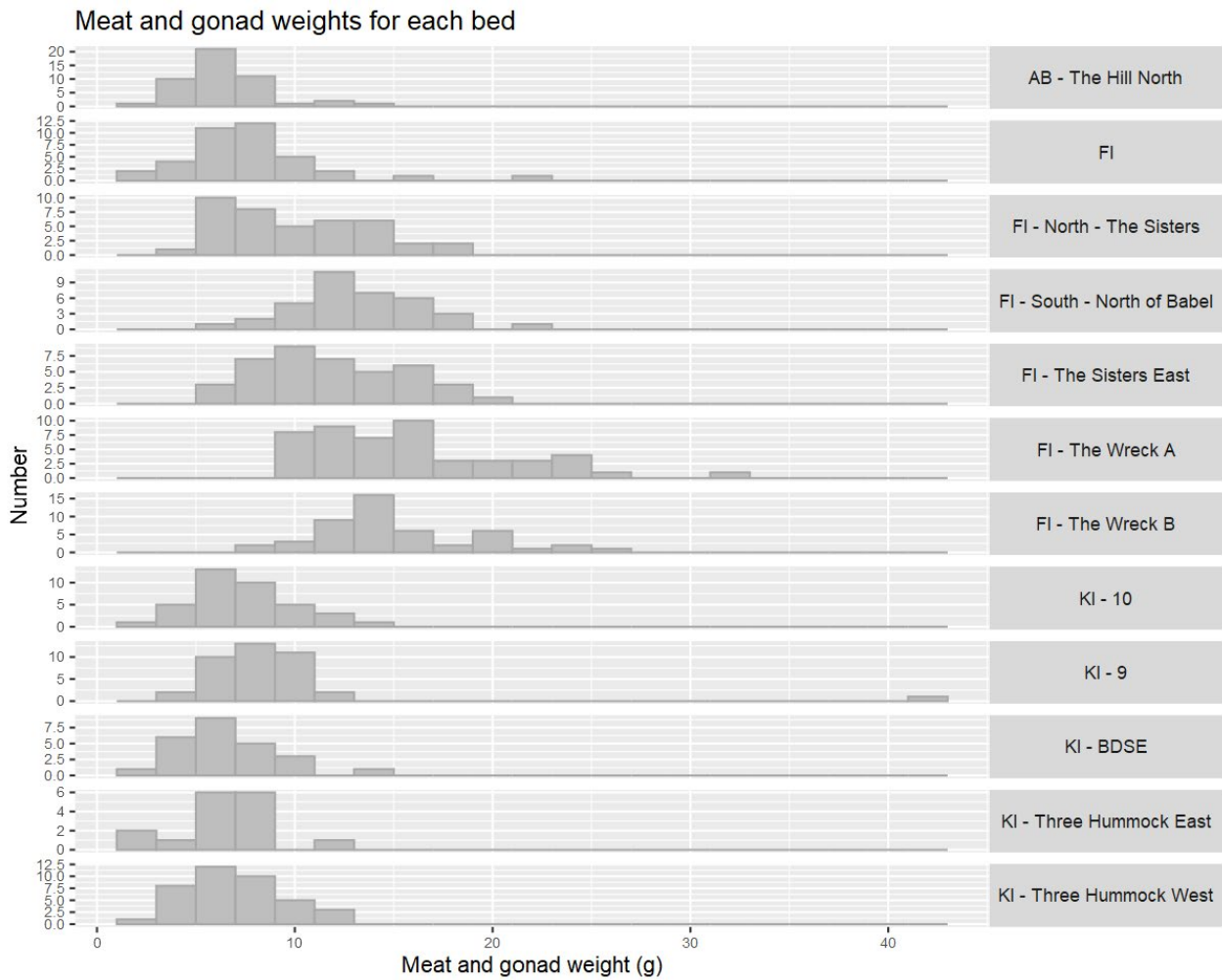


Figure 12. Frequency of combined meat and gonad weights of scallops >85 mm measured from each bed binned into 2 g weight categories.

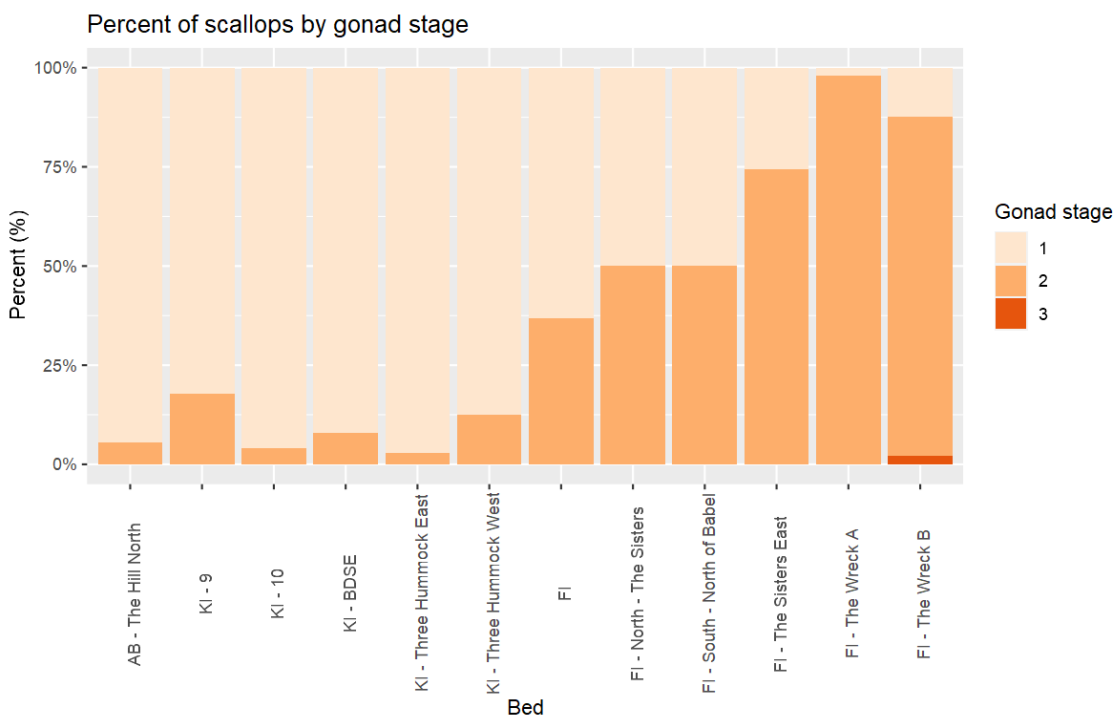


Figure 13. Percent of scallops at each stage from each bed based on macroscopic staging criteria shown in Table 10.

Catch of top 5 species

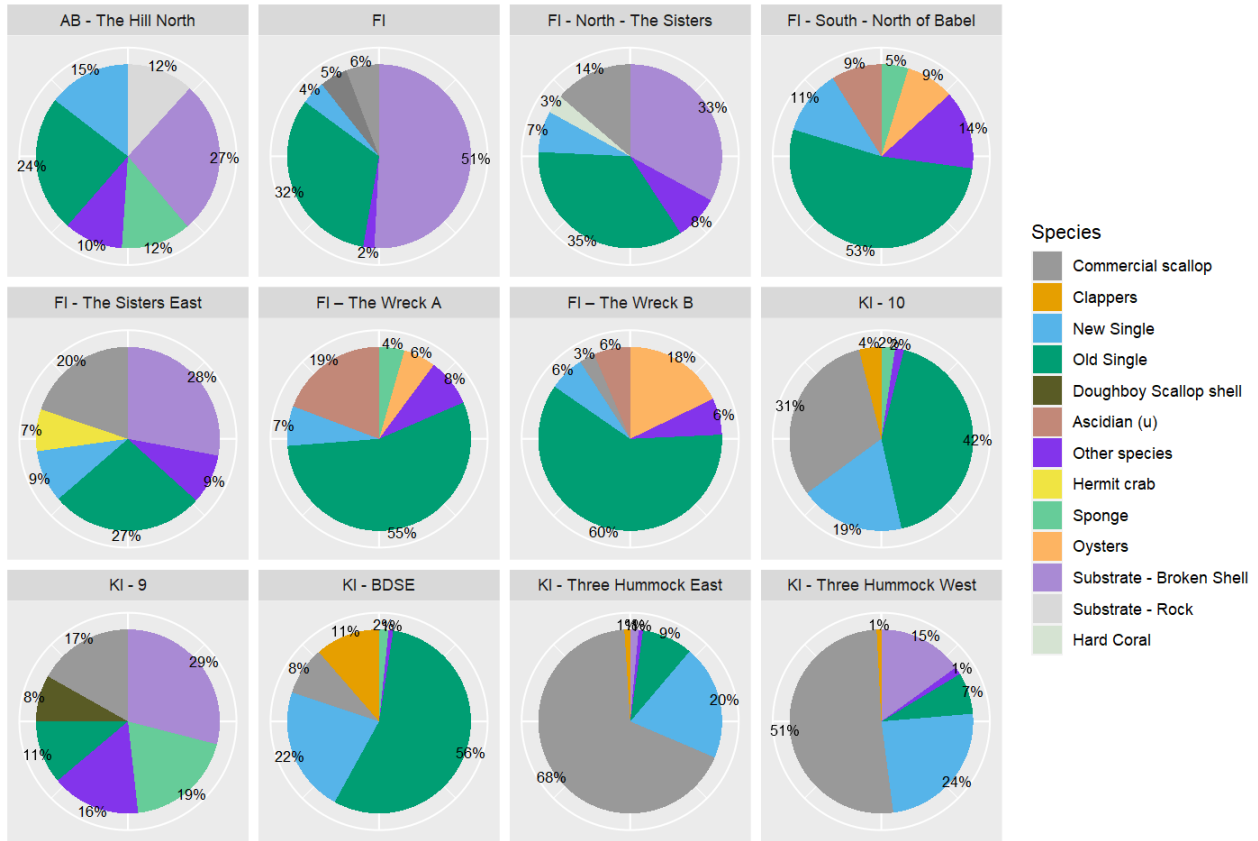


Figure 14. Percent catch composition by weight from all beds.

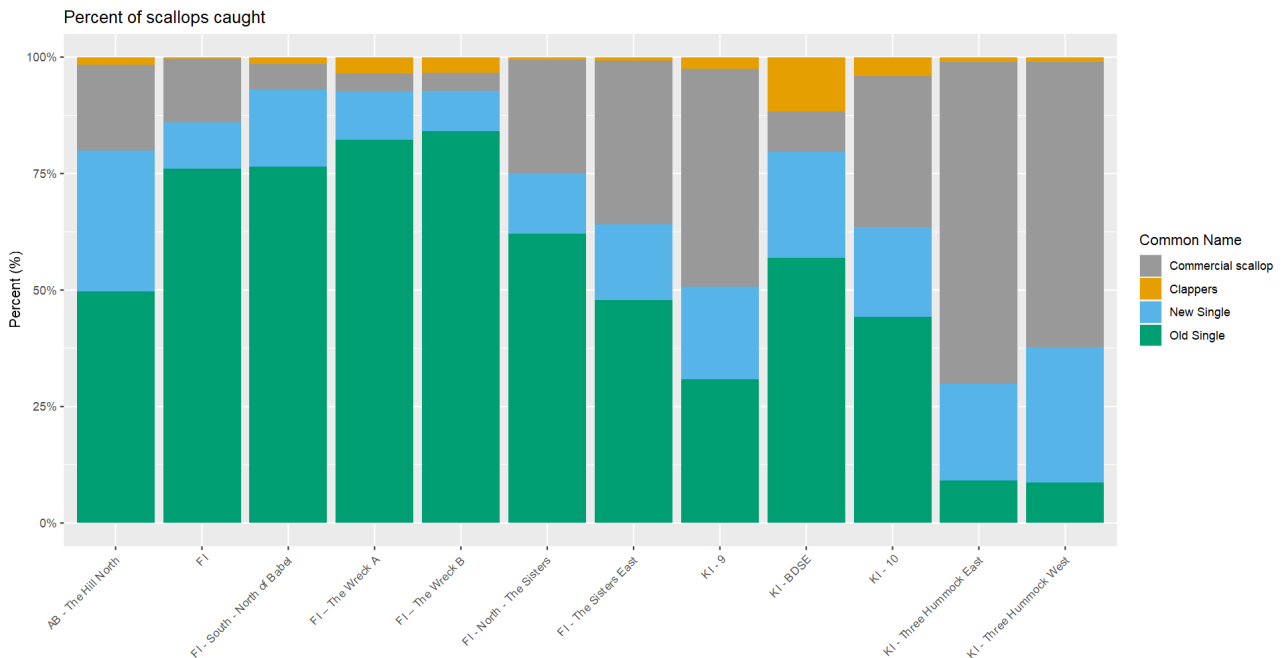


Figure 15. Percent composition of clappers, live scallop, new single and old single shell from each Bed.

4 Discussion

Random stratified surveys were successfully undertaken on twelve scallop beds off FI, KI and AB. Beds were selected based on a combination of previous surveys, distribution of catch and effort, advice from ScallopRAG and marks provided by industry. In total, 299 valid, random survey tows were undertaken. Biomass was calculated for each bed using area swept calculated from the straight-line distance between the start and end tow points and the measured internal width of the dredges.

Biomass of Commercial Scallops greater than 85 mm was estimated to be 1,861 t at the AB – The Hill bed, 42,256 t at the five FI Beds and 4,927 t at the six FI beds (Table 9). Total biomass greater than 85 mm at all sites combined was 49,044 t. The percent of Commercial Scallops greater than 85 mm was less than 80% at most sites, with as few as 43.9% at KI – Three Hummock East, and as high 95.9% at FI – The Wreck A. Densities in individuals per m² ranged 0.02 at FI – South – North of Babel to 2.86 at KI – Three Hummock East (Table 9).

Results were presented at the ScallopRAG meeting on 7 June 2023 and at the ScallopMAC meeting on 8 June 2023.

Table 9. Summary of biomass, density and size data.

Area	Bed	Estimated biomass (t)	% weight > 85 mm	Estimated Biomass (t >85mm)	Density (ind/m ² >85mm)	Mean length (mm)
Apollo	AB – The Hill	2,436	76.4	1,861	0.22	91
Sub-total		2,436		1,861		
King	KI – 10	1,464	80.6	1,180	0.61	90
	KI – 9	3,293	70.7	2,330	0.71	87
	KI – BDSE	1,714	55.5	950	0.14	84
	KI – Three Hummock East	62,075	43.9	27,274	2.86	82
	KI – Three Hummock West	14,479	72.7	10,522	2.40	87
Sub-total		83,025		42,256		
Flinders	FI – North – The Sisters	880	88.6	780	0.57	93
	FI – South – North of Babel	122	87.4	107	0.02	98
	FI – The Sisters East	345	91.2	315	0.27	94
	FI – The Wreck A	249	95.9	239	0.06	101
	FI – The Wreck B	284	92.0	262	0.06	99
	FI	4,229	76.2	3,224	0.31	89
Sub-total		6,109		4,927		
Total		91,570		49,044		

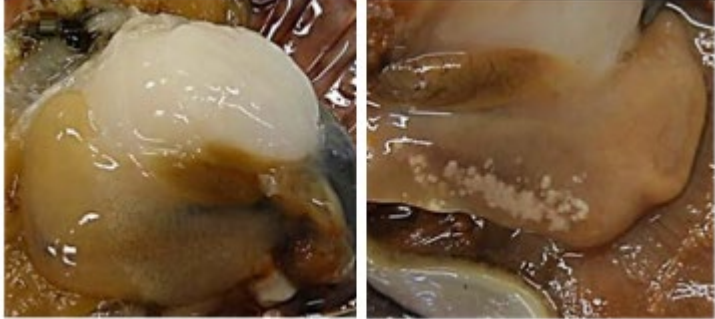


5 References

- Fishwell (2023). 2023 BSCZSF Survey. Operation and Procedures Manual. Fishwell Consulting 28 pp.
- Haddon, M., Harrington, J.J. and Semmens, J.M. (2006). Juvenile Scallop Discard Rates and Bed Dynamics: Testing the Management Rules for Scallops in Bass Strait. Tasmanian Aquaculture and Fisheries Institute, Taroona, Tasmania.
- Harrington, Semmens & Haddon (2008). 2008 Commonwealth Bass Strait Central Zone Scallop Fishery Survey. Survey Final Report. Tasmanian Aquaculture and Fisheries Institute. University of Tasmania.
- Knuckey, I., Koopman, M., and Davis, M. (2015). Bass Strait and Central Zone Scallop Fishery - 2015 Survey. AFMA Project 2015/001291. Fishwell Consulting 22pp.
- Knuckey, I., Koopman, M., and Davis, M. (2016). Bass Strait and Central Zone Scallop Fishery - 2016 Survey. AFMA Project 2016/0804. Fishwell Consulting. 30pp
- Knuckey, I., Koopman, M., Hudson, R., Davis, M., and A. Sullivan (2017). Bass Strait and Central Zone Scallop Fishery - 2017 Survey. AFMA Project 2016/0806. Fishwell Consulting. 42pp.
- Knuckey, I., Koopman, M. and, Hudson, R., (2018). Bass Strait and Central Zone Scallop Fishery - 2018 Survey. AFMA Project 2017/0822. Fishwell Consulting. 44pp.
- Koopman, M., Knuckey, I., Sih, T. and Kube, J. (2019). Bass Strait and Central Zone Scallop Fishery - 2019 Survey. AFMA Project 2019-0812. Fishwell Consulting. 39 pp.
- Koopman, M., Knuckey, I., Kube, J., Davis, A. and Sullivan, A. (2021). Bass Strait and Central Zone Scallop Fishery - 2021 Survey. AFMA Project 2019-0812. Fishwell Consulting. 39 pp.
- Koopman, M., Knuckey, I., Kube, J., Davis, A. and Sullivan, A. (2021). Bass Strait and Central Zone Scallop Fishery - 2021 Survey. AFMA Project 2019-0812. Fishwell Consulting. 39 pp.
- Koopman, M., and Knuckey, I. (2022). Bass Strait and Central Zone Scallop Fishery - 2022 Survey. AFMA Project 2019-0807. Fishwell Consulting. 39 pp.
- Pebesma, E. (2018). Simple Features for R: Standardized Support for Spatial Vector Data. The R Journal 10 (1), 439-446, <https://doi.org/10.32614/RJ-2018-009>
- R Core Team (2023). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <https://www.R-project.org/>.
- Semmens, J.M., Mendo, T., Jones, N., Keane, J., Leon, R., Ewing, G. and Hartmann, K. (2018). Determining when and where to fish: Linking scallop spawning, settlement, size and condition to collaborative spatial harvest and industry in-season management strategies, Institute for Marine and Antarctic Studies and University of Tasmania, Hobart, June. CC BY 3.0
- Semmens, J. and Jones, N. (2014). Draft 2014 BSCZSF survey report. Institute for Marine and Arctic Studies. July 2014.

6 Appendix 1 – Methods

6.1 Gonad Staging

Table 10. Gonad maturation scheme for macroscopic field staging of scallops (modified from Semmens *et al.*, 2019).²

Stages	Description
<p>1</p> <p>Developing or spent</p>	<p>Gonad is small, thin, translucent, brownish colour. Intestinal loop usually visible. Ovarian and testicular tissues difficult to differentiate.</p> 
<p>2</p> <p>Maturing or atretic (reabsorbing eggs as spawning is delayed)</p>	<p>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.</p> 
<p>3</p> <p>Partially spawned</p>	<p>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.</p> 

² 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

6.2 Shell measurements

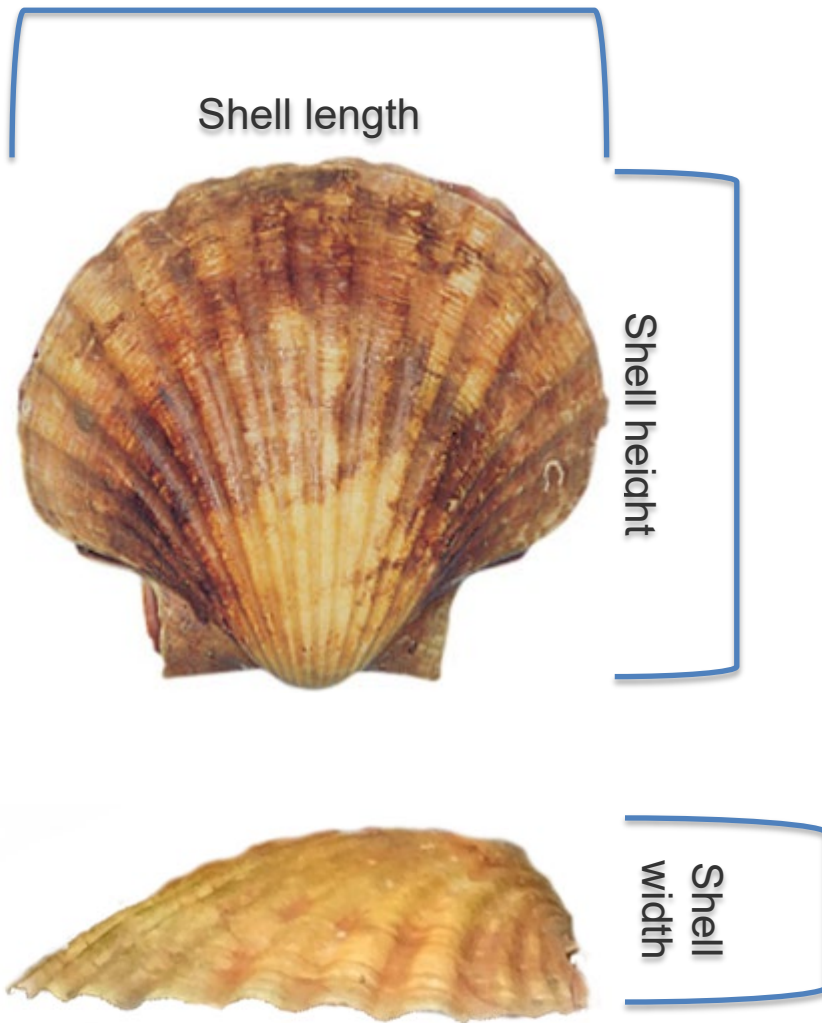


Figure 16. Scallop width, length and height to be measured.

7 Appendix 2 - Time series data

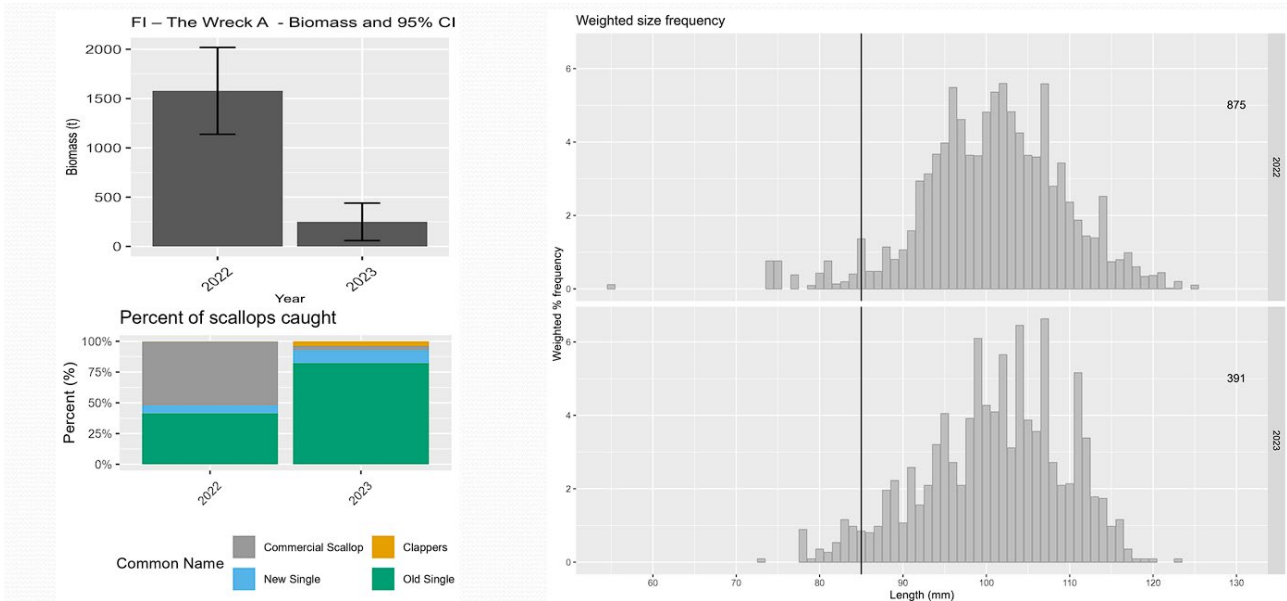


Figure 17. Time series of biomass estimate, size frequency and percent of scallop (live/shell type) at the FI – The Wreck A bed.

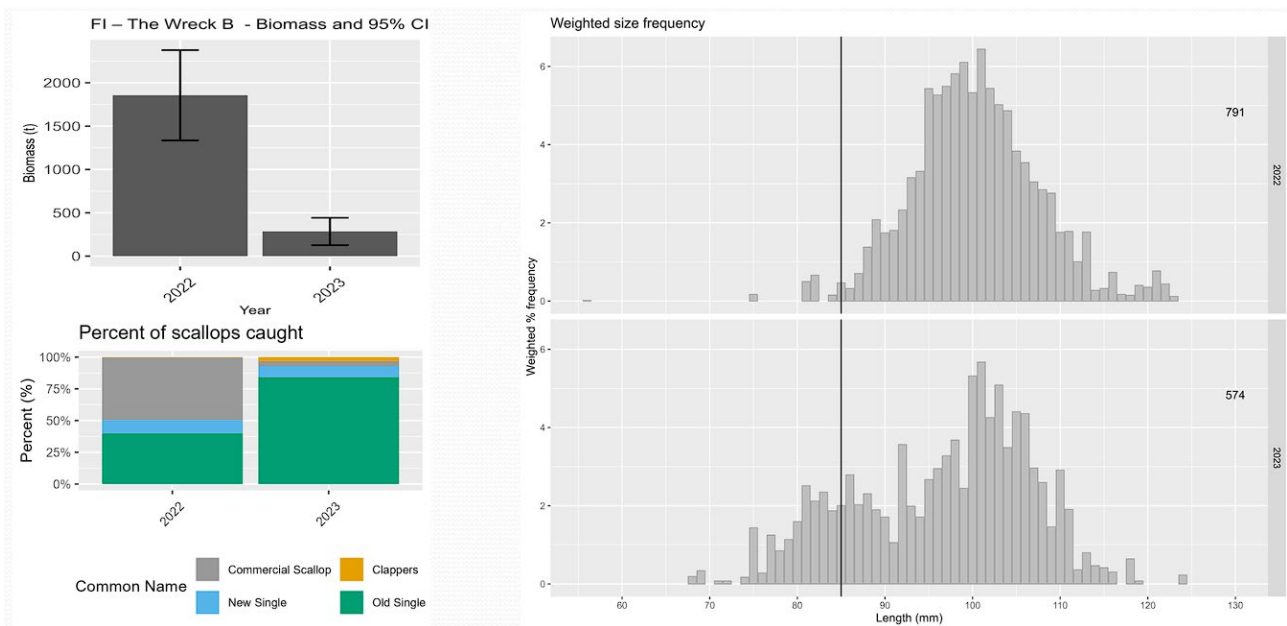


Figure 18. Time series of biomass estimate, size frequency and percent of scallop (live/shell type) at the FI – The Wreck B bed.

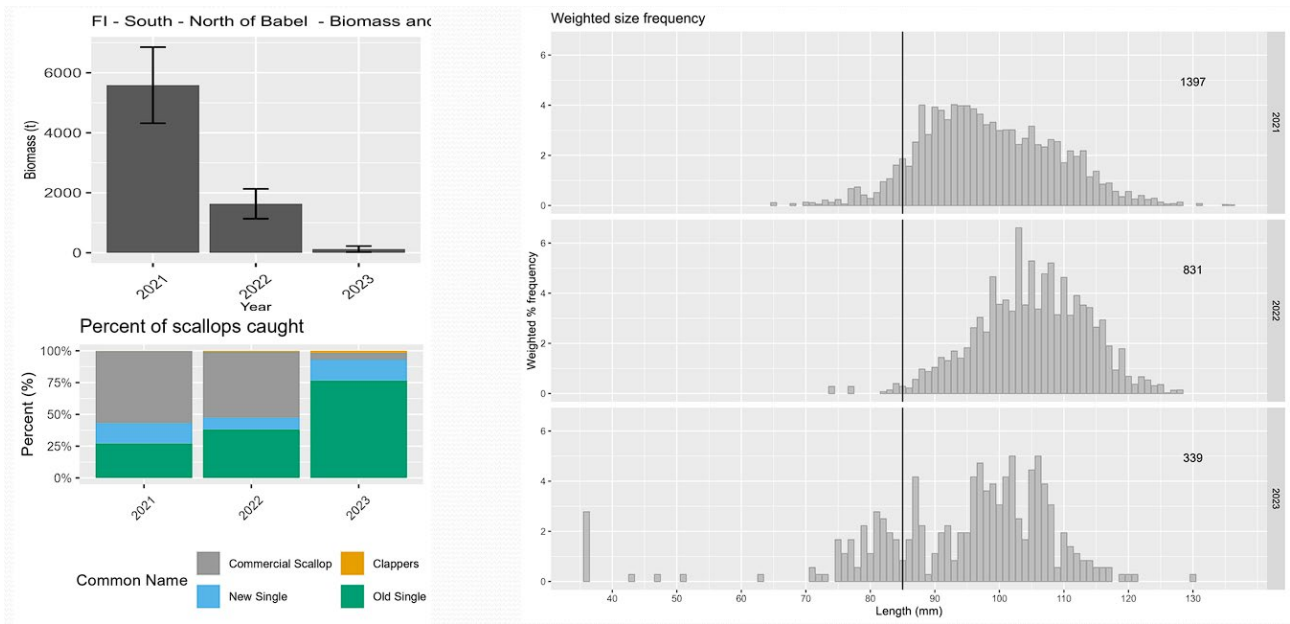


Figure 19. Time series of biomass estimate, size frequency and percent of scallop (live/shell type) at the FI – South – North of Babel bed.

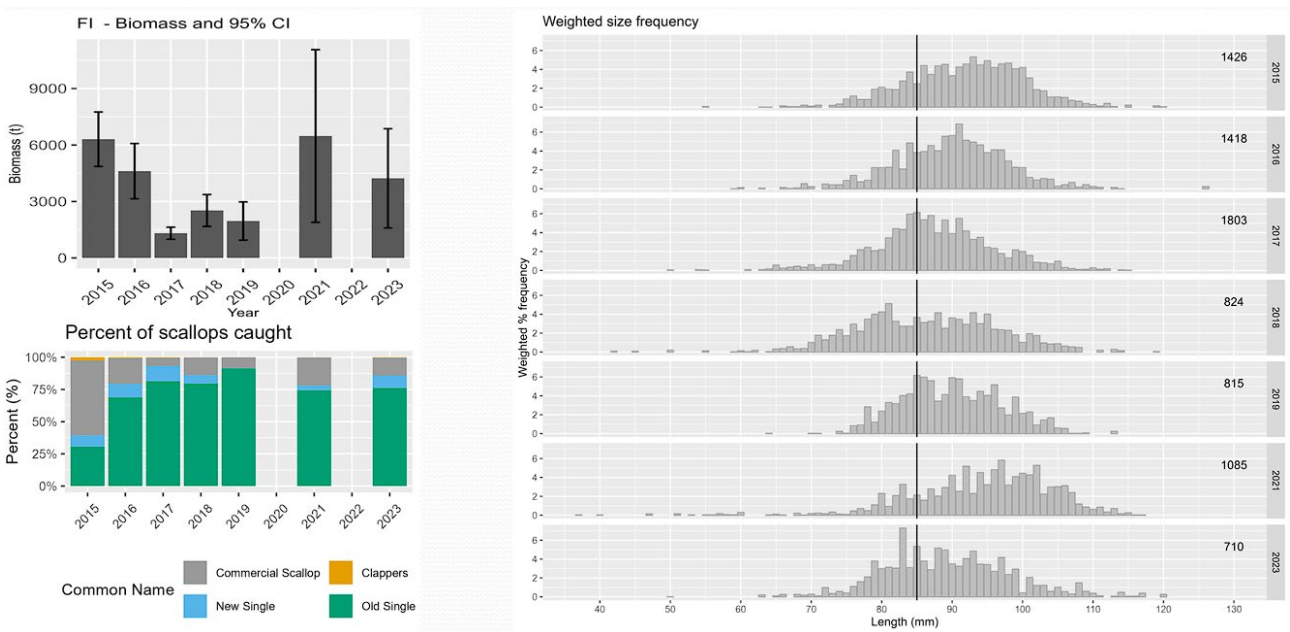


Figure 20. Time series of biomass estimate, size frequency and percent of scallop (live/shell type) at the FI bed.

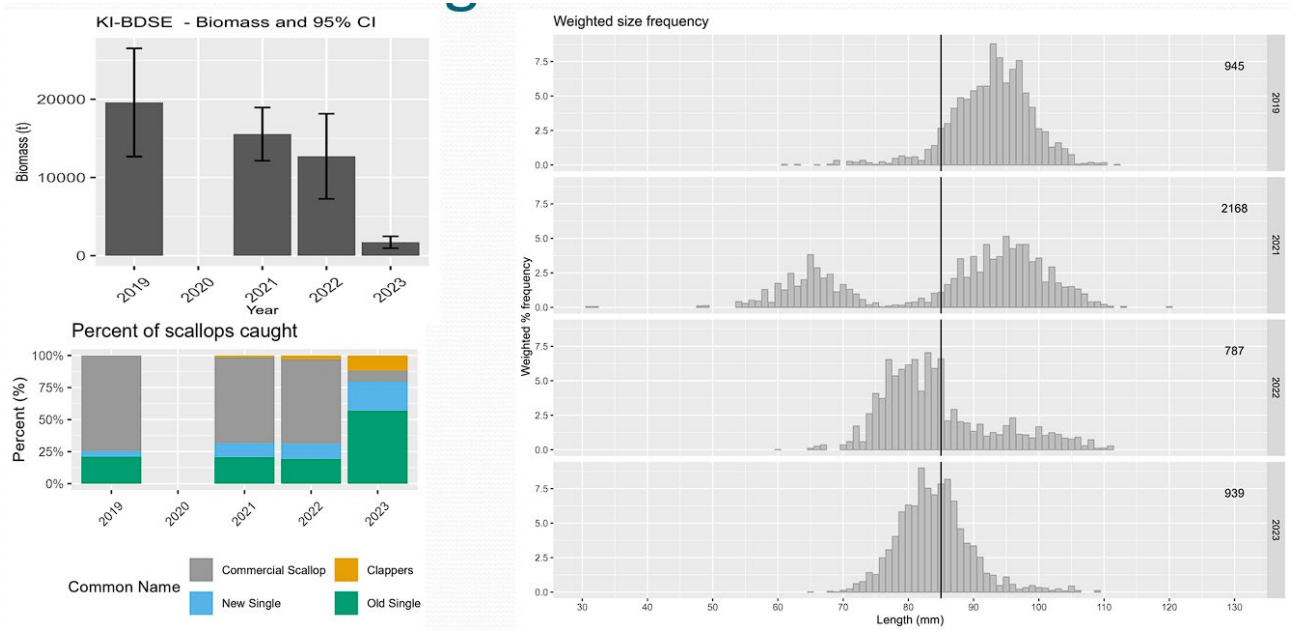


Figure 21. Time series of biomass estimate, size frequency and percent of scallop (live/shell type) at the KI – BDSE.

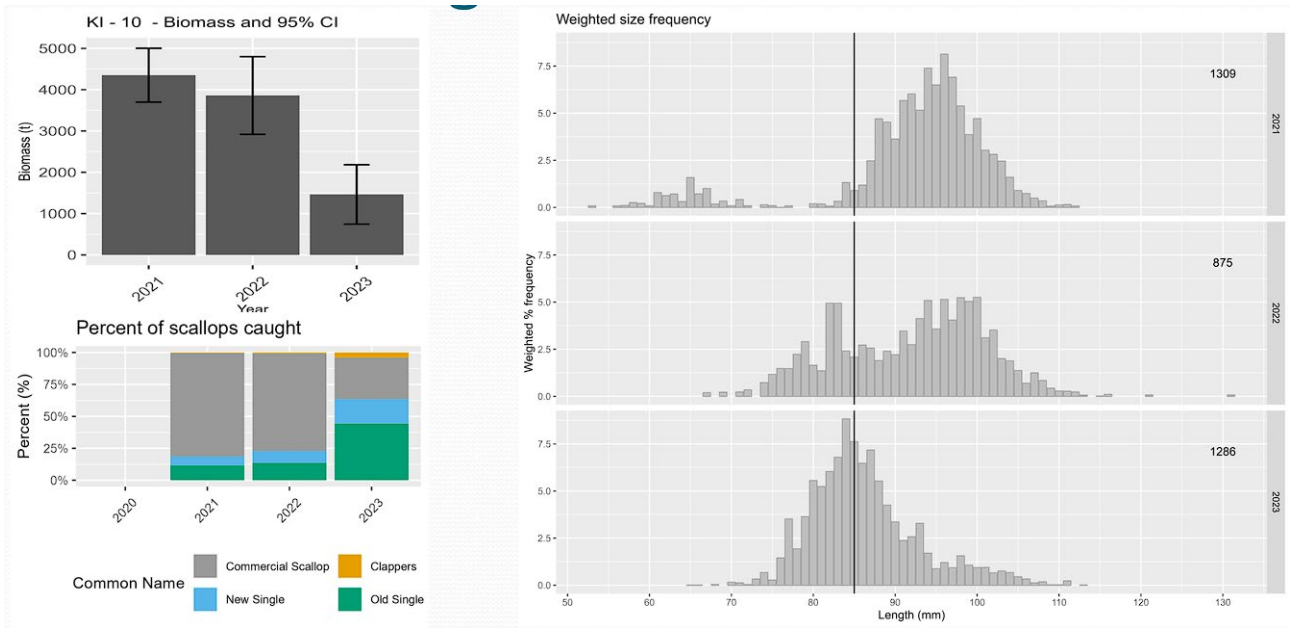


Figure 22. Time series of biomass estimate, size frequency and percent of scallop (live/shell type) at the KI – 10 bed.

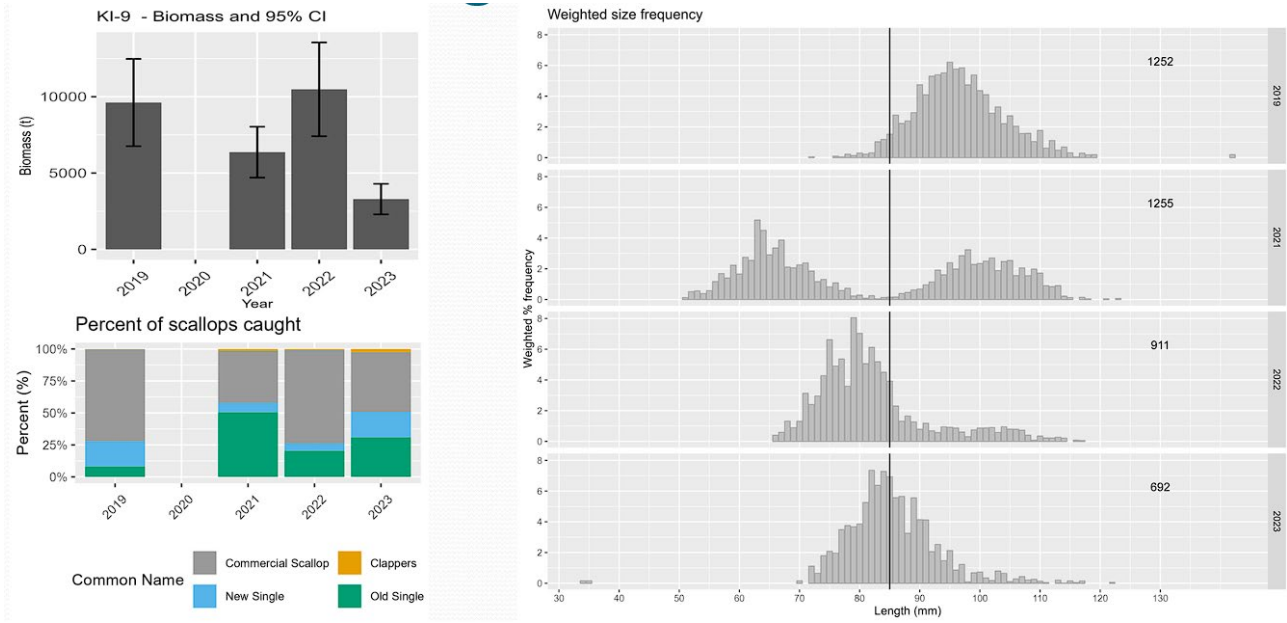


Figure 23. Time series of biomass estimate, size frequency and percent of scallop (live/shell type) at the KI – 9 bed.

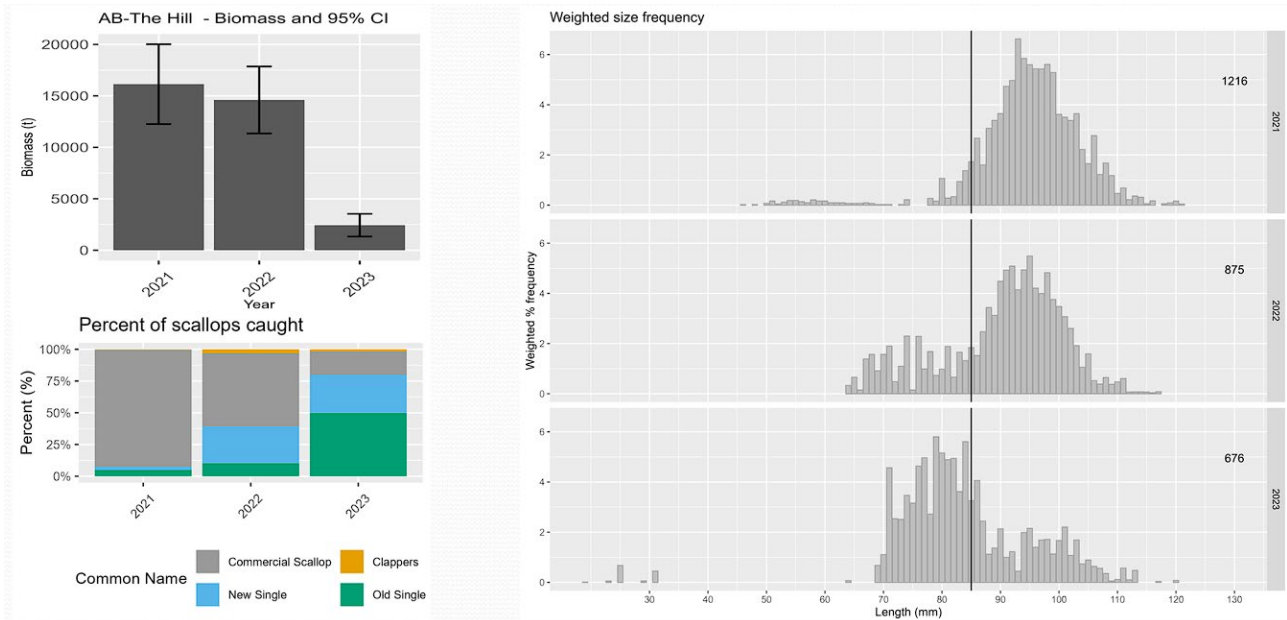


Figure 24. Time series of biomass estimate, size frequency and percent of scallop (live/shell type) at the AB – The Hill bed.

Appendix 3 - 2023 Survey bed verticies

X	Y	name	id	Longitude	Latitude	Strata	DecLong	Declat
144.5133333	-39.2217	AB - The Hill North	1	144° 30' 47.99" E	39° 13' 18.11" S	Apollo Bay	144 30.799	-39 13.301
144.5133333	-39.28	AB - The Hill North	1	144° 30' 47.99" E	39° 16' 48.00" S	Apollo Bay	144 30.799	-39 16.8
144.405	-39.28	AB - The Hill North	1	144° 24' 18.00" E	39° 16' 48.00" S	Apollo Bay	144 24.3	-39 16.8
144.405	-39.2217	AB - The Hill North	1	144° 24' 18.00" E	39° 13' 18.11" S	Apollo Bay	144 24.3	-39 13.301
144.5133333	-39.2217	AB - The Hill North	1	144° 30' 47.99" E	39° 13' 18.11" S	Apollo Bay	144 30.799	-39 13.301
148.3458	-39.7898	FI - South - North of Babel	12	148° 20' 44.87" E	39° 47' 23.27" S	Flinders I	148 20.748	-39 47.388
148.3825	-39.79617	FI - South - North of Babel	12	148° 22' 56.99" E	39° 47' 46.21" S	Flinders I	148 22.95	-39 47.770
148.3213	-39.8723	FI - South - North of Babel	12	148° 19' 16.68" E	39° 52' 20.28" S	Flinders I	148 19.278	-39 52.338
148.2818	-39.865	FI - South - North of Babel	12	148° 16' 54.48" E	39° 51' 54.00" S	Flinders I	148 16.907	-39 51.9
148.3458	-39.7898	FI - South - North of Babel	12	148° 20' 44.87" E	39° 47' 23.27" S	Flinders I	148 20.748	-39 47.388
145.1075685	-39.8999981	KI - 10	2	145° 06' 27.24" E	39° 53' 59.99" S	King I	145 06.4541	-39 53.999
145.1437184	-39.90022291	KI - 10	2	145° 08' 37.38" E	39° 54' 00.80" S	King I	145 08.6231	-39 54.013
145.1431344	-39.95002409	KI - 10	2	145° 08' 35.28" E	39° 57' 00.08" S	King I	145 08.5880	-39 57.001
145.1069616	-39.94999994	KI - 10	2	145° 06' 25.06" E	39° 56' 59.99" S	King I	145 06.4176	-39 56.999
145.1075685	-39.8999981	KI - 10	2	145° 06' 27.24" E	39° 53' 59.99" S	King I	145 06.4541	-39 53.999
144.3666667	-39.55	KI - 9	3	144° 21' 59.99" E	39° 33' 00.00" S	King I	144 21.999	-39 33.000
144.3666667	-39.60666667	KI - 9	3	144° 22' 00.00" E	39° 36' 24.00" S	King I	144 22.000	-39 36.400
144.2833333	-39.60666667	KI - 9	3	144° 17' 00.00" E	39° 36' 24.00" S	King I	144 17.000	-39 36.400
144.2833334	-39.58	KI - 9	3	144° 17' 00.00" E	39° 34' 48.00" S	King I	144 17.000	-39 34.800
144.3137212	-39.56316983	KI - 9	3	144° 18' 49.39" E	39° 33' 47.41" S	King I	144 18.823	-39 33.790
144.3316667	-39.56391667	KI - 9	3	144° 19' 54.00" E	39° 33' 50.10" S	King I	144 19.900	-39 33.835
144.3314436	-39.55335432	KI - 9	3	144° 19' 53.19" E	39° 33' 12.07" S	King I	144 19.886	-39 33.201
144.3375	-39.55	KI - 9	3	144° 20' 14.99" E	39° 32' 59.99" S	King I	144 20.249	-39 32.999
144.3666667	-39.55	KI - 9	3	144° 21' 59.99" E	39° 33' 00.00" S	King I	144 21.999	-39 33.000
144.95795	-39.82167001	KI - BDSE	4	144° 57' 28.62" E	39° 49' 18.01" S	King I	144 57.477	-39 49.300
145.01667	-39.82167003	KI - BDSE	4	145° 01' 00.01" E	39° 49' 18.01" S	King I	145 01.0002	-39 49.300
145.11333	-39.9	KI - BDSE	4	145° 06' 47.98" E	39° 54' 00.00" S	King I	145 06.7998	-39 54.000
145.01	-39.9	KI - BDSE	4	145° 00' 36.00" E	39° 53' 59.99" S	King I	145 00.6000	-39 53.999
144.9418191	-39.82548333	KI - BDSE	4	144° 56' 30.54" E	39° 49' 31.73" S	King I	144 56.509	-39 49.528
144.95795	-39.82548333	KI - BDSE	4	144° 57' 28.62" E	39° 49' 31.73" S	King I	144 57.477	-39 49.528
144.95795	-39.82167001	KI - BDSE	4	144° 57' 28.62" E	39° 49' 18.01" S	King I	144 57.477	-39 49.300
148.3919311	-39.70249938	FI - The Wreck B	9	148° 23' 30.95" E	39° 42' 08.99" S	Flinders I	148 23.515	-39 42.149
148.4570542	-39.73648587	FI - The Wreck B	9	148° 27' 25.39" E	39° 44' 11.34" S	Flinders I	148 27.423	-39 44.189
148.426001	-39.78100336	FI - The Wreck B	9	148° 25' 33.60" E	39° 46' 51.61" S	Flinders I	148 25.560	-39 46.860
148.365001	-39.74916748	FI - The Wreck B	9	148° 21' 54.00" E	39° 44' 57.00" S	Flinders I	148 21.900	-39 44.950
148.3919311	-39.70249938	FI - The Wreck B	9	148° 23' 30.95" E	39° 42' 08.99" S	Flinders I	148 23.515	-39 42.149
148.4570542	-39.73648587	FI - The Wreck B	8	148° 27' 25.39" E	39° 44' 11.34" S	Flinders I	148 27.423	-39 44.189
148.3919311	-39.70249938	FI - The Wreck B	8	148° 23' 30.95" E	39° 42' 08.99" S	Flinders I	148 23.515	-39 42.149
148.40501	-39.6798345	FI - The Wreck B	8	148° 24' 18.03" E	39° 40' 47.40" S	Flinders I	148 24.300	-39 40.790
148.5025011	-39.67133361	FI - The Wreck B	8	148° 30' 09.00" E	39° 40' 16.80" S	Flinders I	148 30.150	-39 40.280
148.4570542	-39.73648587	FI - The Wreck B	8	148° 27' 25.39" E	39° 44' 11.34" S	Flinders I	148 27.423	-39 44.189
148.13	-39.25	FI1	7	148° 07' 47.99" E	39° 15' 00.00" S	Flinders I	148 7.8	-39 15.0
148.13	-39.33	FI1	7	148° 07' 47.99" E	39° 19' 47.99" S	Flinders I	148 7.8	-39 19.8
148.05	-39.33	FI1	7	148° 03' 00.00" E	39° 19' 47.99" S	Flinders I	148 3.0	-39 19.8
148.05	-39.25	FI1	7	148° 03' 00.00" E	39° 15' 00.00" S	Flinders I	148 3.0	-39 15.0
148.05	-39.19	FI1	7	148° 03' 00.00" E	39° 11' 23.99" S	Flinders I	148 3.0	-39 11.4
148.13	-39.19	FI1	7	148° 07' 47.99" E	39° 11' 23.99" S	Flinders I	148 7.8	-39 11.4
148.13	-39.25	FI1	7	148° 07' 47.99" E	39° 15' 00.00" S	Flinders I	148 7.8	-39 15.0
148.3005	-39.215	FI - North - The Sisters	11	148° 18' 01.79" E	39° 12' 54.00" S	Flinders I	148 18.030	-39 12.9
148.3273	-39.2155	FI - North - The Sisters	11	148° 19' 38.28" E	39° 12' 55.79" S	Flinders I	148 19.638	-39 12.929
148.36	-39.24883	FI - North - The Sisters	11	148° 21' 36.00" E	39° 14' 55.78" S	Flinders I	148 21.6	-39 14.929
148.32617	-39.26217	FI - North - The Sisters	11	148° 19' 34.21" E	39° 15' 43.81" S	Flinders I	148 19.570	-39 15.730
148.3005	-39.215	FI - North - The Sisters	11	148° 18' 01.79" E	39° 12' 54.00" S	Flinders I	148 18.030	-39 12.9
148.3424198	-39.20900581	FI - The Sisters East	1	148° 20' 32.71" E	39° 12' 32.42" S	Flinders I	148 20.545	-39 12.540
148.3863266	-39.25242757	FI - The Sisters East	1	148° 23' 10.77" E	39° 15' 08.73" S	Flinders I	148 23.179	-39 15.145
148.3261702	-39.26217026	FI - The Sisters East	1	148° 19' 34.21" E	39° 15' 43.81" S	Flinders I	148 19.570	-39 15.730
148.3261701	-39.26216997	FI - The Sisters East	1	148° 19' 34.21" E	39° 15' 43.81" S	Flinders I	148 19.570	-39 15.730
148.36	-39.24883	FI - The Sisters East	1	148° 21' 36.00" E	39° 14' 55.78" S	Flinders I	148 21.6	-39 14.929
148.3273	-39.2155	FI - The Sisters East	1	148° 19' 38.28" E	39° 12' 55.79" S	Flinders I	148 19.638	-39 12.929
148.3005001	-39.215	FI - The Sisters East	1	148° 18' 01.80" E	39° 12' 54.00" S	Flinders I	148 18.030	-39 12.900
148.3005	-39.21499968	FI - The Sisters East	1	148° 18' 01.79" E	39° 12' 53.99" S	Flinders I	148 18.029	-39 12.899
148.3424198	-39.20900581	FI - The Sisters East	1	148° 20' 32.71" E	39° 12' 32.42" S	Flinders I	148 20.545	-39 12.540
144.9884021	-39.87639513	KI - Three Hummock West	5	144° 59' 18.24" E	39° 52' 35.02" S	King I	144 59.304	-39 52.583
144.9860833	-39.98323333	KI - Three Hummock West	5	144° 59' 09.89" E	39° 58' 59.63" S	King I	144 59.164	-39 58.993
144.9860833	-39.98323333	KI - Three Hummock West	5	144° 59' 09.89" E	39° 58' 59.63" S	King I	144 59.164	-39 58.993
144.9659018	-39.91705589	KI - Three Hummock West	5	144° 57' 57.24" E	39° 55' 01.40" S	King I	144 57.954	-39 55.023
144.8752333	-39.93821667	KI - Three Hummock West	5	144° 52' 30.83" E	39° 56' 17.58" S	King I	144 52.513	-39 56.293
144.8843662	-39.88921621	KI - Three Hummock West	5	144° 53' 03.71" E	39° 53' 21.17" S	King I	144 53.061	-39 53.352
144.9588333	-39.86861667	KI - Three Hummock West	5	144° 57' 31.79" E	39° 52' 07.02" S	King I	144 57.529	-39 52.117
144.9884021	-39.87639513	KI - Three Hummock West	5	144° 59' 18.24" E	39° 52' 35.02" S	King I	144 59.304	-39 52.583
144.9860833	-39.98323333	KI - Three Hummock East	10	144° 59' 09.89" E	39° 58' 59.63" S	King I	144 59.164	-39 58.993
144.9884021	-39.87639513	KI - Three Hummock East	10	144° 59' 18.24" E	39° 52' 35.02" S	King I	144 59.304	-39 52.583

144.9884021	-39.87639513	KI - Three Hummock East	10	144° 59' 18.24" E	39° 52' 35.02" S	King I	144 59.304	-39 52.583
145.01	-39.9	KI - Three Hummock East	10	145° 00' 36.00" E	39° 53' 59.99" S	King I	145 00.6000	-39 53.999
145.01	-39.9	KI - Three Hummock East	10	145° 00' 36.00" E	39° 53' 59.99" S	King I	145 00.6000	-39 53.999
145.0244949	-39.9	KI - Three Hummock East	10	145° 01' 28.18" E	39° 53' 59.99" S	King I	145 01.4696	-39 53.999
145.1075685	-39.9	KI - Three Hummock East	10	145° 06' 27.24" E	39° 54' 00.00" S	King I	145 06.4541	-39 54.000
145.1069616	-39.94999994	KI - Three Hummock East	10	145° 06' 25.06" E	39° 56' 59.99" S	King I	145 06.4176	-39 56.999
145.1162833	-39.99086667	KI - Three Hummock East	10	145° 06' 58.61" E	39° 59' 27.12" S	King I	145 06.9769	-39 59.452
145.01	-39.98463551	KI - Three Hummock East	10	145° 00' 36.00" E	39° 59' 04.68" S	King I	145 00.6000	-39 59.078
144.9860833	-39.98323333	KI - Three Hummock East	10	144° 59' 09.89" E	39° 58' 59.63" S	King I	144 59.164	-39 58.993