Eastern Zone 2023-2025 Size-limit Changes

Jaime McAllister

2024-07-31

Contents

1 Background

Since 2019 a series of Size Limit changes have gradually been introduced to the fishery with the aim of providing three years of protection post reproductive maturity of abalone populations around Tasmania. That required an increase in the Legal Minimum Length (LML) for the Tasmanian Eastern Zone blacklip fishery from 138 mm to 145 mm. This increase in LML was scheduled to occur in three steps, with the first step (138 mm to 140mm)implemented in 2023. The second step (140 mm to 142 mm) in 2024, and third (142 mm to 145 mm) is scheduled for 2025.

Altering size limits is anticipated to impact abalone stocks in various ways. An increase in the LML initially reduces the exploitable biomass, which is predicted to have short-term impacts on catch and catch rates, along with long-term advantages such as enhanced stock and stock biomass. However, there are diverse opinions within the industry regarding size limits. While most support the long-term benefits, there's often a counterargument that some populations may never reach the sizes of an increased LML, thereby reducing available biomass and causing a decrease in CPUE. Given that CPUE is a crucial element of the Harvest Control Rule (HCR) in the empirical Harvest Strategy (eHS), there's a worry that this might lead to a decrease in the total allowable commercial catch (TACC) in the year following the implementation of an LML increase. Abalone exhibit indeterministic growth that can be slower or faster, influenced by various biological and environmental factors. As a result, the time it takes for abalone to reach a certain size, such as the increased Legal Minimum Length (LML), may differ based on their location and the conditions they experience. This concern is particularly prevalent in the Eastern Zone, where it's been suggested that the planned LML increase to 145 mm in Block 13 (Actaeon's Region) is too high and abalone will never reach these sizes. The aim of these analyses is to offer a summary of the available size structure trends in Actaeon's region to evaluate the impact of LML increases on stock availability and aid in making informed management decisions. The primary objectives were to:

1. Investigate historical trends in size structure.
2. Analyze recent length-weight data to determine its effect on abalone harvest numbers and biomass.

2 Size structure compositions

2.1 Historical size stucture 1984-2024

Size composition data collected since 1984 has varied markedly between years. Catch compositions were comprised of a broader size distribution up until the early 2000s, however, since then have become increasingly dominated by animals between the LML and 155 mm (Figure 1). In all years there is clearly evidence of large abalone >160 mm and in many cases animals in excess of 200 mm present in catches, and since 2010 the median size has regularly exceeded the the scheduled 145 mm LML increase.

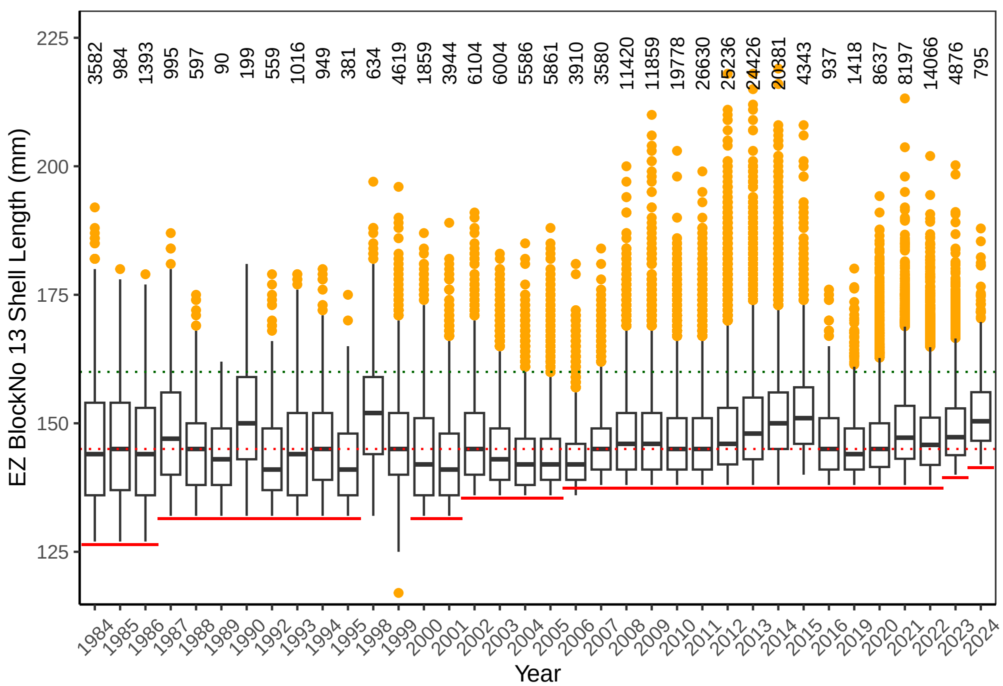

Figure 1: Block 13 EZ: Boxplot of length frequency distributions between 1984 and 2024. Red line under each boxplot indicates LML for that year. Red dotted line represents LML = 145 mm; green dotted line denotes a shell length = 160 mm; oranges dots are individual abalone measurments (outliers). Number of abalone measured given above each boxplot.

2.2 Percentage contribution of scheduled LML changes to catch

A breakdown of historical catch compositions into the scheduled LML changes in the Eastern Zone demonstrates that catches have been dominated by abalone with a median around 145 mm throughout time series (Figure 1). Cycles in recruitment are also apparent with a significant period of re-build and recruitment occurring during the mid 2000s demonstrated by a higher proportion of smaller individuals dominating catches (Figure 2). A similar pattern of recruitment has also occurred in recent years with an apparent pulse of smaller individuals entering the fishery around 2019 which have since progressed to dominate catches as larger individuals in latter years (Figure 2).

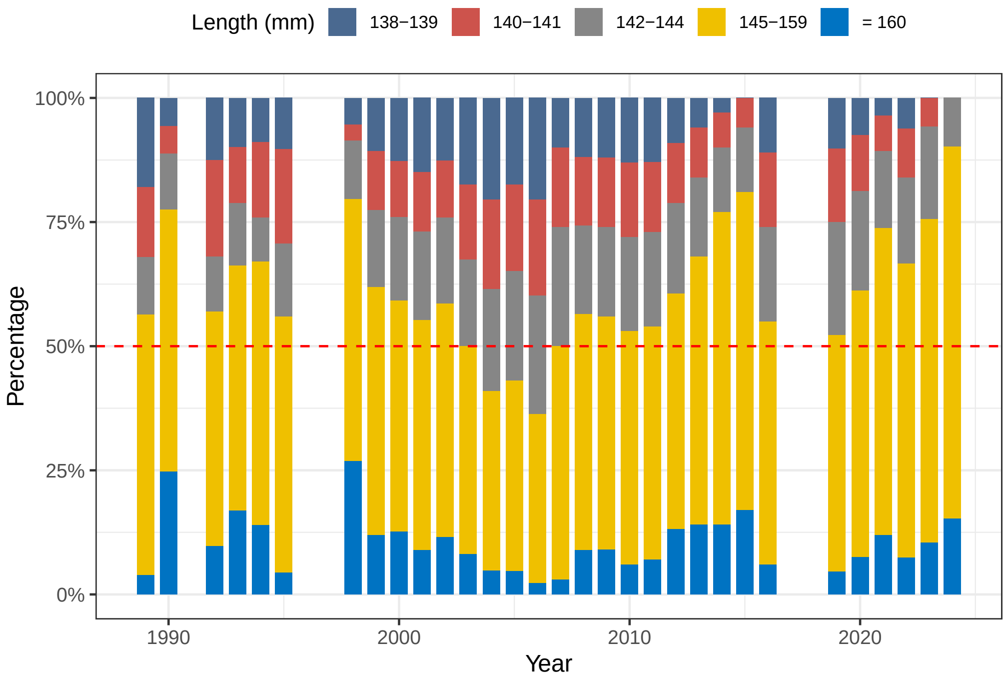

Figure 2: Block 13 EZ: Percentage contribution of size classes to commercial abalone catches collected between 2019-2024.

3 Size structure 2019-2024

Further examination of more recent size composition data between 2019 and 2024 shows the majority of catches have been dominated by animals between the LML and 155 mm (Figure 3). There are clearly animals still reaching sizes >155 mm, however, the fishery has largely become recruitment driven and catches dominated by animals <155 mm. Off concern, is these recent catches (2019-2024) appear to have been dominated by a single cohort from an initial recruitment pulse around 2019, evidenced by an increasing median size and absence of animals nearer to the LML. These trends suggest there has likely been a suppression of recruitment sometime in fishery since around 2019 and has resulted in an increasing dependence on older cohorts animals that are gradually increasing in size. Consequently, as fishing depletes the older cohorts, their abundance decreases, and without new recruits, this is likely to result in declining CPUE.

3.1 Within year size composition

Productivity is therefore highly variable across reefs which in turn can determine the spatial distribution of fishing effort and rate of harvest. More productive, faster growing areas tend to be fished more regularly whereas less effort may be directed towards slower growing and less productive areas. Abalone populations are also spatially dynamic and can vary in size structure across small spatial distances (i.e. 10s to 100s metres). Therefore it is not surprising that within a fishing year (2023) there is high variability in size structure between catches from the Actaeons (Figure 4). However, it is interesting to note that in 93% of catches, the median size of animals was >145 mm and in every catch there was at least one animal >158 mm.

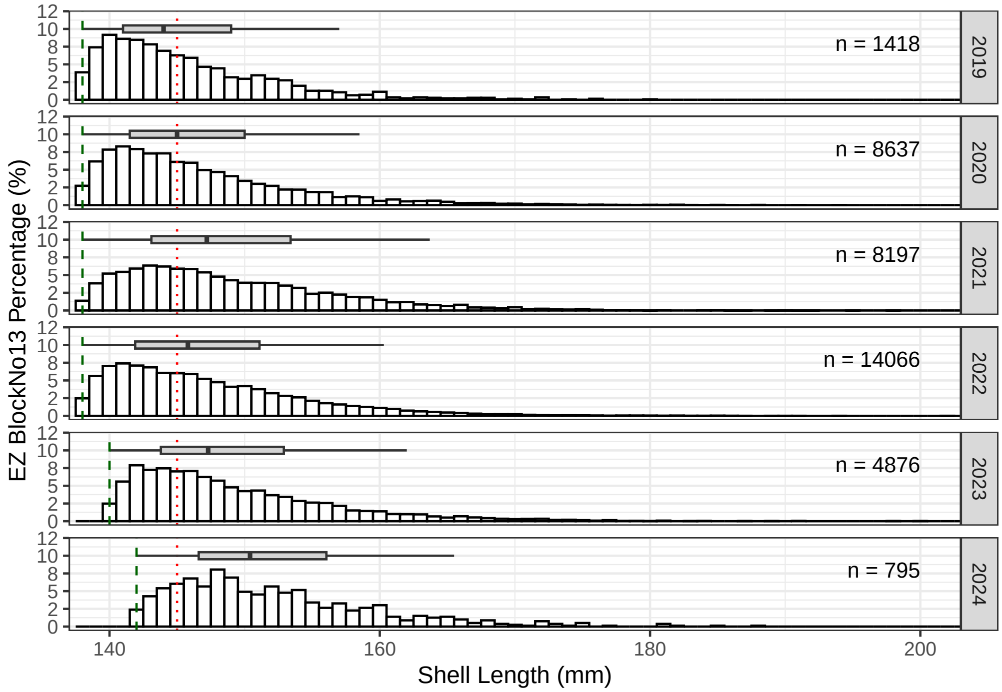

Figure 3: Block 13 EZ: Length frequency distributions between 2019 and 2024. Green dashed line indicates LML for that year; red dotted line indicates LML = 145 mm. n = number of abalone measured.

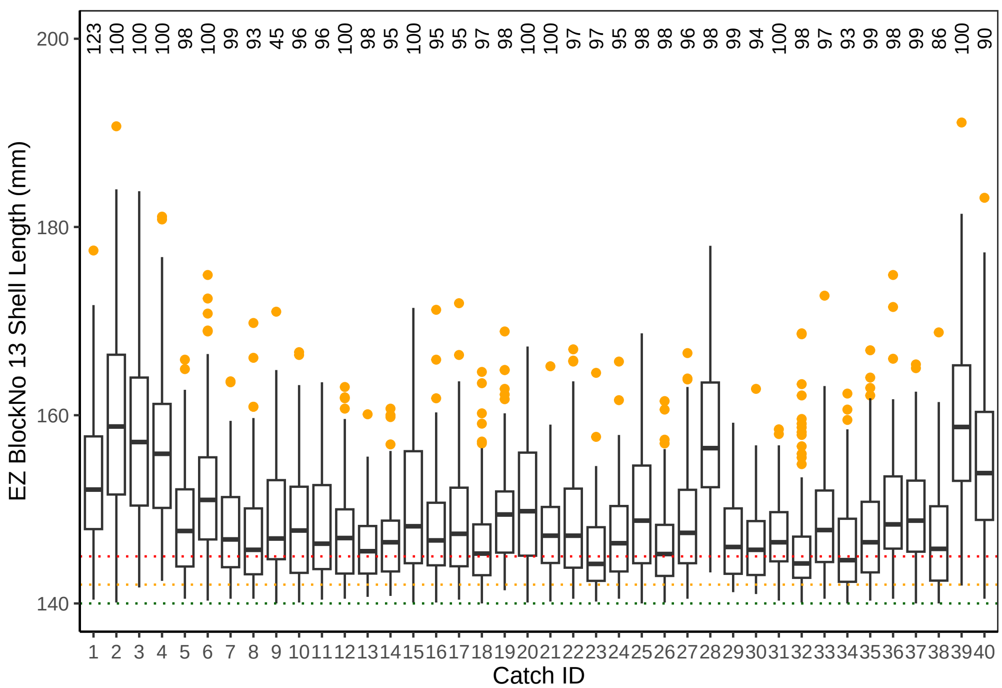

Figure 4: Block 13 EZ: Range of size compositions between individual commercial abalone catches collected in 2023.

4 Length-weight relationship 2019-2024

4.1 Background

Length and weight data have been collected concurrently since 2019 using Scielex NextGen measuring boards with integrated platform scales at various abalone processing factories around Tasmania. This is providing an improved understanding of stock performance across many parts of the fishery whilst also facilitating processors with grading and handling information on processed catches. Importantly these data have enabled a refinement of length-weight relationships for stock assessments which are used here for translating catch composition in terms of catch numbers to weight estimates in assessing the effects of size limit changes to landed biomass. Whilst it is evident from length composition data that 61% of abalone measured each year during the period 2019-2024 were on average >145 mm, in order to evaluate how the LML increases may affect harvested biomass and ultimately catch rates (kg/hr), a length-weight relationship was required.

4.2 Length-weight data prepartion

4.2.1 Length-weight data filtering

An initial plot of all length and weight data collected since 2019 to look for any obvious data outliers (Figure 5). There are clearly several erroneous length and weight data collected in the initial plot and can be attributed to:

1. Abalone weights <200 g or >1500 g are highly unlikely.
2. Calibration and practice measurements taken at the default return position of the measuring gates (i.e. 100 mm).
3. Measurement errors caused by operator error where animals are below the LML for a particular Zone especially where the measurement is >5 mm below the LML (e.g. animals being measured shell side down or passed through the gates at an angle).
4. Failure to tare scales and abalone weights unlikely to correspond to appropriate length depending on the Zone (e.g. EZ - shell length > 175 mm and whole weight <600 g; shell length > 180 mm and whole weight <1000 g).

4.2.2 Summary of available length-weight data for Zone and Block

Summary of catches measured in chosen Zone and Block where the catch can be assigned to a single Block (i.e. only a single Block listed on Docket) (Table 1).

Table 1: Block 13 EZ: Summary of catches measured from commercial abalone catch sampling data collected between 2019-2024.

Fishing Year	Catches	n	Mean Length (mm)	Mean Weight (g)
2019	10	912	146	510
2020	45	3966	148	565
2021	83	8040	149	550
2022	96	9244	147	551
2023	40	3765	150	582
2024	10	767	152	595

4.2.3 Selected Zone and Block data filtering

Re-examining the length and weight data collected since 2019 to look for any remaining data outliers that may be specific to this region (Figure 6). For the Actaeon's there are specific erroneous data which are

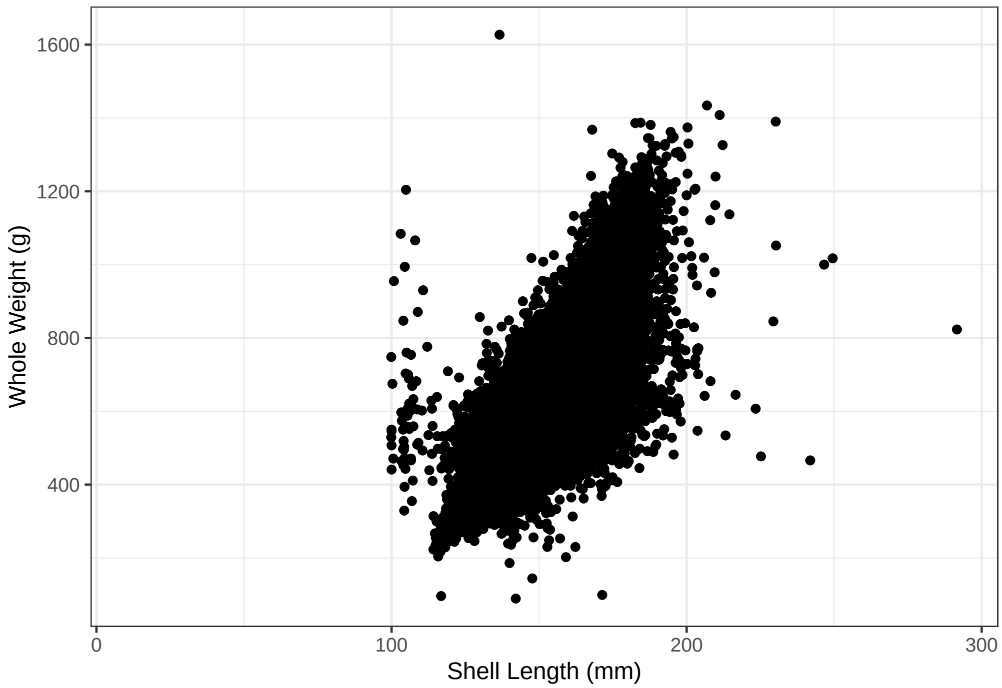

Figure 5: Length-weight relationship of all commercial abalone catch sampling data collected between 2019-2024.

apparent based on known size and likely weights, shell length >175 mm and whole weight <600 g, or shell length >180 mm and whole weight <1000 g are likely to be measuring board operator errors and the failure to tare the platform scales. Removal of these data can be seen in cleaned length-weight relationship plot (Figure 7).

4.3 Calculation of length-weight relationships for selected Zone and Block

The length-weight relationship was calculated by fitting the data to a two-parameter power function of the form

$W_i = aL_i^b$ (1)

where a and b are constants. The length-weight model (1)can be transformed to a linear model by taking the natural logarithms of both sides and simplifying,

$\log(W_i) = \log(a) + \log(L_i)$ (2)

Thus, with *y=log(W)*, *x=log(L)*, slope=b, and intercept=*log(a)*, (2) is in the form of a linear model. The transformed model is then fit with *lm()* by submitting a formula of the form *y~x* as the first argument followed by a *data=* argument set equal to the data frame where the log-tranformed variables can be found.

Table 2: Block 13 EZ: Estimated length-weight model parameters from commercial abalone catch sampling data collected between 2019-2024.

Zone	BlockNo	a	b	n
E	13	0.0053805	2.307653	26625

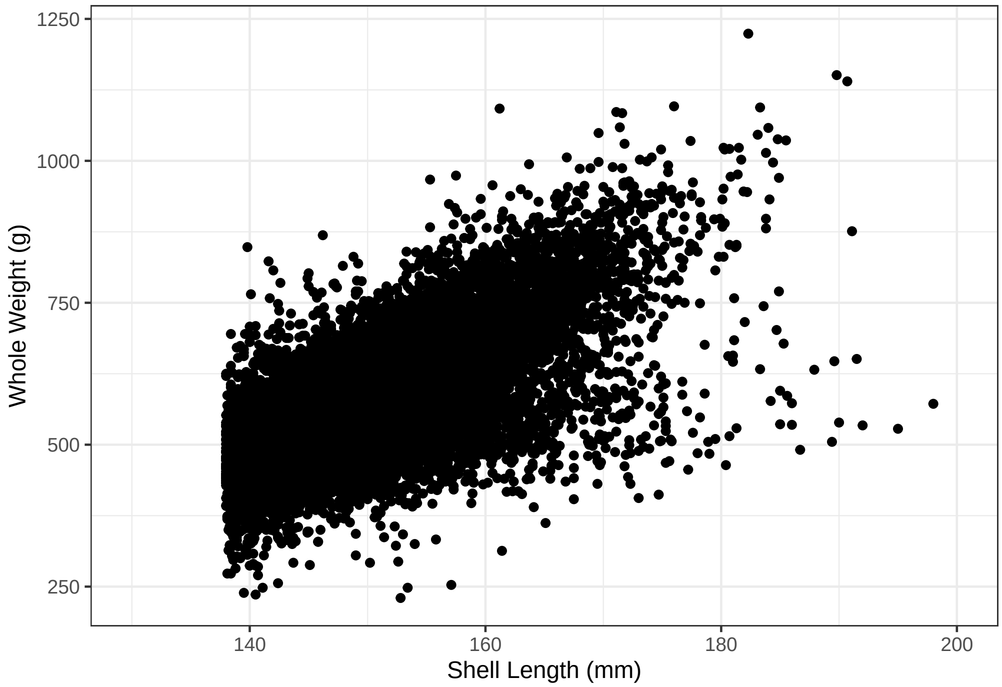

Figure 6: Block 13 EZ: Length-weight relationship of commercial abalone catch sampling data collected between 2019-2024.

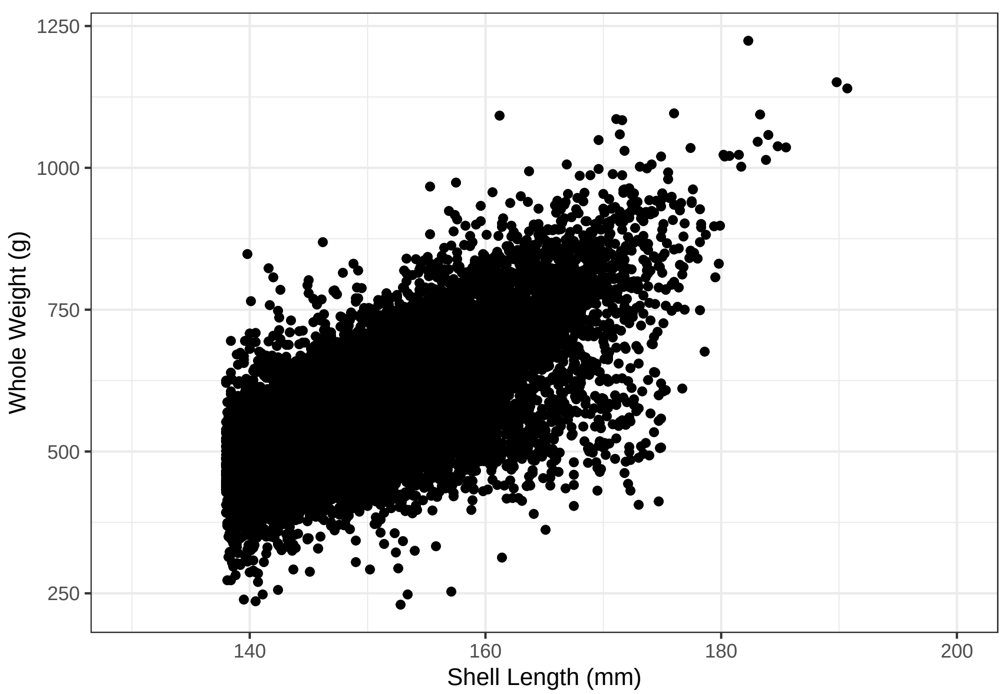

Figure 7: Block 13 EZ: Length-weight relationship of cleaned commercial abalone catch sampling data collected between 2019-2024.

4.4 Calculate percent contribution of abalone by weight and numbers

The calculated length-weight model parameters for the Zone and Block were used to estimate the individual abalone weight for each 1 mm size class above the previous LML (i.e. 138 mm). The estimated size class weight was then multiplied by the total number of individuals measured to determine the total weight of that size class. The estimated total weight and numbers measured were then grouped into the LML incremental changes and summed to determine the percentage by weight and numbers of that size class to the overall size composition data.

Table 3: Block 13 EZ: Estimated percentage contribution of each 1 mm size class by weight and numbers using length-weight model parameters from commercial abalone catch sampling data collected between 2019-2024 *(a = 0.00538; b = 2.308)*.

Shell Length (mm)	Estimated Weight (g)	n	Catch Weight (kg)	Percent n	Percent Weight
138	466.6	790	369	2.959	2.513
139	474.4	1236	586	4.630	3.990
140	482.3	1579	762	5.915	5.189
141	490.3	1703	835	6.380	5.686
142	498.4	1766	880	6.616	5.992
143	506.5	1751	887	6.560	6.040
144	514.7	1684	867	6.309	5.904
145	523.0	1637	856	6.132	5.829
146	531.4	1564	831	5.859	5.658
147	539.8	1373	741	5.143	5.046
148	548.3	1317	722	4.934	4.916
149	556.9	1120	624	4.196	4.249
150	565.6	1072	606	4.016	4.126
151	574.3	983	565	3.682	3.847
152	583.1	897	523	3.360	3.561
153	592.0	856	507	3.207	3.452
154	601.0	692	416	2.592	2.833
155	610.0	624	381	2.338	2.594
156	619.1	583	361	2.184	2.458
157	628.3	471	296	1.764	2.016
158	637.6	415	265	1.555	1.804
159	647.0	419	271	1.570	1.845
160	656.4	311	204	1.165	1.389
161	665.9	257	171	0.963	1.164
162	675.5	228	154	0.854	1.049
163	685.1	226	155	0.847	1.055
164	694.9	170	118	0.637	0.803
165	704.7	156	110	0.584	0.749
166	714.6	129	92	0.483	0.626
167	724.6	110	80	0.412	0.545
168	734.6	103	76	0.386	0.517
169	744.7	72	54	0.270	0.368
170	755.0	74	56	0.277	0.381
171	765.2	64	49	0.240	0.334
172	775.6	50	39	0.187	0.266
173	786.1	39	31	0.146	0.211
174	796.6	32	25	0.120	0.170

175	807.2	30	24	0.112	0.163
176	817.9	18	15	0.067	0.102
177	828.6	11	9	0.041	0.061
178	839.5	12	10	0.045	0.068
179	850.4	6	5	0.022	0.034
180	861.4	13	11	0.049	0.075
181	872.5	12	10	0.045	0.068
182	883.7	3	3	0.011	0.020
183	894.9	7	6	0.026	0.041
184	906.2	8	7	0.030	0.048
185	917.6	5	5	0.019	0.034
186	929.1	3	3	0.011	0.020
187	940.7	1	1	0.004	0.007
189	964.1	3	3	0.011	0.020
190	975.9	2	2	0.007	0.014
191	987.8	2	2	0.007	0.014
192	999.7	1	1	0.004	0.007
195	1036.2	1	1	0.004	0.007
198	1073.3	1	1	0.004	0.007
203	1136.9	1	1	0.004	0.007
213	1270.3	1	1	0.004	0.007

5 Results

5.1 Percentage contribution of scheduled LML increases to current catch

Translating catch numbers to weight suggests the 61% of animals measured larger than maximum LML increase to 145 mm would equate to approximately 65% of the harvested biomass (Table 4). Whilst this may represent an initial 40% and 35% reduction in harvested numbers and biomass, respectively, it assumes a scenario where the LML increase occurs in a single step from 138 mm to 145 mm and therefore does not account for any growth or modal progression of animals likely to occur under the staged LML schedule. Understanding the modal size progression of abalone from one year to the next requires estimated annual growth increments for each size class to determine, for example, what proportion of animals at the present LML at the beginning of one year would have been available at an increased LML later in that year or the year following.

Table 4: Block 13 EZ: Estimated percentage contribution of abalone by weight and numbers to size classes representing the scheduled LML increases using length-weight model parameters from commercial abalone catch sampling data collected between 2019-2024 *(a = 0.00538; b = 2.308)*.

Size Class (mm)	Percent Weight	Percent n
138-139 mm	6.5	7.6
140-141 mm	10.9	12.3
142-144 mm	17.9	19.5
$\geq$ 145 mm	64.7	60.6

5.2 Percentage change in catch numbers harvested with increased LML

While incremental growth data could offer a more comprehensive understanding of animal availability year by year, we can infer potential changes in the number of animals harvested under increased Legal Minimum Lengths (LMLs) using length-weight data. This inference is made possible by considering the additional size and subsequently, the individual weight increase that an elevated LML would allow. In this scenario, we utilize the estimated weight of an individual abalone at various sizes to calculate the change in the number of abalone needed to harvest 100 kg. With an LML of 138 mm, it requires 214 abalone to be harvested. However, if the LML were increased to 145 mm, 10% fewer abalone (i.e., n = 191) would be needed (Table 5).

Table 5: Block 13 EZ: Estimated number of animals in 100 kg of catch and percentage change in animals harvested to attain the same level of catch for the nominated LML increase based on length-weight model parameters from commercial abalone catch sampling data collected between 2019-2024 *(a = 0.00538; b = 2.308).*

LML (mm)	Estimated Weight (g)	Estimated n	Percent Change
138	466.6	214	
145	523.0	191	11

6 Summary

Abalone catches from the Actaeons are currently dominated by animals from a small size range close to the (i.e. LML 138-155 mm) which has become increasingly skewed towards the upper limits of this range in more recent years (2019-2024). There is clear evidence of animals attaining sizes >155 mm throughout the time series. These size structures suggest the Acteaon's has become something of a recruit based fishery, where individuals are taken within a few years if reaching the LML and enter the fishery. However, the presence of large individuals >155 mm does not support the idea that growth in these populations is limiting and that something like a 145 mm LML is too high, rather it indicates that exploitation and harvest rates are likely still too high to allow animals time to reach these larger sizes in any great numbers. Consequently, any external events (e.g. MHW, storms) that affect recruitment, means that the harvest has to switch to larger size classes (>145mm) of which there is not much, and CPUE is likely to fall quickly.