Shell Measurement

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Purpose

The current definition of scallop biological measurement of shell height is

"The scallop biological measurement is shell height (in mm). This is defined as the straight-line distance from the umbo to the outer shell margin, perpendicular to the hinge. The top valve of the animal is measured when determining shell height. The bottom valve is typically larger than the top valve and it protrudes beyond the top shell's margin. Care should be given when measuring shell height so not to include the bottom valve."

The top valve is thinner and more fragile than the bottom valve and commonly is chipped during dredge fishing, owing to the disparity in valve size that is often observed. Further, collection of top valve measurements is only possible with calipers, which takes more time and dexterity than the typical alternative - a measuring board. To increae measurement efficiency and possibly reduce measurement error, a new defintion of shell height measurement was purposed

"The scallop biological measurement is shell height (in mm). This is defined as the straight-line distance from the umbo to the outer shell margin, perpendicular to the hinge."

This shift in definition would also bring shell height measurment into closer alignment with that used for Atlantic sea scallops (*Placopecten magellanicus*) by federal regulation

"...Shell height is a straight-line measurement from the hinge to the part of the shell that is farthest away from the hinge" (50 CFR, 648.50).

Prior to implementing a switch in shell height measurement, it is necessary to quantify the different between measurement methods and consider possible data treatments (i.e. if needed) for data collected under the previous definition. During the 2021 dredge survey, a special project was conducted to collect top and bottom valve measurements from a subsample of individuals across the entire survey area in East and West Kayak Island and Yakutat districts.

Data

Data collection targeted measuring ($n = 30$) scallops per 10 mm size bin based on the top valve across the entire survey area. Actual sample sizes are listed in Table (1). Three data points were presumed to be outliers and removed (Figure 1). All bottom valve measurements were either equal to or larger than top valve measurements (Figure 1). Difference between valves increases with scallop size (Table 1).

Table 1: Number of scallops measured sampled across n hauls, mean top valve measurement (mm), and mean valve difference (bottom - top; mm) per 10 mm size bin.

Size bin (mm)	Number measured	Number of hauls	Mean top valve (mm)	Mean diff(mm)
10-19 mm	28	7	17	0
20-29 mm	38	8	25	0
30-39 mm	41	16	33	0
40-49 mm	31	11	45	1
50-59 mm	32	12	55	1
60-69 mm	31	10	65	1
70-79 mm	28	7	75	2
80-89 mm	39	8	85	2
90-99 mm	36	12	94	2
100-109 mm	59	13	104	2
110-119 mm	46	17	115	2
120-129 mm	29	14	126	2
130-139 mm	35	12	135	2
140-149 mm	47	8	145	2
150-159 mm	37	6	154	3
160-169 mm	14	9	162	3
170-179 mm	1	1	170	4
180-189 mm	1	1	184	5

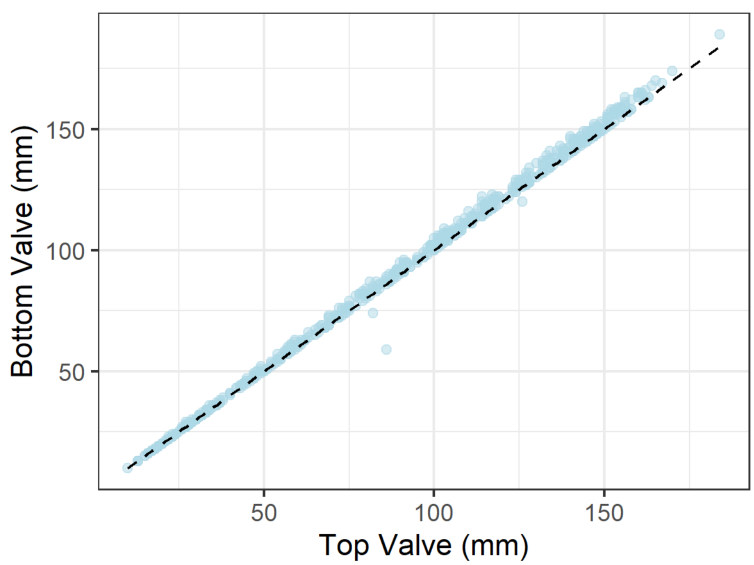

Figure 1: Scatter plot of all top and bottom valve measurements (mm). The dotted line represents a 1:1 relationship.

Length Conversion

Length (L) conversions in fishes (total length to fork length, standard length, etc.) are often made in the form of a simple linear regression in the form of

$$L_2 = \beta_0 + \beta_1 L_1 \tag{1}$$

When lengths are directly proportional, $\beta_0 = 0$ and β_1 represents the ratio between sizes. Linear models were fit to scallop shell height data with and without an intercept parameter (β_0) as

$$L_{bottom} = \beta_0 + \beta_1 L_{top} + \epsilon \tag{2}$$

where L is shell height (either bottom or top valve) and ϵ is normally distributed error. The better parameterization was chosen via ANOVA (2). The intercept term did not significantly differ from zero, and the ratio between valve measurements was near 1 ($\beta_1 = 1.018$) (Figure 2). Although the conversion ratio suggests valve measurements are near equal, it equates to a difference of several millimeters at large sizes which could be meaningful in certain circumstances.

Table 2: ANOVA table for length conversion models with and without and intercept term.

Model	Residual df	RSS	F	P-value
OLS w/ intercept	571	1,346.2	0.09	0.76
OLS w/o intercept	572	1,346.4		

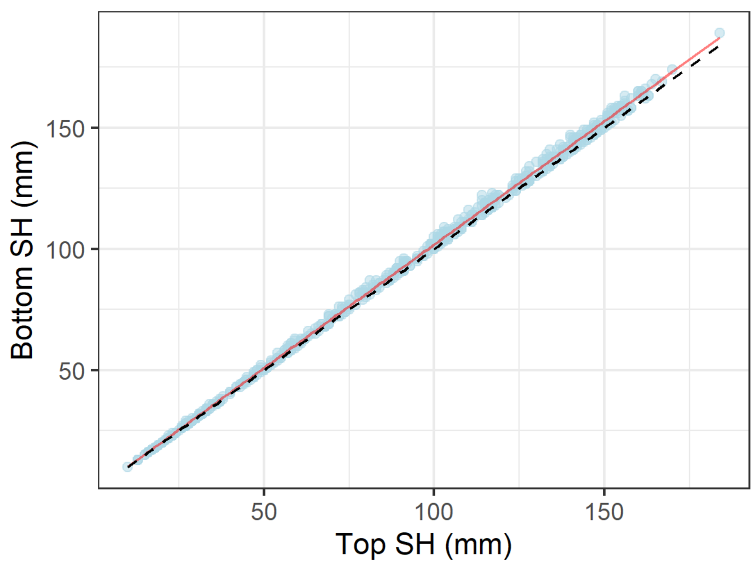

Figure 2: Scatter plot of top and bottom valve measurements (mm) with linear fitted line, in which $\beta_0 = 0$ (red line). The dotted line represents a 1:1 relationship.

How to Treat Previous Data

The decision of whether to convert data collected prior to the formal switch measuring boards is made difficult by the nature of difference bewteen top and bottom valve measurements, that is, differences are caused by disturbance rather than shell anatomy (Burt and hopkins, ADF&G, pers. commun.). If it can be assumed that the dergee of top valve damage (i.e. difference in measurement) found in this sample is consistent with other data sources (e.g. prior surveys, observer data) and locations (e.g. Kodiak districts, etc.) it may be reasonable to convert shell height measurements from data sources where it is known that only the top valve was measured. Shell heights collected by observers during scallop fisheries from 1996 - 2021 exclusively measured only the top valve, using calipers. Dredge surveys from 1996 - 2019 used both calipers and measuring boards, and thus measured both top and bottom valves. Dredge survey data collected from 2020 - 2021 included only top valve measurements. Under most circumstances a small directional bias in shell height measurement will not influence scallop fishery management, and would go unnoticed (i.e., there is no quantitative analysis of size composition that influences harvest controls). However, measurement bias would likely impact size-based population dynamics modelling, especially when the width of size stages is refined ($\leq$ 5 mm). Modelling efforts could evaluate wider size stages, or evaluate model fit with and without size conversion. These data provide an adequete estimate of a conversion factor for that purpose, though it may be prudent to repeat this analysis with data collected during the fishery since it is known that that timeseries consists of only top valve measurements and larger gear and catch may result in slightly different rates of top valve damage.