VIMS Dredge Survey Nantucket Lightship SHMW Analysis

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<u>Methods</u>

Shell height meat weight relationships (SHMW) were estimated for the Nantucket Lightship (NL) survey for the NLS_West, NLS_North, and NLS_South_Deep SAMS Areas with VIMS dredge survey data. SHMW relationships were developed using a combined dataset from 2016 - 2022. Surveys from 2016 - 2019, 2021, and 2022 occurred in June or July of a given year. The 2020 survey was delayed due to COVID-19 travel restrictions and was completed in late September of 2020.

Station-level data from the 2016 - 2019 surveys were reassigned to 2022 SAMS Areas for analysis. These SAMS Areas have been consistent for 2020 – 2022. VIMS' protocols dictate that at every station with scallop catch, up to 15 scallop that encompass the length distribution of scallops at a given station are sampled to collect data on meat weight, gonad weight, meat quality, sex, maturity stage, and disease prevalence. The shell height is taken for each scallop assessed, and then the adductor muscle and gonad are carefully removed. The adductor muscle and gonad are weighed with a Marel M2200 motion compensating scale. Maturity stage, classified into six stages, is assessed by visual examination of the gonad.

SHMW mixed effect models were developed with forward selection and variables were retained in the model if the AIC was reduced three or more units. SAMS Area was included in all models to estimate the SAMS Area effect. The model with the lowest AIC was selected as the preferred model and used to predict SHMW relationships by SAMS Area. If models were within three units of each other, a likelihood ratio test was used to test for significant differences between models. If there was no significant difference between the models, the more parsimonious model was selected as the preferred model. Variables considered were: ln shell height, ln depth (average depth for a station), SAMS Area (retained in all models), latitude (beginning latitude of a station), and an interaction term of shell height and depth. The impact on a delayed 2020 survey on SHMW relationships was investigated in 2021 by including maturity stage as a predictor variable. There were no differences between SHMW curves with and without maturity and as such this variable was not considered in 2022. A Tukey's honestly significant difference post-hoc test was run to test for differences between SAMS Area means for all three SAMS Areas. Tables provided below include the SHMW models with parameters and AIC by SAMS Area. Parameter estimates for the preferred model and predicted SHMW relationships are also provided. Predicted SHMW curves estimated for the South Deep SAMS Area from the VIMS preferred model were compared to those using the SARC 65 parameters as well as the VIMS 2021 annual SHMW equation, and the VIMS 2015-2021 SHMW equation.

<u>Results</u>

The preferred model included shell height, SAMS Area, latitude, and depth as fixed effects (Table 1). This is consistent with results from 2020 and 2021.   All predictor variables were significant (Table 2). The NL_South_Deep and NLS_West SAMS Areas were significantly different from the reference SAMS Area, the NLS_North SAMS Area. Predicted SHMW curves indicate the NLS_South_Deep continues to have lower meat weights across the length range compared to the other three SAMS Areas (Figure 1).

Post-hoc pairwise comparisons for SAMS Area indicated significant differences between all pairs of SAMS Areas (all p-values < 0.001). The SARC 65 and VIMS 2021 SHMW curves were higher compared to the VIMS 2022 and combined VIMS 2016-2021 curves, with the VIMS 2021 curve having the greatest meat weight at a given shell height (Figure 2).

Table 1. SHMW models for the 2016 - 2022 VIMS NL survey data. Model in bold was selected as the preferred model. The number of parameters (K), AIC, ΔAIC, AIC weight, and Deviance explained are also included.

Models	Parameters	K	AIC	ΔAIC	AIC Weight	Deviance
m4	**~1 + Shell Height + SAMS Area + Depth + Latitude**	**8**	**59,797.90**	**-**	**0.77**	**75.19**
m2	~1 + Shell Height*Depth + SAMS Area + Latitude	9	59,800.29	2.40	0.23	75.19
m5	~1 + Shell Height + SAMS Area + Latitude	7	59,813.25	15.36	0	75.20
m3	~1 + Shell Height + SAMS Area + Depth	7	59,819.42	21.53	0	75.18
m1	~1 + Shell Height*Depth + SAMS Area	8	59,821.10	23.20	0	75.18
null	~1	3	74,657.66	14,859.76	0	

Table 2. Parameter estimates for model m4 from Table 1.

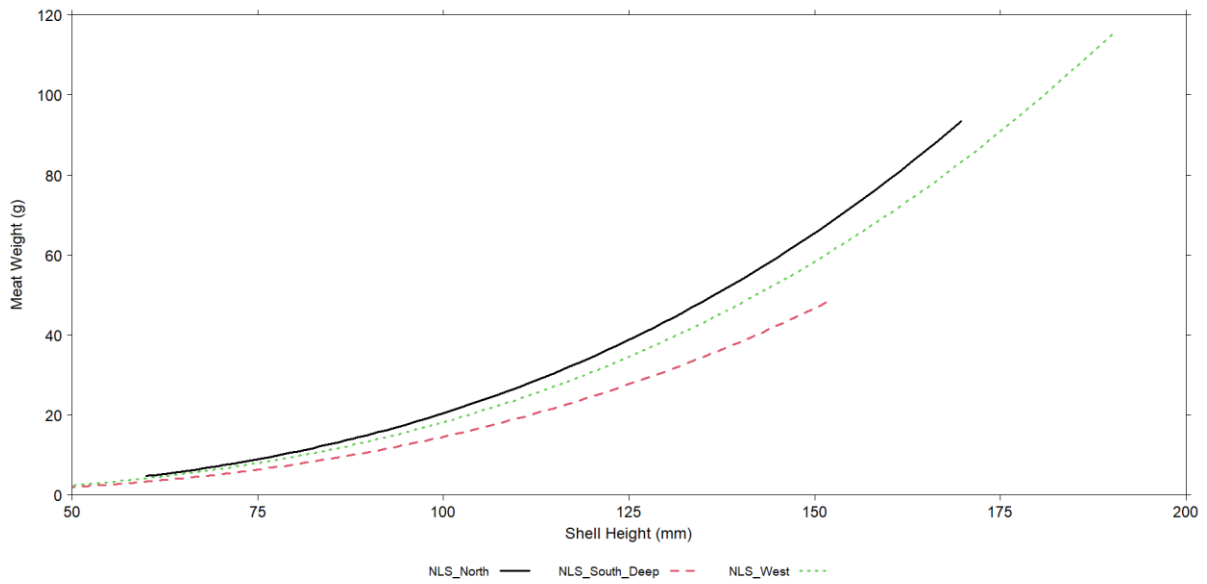| Parameter	Parameter Estimate
Intercept	-30.73
Shell Height	2.87
NLS_South_Deep	-0.19
NLS_West	-0.08
Depth	-0.26
Latitude	0.53

Figure 1. Predicted SHMW relationships by SAMS Area using the preferred model m4 from Table2.
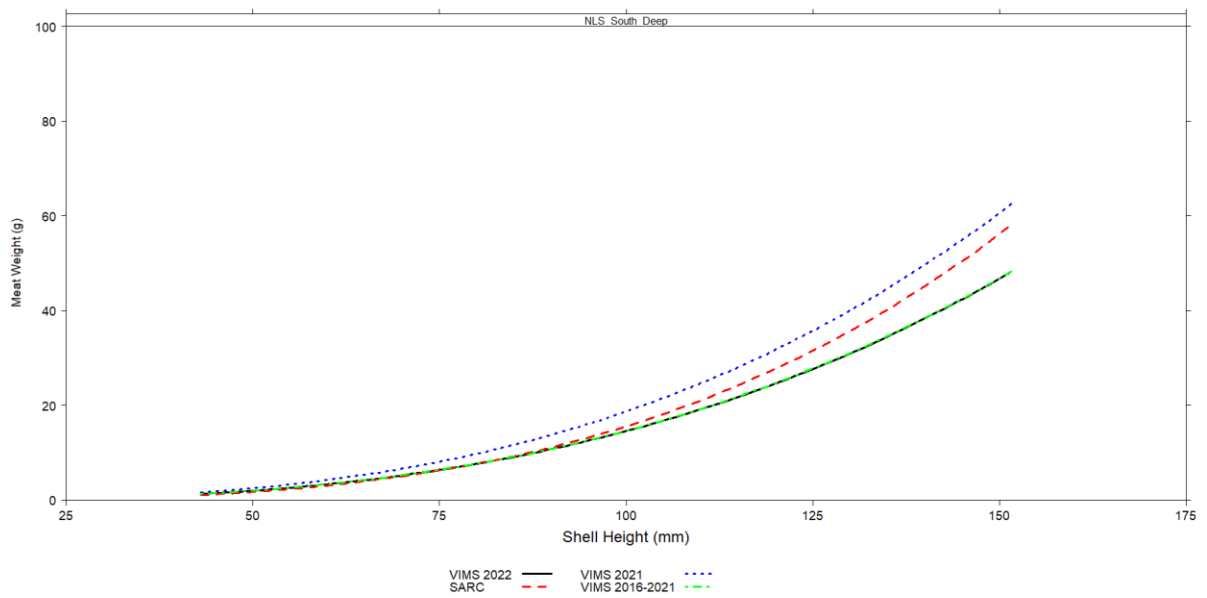

Figure 2. Predicted SHMW relationships for the South Deep using the VIMS 2022 annual SHMW equation, the VIMS 2021 annual SHMW, the SARC 65 SAHMW equation, and the VIMS combined 2016-2021 SHMW equation.

Discussion

SHMW relationships in the NL continue to show a similar trend across years. Results from the 2020 and 2021 SHMW analyses are similar to this year's analysis with respect to the preferred model, parameter estimates, and predicted SHMW curves by SAMS Area. The South_Deep SAMS Area continues to have a lower meat weight at shell height compared to the other SAMS Areas. This SAMS Area is significantly different from the reference case, NLS_North SAMS Area and the NL_West SAMS Area. A comparison of biomass estimates for the three SAMS Areas is provided below. Table 3 compares total biomass (mt) using the SARC 65 SHMW parameters and the VIMS SAMS Area specific SHMW parameters for all three SAMS Areas. As with 2021, applying VIMS SHMW parameters lowers biomass estimates.

The difference between the VIMS 2021 SHMW curve and the VIMS 2022 and VIMS combined years SHMW curves may be explained by the growth observed in this SAMS Area in 2021. Prior to 2021, scallops in the South Deep SAMS Area had limited growth and increases in yield. This was the first year scallop shell height and mean meat weight increased substantially. There was some limited growth in 2019 and 2020. The difference observed between the SARC and VIMS 2022 curves indicates long term resource conditions in this SAMS Area remain below expectations.

Table 3. Total biomass (mt) estimates for the three NL SAMS Areas using the SARC 65 and VIMS 2016-2022 SHMW equations along with the relative difference.

SAMS Area	Total Biomass (mt)		Relative Difference
	SARC 65	VIMS 2016-2022	
NLS_North	857.20	668.05	-22%
NLS_South_Deep	3,381.79	2,842.72	-16%
NLS_West	292.95	175.32	-40%