ALLOMETRIC RELATIONSHIPS AND GROWTH IN THE SEA SCALLOP, *PLACOPECTEN MAGELLANICUS*: THE EFFECTS OF SEASON AND DEPTH

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ABSTRACT

The rates of growth over several years have been compared between two shallow-water (20 m) and two deep-water (170 m) populations of sea scallops, *Placopecten magellanicus*, in the Gulf of Maine. One shallow-water population was tagged and released in 1977 with commercial returns over the following four years. The other was tagged and released in 1978 and periodically retrieved and measured by divers over a four year period. The two deep-water populations were sampled periodically over eight years and growth was measured through analysis of length frequency of an anomalous year class. Significant differences in rate of growth were found between the scallop populations at the two depths, with the shallow-water populations exhibiting the greater rates of growth.

In a subsequent study of a scallop population at each of the two depths, seasonal changes in allometric relationships have been compared. Shell length, width and weight as well as whole tissue, gonad, adductor muscle, mantle and viscera dry weights have been regressed on shell height for each season for both populations. Significant differences were found between the two populations with respect to shell/tissue relationships. Shallow-water scallops have heavier, more concave shells and significantly more tissue when compared with animals of comparable height or comparable age from the deep-water population. Adductor muscle weight is doubled and gonad tissue production is vastly more successful in the shallow-water population; however, differences in gamete maturity and viability are not yet known.

INTRODUCTION

The sea scallop, *Placopecten magellanicus* (Gmelin, 1791), supports an intensive fishery throughout its range from Newfoundland to North Carolina (Posgay, 1957). Consequently, there have been a number of studies dealing with the relationship between meat weight and shell height (Baird, 1954; Bourne, 1964; Haynes, 1966; Serchuk, 1983; MacDonald & Thompson, 1985; Langton et al., 1987) and growth (see MacDonald & Thompson, 1985; Schick et al., 1988 for reviews). Growth rate has been the most extensively studied facet and will only be discussed here in relation to depth. A reduction in growth rate with depth has been demonstrated by Posgay (1979) and MacDonald & Thompson (1985). Schick et al. (1988) recently extended the depth range for measured scallop growth to 170 meters and provide most of the comparative data presented here.

While several studies have examined the relationships between shell height to meat weight and gonad weight, little emphasis has been placed on other allometric relationships in the species. One of the first studies to examine such parameters found that meats (adductor muscles) for the same sized scallop varied by as much as 50% between five sampling areas (Bourne, 1964). Serchuk & Rak (1983) reviewed the meat weight to shell height relationships for several areas within the Gulf of Maine and found a similar variation between areas. In addition to the differences demonstrated between areas, several authors have demonstrated seasonal variation in the shell height to meat weight ratios (Haynes, 1966; Robinson et al., 1981; Serchuk, 1983). These seasonal variations are generally attributed to concurrent variations in food availability, energy storage and the gametogenic cycle. Robinson et al. (1981) have shown a correlation between seasonal changes in biochemical composition and meat weights; however, to date, no data are available for seasonal changes in food availability for this species.

Similarly, Serchuk & Rak (1983) have surveyed several areas in the Gulf of Maine and showed that weights of ripe gonads for the same size scallop varied by up to 250%. Expectedly, the seasonal variability in gonad weight to shell height ratios is directly related to the gametogenic cycle (Barber et al, 1988; Naidu, 1970; Robinson et al., 1981). In addition, Robinson et al. (1981) have demonstrated a seasonal variability in the relationship between digestive gland weight and shell height.

Data are presented here for seasonal changes in relationships between a number of allometric parameters in scallops, *P. magellanicus*, collected from normal (20 m) and extreme (170 m) depths in the Gulf of Maine. These data are discussed in relation to previously recorded growth rates for the same populations.

MATERIALS AND METHODS

Sea scallops, *Placopecten magellanicus*, were collected quarterly for six quarters beginning in February, 1984. Deep-water scallops were obtained from a local fisherman for each quarter with the exception of May, 1984. The location and depth (170 m) were as consistent as possible and as near as possible to the collection station previously used for determining growth (Schick et al., 1988), 20 miles south of Boothbay Harbor (43°26.5', 69°33.3') (fig 1). Shallow-water collections were made by SCUBA divers at a site approximately 20 m in depth (MLW) in the lower Damariscotta river (43°51.26', 69°34.0'). One hundred scallops representing as wide a size range as possible were selected from each sampling site each quarter. Specimens were measured to the nearest mm for shell height, length and depth. The animals were then drained, blotted dry and weighed whole. Individual tissues (adductor muscle, mantle, gonad) were removed and blotted dry. The remaining tissue, including the foot, were termed 'viscera' and blotted dry. The crystalline style and food particles were flushed from the intestinal loop in the gonad prior to blotting. Tissues were weighed individually to the nearest 0.001 g. Tissues were then oven dried to constant weight and reweighed. The summed dry weights of the four tissues (muscle, gonad, mantle, viscera) were used as the total dry tissue weight for each scallop. Regression analyses were carried out on an IBM 370 computer using the Statistical Analysis System (SAS) General Linear Models (GLM) procedure.

Growth data are taken from Schick et al. (1988) for scallops from two shallow-water coastal Maine sites and two deep-water Gulf of Maine sites. Details of growth measurements are given in that paper. Linear regressions of the logarithmic transformation of the exponential relationship of various tissue dry weights (whole tissue, gonad, adductor muscle, mantle and viscera) to shell height were determined according to the equation: $[\log_{10}Y = \log_{10}a + b \log_{10}X]$ where Y is the tissue dry weight, X is the shell height and '$\log_{10}a$' and 'b' are fitted parameters. These regressions were used to determine tissue weights for a standard sized scallop of 120 mm shell height for each season from each site. Tissue weight-at-age was also plotted, using the age of a 120 mm shallow-water scallop (4 years) as the standard and plotting the tissue weights for the same aged scallop from deep water with an equivalent shell height of 90 mm.

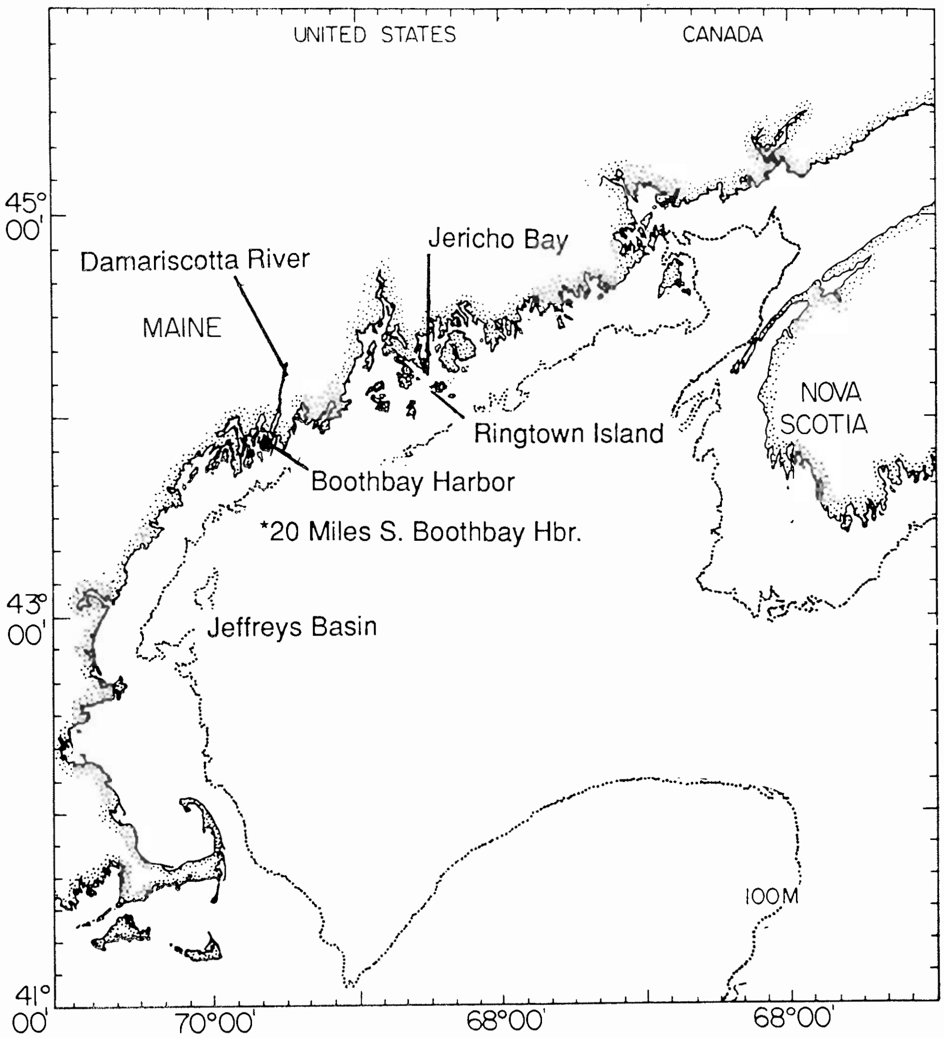

Fig. 1. The location of shallow-water and deep-water sampling sites in the Gulf of Maine.

RESULTS AND DISCUSSION

Growth in deep-water scallops collected at two locations, Jeffrey's Basin and 20 miles south of Boothbay Harbor (fig. 1) was characterized (Schick et al., 1988) by the Von Bertalanffy growth equation $H_t = H_\infty(1\text{-}e^{-k(t-t_0)})$. A least squares fit of the parameters H_∞, k and t_0 to the age-height data yielded values (table 1) that differed between the two locations (fig. 2). The age-height data were generated from observed shell height frequencies over time for the two deep-water populations (Schick et al., 1988). Height-at-age keys for the scallops from the shallow-water sites at Ringtown Island and Jericho Bay were used to fit Von Bertalanffy parameters (table 1) and curves (fig. 2). As with the deep-water scallops, the parameters varied widely between the two sites. The Von Bertalanffy growth curves for the four populations demonstrated some differences worth noting. The data from the two shallow-water populations resulted in curves substantially higher than the two deep-water populations showing a decrease in the rate of growth with depth.

TABLE 1

Least squares regressions for Von Bertalanffy parameters for sea scallops from four locations in the Gulf of Maine. Values are ± one asymptotic confidence interval.

LOCATION	DEPTH (m)	H_∞	k	T_0	YEARS FITTED
SHALLOW WATER					
Jericho Bay	25	248±47.9	0.13±0.036	0.17±0.095	1-8
Ringtown Island	15	148±7.7	0.27±0.059	0.10±0.494	1-9
DEEP WATER					
20 miles south Boothbay Harbor	170	116±3.7	0.28±0.025	-0.01±0.103	1-8
W. Jeffrey's Ledge	174	223±35.3	0.09±0.019	-0.37±0.110	1-7

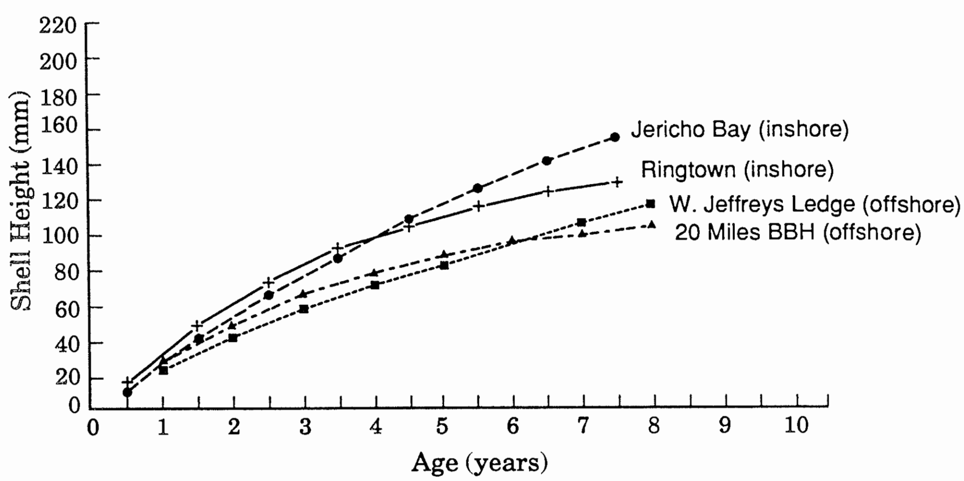

Fig. 2. Von Bertalanffy growth curves for sea scallops from two deep-water and two shallow-water populations in the Gulf of Maine.

Welch (1950) and Posgay & Merrill (1979) presented data for scallop growth in shallow Maine waters that are indistinguishable from the Jericho Bay data presented here. The two shallow-water populations are, however, different from each other in that the curve representing the Ringtown Island population tails off more so than the curve for the Jericho Bay population curve. This difference is due, at least in part, to the effects of repeated handling of the Ringtown Island scallops during their last four years. Chapman (Pers. Comm.) and Naidu (Pers. Comm.) indicate that handling (even slight manipulation in an aquarium setting) will reduce the rate of shell deposition in the scallop. The effect of this tailing off is that the computer iterative process produces a best fit by least squares at a lower H_∞ f for the Ringtown Island population. Since k is inversely related to H_∞, the k is selected artificially high. Thus, while the curves for the Jericho Bay and Ringtown island scallops appear grossly similar, the parameters vary widely.

Much the same difference occurs between the deep-water scallop populations. The curve representing the population 20 miles south of Boothbay Harbor tails off in the last few years compared to the Jeffrey's Basin population. Again, while the curves are grossly similar, the parameters vary significantly. The apparent decrease in rate of growth of the scallops 20 mile south of Boothbay Harbor is thought to be due to heavy fishing pressure in that area, i.e., the larger individuals in the year class during the last three years of the study were removed by commercial fishermen. This created artificially low mean heights for the year class compared to the Jeffrey's Basin scallops. Any method of determining age and growth in a population that utilizes survivors to back calculate age and growth from ring structure, otolith rings, etc. is prone to Lee's phenomenon (Lee, 1912). Bias is introduced via size selection pressure by differential mortality favoring either fast or slow growing individuals. It is likely that Lee's phenomenon is present in the 20 mile south of Boothbay Harbor population, since it was heavily fished, whereas the Jeffrey's Basin population was not.

There are no other data available on growth of scallops at 170 meters, the deepest area studied being 144 meters (Caddy et al., 1970). Both Posgay (1979) and MacDonald & Thompson (1985) have correlated a decrease in scallop growth with depth. Most recently MacDonald & Thompson (1985) demonstrated a decrease in growth with depth from 10 to 30 meters in all one of the areas tested except the area in the Bay of Fundy. Caddy (1970) also demonstrated little change in growth over a much greater depth range from samples in Bay of Fundy. The strong tidal mixing in the Bay creates a homogeneous water mass in terms of temperature and food which probably explains the uniform growth rates with depth in this area.

The differences in rate of growth between shallow-water and deep-water scallops in this study and the observation of gross morphological differences between the two populations led to an examination of their allometric relationships. Shell morphometrics did not change with season at either the shallow-water (Damariscotta river) or the deep- water (20 miles south of Boothbay Harbor) collection sites and the data for shell height, length, width and weight were combined for each site. The regressions of shell length and shell width on shell height (table 2) for both shallow-water and deep-water populations showed no differences between sites for shell length, but considerably greater shell width in relation to shell height for the shallow-water scallops (fig. 3). The regression of shell weight on shell height (table 2) revealed a two fold gain in weight in shallow-water shells compared to deep-water shells (fig. 4). Thus, scallops from shallow-water populations have considerably greater cupping or curvature in their shells and much heavier shells than their offshore counterparts.

TABLE 2

Parameters for the regression equations relating shell height ($Log_{10}x$) to other characters in the sea scallop *Placopecten magellanicus* in the Gulf of Maine. Data are fitted to the general equation $\log_{10}Y = \log_{10}a + b(\log_{10}x)$.

DATE	$\log_{10}A$	±95%C.I.	b	±95%C.I.	R^2	N-1	y val. for STD x =120mm	y val. for STD x =4yr*
SHELL LENGTH VS SHELL HEIGHT								
Shallow water comb.	-0.191	0.018	1.099	0.009	0.990	547	124.17	124.17
Deep water comb.	-0.180	0.034	1.092	0.017	0.973	463	123.16	89.96
SHELL WIDTH VS SHELL HEIGHT								
Shallow water comb.	-0.861	0.070	1.155	0.035	0.884	546	34.71	34.71
Deep water comb.	-1.174	0.178	1.247	0.088	0.626	463	26.23	18.32
SHELL WEIGHT VS SHELL HEIGHT								
Shallow water comb.	-3.701	0.101	2.839	0.050	0.957	547	159.15	159.15
Deep water comb.	-6.502	0.304	4.040	0.150	0.859	458	79.05	24.73
WHOLE TISSUE DRY WEIGHT VS SHELL HEIGHT								
Shallow water								
Feb.84	-4.81	0.34	2.89	0.17	0.967	41	15.81	15.81
May 84	-5.25	0.19	3.13	0.10	0.977	98	18.11	18.11
Aug.84	-4.89	0.33	2.96	0.16	0.932	96	18.38	18.38
Nov.84	-4.42	0.21	2.69	0.11	0.963	97	14.89	14.89
Feb.85	-5.03	0.26	3.02	0.13	0.956	99	17.75	17.75
May.85	-5.55	0.26	3.29	0.13	0.963	93	19.52	19.52
Deep water								
Feb.84	-3.93	0.81	2.32	0.40	0.596	90	7.83	4.02
Aug.84	-4.57	0.25	2.66	0.13	0.948	98	9.13	4.25
Nov.84	-4.23	0.73	2.47	0.35	0.669	95	8.05	3.95
Feb.85	-4.51	0.33	2.61	0.16	0.910	99	8.25	3.90
May.85	-3.13	0.90	1.99	0.43	0.587	61	10.18	5.74
ADDUCTOR DRY WEIGHT VS SHELL HEIGHT								
Shallow water								
Feb.84	-5.24	0.40	2.95	0.20	0.957	42	7.83	7.83
May.84	-5.13	0.23	2.90	0.11	0.963	98	7.94	7.94
Aug.84	-5.09	0.31	2.86	0.15	0.939	96	7.19	7.19
Nov.84	-4.71	0.26	2.70	0.13	0.946	99	8.01	8.01
Feb.85	-5.46	0.27	3.08	0.13	0.955	99	8.79	8.79
May.85	-5.66	0.28	3.18	0.15	0.950	98	8.95	8.95
Deep water								
Feb.84	-4.35	1.03	2.34	0.51	0.486	90	3.28	1.67
Aug.84	-4.80	0.39	2.60	0.19	0.878	99	4.04	1.91
Nov.84	-4.89	0.98	2.64	0.48	0.551	99	3.97	1.86
Feb.85	-4.49	0.45	2.42	0.23	0.820	99	3.48	1.73
May.85	-4.07	1.25	2.29	0.60	0.476	65	4.91	2.54

DATE	$log_{10}A$	±95%C.I.	b	±95%C.I.	R^2	N-1	y val. for STD x =120mm	=4yr*
GONAD DRY WEIGHT VS SHELL WEIGHT								
Shallow water								
Feb.84	-7.58	1.22	3.63	0.61	0.781	42	0.93	0.93
May.84	-10.36	0.98	5.27	0.49	0.822	99	3.96	3.96
Aug.84	-6.83	1.17	3.60	0.57	0.620	96	4.52	4.52
Nov.84	-8.38	0.52	3.89	0.26	0.901	99	0.51	0.51
Feb.85	-8.76	0.69	4.24	0.35	0.858	99	1.14	1.14
May.85	-11.71	1.29	5.95	0.66	0.773	94	4.58	4.58
Deep water								
Feb.84	-4.90	3.47	2.19	1.71	0.066	92	0.45	0.24
Aug.84	-5.48	1.62	2.59	0.80	0.296	98	0.80	0.38
Nov.84	-5.90	1.83	2.52	0.89	0.249	97	0.22	0.11
Feb.85	-7.25	1.72	3.36	0.86	0.379	99	0.54	0.21
May.85	-1.51	3.50	0.77	1.68	0.013	63	1.23	0.99
MANTLE DRY WEIGHT VS SHELL HEIGHT								
Shallow water								
Feb.84	-5.33	0.35	2.74	0.17	0.962	41	2.33	2.33
May.84	-5.54	0.18	2.83	0.09	0.976	99	2.21	2.21
Aug.84	-5.59	0.23	2.84	0.11	0.963	96	2.06	2.06
Nov.84	-5.17	0.20	2.66	0.10	0.967	97	2.29	2.29
Feb.85	-5.49	0.19	2.82	0.10	0.971	99	2.36	2.36
May.85	-5.69	0.22	2.92	0.11	0.965	98	2.41	2.41
Deep water								
Feb.84	-4.61	0.81	2.30	0.40	0.591	91	1.49	0.77
Aug.84	-5.55	0.22	2.77	0.11	0.962	97	1.62	0.73
Nov.84	-5.12	0.61	2.55	0.30	0.750	97	1.52	0.73
Feb.85	-5.30	0.32	2.62	0.16	0.917	99	1.40	0.66
May.85	-4.01	0.90	2.00	0.43	0.581	63	1.41	0.79
VISCERA DRY WEIGHT VS SHELL HEIGHT								
Shallow water								
Feb.84	-5.02	0.31	2.73	0.15	0.970	42	4.53	4.53
May.84	-5.02	0.24	2.70	0.12	0.951	99	3.92	3.92
Aug.84	-4.68	0.30	2.51	0.14	0.926	96	3.46	3.46
Nov.84	-4.62	0.21	2.50	0.10	0.959	99	3.78	3.78
Feb.85	-5.13	0.30	2.81	0.15	0.933	99	5.16	5.16
May.85	-5.46	0.26	2.96	0.13	0.953	98	4.95	4.95
Deep water								
Feb.84	-4.46	0.77	2.32	0.38	0.619	92	2.31	1.19
Aug.84	-5.39	0.25	2.79	0.12	0.953	99	2.58	1.15
Nov.84	-4.78	0.50	2.46	0.24	0.804	99	2.16	1.07
Feb.85	-5.16	0.26	2.68	0.13	0.944	99	2.58	1.20
May.85	-3.48	1.18	1.84	0.56	0.400	65	2.22	1.31

* Standard scallop at 4 years is 120mm shell height in shallow water and 90mm shell height in deep water.

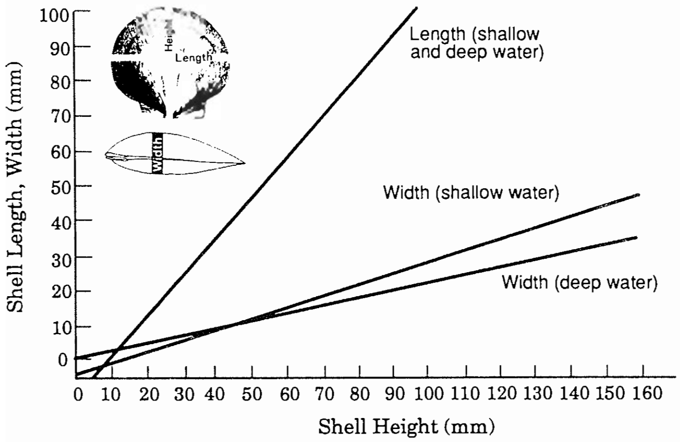

Fig. 3. Regressions of shell length and depth on shell height for shallow-water and deep- water populations of scallops in the Gulf of Maine.

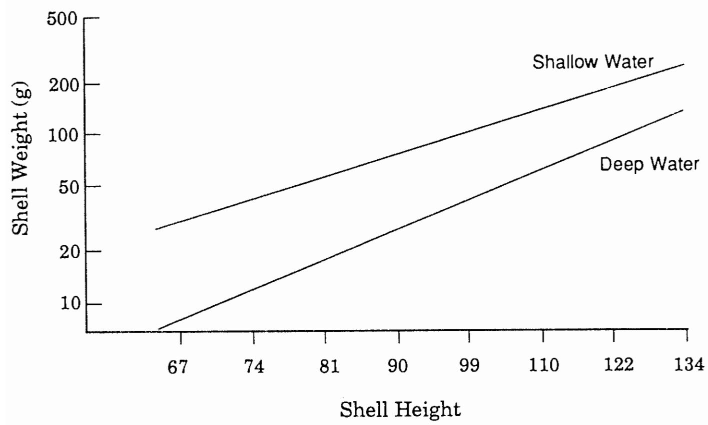

Fig. 4. Regression of shell weight on shell height for shallow-water and deep-water populations of scallops in the Gulf of Maine.

Whole tissue dry weight is the sum of the individual tissue dry weights and is a good measure of the general condition of the scallop. Predicted whole tissue dry weight for shallow-water scallops was 1.85 to 2.15 times that of deep-water scallops of the same size and 3.40 to 4.55 times that of deep-water scallops of the same age during each season (table 2). In addition, there was considerably more seasonal variability in the shallow-water individuals than in the deep-water scallops (fig. 5). Four-year-old scallops (90mm) from deep water showed even less seasonal variability in whole tissue dry weight than did the standard size (120mm) deep-water scallop (fig. 5).

The gonad dry weight for both shallow- and deep-water scallop populations followed the established gametogenic cycle (table 2). The changes in weight with season were, however, much greater in shallow-water scallops where the gonad dry weight was close to that of deep-water scallop during November, 1984, but four times as heavy in August, 1984 and 1985 (fig. 6). The gonad dry weight to shell height regressions for deep-water scallops show that little relationship exists between the gonad dry weight and the shell height as evidenced by very low r^2 values. This is due to the sporadic nature of spawning in these deep-water scallops. Some scallops had poorly developed gonads and others the same size showed no sign of development at all, producing a wide scatter of gonad dry weight to shell height data points (see also Barber et al., 1988).

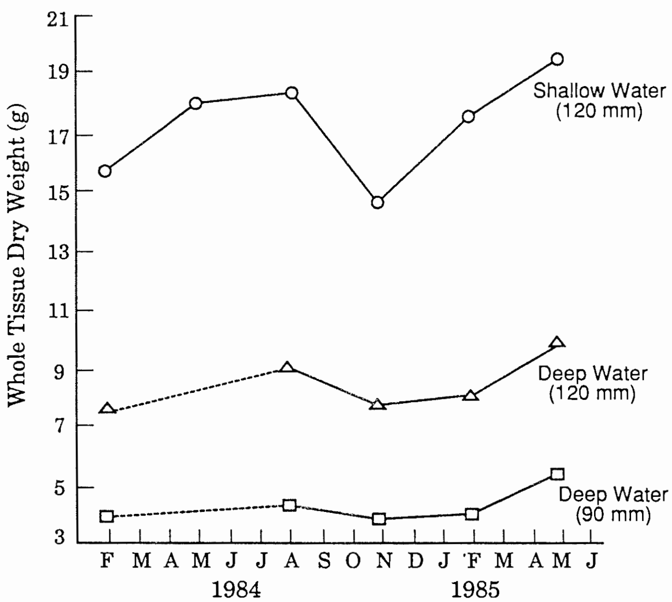

Fig. 5. Seasonal variation in whole tissue dry weight for four-year-old, shallow-water scallops (120 mm) and for the same sized scallops and the same aged scallops (90 mm) from deep water in the Gulf of Maine.

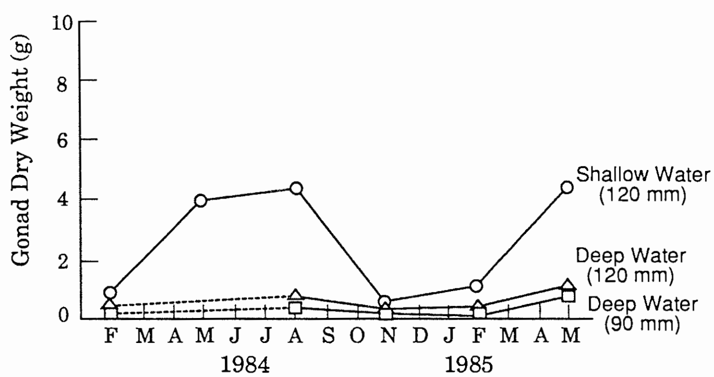

Fig. 6. Seasonal variation in gonad dry weight for four-year-old, shallow-water scallops (120 mm) and for the same sized scallops and the same aged scallops (90 mm) from deep water in the Gulf of Maine.

Differences between spring of 1984 and spring of 1985 in the shallow-water whole tissue weights did not show up in the gonad dry weight. Changes in shallow-water gonad dry weights over the gametogenic cycle agreed closely with results reported by Robinson et al. (1981) who found gonad masses ranging from less than 1 gram in winter months to 2.5 to 4 grams in summer. Gonad wet weight regressed on shell height for several locations in the Gulf of Maine (Serchuk, 1983) showed values intermediate between the shallow-water and deep-water gonad dry weight presented here when converted to wet weights. Indeed, Serchuk's (1983) highest gonad wet weight for a standard scallop, 19+ grams for Georges Bank in 1982, agreed closely with our shallow-water standard scallop gonad wet weight of 18.7 grams. However, Serchuk's lowest predicted gonad weight, for the NMFS mid-Atlantic States continental shelf scallop population in 1982, was 7+ grams compared to 4.2 grams for our deep-water standard scallop.

Adductor muscle dry weight from the regression of adductor dry weight on shell height was twice as great for the shallow-water standard scallop compared to the same sized deep-water scallop and four times as great compared to the same aged deep-water scallop (table 2). The adductor muscle dry weights for both populations showed some seasonal variability (fig. 7). The wet weight of the adductor muscle has been the focus of numerous studies as it is the edible portion of the scallop. Several authors have performed regression analyses of adductor wet weight on shell height and these studies have been summarized by Bourne (1964), Haynes (1966), Serchuk (1983) and Serchuk & Rak (1983). The family of curves of predicted adductor muscle weights for increasing shell height for all these studies showed that the highest predicted weights were equivalent to the shallow-water adductor dry weight and the lowest predicted weights were equivalent to the deep-water values reported here. A visually fitted line through the adductor weight/shell height data on scallops harvested in 1953 (Baird, 1954) in Linekin Bay, a shallow-water site close to the lower Damariscotta River site in the present study, was indistinguishable from the regression in the present study for the same season. Both predicted a 33-35 gram wet adductor for a standard scallop which is over 10 grams heavier than that reported for Penobscot Bay by Haynes (1966) and for Boothbay Harbor region by Serchuk & Rak (1983). The Boothbay Harbor region data comes from scallops collected from the Sheepscot River, which is commercially a much less productive area for scallops than is the Damariscotta River and Linekin Bay area and is therefore probably less suitable for scallop recruitment and growth.

The seasonal variability in the shallow-water standard scallop adductor dry weight in the present study had a range of about 1.5 grams, which is much less than that found by Robinson (1981) of over 3 grams (table 2). The deep-water standard scallop adductor dry weight range was very nearly the same as the shallow-water range, albeit at less than half the size (table 2). Thus, the percent change in deep-water is twice that in shallow-water which indicates that the dependence on the energy in the form of glycogen stored in the adductor is much greater in deep-water scallops (Gould, 1981).

Mantle dry weight was greatest in shallow-water scallops and least in deep-water scallops of the same age and showed no seasonal variability (table 2, fig. 8). The mantle probably plays a minor role in the cycling of energy through the scallop and thus undergoes little weight change (Robinson et al., 1981).

Dry weight of viscera was also greatest in the shallow-water scallop and showed somewhat different seasonal variation between the shallow-water and deep-water scallops (table 2, fig. 9). The shallow-water standard scallop shows a decrease in visceral dry weight from February through August and an increase from August through February with a range of 1.7 grams. This is slightly less than the range of 2 grams reported by Robinson et al. (1981). The deep-water standard scallop visceral dry weight vacillates slightly from season to season, but never varies by more than 0.4 grams (table 2). The shallow-water seasonal variation in visceral dry weight in this study disagrees with that of Robinson et al. (1981). In the present study, the lowest values were recorded in August and the highest values in February, whereas Robinson et al. reported the lowest values in February. This discrepancy may be resolved when biochemical analyses of protein, lipid and carbohydrate for the tissues in the present study are compared to values reported by Robinson et al. (1981). Also, Robinson et al. measured only the digestive gland and this study includes the gills and other remaining tissues.

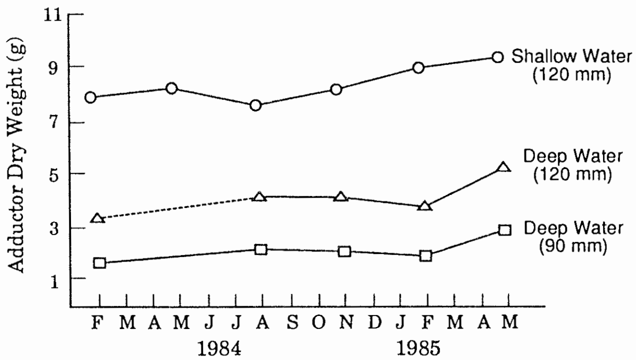

Fig. 7. Seasonal variation in adductor muscle dry weight for four-year-old, shallow-water scallops (120 mm) and for the same sized scallops and the same aged scallops (90 mm) from deep water in the Gulf of Maine.

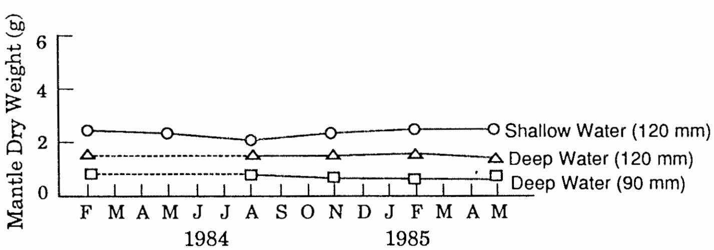

Fig. 8. Seasonal variation in mantle dry weight for four-year-old, shallow-water scallops (120 mm) and for the same sized scallops and the same aged scallops (90 mm) from deep water in the Gulf of Maine.

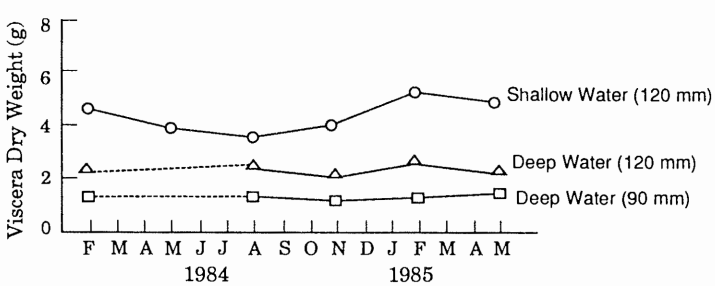

Fig. 9. Seasonal variation in viscera dry weight for four-year-old, shallow-water scallops (120 mm) and for the same sized scallops and the same aged scallops (90 mm) from deep water in the Gulf of Maine.

In summary, it is clear that substantial differences exist between the shallow-water and the deep-water populations of *P. magellanicus* with respect to growth and allometric relationships of the various body components. The shallow-water populations exhibit the greatest amplitude in fluctuations; however, the deep-water scallops showed greater fluctuation in adductor dry weight as a percentage of body tissue weight. Also of particular interest is the fact that the gonad weights from the deep-water populations do not show any substantial weight gain over the year. These facts pose a number of questions regarding differences in somatic tissue production, the quality and quantity of food available to the two populations, the partitioning of energy reserves between individual tissues and gamete production in shallow- and deep-water populations of *P. magellanicus* and studies are currently underway to address these questions.

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REFERENCES

BAIRD, F. T., 1954. Meat yield of Maine scallops (*Pecten magellanicus*). — Res. Bull. Maine Dep. Sea Shore Fish., Augusta, Maine, U.S.A, 16: 1-4.

BARBER, B. J., GETCHELL, R., SHUMWAY, S. & SCHICK, D. F., 1988. Reduced fecundity in a deep-water population of the giant scallop, *Placopecten magellanicus*. — Mar. Ecol. Prog. Ser., 42: 207-212.

BOURNE, N., 1964. Scallops and the offshore fishery of the Maritimes. — Fish. Res. Bd. Can. Bull., 145: 1-54.

GOULD, E., 1981. Field stress in the scallop, *Placopecten magellanicus*. — ICES Publs, C.M., 1981/E-7: 1-16.

HAYNES, E. B., 1966. Length-weight relation of the sea scallop, *Placopecten magellanicus* (Gmelin). — ICNAF Res. Bull., 3: 1-17.

LANGTON, R. ., ROBINSON, W. E. & SCHICK, D. F., 1987. Fecundity, egg diameter and reproductive effort of an inshore population of sea scallops, *Placopecten magellanicus* (Gmelin), from the Gulf of Maine. — Mar. Ecol. Prog. Ser., 37: 19-25.

LEE, R. M., 1912. An investigation into the methods of growth determination in fishes. — Cons. Explor. Mer., Publ. de Circonstance, 63: 1-35.

MACDONALD, B. A. & THOMPSON, R. J., 1985. Influence of temperature and food availability on the ecological energetics of the giant scallop *Placopecten magellanicus*. I. Growth rates of shell and somatic tissue. — Mar. Ecol. Prog. Ser., 25: 279-294.

NAIDU, K. S., 1970. Reproduction and breeding cycle of the giant scallop *Placopecten magellanicus* (Gmelin) in Port au Port Bay, Newfoundland. — Can. J. Zool., 48: 1003-1012.

POSGAY, J. A., 1957. The range of the sea scallop. — Nautilus, 71: 55-57.

POSGAY, J. .A., 1979. Depth as a factor affecting the growth rate of the sea scallop. — ICES. C.M. 1979/K27: 1-5.

POSGAY, J. A. & MERRILL, A. S., 1979. Age and growth data for the Atlantic coast sea scallop, *Placopecten magellanicus*. — NMFS-NEFC Lab. Ref. 79/58.

ROBINSON, W. E., WHELING, W. E., MORSE, M. P. & MCLEOD, G. C., 1981. Seasonal changes in soft body component indices and energy reserves in the Atlantic deep-sea scallop, *Placopecten magellanicus*. — Fish. Bull., U.S., 79: 449-458.

SCHICK, D. F., SHUMWAY, S. E. & HUNTER, M., 1988. A comparison of growth rate between shallow water and deep water populations of scallops *Placopecten magellanicus* (Gmelin, 1791) in the Gulf of Maine. — Amer. Malac. Bull., 6: 1-8.

SERCHUK, F. M., 1983. Seasonality in sea scallop shell height-meat weight relationships: review and analysis of temporal and spatial variability and implications for management measures based on meat count. — Woods Hole Lab. Ref. Doc., 83-35: 1- 30.

SERCHUK, F. M. & RAK, R. S., 1983. Biological characteristics of offshore Gulf of Maine sea scallop populations: size distributions, shell height-meat weight relationships and relative fecundity patterns. — NMFS/Woods Hole Ref. Doc., 83-07: 1-42.

WELCH, W., 1950. Growth and spawning characteristics of the scallop in Maine waters. Unpublished M.S. Thesis, University of Maine, Orono. 95 pp.