

justed for the lack of independence of samples over time. Because significant differences ($p < 0.05$) were generally found on only one or two of the sampling dates, data from both replicates were pooled.

Small oysters in both density treatments showed highest absolute (slopes of growth curve between sampling dates, Fig. 2) and relative (instantaneous growth coefficient, k , Table 2) shell and tissue growth rates prior to and following the period of maximum mortalities occurring between July 11 and July 26. Thus, during peak mortalities the soft tissue growth coefficient dropped to about 1/2 of prior and subsequent levels (Table 2). Interestingly, however, growth did not cease during the mortality episode, as small oysters at both densities continued to deposit shell and doubled in tissue weight during the second part of July. Growth slowed again between August 9 and 23, when the lowest growth coefficients were recorded for this experimental group (Table 2). On this date, histological sections of 18 out of 25 SC oysters and 20 of 26 LC oysters had mature gametes, and in some individuals they were present in the gonoducts. A few males showed empty follicles with remnant sperm, indicative of recent spawning activity. Thus reduced growth in mid-August did not coincide with additional mortalities, and was probably associated with spawning activity.

As expected, relative growth of soft tissues was generally higher for small than large oysters (Table 2). Growth patterns of large oysters were similar to those of small oysters, except that reductions in shell and tissue growth rate during early summer occurred two weeks earlier (June 28 to July 11), i.e. prior to, rather than during, the period of heaviest mortalities. As observed for the SC, there was a second period of slow growth during mid August, marked by minimum values in both shell and tissue growth coefficients for oysters held at high density (Table 2), and coinciding with apparent spawning.

In general, temporal patterns of shell growth within a given cohort were very similar between density treatments. Two-way analyses of variance and *a posteriori* multiple comparisons (Sokal and Rohlf 1971) were used to ascertain the effects of date and density on log-transformed shell height. No significant differences were found between density treatments, except for large oysters on July 26 (Fig. 2). Analysis of covariance (ANCOVA, with log height as covariate) was used to examine the effects of date and culture density on log-transformed tissue weights. Among small oysters, the two density treatments were significantly different ($p < 0.05$) on July 11 and July 26, during the mortality episode,

whereas among large oysters significant differences were found at most dates (Fig. 2).

The ranges in mean condition index (CI) values over the study period were 77 to 166, and 92 to 127 for the SC and LC, respectively. Differences in condition with stocking density were less pronounced in the SC, and were significant ($p < 0.05$) only on June 28 and July 26 [ANCOVA with log-height as covariate, and multiple comparisons of arcsine (CI/1000) transformed data (Sokal and Rohlf 1971)] (Fig. 4). Condition dropped markedly in July (by 53 and 39% in high and low density groups respectively), at the time of peak mortalities, and again to a lesser extent (30-31% reduction) in mid-August. The mean CI of large oysters stocked at low density was consistently greater than at high density, but showed a similar seasonal pattern (Fig. 4). Significant differences in condition between density treatments were detected on June 28, July 26 and September 6. The greatest decline in condition (9 to 18%) occurred between late June and early July, coincident with early mortalities in this cohort, and a second decline (11 to 16%) occurred in mid-August when growth rates of soft tissues attained a seasonal minimum (Table 2).

The "late cohort" also exhibited considerable shell growth prior to the mortality outbreak, but ceased growing during peak mortalities (Table 2). Mean shell heights (\pm SE) were 10.3 (± 0.2), 14.9 (± 0.3), 16.5 (± 0.5) and 16.6 (± 0.6) on August 2, 9, 16 and 23, respectively.

Production of live oysters, expressed as total volume or weight per unit time, is the most relevant descriptor of performance in a commercial growout operation, and is a function of both growth and survival. Based on scaling considerations, whole body weight and total volume are expected to show comparable rates of increase over time. In the present study whole animal weight, determined in the laboratory, was subject to less measurement error than packed volume, the unit generally used by commercial growers to estimate production, and allowed an estimate of individual variability. Biweekly changes in biomass (total live weight) of the 2 experimental cohorts held at high density declined markedly during the July mortality episode (Fig. 5). Both cohorts experienced the highest production (2.9 to 4.7 increase in biomass over a 2-week period for small oysters, and 2.5-2.8 increase for large oysters) prior to and immediately following the period of mass mortalities. During August and September, the biomass increment over 2 weeks ranged from 1.1 to 1.8-fold, with lowest increments coinciding with declining temperatures (Fig. 1, top graph).

TABLE 2.

Instantaneous growth coefficients for shell height (k_H) and dry weight of soft tissues (k_{DW}) of large and small experimental oysters held at the high stocking density in Oyster Bay, and k_H of the "late cohort."

Period	Small		Large		Late Cohort	
	k_H	k_{DW}	k_H	k_{DW}	Period	k_H
6/14-6/28	4.27	ND	2.44	5.54	7/26-8/2	4.28
6/28-7/11	3.24	9.07	0.35	3.18	8/2-8/9	5.23
7/1 1-7/26	1.24	4.32	1.88	6.69	8/9-8/16	1.48
7/26-8/19	3.52	10.17	2.04	7.82	8/16-8/23	0.05
8/8-8/23	0.62	1.68	0.76	0.69		
8/23-9/6	1.50	4.80	0.74	2.74		
9/16-9/20	0.78	2.70	0.90	2.74		

$k = ((\ln X_2 - \ln X_1) / t) \times 100$, where X_2 and X_1 are final and initial heights (mm) or weights (mg) respectively, and t = time interval. ND = not determined; date notation as in Table 1.