Northeastern Naturalist

Volume 33 2026 Number 3



Insights Into Temporal Patterns of Late Season Spawning and Other Biological Parameters in Bay Scallop Populations Over a 30-year Period

Stephen T. Tettelbach[1,*], Dennis M. Bonal[2], Harrison Tobi[1], Stephen Tomasetti[3], and Raymond Czaja Jr.[4]

Abstract - Information on life-history strategies and seasonal patterns of reproduction is essential to management of wild fisheries. In this study, we documented temporal trends in shell metrics (total shell height, height of the single annual growth ring, shell growth after the first winter) and other biological parameters (adductor muscle weight, incidence of parasitic pea crabs, percentage of scallops that were reproductively mature) for adult (1+ yr) *Argopecten irradians irradians* (Bay Scallop) harvested in the Peconic Bays, NY, over a 30-year period. Of 10,620 scallops examined, <1% were 2+ years of age. For scallops 1+ yr of age, the product of fall spawns the prior year, 21.4% had annual growth rings ≤20 mm. These fall-spawned scallops are of particular interest because they may survive to spawn in a second year; extended reproduction of a given year class beyond the usual 1 year may serve to buffer dramatic annual fluctuations in recruitment. Temporal trends in the prevalence of fall-spawned adults were not correlated with mean water temperatures or their degree of change during the prior year. The relationship between scallop shell growth after the first winter versus annual growth-ring size was inverse and highly significant, confirming prior work that demonstrated compensatory growth in this species. Average scallop meat weight increased during 2 time periods with different opening dates for the harvest season (1990–2004, 2005–2019), perhaps due to rising temperatures. There were no obvious trends in the prevalence of *Tumidotheres maculatus* (Squatter Pea Crab) throughout the time series despite the observed increase in average water temperature. Reasons for spatial and temporal variability in prevalence of fall-spawned scallops (0–100%) are not yet clear, but further study is warranted given their importance to the sustainability and growth of Bay Scallop populations.

Introduction

Basic biological information on life-history strategies, including survivorship curves, growth rates, and age/size at first reproduction, is critically important for management of wild fisheries (Jennings et al. 2001). Knowledge of seasonal patterns of reproduction is similarly valuable and often incorporated into management strategies for finfish and shellfish species in the form of seasonal closures and/or minimum size at first capture (King 2007). As the world's oceans continue to warm

[1]Marine Program, Cornell Cooperative Extension, Southold, NY 11971. [2]Department of Medicine at the Alpert Medical School of Brown University, Providence, RI 02912. [3]Department of Natural Sciences, University of Maryland Eastern Shore (UMES), Sarbanes Coastal Ecology Center, Berlin, MD 21811. [4]National Center for Ecological Analysis and Synthesis, University of California, Santa Barbara, CA 93101. [*]Corresponding author - stt47@cornell.edu.

Manuscript Editor: David Rudders

and fishing effort intensifies, changes in life-history parameters (including earlier age at first reproduction and reduced fecundity) have been observed in many species (Byrne and Lamare 2024, Heino et al. 2015, Trippel 1995, Wang et al. 2020) so it is important to revisit fundamental biological data, even for well-studied species, that may have been obtained decades ago.

Argopecten irradians (Lamarck) (Bay Scallop), found along the Atlantic and Gulf coasts of the US, is a commercially and culturally important species which exhibits an unusual life history. Spawning of hermaphroditic adults typically occurs around the age of 1 year; these usually live for several more months, only for most to die before they are able to spawn again (Belding 1910). Consequently, limits are rarely placed on total seasonal harvest of adult Bay Scallops. However, as noted by Belding (1910), up to 20% of individuals in some unfished populations of the northern subspecies, *A. irradians irradians* (Lamarck) may survive to spawn in a second year. Very rarely, Bay Scallops may live to ages of 3+ or 4+ years (L. Stewart [deceased], University of Connecticut, Groton, CT, pers. comm.).

The majority of northern Bay Scallops that survive to spawn a second time are believed to result from late season (fall) spawns (Hall et al. 2015; MacFarlane 1991; Tettelbach et al. 1999, 2001). In New York, 0+ yr (juvenile) scallops resulting from spring and summer spawns commonly reach sizes of 30–55 mm total shell height (SH) by the end of the first growing season (Tettelbach et al. 2001). However, fall-spawned juveniles in New York (defined as ≤20 mm = "small seed"; Tettelbach et al. 2001) and Massachusetts (defined as ≤10 mm = "nubs"; Hall et al. 2015, Kelley and Sisson 1981) may only reach 1 mm by this time. Since shell growth of northern Bay Scallops typically ceases in December, and does not resume until late April/early May of the next year, a record of the size at which scallops enter the winter is preserved as a raised annual growth ring (Fig. 1; Belding 1910, Tettelbach 1986). MacFarlane (1991) and Hall (2014) determined that ~50% and <40% of nub adults (those that grew from nub juveniles resulting from spawns the previous fall) on Cape Cod and Nantucket, MA, respectively, spawned in their first summer/fall (at an age of 1+ yr) while the other 50+% did not spawn until a year later (at 2+ yrs). The latter occurrence thus expands spawning of a given year class from the usual 1 year to 2 years and may serve to buffer dramatic annual fluctuations in recruitment that are commonly exhibited by Bay Scallop populations (Bishop et al. 2005, Geiger et al. 2010) and/or enhance population growth (Hall et al. 2015). The phenomenon of fall spawning may be especially important when recruitment failures result from events such as harmful algal blooms that occur during the usual spring–summer spawning window (Tettelbach et al. 2001).

The prevalence of fall spawning and frequency of resulting offspring in natural populations may vary considerably on temporal as well as spatial scales (Hall et al. 2015; Tettelbach et al. 1999, 2001). Tettelbach et al. (2001) found that frequencies of fall-spawned juveniles (≤20 mm) varied from 0% to 9% in suction-dredge surveys conducted in the winter of 1990–1991 at 8 sites in the Peconic Bays of eastern Long Island, NY. However, in October 1992, at one of the same sampling sites, 100% of sampled adults had a very small (2–7 mm) annual growth ring (this paper). These scallops were the result of fall spawns during the prior year.

In light of the biological significance of fall spawning in Bay Scallop populations, the present study was conducted to document the prevalence of small (≤20 mm) annual growth rings (Tettelbach et al. 2001) in adult (1+ yr) Peconic Bay Scallops that were opportunistically harvested during commercial seasons in the fall of 1990 to 2019. Additionally, we collected data from the same sets of samples on total shell sizes, meat weights, prevalence of reproductively mature individuals, incidence of parasitic *Tumidotheres maculatus* (Say) (Squatter Pea Crab), and percentages of scallops with large (≥57 mm) annual growth rings. The latter was of interest because of the potential premature harvest of these individuals as pre-reproductive juveniles, before the annual growth ring has been laid down. Furthermore, we took advantage of this long time series of samples to examine temporal changes in many of the above parameters in the context of rising nearshore water temperatures (Pales Espinosa et al. 2023, Tomasetti et al. 2023).

Field-site Description

The Peconic Bays, bounded by the North and South Forks of eastern Long Island, NY (Fig. 2), encompass some 100 separate bays, creeks and harbors totaling ~1165 square km of open water (Peconic Estuary Partnership 2025). The

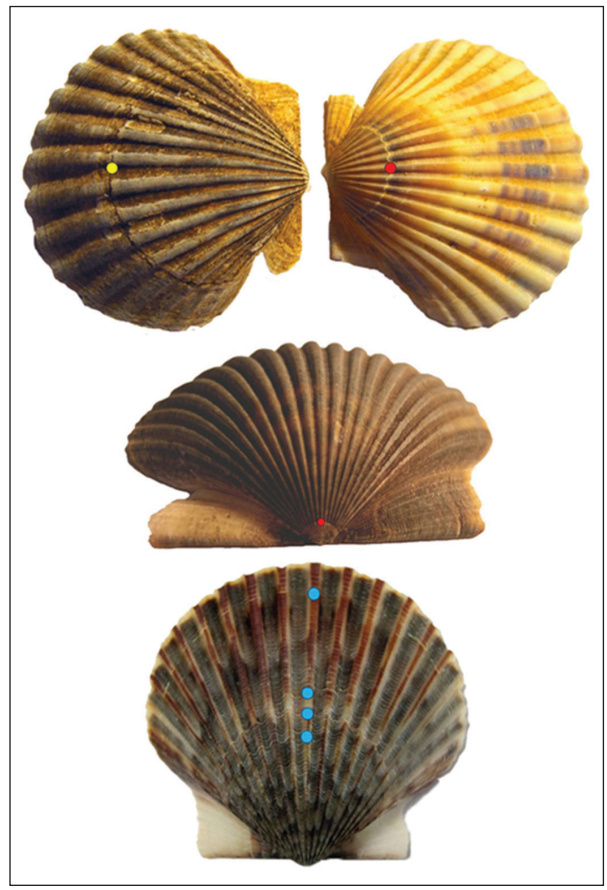


Figure 1. Top: Annual growth rings on shell valves of 1+ yr (adult) northern *Argopecten irradians irradians* (Bay Scallop). Yellow and red circles represent 41- and 18-mm annual growth rings, which resulted from spawns in summer and fall, respectively, of the prior year. Middle: Adult Bay Scallop with 4-mm annual growth ring (red dot). Bottom: Juvenile (0+ yr) Bay Scallop with growth checks (blue dots) that resulted from temporary disturbances, which are almost always less pronounced than annual growth rings. Photographs © S.T. Tettelbach.

western end of the estuary receives a moderate influx of freshwater from the Peconic River, but salinities throughout the great majority of the Peconic Bays are consistently high enough (>25) to support significant Bay Scallop populations (Tettelbach and Wenczel 1993). Much of the western and central Peconic Bays is less than 6 m deep, with mud bottoms in the deeper central basins and more sandy substrates in shallower areas. *Zostera marina* L. (Eelgrass) may be found along the margins, mostly in the eastern bays now, but various species of macroalgae are found throughout (Tettelbach et al. 2025). Historically, the Peconic system has supported rich populations of fish and shellfish, including Bay Scallops (Peconic Estuary Partnership 2025).

Methods

Scallop collections

We opportunistically collected Bay Scallops that we examined in the present study from 18 different areas (Fig. 2, Appendix 1), via SCUBA diving (mostly), free diving, or dredging, during the first 2 months of the commercial harvest season in fall of 1990–2019. The timing of collections coincided with higher scallop availability (i.e., before they were fished out) and more tolerable water temperatures for wetsuit diving. We collected only Bay Scallops legal to harvest (adults with a defined annual growth ring and ≥57 mm SH), but all that met these criteria were harvested (i.e., we did not select for only the largest scallops seen). From 1990 to 2004, the Bay Scallop season extended from the first Monday in October to 31 March of the next year. Beginning in 2005, the start of the harvest season was moved back to the first Monday in November, largely on the basis of our observations of significant numbers of reproductively mature (ripe) scallops in October and even November (Tettelbach et al. 1999).



Figure 2. Sampling sites (*) in the Peconic Bays of eastern Long Island, NY.

We harvested at sites that we chose on the basis of known scallop concentrations and/or where it was difficult for commercial dredge boats to work (e.g., in areas with very dense cover of *Crepidula fornicata* (L.) [Common Atlantic Slippernail]). We sometimes made collections multiple times within a given scallop season at sites that were particularly productive (Appendix 1). We thus define a sample as all Bay Scallops collected from a given site on a particular date. However, we otherwise revisited some areas to ensure we had a series of collections at specific sites over multiple years. Our last collection was made in 2019, as Peconic Bay Scallop populations/fisheries crashed that year (Tettelbach et al. 2023, Tomasetti et al. 2023).

On the day of each harvest, we opened scallops by hand and recorded data on wet meat weight (number of meats/kg, as measured on a postal scale, and later converted to average meat weight for the given number of kilograms of scallop meats obtained in that sample), prevalence of visibly ripe individuals (as reflected by a bright orange ovarian portion of the gonad; Barber and Blake 2016), and incidence of large (≥10 mm) Squatter Pea Crabs (Bologna and Heck 2000, Kruczynski 1972). We set aside scallop shells for subsequent bleaching and measurement and then stored them dry. We usually measured total SH and annual growth ring height (RH) to the nearest mm, but sometimes to the nearest 0.1 mm; these metrics represent the tangential distance from the umbo to the ventral shell margin or annual growth-ring margin, respectively. Annual growth rings, which result from a stoppage of shell growth from December to late April/early May and may be accompanied by a change in shell color, are almost always stronger (thicker, more raised) than growth checks that result from a temporary disturbance such as a predatory attack or other mechanical disturbance (Fig. 1; S.T. Tettelbach, pers. observ.).

Statistical analyses

We did not determine all metrics for all Bay Scallops sampled over the 30-yr period; thus, the number of individuals examined usually varied for each of the different metrics (Table 1, Appendix 1). We only conducted statistical analyses on those collections of 1+ yr-old scallops where $n \geq 20$ at a given site on a given date and calculated metrics from means of samples, unweighted by sample size. For total SH, we considered only Bay Scallops harvested during the first week of the commercial scallop season (early October for 1990–2004, early November for 2005–2019) so as to permit the most meaningful comparisons, since 1+ yr scallops will add shell growth in the fall, into December (Belding 1910, Bricelj et al. 1987b, Tettelbach 1986). We examined data on RH for Bay Scallops collected from October to December, as RH does not change once it has been laid down at the end of winter. We also examined data on meat weight, percentage of scallops with ripe gonads, and Squatter Pea Crab incidence for Bay Scallops collected from October to December because we were interested in examining how these parameters might change over time. We checked temporal autocorrelation, for all analyses in which temporal effectswere examined, by plotting the sample autocorrelation of the residuals across time lags. In only 1 instance (growth after 1st winter as a function of RH), was significant temporal autocorrelation detected (lag of 1 year). So we added

a global first-order autoregressive (AR[1]) temporal correlation parameter to the model for that analysis.

We used density ridge plots from the 'ggridges' R package (ver. 0.5.7: Wilke 2025) to visualize size distributions for SH and RH, by location and year. This data visualization approach was specifically designed to display distribution changes through time and space, particularly when many comparisons are needed, as traditional histograms produce cluttered figures when there are many comparisons (Wilke 2025). For creation of our ridge plots, we grouped together respective SH and RH data from all locations for given years, while data for all years were considered together for respective sites.

We used a mixed linear regression to examine growth after the first winter (SH minus RH) as a function of RH (fixed factor). We treated site and year as random factors to account for nonindependence of scallops that came from the same site and year. Plotting the sample autocorrelation of the residuals across time lags showed a strong time lag at 1 year. Therefore, we included an AR(1) parameter across years. Though, we note that outcomes did not differ between models that included and excluded the AR1 parameter.

We examined temporal changes in average meat weight of harvested scallops versus (a) year and (b) days after September 30 via mixed multiple linear regression, with year and days after September 30 as fixed factors and site as a random factor. Due to the change to a later start date for the harvest season in 2005, we conducted analyses separately for the two 15-year periods. Sites considered in the analyses were those where ≥3 samples were taken within a given time period: 1990–2004 (East Marion, Hallock Bay, Hog Neck Bay, Noyack Bay, Northwest Harbor, North Orient Harbor, and off Shelter Island), and 2005–2019 (Hog Neck Bay, Noyack Bay, and Southold Bay).

Table 1. Metrics for 1+ yr old Peconic Bay Scallops collected during fall, 1990–2019. Annual growth ring, average meat weight, % with ripe ovary and Squatter Pea Crab incidence data from samples collected October–December. For total shell height, only scallops harvested during the first week of the commercial scallop season were considered, where opening dates * and † = first Monday of October (1990–2004) and November (2005–2019), respectively. Sample size min–max = 22–536.

	Sample min–max	Grand median	Grand mean	SE	Total # of samples	Total # of scallops
Annual growth ring ht						
Avg ring ht (mm)	3.9–49.5	35.4	34.4	1.47	52	8539
% with small ring (≤20 mm)	0.0–100.0	11.2	21.4	3.41	52	8515
% with large ring (≥57 mm)	0.0–28.0	0.0	2.3	0.66	52	8515
Avg total shell ht (mm) - Oct*	59.3–69.3	64.4	64.4	0.50	21	4305
Avg total shell ht (mm) - Nov†	66.4–75.0	69.4	69.6	0.68	14	2672
Avg meat wt (#/kg) - Oct	103.6–147.7	114.7	118.6	3.10	17	3801
Avg meat wt (#/kg) - Nov	77.2–149.9	99.2	100.3	2.80	27	5538
% w/ripe gonad - Oct	0.0–15.0	1.3	3.1	1.03	17	3385
% w/ripe gonad - Nov	0.0–18.8	2.5	4.1	0.79	21	4615
% w/female pea crabs	0.0–29.0	2.1	3.5	0.75	55	10,620

We plotted the average annual incidence of female Squatter Pea Crabs in harvested Bay Scallops but performed no formal analysis of temporal trends as (a) preliminary data inspection revealed no clear patterns and (b) the data struggled to meet the requirements of generalized linear models and their variants. The data did not contain normally distributed errors, and variance was not consistent through the dependent variable (year). Using different links and distributions did not drastically improve these violations.

We examined relationships focusing on the frequency of ripe individuals (see above) via 2 analyses. We used a mixed beta regression with a log link (due to proportion data) to predict the proportion of ripe Bay Scallops at individual sites in a given year as a function of the number of days (on the date of sampling) past September 30 and another beta regression to predict the mean proportion of 1+ yr scallops with small (≤20 mm) annual growth rings in year $x + 1$ as a function of the mean proportion of ripe 1+ yr scallops across all sites in year x. Plotting the sample autocorrelation of the residuals across time lags, for both regressions, showed only weak time lags. Therefore, an AR1 parameter was not added.

Finally, we conducted a series of linear regression analyses to examine the effect of water temperature (ºC) in year x on the frequency of adult Bay Scallops with small annual growth rings in the fall of year $x + 1$. Water temperature data represent NOAA daily blended optimum interpolation SST product (DOISST version 2.1) values (Huang et al. 2021), where the data product blends satellite-based observations with in situ observations from ships, buoys, and floats. We corrected these temperature values, obtained from the nearest coastal grid cell to Orient Harbor (Block Island Sound), using simple linear relationships established with 11 years of daily USGS data for Orient Harbor (USGS-01304200; <https://waterdata.usgs.gov>) for each season (Tomasetti et al., 2023). The Block Island grid cell edge was 24.65 km from the monitoring station in Orient Harbor. We believe this provided the best available estimation of actual daily mean temperature in Orient Harbor, going back to 1982; in turn, we used these data as a proxy for all of the Peconic Bays from which we harvested Bay Scallops for this study. From this data set, we considered the following temperature metrics for the linear regressions: (a) average daily temperature (Avg Daily T) for various time periods within a given year (entire year, 1 January–start of harvest, 1 August–start of harvest), (b) maximum temperature change (Max Daily ΔT) observed during a given month (for September, October, and November), and (c) the number of days during the same months where ΔT was greater than its average for 1989–2021 (ΔT days). We analyzed Avg Daily T for different periods and ΔT trends due to their potential importance as cues for spawning induction (Barber and Blake 2016).

All analyses were conducted using R Statistical Software (v. 4.3.0; www.r-project.org) and all plots were created using the 'ggplot2' R package (v. 3.5.1; Wickham 2016, Wickham et al. 2025), unless previously stated. We conducted all analyses using base packages other than beta regressions, which we conducted using the 'mgcv' R package (v. 1.9.1; Marra and Wood 2011). We assessed residuals of all regression analyses using the 'DHARMa' R package (v. 0.4.7; Hartig 2016)

to confirm a relatively uneven distribution of residuals between 0 and 1 and that the Q–Q plot had overall residuals along the 1:1 line.

Results

A total of 15,701 Bay Scallops was collected from 18 sites, on 87 different days, over the 30-year period; sample sizes varied from 22 to 536 scallops (Table 1, Appendix 1). The great majority of those examined were 1+ yr olds. Just a few 2+ yr olds were noted (in 4 of the 87 samples; Appendix 1). Although their overall frequency was not explicitly calculated, we estimated that 2+yr-old scallops comprised <1% of all harvested scallops examined. Total shell height varied between sites and years (Appendix 1), with most size distributions exhibiting quasi-normal, unimodal curves (Fig. 3). However, in some cases (e.g., 2003), multiple modes were evident. For the 1990–2004 time period, when opening day was the first week of October, mean SH was 60–70 mm. For the 2005–2019 period, when opening day was the first week of November, mean SH was sometimes ≥70 mm (Fig. 3).

Annual growth-ring height varied considerably between sites and years (Appendix 1; Fig. 4A, B). Many of the RH size distributions for sites (all years combined) were multimodal, with the first mode <20 mm (Fig. 4A). As shown in ridge plots, median RH for individual years was typically 23–52 mm, but was 4 mm and 13 mm in 1992 and 2019, respectively (Fig. 4B). The overall percentage of fall-spawned adults was 21.4% (Table 1), with frequencies in individual samples varying from 0% to 100% (Appendix 1). The overall frequency of adult Bay Scallops with a large (≥57 mm) annual growth ring was 2.3%, but in some cases these comprised up to 28% of particular samples (Table 1, Appendix 1). The relationship between shell growth after the winter (Y) versus RH was inverse and modeled well by a linear regression: (Y = 63.14 - 0.907•RH, coefficient std error = 0.0050, AR1 parameter = 0.74, conditional R^2 = 0.912, P < 2e-16; Fig. 5).

For the first week of the harvest season in 1990–2004 (October) and 2005–2019 (November), average meat weight per individual Bay Scallop across all samples varied from 6.9 to 12 g (grand mean = 8.4 g = 118.6 meats/kg [53.8 meats/lb]), and 8.9 to 13 g (grand mean = 10.0 g = 100.3 meats/kg [45.5 meats/lb]), respectively (Appendix 1). Average meat weight of harvested scallops (all sites combined) increased significantly after 30 September during both the 1990–2004 (1 October–29 November) period (+0.065 g/day; P < 2e-16) and 2005–2019 (1 October–12 December) period (+0.070 g/day; P = 2.302e-7) (Fig. 6, Appendix 1). This trend was particularly apparent when considering individual sites (NW Harbor – E side, Hog Neck Bay) in years (1992, 2004, 2005, 2006, 2010, 2015), where we had 3 successive samples over periods of 16–42 days (Appendix 1). Average meat weight of harvested scallops (all sites combined) increased significantly from 1990 to 2004 (+0.04 g/yr: T = 0.919, P = 0.023) and from 2005 to 2019 (+0.10 g/yr: T = 2.459, P = 0.0006) (Fig. 6, Appendix 1). Gains in meat weight for the 1990 to 2004 period were represented by the equation Y = -120.800 + 0.067*Days Post Sept 30 + 0.064*Year + Site Random Intercept, with a conditional R^2 of 0.067. Gains in meat weight for the 2005 to 2019 period were represented by the equation Y = -244.000 +

0.070*Days Post Sept 30 + 0.125*Year + Site Random Intercept, with a conditional R^2 of 0.619.

The incidence of female Squatter Pea Crab infection in individual samples was 0–29% (Table 1). There was no clear temporal trend in annual percent incidence over the 30-yr period (Fig. 7).

The proportions of ripe Bay Scallops seen at given sites on given dates was 0–18.8% (Fig. 8, Appendix 1). The relationship between the proportion of ripe scallops and the number of days after September 30 was positive, but the beta regression (Y = exp (0.011*Days Post Sept 30 - 3.765; log link scale) was not significant

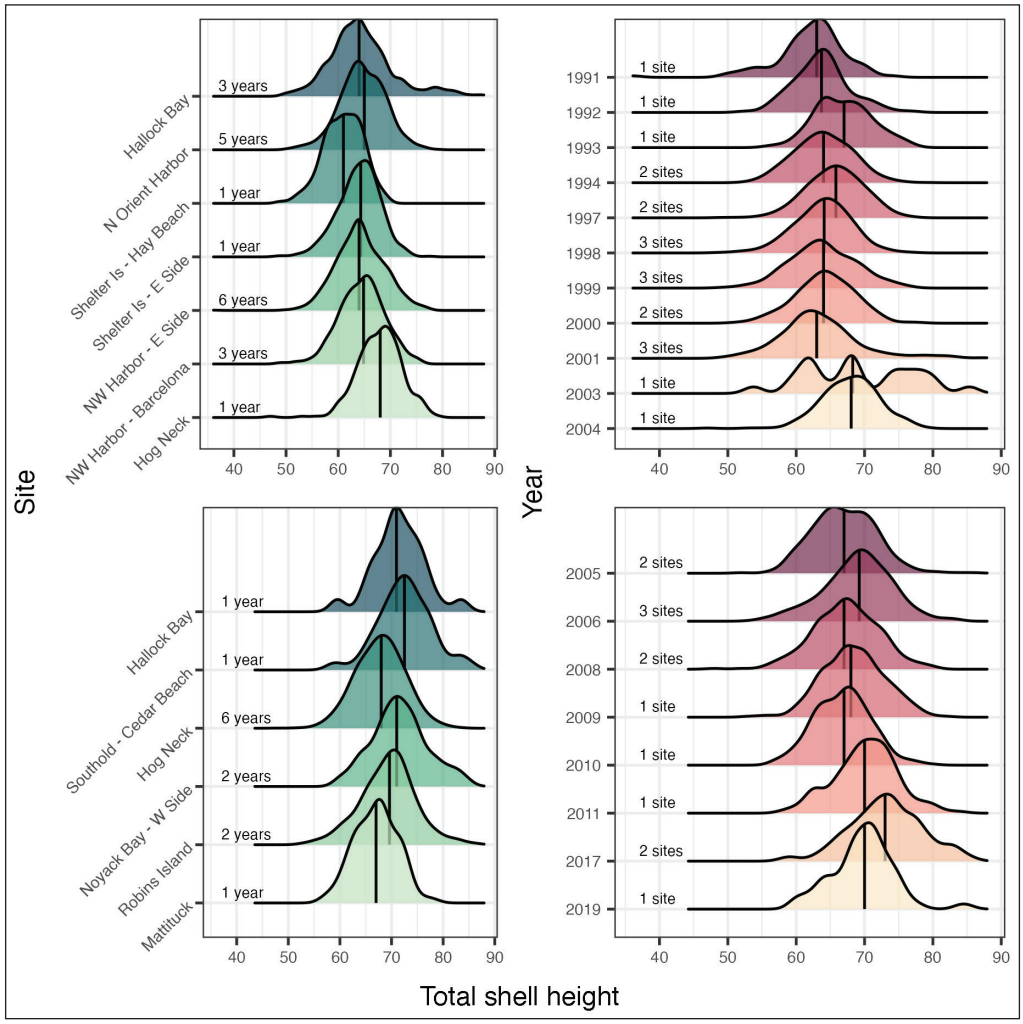


Figure 3. Ridge plots of total shell height (mm) distributions by site (left) and year (right) in October, 1991–2004 (top), and November, 2005–2019 (bottom). These 2 time periods reflect different dates for the opening of the commercial Bay Scallop season in New York: the first Monday in October and November, respectively. Sites are shown in geographical order from the northeast to the southwest part of the Peconic Estuary, NY, from top to bottom. Vertical bars represent medians.

(R^2 = 0.281, P = 0.0811; Fig 8). The proportion of adult scallops with small (≤20 mm) growth rings in year x + 1 was significantly related (R^2 = 0.51, P = 0.0003) to the proportion of ripe adults in the fall of the prior year, x, via a beta regression (Y = exp (30.811*Proportion of Ripe Scallops - 2.168, log link scale; Fig. 9).

No significant relationships were found between mean water temperature in year x (for various periods: starting 1 January and 1 August, leading up to the start of the harvest season, and for the entire year) versus the frequency of adult Bay Scallops with small annual growth rings the following fall, year x + 1 (P > 0.37; Table 2). Similarly, there was no trend in the frequency of fall-spawned adult Bay Scallops harvested through time (Fig. 10). No significant relationships (P > 0.27) were found between maximum daily change in water temperature (ΔT) for September, October, and November in year x and the frequency of fall-spawned scallops in year x + 1 (Table 2). When we conducted similar analyses based on the number of days in each of the 3 months where ΔT was greater than its average from 1989 to 2021, the only month where there was a significant positive relationship with frequency of small-ringed adults the following fall was November (F = 4.93, R^2 = 0.20, P = 0.038; Table 2).

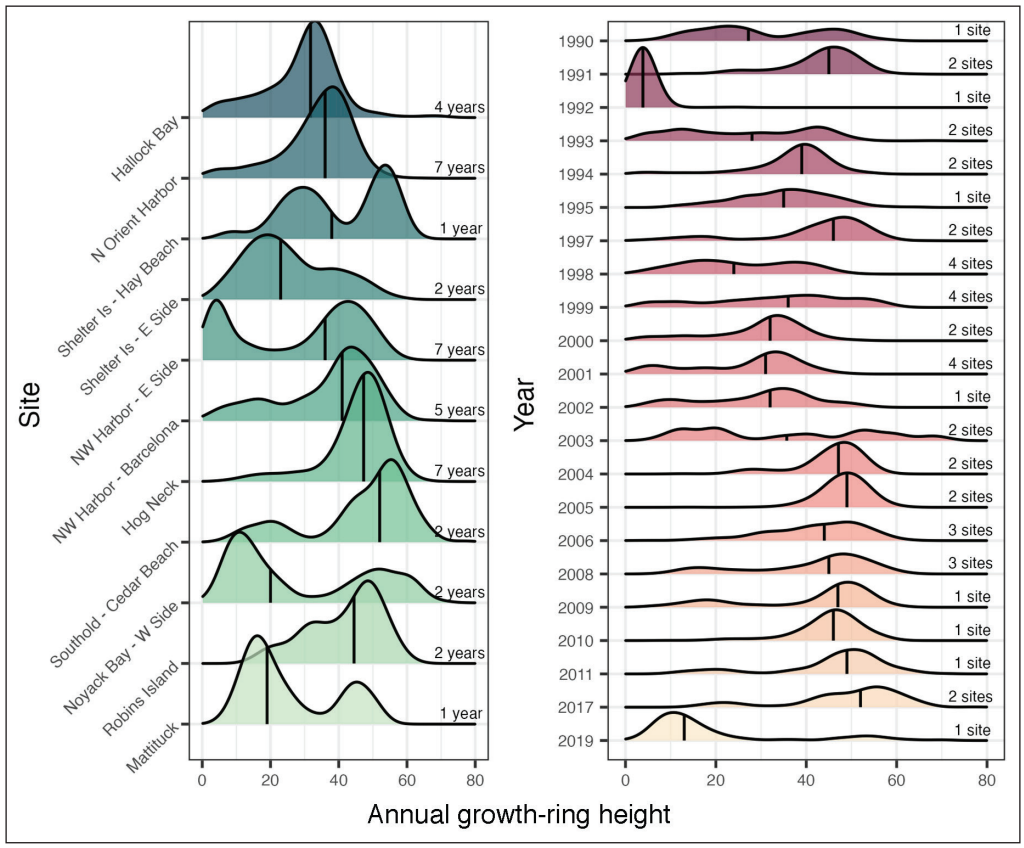


Figure 4. Ridge plots of annual growth-ring height (mm) distributions by site (left) and year (right). Sites are shown in geographical order from the northeast to the southwest part of the Peconic Estuary, NY, from top to bottom. Vertical bars represent medians.

Discussion

Our opportunistic harvesting of scallops at a wide range of sites over a 30-yr period largely reflected the marked variability in spatial and temporal abundance for which Bay Scallop populations are so well known (Belding 1910). The vagaries of larval settlement and recruitment (Eckman 1987, Eggleston and Armstrong 1995, Gaines et al. 1985, Tettelbach et al. 2013) certainly may contribute to this variability, but the short lifespan and mostly semelparous reproduction of Bay Scallops are especially important in this context (Belding 1910). Here, we have embraced this variability and taken advantage of large sample sizes over multiple years at various sites to examine important aspects of northern Bay Scallop biology.

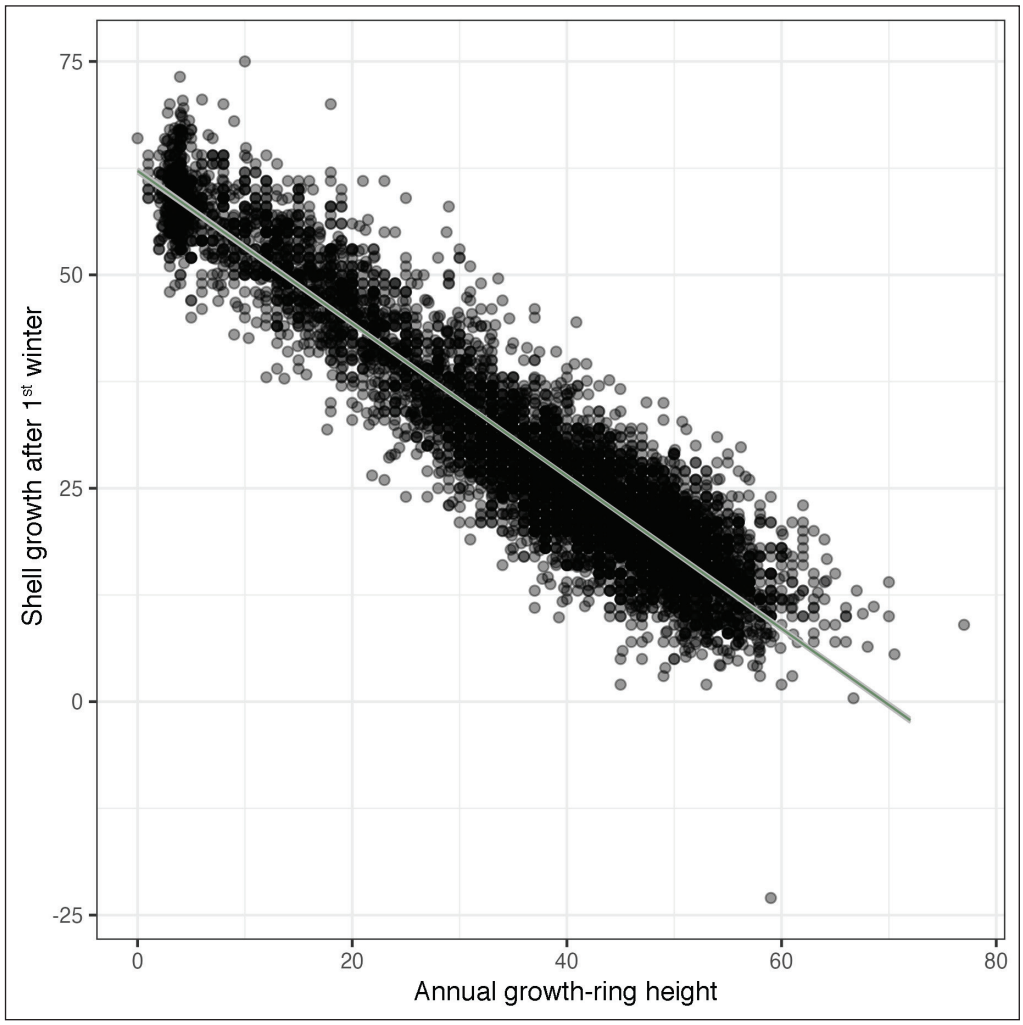


Figure 5. Shell growth (mm) after the first winter (until the time of harvest) as a function of annual growth-ring height (mm). The line is the fit from a mixed linear regression; the shaded region around this line denotes 95% confidence intervals. Datapoints = individual Bay Scallops.

Frequency curves for SH were mostly similar between sites and years, but there was clear evidence in some cases of multiple cohorts within a given year. These likely reflected multiple spawns, which may number up to 3–4 per year (McFarlane 1991, Tettelbach and Weinstock 2008). Mean SH (59–75 mm) of Bay Scallops harvested in the present study were comparable to those of 1+ yr scallops from the

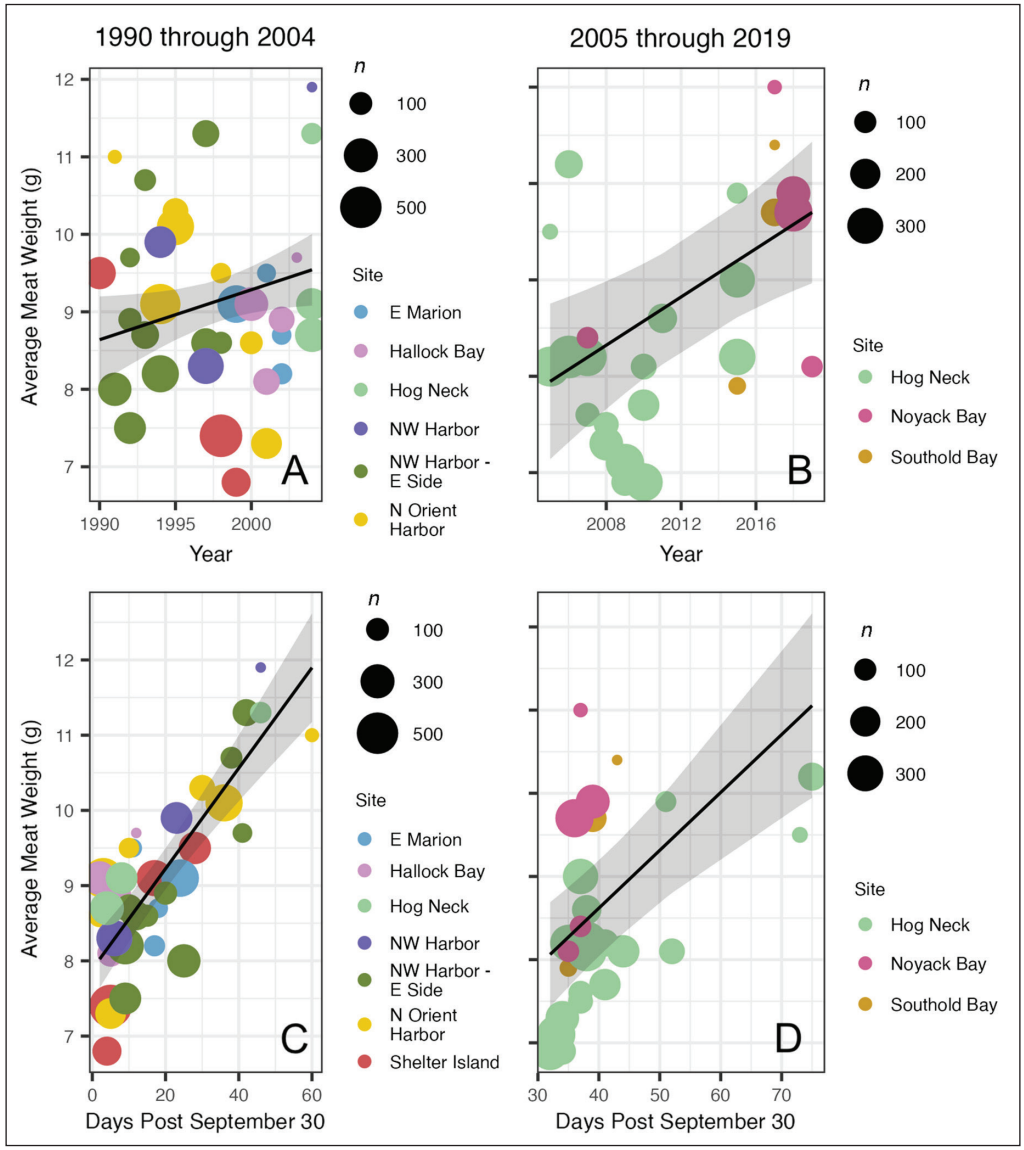


Figure 6. Temporal changes in average Bay Scallop adductor muscle (meat) weight (g) by year and as a function of the number of days after September 30: (A, C) 1990–2004, (B, D) 2005–2019. Different colors denote different sites. Bubble size (which is different for the 2 time periods) denotes the number of individual scallops used to calculate average meat weights. Shaded regions denote 95% confidence intervals from mixed linear regressions. Scallop season opened in early October in 1990–2004 and early November in 2005–2019.

Poquonnock River, CT (63.3 mm in mid-November; Tettelbach 1986) and Cape Cod, MA (~61 mm on 1 December; Belding 1910), but larger than those from the Niantic River, CT (~46-47 mm in mid-November; Marshall 1960). Various environmental factors contribute to differing rates of shell growth (Belding 1910), so it is difficult to know if the above differences reflect latitudinal clines in water temperature and/or temporal trends in the northeastern US over the last several decades, coincident with global warming (Tomasetti et al. 2023).

The very low (<1%) overall prevalence of 2+ yr Bay Scallops in our samples can likely be attributed to intense fishing pressure, as this frequency is much lower than the figure of up to 20% given by Belding (1910) for unharvested populations in Massachusetts. Marshall (1960) reported that only 9 of 4143 (0.2%) adult scallops from the Niantic River, CT, were 2+ yr olds, whereas Hall (2014)

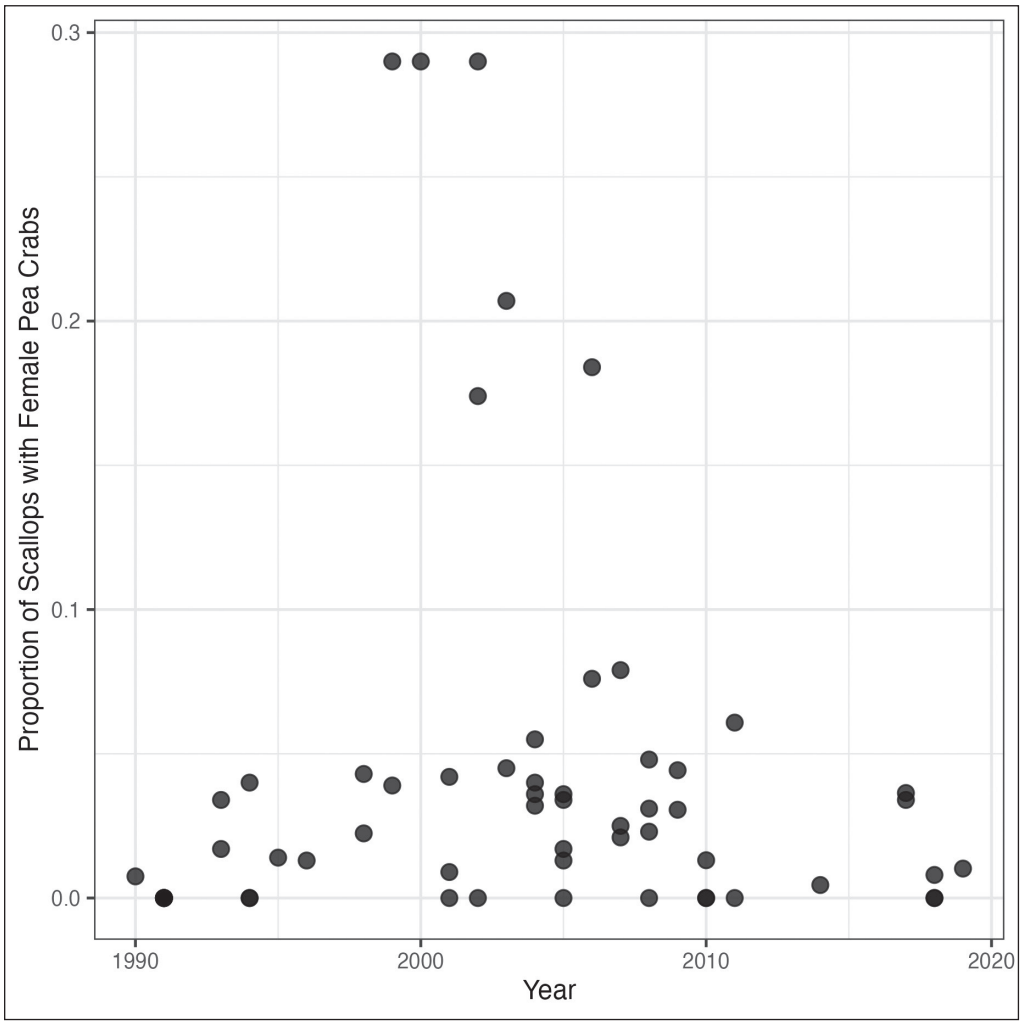


Figure 7. Temporal changes in the proportion of harvested scallops with large (≥10 mm) female *Tumidotheres maculates* (Squatter Pea Crab), 1990–2019. No fitted line is included as no formal statistical analysis was conducted. Datapoints = samples from individual sites.

observed frequencies of 0–5.6% at Nantucket, MA, over a 5-yr period. The highest frequencies of 2+ yr Bay Scallops we have ever seen were in Napeague Bay in 1996 (estimated at 40%; this study), a year after an intense brown tide in the Peconic Bays had decimated adult populations (Tettelbach et al. 2013), at our Narrow River site in Hallock Bay (12%; this study), and in Dering Harbor, Shelter Island in 2022 (estimated at 30%; S.T. Tettelbach, unpubl. data)—an area closed to shellfishing (NYSDEC 2026).

Adults with small (≤20 mm) annual growth rings comprised a significant percentage of Bay Scallops harvested in 1990–2019 from eastern Long Island populations: 21.4% of the more than 8500 scallops examined. In Massachusetts, MacFarlane (1991) noted that 9% of Bay Scallops were 1+ yr nub adults (annual

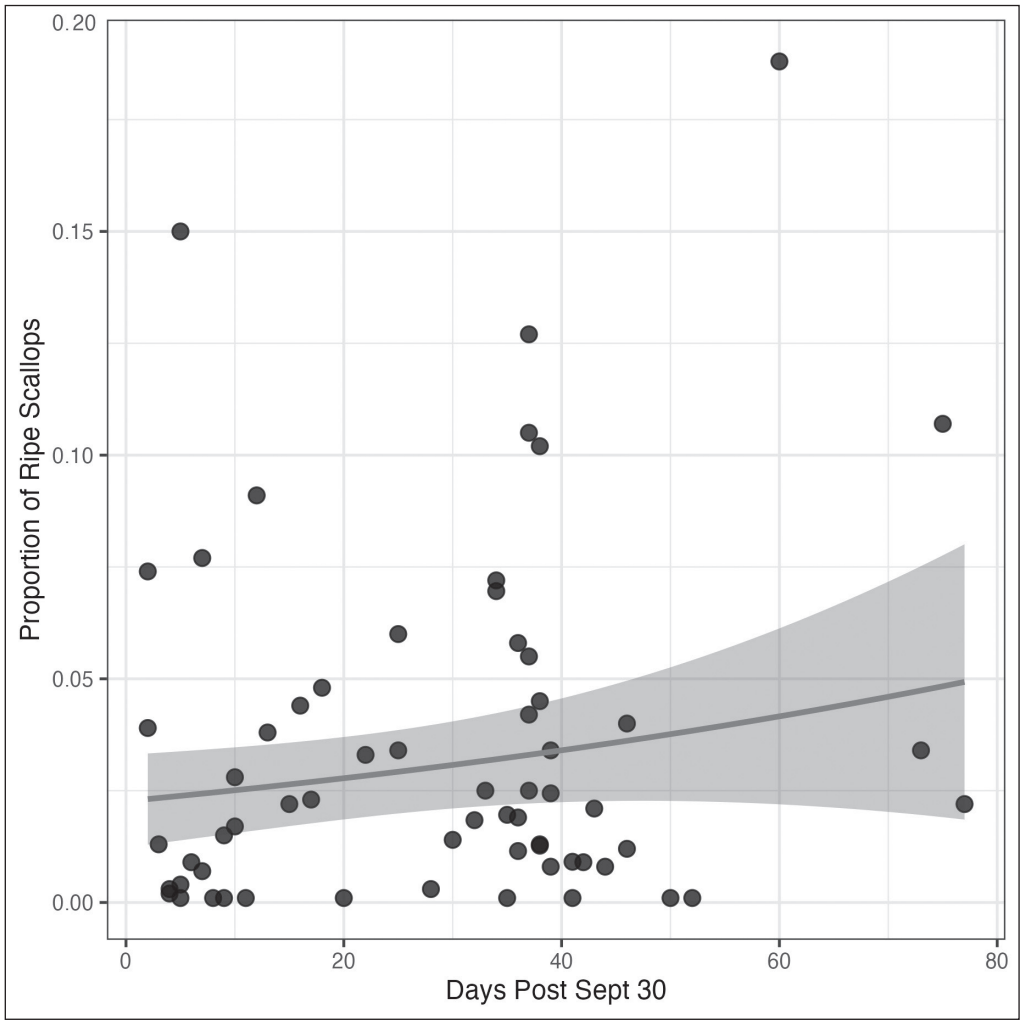


Figure 8. Proportions of ripe scallops as a function of the number of days after 30 September 1990–2019. The line is the fit (not statistically significant, $P = 0.08$) from a beta regression. Shaded regions denote 95% confidence intervals. Datapoints = samples from individual sites/years.

growth ring of <10 mm) in Pleasant Bay, Cape Cod, while on Nantucket, 1+ yr nub adult frequencies varied from 10.3 to ~44% over a 5-year period (Hall et al. 2015), but have been found to comprise up to 80% of the Nantucket population (Conant and Curley 2005). The underlying cause for the very wide range in frequency within given samples (0–100%) in our study is not clear (see below). However, in the case of scallops harvested in 1992 from the east side of Northwest Harbor, where 100% of scallops had RH of 2–7 mm, these apparently resulted from a spawn that occurred in fall 1991, after a brown tide event that summer (Tettelbach and Wenczel 1993). Over the entire 1990–2019 timeframe, periodic peaks in frequencies of fall-spawned adult scallops, incidence of female Squatter Pea Crabs, and possibly the percentage of Bay Scallops with ripe gonads in fall (see below) may be suggestive

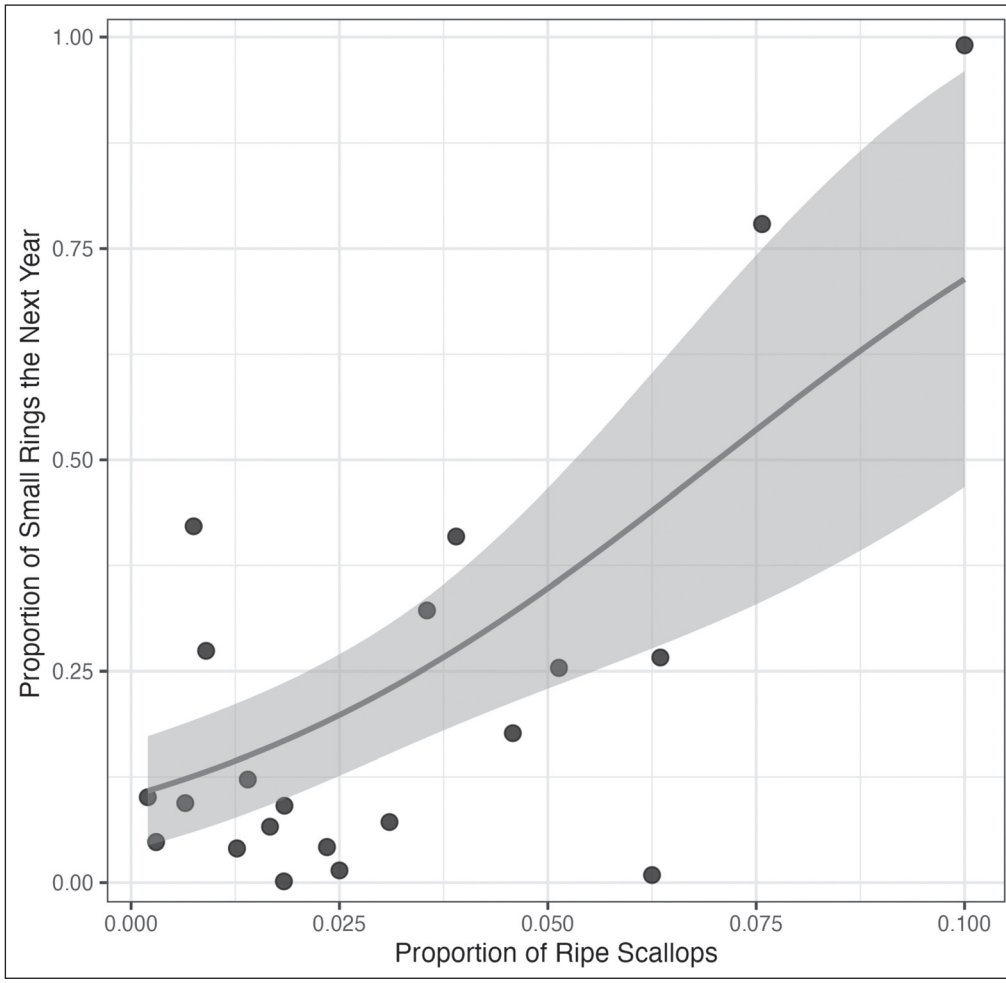


Figure 9. Averaged proportion of harvested adult (1+ yr) scallops with small (≤20 mm) annual growth rings in year $x + 1$ (across all sites) as a function of the mean proportion of ripe 1+ yr scallops across all sites in fall of the previous year, x. The line is the fit from a beta regression. Shaded regions denote 95% confidence intervals. Datapoints = mean proportions across all sampled locations for given years.

of decadal or multi-decadal cycles; however, analyses of such trends are beyond the scope of the present paper.

Table 2. Summary of linear regression analyses of the effect of water temperature (°C) in year x on the frequency of adult scallops with small annual growth rings (≤20 mm from the umbo) in the fall of year x + 1. Temperature metrics considered were: average daily temperature for a given period (Ave daily T), maximum temperature change during 1 day for a given month (Max daily ΔT), and # of days in a given month where ΔT was greater than its average from 1989 to 2021 (ΔT days). CI = 95% confidence interval.

Temperature metric	Slope	CI	*F*-statistic	R^2	*P*-value
Ave daily T: 1 Aug–start of harvest	3.04	-9.20, 15.27	0.26	0.01	0.610
Ave daily T: 1 Jan–start of harvest	6.69	-8.79, 22.17	0.81	0.04	0.378
Ave daily T: entire year	-0.30	-1.73, 1.12	0.20	0.01	0.661
Max daily ΔT: September	9.59	-8.19, 27.37	1.27	0.06	0.274
Max daily ΔT: October	-5.87	-28.93, 17.18	0.28	0.01	0.601
Max daily ΔT: November	4.51	-7.48, 16.50	0.62	0.03	0.442
ΔT days: September	0.31	-3.18, 3.80	0.03	0.00	0.855
ΔT days: October	-0.79	-3.96, 2.36	0.27	0.01	0.606
ΔT days: November	4.26	0.26, 8.26	4.93	0.20	0.038

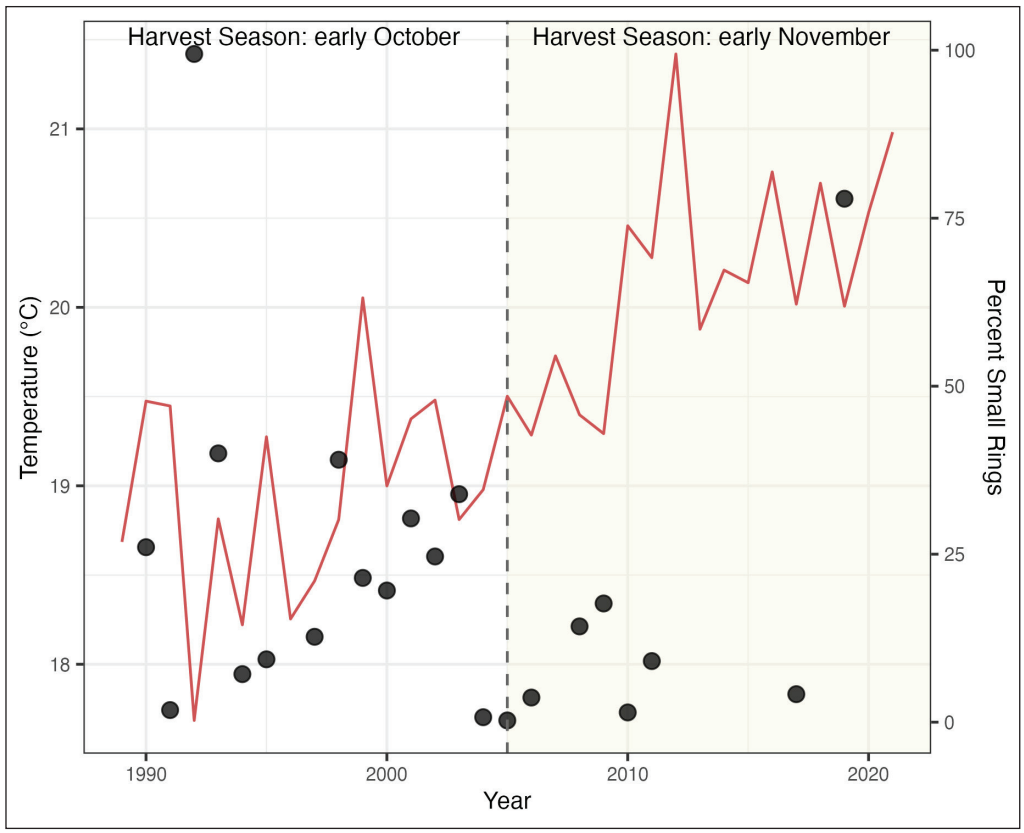


Figure 10. Temporal changes in the percentage of harvested adult scallops with small (≤20 mm) annual growth rings (•) and mean water temperature (-) during 1 May–31 October, through time.

The overall percentage of harvested Bay Scallops with a large (≥57 mm) annual growth ring was low. This result may reflect the actual prevalence of large juveniles (0+ yr scallops) from the prior fall or may represent a lower proportion due to premature harvest. As juveniles, 57+ mm individuals are above the legal size for harvest in New York so they may be targeted sometimes even though they don't possess a well-defined annual growth ring (as also required for harvest under NY state law). One complicating factor is that the annual growth ring is not always easy to identify; however, we have regularly seen juveniles of this large size (≥57 mm) in our annual October population surveys in the Peconic Bays (S.T. Tettelbach, unpubl. data). Several fishermen have suggested in the past (including in New York, before the ongoing die-off that began in 2019; Tettelbach et al. 2023) that large juveniles should be targeted because they often die naturally before they recruit to the fishery the next year (MacFarlane 1991; P. Winters, commercial bayman, Southold, NY, pers. comm.). We have not confirmed this natural mortality in our work, but this is an important matter that should be investigated further.

The highly significant inverse relationship between shell growth after the winter (Y) and RH across all sites, over the 1990–2019 period, is clearly indicative of compensatory shell growth (Ricker 1958). This phenomenon results in adult Bay Scallops reaching comparable sizes by the fall harvest season, despite marked differences in the size at which they entered their first winter. Our linear regression for Peconic Bay Scallops over multiple sites and years ($Y = 63.51 - 0.907 \bullet RH$) agrees very closely with that obtained by Auster and Stewart (1984) for a single year class of scallops from the Poquonnock River, CT, in 1979 ($Y = 64.20 - 1.02 \bullet RH$). The fact that fall-spawned juveniles enter the winter at small sizes and grow at higher rates after the winter than scallops that resulted from spawns in the late spring or in summer may potentially explain why ≤50% of fall-spawned scallops spawn themselves at an age of 1 year (Hall 2014, MacFarlane 1991).

Average meat weights of harvested scallops were expectedly higher during the 2005–2019 period, compared to 1990–2004, when the season opened a month earlier. The rate of increase in meat weight after 30 September during both periods was rapid, as also shown by Bricelj et al. (1987b) for some Peconic populations. This gain in mass typically happens after northern Bay Scallops complete summer spawning and begin to store energy in their adductor muscle for later conversion to gonadal material via gametogenesis in the winter (Sastry 1963, 1968, 1970). Interestingly, average meat weight increased significantly over the years from 1990 to 2004 and 2005 to 2019, albeit with many of those samples coming from a single site (Hog Neck Bay). If this trend is real, it may perhaps reflect more rapid growth rates due to rising water temperatures (and assumedly high enough levels of available food; Jobling 1997). Similarly, *Crassostrea virginica* (Gmelin) (Eastern Oyster) growers in the Peconic system have seen very high growth rates in the past 10+ years (K. Rivara, Aeros Cultured Oyster Company, Southold, NY, pers. comm.). Low average Bay Scallop meat weights at some sites during certain years, e.g., off the east side of Shelter Island in 1998 (7.4 g/meat, 135.1 meats/kg [61.3 meats/lb]), off Hay Beach in 1999 (6.8 g/meat, 147.1 meats/kg [67.0 meats/lb]), and off Mattituck in 2012 (6.6 g/meat, 151.5 meats/kg [68.4 meats/lb]) (Appendix 1) may have

reflected depressed growth rates, as these samples were obtained from populations with qualitatively higher scallop densities (Bricelj et al. 1987a).

The incidence of female Squatter Pea Crabs did not demonstrate a clear temporal pattern, as perhaps might be expected during the era of climate change (Marcogliese 2008), suggesting the level of infestation was not related to the increase in average water temperature which occurred over the course of the 30-yr period. While Squatter Pea Crabs are known to depress growth rates of Bay Scallops (Bologna and Heck 2000, Krucynski 1972), we did not parse out meat weights of scallops infected with female Squatter Pea Crabs to determine how much of an impact they had on average meat weight and SH.

While ripe Bay Scallops are not uncommon in October and November (Tettelbach et al. 1999, this study) very few ripe individuals are seen in December (S.T. Tettelbach, pers. observ.). Thus, it is not surprising that the relationship between the percentage of ripe scallops and the number of days past 30 September was not significant—especially because Bay Scallops typically begin to undergo gametogenesis in January (Sastry 1970). However, further study of seasonal patterns of gametogenesis and spawning may need to be revisited in light of the continued warming of nearshore waters (Tomasetti et al. 2023).

We interpret the robust relationship between the percentage of ripe adults in the fall of year x with the frequency of fall-spawned adults the following fall (year $x + 1$) to mean that (1) these ripe adults are in fact spawning and contributing to recruitment (Tettelbach et al. 2001) and (2) survival of these recruits is high enough for the pulse to be recognizable the following fall. While the process by which Bay Scallops condition for fall spawning is not well understood (Tettelbach et al. 1999), induction of fall spawning is most likely due to proximal temperature cues (sharp drop or increase) and mechanical agitation (from winds) (Barber and Blake 2016, Tettelbach and Weinstock 2008). Hall (2014) observed that in some years a sharp (2 °C) increase in water temperature followed by a sharp decline (2–5 °C) occurred around the time of fall spawns on Nantucket. However, she also noted that reduced salinities resulting from rainstorms may have cued spawns in the fall (as well as in late spring/summer). One other possibility is that fall spawns are more likely in Bay Scallop populations found in deeper channels, where water temperatures are cooler and spawning occurs later than in shallower waters (Taylor and Capuzzo 1983).

Our finding of an overall absence of a temperature effect (mean or ΔT) in year x on the frequency of adult Bay Scallops with small annual growth rings the following fall suggests that our temperature analyses may not have been fine enough to detect a relationship—perhaps requiring hourly data for specific sites/dates (Tettelbach and Weinstock 2008). However, other environmental factors (particularly food levels) may be driving the extent of fall spawning (Barber and Blake 2016, MacDonald and Bourne 1987).

The intensity of the fall spawn may ultimately reflect the totality of events that occurred during the course of the year, including the amount of energy stored and converted to gametes during the prior winter (Sastry 1963, 1968, 1970) and how many eggs and sperm were released during spring and summer spawns (Barber and Blake 2016, Styan and Butler 2003). The extent of fall spawns may also reflect the

intensity of proximal cues to induce spawning (Tettelbach and Weinstock 2008). If cues are less intense, even when scallops are ripe, they may undergo "dribble" (non-catastrophic) spawning (Langton et al. 1987, Paulet et al. 1988) or may not spawn at all (Osanai 1975, Yamamoto 1950). On Nantucket, Hall (2014) determined that for those nub adults that spawned at an age of ~1 year, almost all did so in the fall. This finding might suggest that this phenomenon would perpetuate across years, but marked fluctuations observed in annual proportions of nub adults (Hall 2014, this study) seem to indicate otherwise.

The specific timing of fall spawns in October and November is also uncertain, as reproductive sampling (including our own) is rarely conducted this late in the year in the northeastern US. One of the primary questions centering on the very small sizes (down to 1 mm) of nubs that enter the winter is the duration of the larval period during the colder fall months; i.e., are larvae spending the typical 1–2 weeks in the plankton phase before settlement (Belding 1910, Loosanoff and Davis 1963) or is this period protracted at sub-optimal temperatures? Tettelbach and Rhodes (1981) showed, for example, that at a salinity of 25 the relative percentage growth of Bay Scallop larvae through 5 d after fertilization at 10 °C was only 7% of that seen at 25 °C.

In light of our observations and those of other authors, the importance of fall-spawned Bay Scallops cannot be overstated, particularly because (1) they appear to experience higher survival rates compared to those produced by spring and summer spawns (Bishop et al. 2005, Hall 2014, Tettelbach et al. 2001) perhaps due to a temporal mismatch with their predators, and (2) the fecundity of 2+ yr scallops is considerably higher than that of 1+ yr olds when spawning occurs in spring/summer (Hall 2014; K. Tetrault, Cornell Cooperative Extension, Southold, NY, pers. comm.). Furthermore, since ≥50% of nub adult scallops survive to spawn at an age of 2+ years (Hall 2014, MacFarlane 1991), they may extend the usual semelparous life history of Bay Scallops to an iteroparous one and thus provide an important buffer to fluctuations in recruitment that may enhance the ability of populations to persist (Bishop et al. 2005, Geiger et al. 2010, Tettelbach et al. 2001) or to increase in size (Hall et al. 2015). The phenomenon of fall spawning appears to represent a form of bet-hedging (Bishop et al. 2005, Hall et al. 2015, Slatkin 1974) that is especially advantageous when environmental conditions are unpredictable. The downside of this strategy is that a significant proportion of nub scallops do not spawn in their first year, but are available to the fishery in the fall because they exhibit compensatory shell growth and reach the same SH as spring- and summer-spawned scallops (Auster and Stewart 1984, this paper).

Management of Bay Scallop fisheries (including in New York) rarely considers that fall-spawned 1+ yr adult scallops may not have spawned by the time the harvest season commences. This oversight likely occurs because (1) little was known historically of their importance and (2) it would require fishermen to measure annual growth rings, which is not only time consuming but may be especially difficult to do for scallops with a heavy cover of algae or Atlantic Slipper Snails (which are abundant in the Peconic Bays). The exception in Bay Scallop fishery management is Massachusetts, where harvest restrictions have been adopted that factor in the

importance of fall-spawned scallops: only adult Bay Scallops with a well-defined [annual] growth ring ≥10 mm are legal to harvest; scallops with an annulus <10 mm may only be taken when the shell height is >63.5 mm (Legal Information Institute, Cornell Law School 2026; Town of Nantucket, MA 2024). Currently, there is little evidence to suggest that the extent of fall spawning from one year to the next is a heritable trait (V. Hall, Mariah Mitchell Association, Nantucket, MA, pers. comm.). However, the importance of fall-spawned Bay Scallops to the sustainability and growth of populations warrants further investigation of the underlying reasons for varying frequencies in different years and at different sites.

Acknowledgments

We thank the dozens of scallop divers/culinary research specialists who buddied with S.T. Tettelbach over the years, particularly Lisa Tettelbach, whose patience for the process of data collection while scallops were being opened for dinner is especially appreciated. We also thank baymen Steve Latson and Peter Wenczel for providing shells of scallops dredged in the 1990s, Valerie Hall for insightful conversations about nub scallops, and Nicole Davis, Kate Muldoon, Sarah Kirschner, and John Carroll for assistance with data collection/processing. We are grateful to the Long Island Green Seal Commission, New York Sea Grant, the Peconic Estuary Partnership, the New York State Department of State and the Suffolk County Water Quality Protection and Restoration Program for funding restoration and research efforts that drove the resurgence of Peconic Bay Scallop populations for many years.

Literature Cited

Auster, P.J., and L.L. Stewart. 1984. Compensatory growth in the Bay Scallop, *Argopecten irradians* (L.). Journal of Northwest Atlantic Fisheries Science 5:103–104.

Barber, B.J., and N.J. Blake. 2016. Reproductive physiology. Pp. 253–299, *In* S.E. Shumway and G.J. Parsons (Eds.). Scallops: Biology, Ecology, and Aquaculture. Second Edition. Elsevier, New York, NY. 1196 pp.

Belding, D.L. 1910. The scallop fishery of Massachusetts. Marine Fisheries Series – No. 3. Division of Fisheries and Game, Department of Conservation, Commonwealth of Massachusetts, Boston, MA. 51 pp.

Bishop, M. J., E.A. Rivera, W.G. Irlandi, W.G. Ambrose, and C.H. Peterson. 2005. Spatiotemporal patterns in the mortality of Bay Scallop recruits in North Carolina: Investigation of a life-history anomaly. Journal of Experimental Marine Biology and Ecology 315:127–146.

Bologna, P.A., and K.L. Heck Jr. 2000. Relationship between Pea Crab (*Pinnotheres maculatus*) parasitism and gonad mass of the Bay Scallop (*Argopecten irradians*). Gulf and Caribbean Research. 12(1):43–46.

Bricelj, V.M., J. Epp, and R.E. Malouf. 1987a. Comparative physiology of young and old cohorts of Bay Scallop, *Argopecten irradians irradians* (Lamarck): Mortality, growth, and oxygen consumption. Journal of Experimental Marine Biology and Ecology 112:73–91.

Bricelj, V.M., J. Epp, and R.E. Malouf. 1987b. Intraspecific variation in reproductive and somatic growth cycles of Bay Scallops, *Argopecten irradians*. Marine Ecology Progress Series 36:123–137.

Byrne, M., and M.D. Lamare. 2024. Climate change and polar marine invertebrates: life-history responses in a warmer, high-CO_2 world. Journal of Experimental Marine Biology and Ecology 227:article jeb245765. <https://doi.org/10.1242/jeb.245765>

Conant, K.L., and T.L. Curley. 2005. Nantucket nub scallops, *Argopecten irradians*, overwinter twice and spawn for the first time at 21–22 months of age. Town of Nantucket Marine and Coastal Resources Department. Nantucket, MA. 17 pp.

Eckman, J.E. 1987. The role of hydrodynamics in recruitment, growth, and survival of *Argopecten irradians* (L.) and *Anomia simplex* (D'Orbigny) within Eelgrass meadows. Journal of Experimental Marine Biology and Ecology 106:165–191.

Eggleston, D.B., and D.A. Armstrong. 1995. Pre- and post-settlement determinants of estuarine Dungeness Crab recruitment. Ecological Monographs 65:193−216.

Gaines, S., S. Brown, and J. Roughgarden. 1985. Spatial variation in larval concentrations as a cause of spatial variation in settlement for the barnacle *Balanus glandula*. Oecologia 67:267−272.

Geiger, S.P., S.P. Stephenson, and W.S. Arnold. 2010. Protracted recruitment in the Bay Scallop, *Argopecten irradians*, in a west Florida estuary. Journal of Shellfish Research 29:809–817.

Hall, V.A. 2014. Impact of the second seasonal spawn on reproduction, recruitment, population, and life history of the northern Bay Scallop, *Argopecten irradians irradians* (Lamarck, 1819). Ph.D. Dissertation. University of Massachusetts, Dartmouth, MA. 197 pp.

Hall, V.A., C. Liu, and S.X. Cadrin. 2015. The impact of the second seasonal spawn on the Nantucket population of the northern Bay Scallop. Marine and Coastal Fisheries 7:419−433.

Hartig, F. 2016. DHARMa: Residual diagnostics for hierarchical (multi-level/mixed) regression models. Version 0.4.7. Available online at <https://cran.r-project.org/web/packages/DHARMa/index.html>.

Heino M., B.D. Pauli, and U. Dieckmann. 2015. Fisheries-induced evolution. Annual Review Ecology, Evolution, and Systematics 46:461–480.

Huang, B., C. Liu, V. Banzon, E. Freeman, G. Graham, B. Hankins, T. Smith, and H.-M. Zhang. 2021. Improvements of the daily optimum interpolation sea-surface temperature (DOISST) version 2.1. Journal of Climate 34:2923–2939.

Jennings, S., M.J. Kaiser, and J.D. Reynolds. 2001. Marine Fisheries Ecology. Blackwell Science Ltd., Malden, MA. 417 pp.

Jobling, M. 1997. Temperature and growth: Modulation of growth rate via temperature change. Pp. 225–254, *In* C.M. Wood, and D.G. McDonald (Eds.). Global Warming: Implication of Fresh Water and Marine Fish. Cambridge University Press, Cambridge, UK. 444 pp.

Kelley, K.M., and J.D. Sisson. 1981. Seed sizes and their use in determining spawning and setting times of Bay Scallops on Nantucket. Pp. 43–49, *In* K.M. Kelley (Ed.). The Nantucket Bay Scallop Fishery: The Resource and Its Management. Shellfish and Marine Department. Nantucket, MA. 108 pp.

King, M. 2007. Fisheries Biology, Assessment and Management, 2nd Edition. Blackwell Publishing Ltd, Oxford, UK. 396 pp.

Kruczynski, W.L. 1972. The effect of the Pea Crab, *Pinnotheres maculatus* Say, on growth of the Bay Scallop, *Argopecten irradians concentricus* (Say). Chesapeake Science 13:218–222.

Langton, R.W., W.E. Robinson, and D. Schick. 1987. Fecundity and reproductive effort of Sea Scallops, *Placopecten magellanicus*, from the Gulf of Maine. Marine Ecology Progress Series 37:19–25

Legal Information Institute, Cornell Law School. 2026. 22 CMR, § 6.11 - Bay Scallops harvest criteria. Available online at <https://www.law.cornell.edu/regulations/massachusetts/322-CMR-6-11>. Accessed 18 May 2026.

Loosanoff, V.L., and H.C. Davis. 1963. Rearing of bivalve mollusks. Advances in Marine Biology 1:1–136.

MacDonald, B.A., and N.F. Bourne. 1987. Growth, reproductive output, and energy partitioning in Weathervane Scallops, *Patinopecten caurinus*, from British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 44:152–160.

MacFarlane, S.L. 1991. Managing scallops *Argopecten irradians irradians* (Lamarck, 1819) in Pleasant Bay, Massachusetts: Large is not always legal. Pp. 264–272, *In* S.E. Shumway and P.A. Sandifer (Eds.). An International Compendium of Scallop Biology and Culture. World Aquaculture Society, Baton Rouge, LA. 357 pp.

Marcogliese, D.J. 2008. The impact of climate change on the parasites and infectious diseases of aquatic animals. Reviews in Science and Technology 27(2):467–484.

Marshall, N. 1960. Studies of the Niantic River, Connecticut, with special reference to the Bay Scallop, *Argopecten irradians*. Limnology and Oceanography 5:86–105.

Marra, G., and S.N. Wood. 2011. Practical variable selection for generalized additive models. Computational Statistics and Data Analysis 55:2372–2387.

New York State Department of Environmental Conservation (NYSDEC). 2026. Shellfishing closures, Town of Shelter Island: (i) Shelter Island Sound and Dering Harbor. Available online at <https://dec.ny.gov/things-to-do/shellfishing/closures>. Accessed 18 May 2026.

Osanai, K. 1975. Seasonal gonad development and sex alternation in the scallop *Patinopecten yessoensis*. Bulletin of the Marine Biological Station of Asamushi 15:81–88.

Pales Espinosa, E., Y. Bouallegui, D. Grouzdev, C. Brianik, R. Czaja, S. Geraci-Yee, A. Kristmundsson, M. Muehl, C. Schwaner, S.T. Tettelbach, H. Tobi, and B. Allam. 2023. An apicomplexan parasite drives the collapse of the Bay Scallop population in New York. Scientific Reports 13:article 6655. <https://doi.org/10.1038/s41598-023-33514-3>

Paulet, Y.M., A. Lucas, and A. Gerard. 1988. Reproduction and larval development in two *Pecten maximus* (L.) populations from Brittany. Journal of Experimental Marine Biology and Ecology 119:145–156.

Peconic Estuary Partnership. 2025. The Peconic Estuary story. Available online at <https://www.peconicestuary.org/peconic-estuary/the-peconic-estuary-story>. Accessed 11 August 2025.

Ricker, W.E. 1958. Handbook of computations for biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada 119:1–300.

Sastry, A.N. 1963. Reproduction of the Bay Scallop, *Aequipecten irradians* Lamarck: Influence of temperature on maturation and spawning. The Biological Bulletin 125:146–153.

Sastry, A.N. 1968. The relationships among food, temperature, and gonad development of the Bay Scallop, *Aequipecten irradians* Lamarck. Physiological Zoology 41:44–53.

Sastry, A.N. 1970. Reproductive physiological variation in latitudinally separated populations of the Bay Scallop, *Aequipecten irradians* Lamarck. The Biological Bulletin 138:56–65.

Slatkin, M. 1974. Hedging one's evolutionary bets. Nature 250:704–705.

Styan, C.A., and A.J. Butler. 2003. Scallop size does not predict amount or rate of induced sperm release. Marine and Freshwater Behaviour and Physiology 36:59–65.

Taylor, R.E., and J.M. Capuzzo. 1983. The reproductive cycle of the Bay Scallop, *Argopecten irradians irradians* (Lamarck), in a small coastal embayment of Cape Cod, Massachusetts. Estuaries 6:431–435.

Tettelbach, S.T. 1986. Dynamics of crustacean predation on the northern Bay Scallop, *Argopecten irradians irradians*. Ph.D. Dissertation. University of Connecticut, Storrs, CT. 229 pp.

Tettelbach, S.T., and E.W. Rhodes. 1981. Combined effects of temperature and salinity on embryos and larvae of the northern Bay Scallop, *Argopecten irradians*. Marine Biology 63:249–256.

Tettelbach, S.T., and A. Weinstock. 2008. Direct observation of Bay Scallop spawning in New York waters. Bulletin of Marine Science 82:213–219.

Tettelbach, S.T., and P. Wenczel. 1993. Reseeding efforts and the status of Bay Scallop *Argopecten irradians* (Lamarck, 1819) populations in New York following the appearance of "brown tide" algal blooms. Journal of Shellfish Research 12:423−431.

Tettelbach, S.T., C.F. Smith, R. Smolowitz, K. Tetrault, and S. Dumais. 1999. Evidence for fall spawning of northern Bay Scallops, *Argopecten irradians irradians* (Lamarck, 1819), in New York. Journal of Shellfish Research 18:47−58.

Tettelbach, S.T., P. Wenczel, and S.W.T. Hughes. 2001. Size variability of juvenile (0+ Yr) Bay Scallops, *Argopecten irradians irradians* (Lamarck, 1819), at eight sites in Eastern Long Island, New York. The Veliger 44:389–397.

Tettelbach, S.T., B.J. Peterson, J.M. Carroll, S.W.T. Hughes, D.M. Bonal, A.J. Weinstock, J.R. Europe, B.T. Furman, and C.F. Smith. 2013. Priming the larval pump: Resurgence of Bay Scallop recruitment following initiation of intensive restoration efforts. Marine Ecology Progress Series 478:153–172.

Tettelbach, S.T., R.E. Czaja Jr., H. Tobi, S.W.T. Hughes, B.J. Peterson, J. MacGregor, F. Delany, B. Scannell, E. Pales Espinosa, and B. Allam. 2023. Collapse of the New York Bay Scallop fishery despite sustained larval and juvenile recruitment. Marine Ecology Progress Series 714:45–56.

Tettelbach, S.T., J.R. Europe, C.R.H. Tettelbach, M. Schwartz, J. Havelin, B. Maloney, D.M. Bonal, B.T. Furman, and R.E. Czaja Jr. 2025. Life in a post-Eelgrass world: Temporal compression of a spatial refuge from predation. Ecosphere 16:article e70367. <https://doi.org/10.1002/ecs2.70367>

Tomasetti S., B. Hallinan, S. Tettelbach, O. Doherty, B. Allam, and C. Gobler. 2023. Warming and hypoxia reduce performance and survival of northern Bay Scallops (*Argopecten irradians irradians*) amid a fishery collapse. Global Change Biology 29:2092−2107.

Town of Nantucket, MA. 2024. Town regulations: Fishing and shellfishing. Available online at <https://ecode360.com/32940096>. Accessed 25 August 2025.

Trippel, E.A. 1995. Age at maturity as a stress indicator in fisheries. Bioscience 45:759–771.

Wang, H.Y., S.F. Shen, Y.S. Chen, Y.K. Kiang, and M. Heino. 2020. Life histories determine divergent population trends for fishes under climate warming. Nature Communications 11:article 4088. <https://doi.org/10.1038/s41467-020-17937-4>

Wickham, H. 2016. ggplot2: Elegant Graphics for Data Analysis. Second Edition. Springer, New York, NY. 276 pp.

Wickham, H., W. Chang, L. Henry, T.L. Pedersen, K. Takahashi, C. Wilke, K. Woo, H. Yutani, D. Dunnington, and T. van den Brand. 2025. ggplot2: Create elegant data visualizations using the grammar of graphics. Version 3.5.1. Available online at <https://cran.r-project.org/web/packages/ggplot2/index.html>.

Wilke, C.O. 2025. ggridges: Ridgeline plots in ggplot2. Version 0.5.7. Available online at <https://doi.org/10.32614/CRAN.package.ggridges>.

Yamamoto, G. 1950. Ecological note of the spawning cycle of the scallop (*Pecten yessoensis* (Jay)) in Mutsu Bay. Science Reports of the Tohoku University, 4th Series, Biology 18:477–481.

Appendix 1. Sites and dates of Bay Scallop harvests in the Peconic Bays, Long Island, NY, 1990–2019, plus shell metrics and other biological parameters of sampled scallops. The harvest season started on the first Monday in October from 1989 to 2004 and on the first Monday in November from 2005 to 2019. All scallops were collected by SCUBA diving unless noted otherwise. Bottom type: S = sand; M = mud; SM = sandy mud; MS = muddy sand; Gr = gravel; C = cobble; B = boulders; Sh = shells and shell hash; Cf = *Crepidula fornicata* (Common Atlantic Slippersnail) barrens; E = *Zostera marina* (Eelgrass); Ma = macroalgae. % small ring = % with small annual growth ring (≤20 mm); % large ring = % with large annual growth ring (≥57 mm); % ripe = % with bright orange ovary; % w/ pea crabs = % with female Squatter Pea Crabs. Nov 7 2006 sample from Hog Neck Bay: *n* = 420 for Squater Pea Crabs, ripe ovary; *n* = 449 for shell metrics.

Collection site	~ Depth at MLW (m)	Bottom type	Date	*n*	Total shell height (mm)		
					Mean	SE	Median
Napeaque Bay (East Channel)	1.5–7.0	M,S,E	7-Oct-96	~150			
Hallock Bay - N corner - Narrow River	1.0–2.0	MS, E	2-Oct-00	294	63.6	0.2	64.0
Hallock Bay - N corner - Narrow River	1.0–2.5	MS, E, Ma	5-Oct-01	153	65.4	0.7	64.0
Hallock Bay - N corner - Narrow River	1.0–2.0	MS, E, Ma	7-Oct-02	142			
Hallock Bay - N corner - Narrow River	1.0–2.5	MS, E, Ma	12-Oct-03	25	69.3	1.6	68.3
Hallock Bay - N corner - Narrow River	1.5–2.0	M, MS, Cf, Ma	10-Nov-06	28	70.2	0.9	70.7
Hallock Bay - central flats	1.5–2.0	S, Cf, Ma	10-Nov-06	22	73.1	1.0	73.6
Hallock Bay - central flats	1.5–2.0	MS, Cf, Ma	19-Nov-18	81			
Orient Harbor - N side	1.0–2.0	S, Sh, E	2-Oct-91	26	59.3	0.7	60.0
Orient Harbor - N side	1.5–2.0	S, Sh, E	29-Nov-91	31	69.7	0.9	70.0
Orient Harbor - N side	1.0–1.5	S, Gr, Sh, E	3-Oct-94	462	65.7	0.2	65.0
Orient Harbor - N side	1.0–1.5	S, Gr, Sh, E	30-Oct-95	139	62.9	0.4	63.0
Orient Harbor - N side	1.0–2.5	S, Gr, Sh, E	10-Oct-98	72	65.1	0.5	64.5
Orient Harbor - N side	1.0–2.0	S, Gr, Sh, E	5-Nov-98	376			
Orient Harbor - N side	1.0–2.0	S, Gr, Sh, E	7-Oct-99	116	64.4	0.4	64.0
Orient Harbor - N side	1.0–2.0	S, Gr, Sh, E	2-Oct-00	99	65.9	0.4	66.0
Orient Harbor - N side	1.0–2.0	S, Gr, Sh, E, Ma	5-Oct-01	229	62.2	0.3	62.0
East Marion - by trapnet	1.0–3.0	MS, Gr, B, Sh, Cf, E	24-Oct-99	388			
East Marion (Just NE of Bay Ave)	1.0–2.0	S, Gr, Sh, E, Ma	14-Oct-99	60	62.1	0.5	62.0
East Marion (Just NE of Bay Ave)	1.0–2.0	S, Gr, Sh, E, Ma	11-Oct-01	59	62.3	0.6	61.9
East Marion (Just NE of Bay Ave)	1.0–2.0	S, Gr, Sh, E, Ma	17-Oct-02	81	62.5	0.5	62
East Marion (Just NE of Bay Ave)	1.0–2.0	S, Gr, Sh, E, Ma	18-Oct-02	65	63	0.6	63.0

Collection site	~ Depth at MLW (m)	Bottom type	Date	*n*	Total shell height (mm) Mean	SE	Median
Shelter Island - N Tip (off Hay Beach)	1–1.5	S, Gr, Sh, E, Ma	4-Oct-99	196	61.0	0.3	61.0
Shelter Island - off NE corner ('Bunker City') - dredged			Nov-90	100	69.9	0.5	70.0
Shelter Island - E side	2.0	S, C, B, Cf, E, Ma	28-Oct-90	261	69.3	0.3	69.3
Shelter Island - E side	1.5–3.0	S, C, B, Cf, E, Ma	5-Oct-98	536	63.9	0.2	64.3
Shelter Island - E side	1.0–2.5	S, B, E, Ma	17-Oct-99	~350			
NW Harbor - E side (S of Alewife Creek)	1.0–1.5	S, Sh, E	22-Oct-91	~300			
NW Harbor - E side (S of Alewife Creek)	1.0–2.0	S, Sh, E	25-Oct-91	284			
NW Harbor - E side (S of Alewife Creek)	1.0–2.0	S, Sh, E	9-Oct-92	252	63.7	0.3	63.7
NW Harbor - E side (S of Alewife Creek)	1.0–2.0	S, Sh, E	20-Oct-92	104	65.9	0.3	65.8
NW Harbor - E side (S of Alewife Creek)	1.0–2.0	S, Sh, E	10-Nov-92	66			
NW Harbor - E side (S of Alewife Creek)	1.0–2.0	S, Sh, E	10-Oct-93	173	66.9	0.3	67.0
NW Harbor - E side (S of Alewife Creek)	1.0–3.5	S, Sh, E	7-Nov-93	88	69.5	0.5	70.0
NW Harbor - E side (S of Alewife Creek)	1.0–2.5	S, Sh, E, Ma	9-Oct-94	377	61.9	0.2	62.0
NW Harbor - E side (S of Alewife Creek)	1.0–2.5	S, Sh, E, Ma	12-Oct-97	198	65.9	0.3	66.0
NW Harbor - E side (N of Alewife Creek)	1.5–3.0	MS, Sh, Ma	11-Nov-97	~160			
NW Harbor - E side (S of Alewife Creek)	1.0–2.0	S, Sh, E, Ma	15-Oct-98	91	64.3	0.4	64.0
NW Harbor - E side (S of Alewife Creek)	1.0–2.0	S, Sh, E, Ma	10-Oct-99	173	66.8	0.3	67.0
NW Harbor - E side (S of Alewife Creek)	2–4.5.0	MS, Sh, Cf, Ma	11-Nov-14	332			
NW Harbor - E side (Off Split Rock)	1.0–2.0	S, Sh, E	3-Oct-91	84	62.8	0.4	63.0
NW Harbor - E side (Off Split Rock)	1.0–2.0	S, Sh, E	13-Oct-91	192	62.4	0.3	63.0
NW Harbor - E side (Off Split Rock)	1.0–2.0	S, Sh, E	16-Oct-91	~175			
NW Harbor - SE corner (N of Mile Hill Rd)	2.0–4.5	M, S, Ma	15-Nov-04	25	72.6	0.9	72.0
NW Harbor - S side - Barcelona Neck	1.0–2.0	S, Sh, E	14-Oct-93	49	67.2	0.8	68.0
NW Harbor - S side - Barcelona Neck	1.0–2.0	S, Sh, B, E, Ma	23-Oct-94	~250			
NW Harbor - S side - Barcelona Neck	1.0–2.0	S, Sh, E, Ma	6-Oct-97	345	65.5	0.2	65.6
NW Harbor - S side - Barcelona Neck	1.0–2.0	S, Sh, E, Ma	8-Oct-98	41	61.1	0.6	61.1
NW Harbor - S side - Barcelona Neck	1.0–2.0	S, Sh, E, Ma	4-Oct-01	156	63.3	0.3	63.0
NW Harbor - S side - Barcelona Neck	1.0–2.0	MS, Sh, Ma	11-Nov-16	96			

Collection site	~ Depth at MLW (m)	Bottom type	Date	*n*	Total shell height (mm) Mean	SE	Median
Southold Bay - N central, by spat site	3.0	SM, Cf, Ma	4-Nov-15	67			
Southold Bay - N central hole	2.0–8.0	M, SM, Cf, Ma	8-Nov-17	162	72.6	0.4	72.5
Southold Bay - N central hole	1.0–7.0	M, SM, Cf, Ma	12-Nov-17	48			
Southold - off Cedar Beach	3.0–3.5	S, Sh, Cf, Ma	25-Oct-03	31	70.1	0.9	70.7
Hog Neck Bay - SE Corner	1.5–4.0	S, Sh, Cf, Ma	4-Oct-04	298	67.9	0.2	68.0
Hog Neck Bay - SE Corner	2.0–3.0	S, Sh, Cf, Ma	8-Oct-04	~250			
Hog Neck Bay - SE Corner	2.0–3.0	S, Sh, Cf, Ma	15-Nov-04	84	72.3	0.5	72.4
Hog Neck Bay - SE Corner	2.0–3.5	S, Sh, Cf, Ma	7-Nov-05	387	66.4	0.2	66
Hog Neck Bay - SE Corner	1.5–3.0	S, Sh, Cf, Ma	13-Nov-05	~236			
Hog Neck Bay - SE Corner	2.0–3.0	S, Sh, Cf, Ma	12-Dec-05	59			
Hog Neck Bay - SE Corner	2.0–3.0	S, Sh, Cf, Ma	7-Nov-06	449	68.7	0.2	69.0
Hog Neck Bay - SE Corner	2.0–3.0	S, Sh, Cf, Ma	10-Nov-06	159			
Hog Neck Bay - SE Corner	2.0–3.0	S, Sh, Cf, Ma	14-Dec-06	168			
Hog Neck Bay - SE Corner	2.5–3.5	S, Sh, Cf, Ma	5-Nov-07	350			
Hog Neck Bay - SE Corner	2.5–3.5	S, Sh, Cf, Ma	6-Nov-07	120			
Hog Neck Bay - SE Corner	2.0–5.0	MS, S, Sh, Cf, Ma	3-Nov-08	257	67.4	0.3	67.0
Hog Neck Bay - SE Corner	2.5–3.5	MS, S, Sh, Cf, Ma	6-Nov-08	128			
Hog Neck Bay - SE Corner	3.0–4.5	MS, S, Sh, Cf, Ma	2-Nov-09	351	68.4	0.2	68.0
Hog Neck Bay - SE Corner	2.0–4.0	MS, S, Sh, Cf, Ma	3-Nov-09	158			
Hog Neck Bay - SE Corner	2.0–3.5	MS, S, Sh, Cf, Ma	1-Nov-10	345	66.8	0.2	67.0
Hog Neck Bay - SE Corner	2.0–3.5	MS, S, Sh, Cf, Ma	10-Nov-10	219			
Hog Neck Bay - SE Corner	2.5–3.0	MS, S, Sh, Cf, Ma	21-Nov-10	139			
Hog Neck Bay - SE Corner	3.0–4.0	MS, S, Sh, Cf, Ma	7-Nov-11	187	70.2	0.3	70.0
Hog Neck Bay - SE Corner	2.0–3.0	MS, S, Sh, Cf, Ma	4-Nov-15	311			
Hog Neck Bay - SE Corner	2.5–3.0	MS, S, Sh, Cf, Ma	6-Nov-15	290			
Hog Neck Bay - SE Corner	2.5–3.0	MS, S, Sh, Cf, Ma	20-Nov-15	90			
Noyack Bay - SW corner	3.0–4.0	MS, Sh, Cf, Ma	6-Nov-07	95			
Noyack Bay - NW corner	2.5–3.5	S, Cf	6-Nov-17	54	75	0.7	75.0
Noyack Bay - NW corner	2.0–4.0	M, S, Cf, Ma	5-Nov-18	347			
Noyack Bay - NW corner	2.0–3.5	M, S, Cf, Ma	8-Nov-18	262			

Collection site	~ Depth at MLW (m)	Bottom type	Date	*n*	Total shell height (mm) Mean	SE	Median
Noyack Bay - NW corner	1.5–3.5	M, S, Cf, Ma	4-Nov-19	95	69.7	0.5	70.0
Noyack Bay - W side	5.0	MS, Sh, Cf, Ma	20-Nov-15	26			
Robin's Island - W side (dredged)	1.5–5.0	S, Sh, Cf, Ma	8-Nov-05	86	69.7	0.5	69.8
Robin's Island - W side (dredged)	1.5–5.0	S, Sh, Cf, Ma	6-Nov-06	156	69.1	0.5	69.5
Great Peconic Bay - off Mattituck	3.0–4.0	S, Ma	4-Nov-08	93	67.0	0.4	67.0
Great Peconic Bay - off Mattituck	3.5–4.5	S, Ma	11-Nov-12	514			
Flanders Bay	3.0–4.0	SM, Cf, Ma	16-Dec-08	78	65.4	0.5	65.5

Collection site	Annual growth ring height (mm) Mean	SE	Median	% small ring	% large ring	Meat wt (#/kg) Mean	SE	% ripe	% w/ pea crabs	Water temp (°C)	% 2+ yr
Napeaque Bay (East Channel)						103.6		0.7	1.3	15.6	~40
Hallock Bay - N corner - Narrow River	28.0	0.6	32.0	22.8	0.0	109.4	2.0		lots	18.3	
Hallock Bay - N corner - Narrow River	28.1	0.7	30.0	21.6	0.0	123.5		15.0	0.0	20.0	12.5
Hallock Bay - N corner - Narrow River						112.5	10.1	7.7	0.0	18.9	
Hallock Bay - N corner - Narrow River	41.8	3.7	40.7	16.0	28.0	103.6		9.1	4.5		several
Hallock Bay - N corner - Narrow River	29.9	1.8	31.8	14.3	0.0					12.0	
Hallock Bay - central flats	32.1	2.0	30.7	4.5	0.0					12.2	
Hallock Bay - central flats						76.4	0.7	0.0	0.0	8.3	
Orient Harbor - N side	37.6	1.6	39.0	7.4	0.0			7.4		18.9	
Orient Harbor - N side	34.5	1.9	34.0	6.5	0.0	91.1		18.8	0	8.9	
Orient Harbor - N side	36.3	0.4	39.0	6.9	0.0	110.3		1.3	0	16.1	
Orient Harbor - N side	35.1	0.9	35.0	9.4	9.8	97.0		1.4	1.4	14.4	
Orient Harbor - N side	24.8	1.4	27.0	33.3	0.0	105.8		2.8		17.8	
Orient Harbor - N side						99.2		1.9		12.5	
Orient Harbor - N side	38.2	0.8	39.5	3.4	0.01						
Orient Harbor - N side	33.0	0.8	33.0	10.1	0.0	116.4	6.1	3.9	few	18.3	
Orient Harbor - N side	26.9	0.8	32.0	26.6	0.0	136.3	5.0	0.4	0.9	21.1	

Collection site	Annual growth ring height (mm)			% small ring	% large ring	Meat wt (#/kg)		% ripe	% w/ pea crabs	Water temp (°C)	% 2+ yr
	Mean	SE	Median			Mean	SE				
East Marion - by trapnet						110.3			3.9		
East Marion (Just NE of Bay Ave)	31.0	2.2	37.7	30.0	0.0					15.6	
East Marion (Just NE of Bay Ave)	14.7	1.4	8.8	74.6	0.0	105.8		0.0	4.2		
East Marion (Just NE of Bay Ave)	31.9	1.3	33.0	18.5	0.0	121.3		2.3	17.4		
East Marion (Just NE of Bay Ave)	26.0	1.6	27.0	32.3	0.0	115.1		4.8	29.0	16.1	
Shelter Island - N Tip (off Hay Beach)	39.9	1.0	38.0	6.6	9.7	147.7		0.2	lots	20.6	
Shelter Island - off NE corner ('Bunker City') - dredged	23.5	1.1	21.0	42.0	0.0						
Shelter Island - E side	33.4	0.8	36.2	19.9	1.9	105.8		~0.3	~0.8	15.6	
Shelter Island - E side	21.9	0.5	20.3	48.9	0.0	135.2	2.0	0.0	~2.2	17.8	
Shelter Island - E side						50.0	2.4			16.7	
NW Harbor - E side (S of Alewife Creek)								3.3	0.0	15.6	
NW Harbor - E side (S of Alewife Creek)				25.8		125.2		6.0	0.0	15.6	
NW Harbor - E side (S of Alewife Creek)	3.9	0.1	3.9	100.0	0.0	113.8		1.5		16.0	
NW Harbor - E side (S of Alewife Creek)	4.4	0.3	4.0	98.1	0.0	112.5		0.0		13.3	
NW Harbor - E side (S of Alewife Creek)						103.6		0.0		8.3	
NW Harbor - E side (S of Alewife Creek)	24.3	1.1	22.0	46.8	0.0	114.7		1.7	1.7	15.6	
NW Harbor - E side (S of Alewife Creek)	27.4	1.5	28.0	37.5	1.1	93.7		4.5	3.4	10.0	
NW Harbor - E side (S of Alewife Creek)	37.3	0.5	39.0	7.4	0.0	121.3		0.0	0.0	17.2	
NW Harbor - E side (N of Alewife Creek)	41.4	1.0	47.0	13.6	1.5	115.8				18.3	
NW Harbor - E side (S of Alewife Creek)						88.2	1.3			11.1	
NW Harbor - E side (S of Alewife Creek)	40.8	0.5	41.0	0.0	0.0	116.0		2.2	4.3		
NW Harbor - E side (S of Alewife Creek)	24.2	1.1	22.0	47.4	0.0						
NW Harbor - E side (S of Alewife Creek)						88.8	0.8	0.9	0.5	11.7	
NW Harbor - E side (Off Split Rock)	45.0	0.8	46.0	1.2	1.2				0.0		
NW Harbor - E side (Off Split Rock)	45.3	0.5	46.0	0.5	1.56			3.8	0.0	16.7	
NW Harbor - E side (Off Split Rock)								~4.4	0.0	15.6	
NW Harbor - SE corner (N of Mile Hill Rd)	48.4	0.8	49.0	0.0	0.0	84.0		4.0	4.0	7.2	

Collection site	Annual growth ring height (mm)			% small ring	% large ring	Meat wt (#/kg)		% ripe	% w/ pea crabs	Water temp (°C)	% 2+ yr
	Mean	SE	Median			Mean	SE				
NW Harbor - S side - Barcelona Neck	34.1	2.0	40.0	20.4	0.0						
NW Harbor - S side - Barcelona Neck						101.4			4.0	15.6	
NW Harbor - S side - Barcelona Neck	42.1	0.7	45.3	12.2	4.9	120.2		0.9		18.3	
NW Harbor - S side - Barcelona Neck	36.6	1.6	39.9	7.3	0.0						
NW Harbor - S side - Barcelona Neck	28.6	1.1	32.0	27.6	0.0						
NW Harbor - S side - Barcelona Neck						105.8	2.2			11.7	
Southold Bay - N central, by spat site						101.4				15.6	
Southold Bay - N central hole	49.5	1.0	53.0	4.4	0.0	85.4	2.3	2.4	~3.4		
Southold Bay - N central hole						80.7		2.1		11.7	
Southold - off Cedar Beach	31.0	3.5	24.1	48.4	9.7	92.6		3.4	20.7	12.8	
Hog Neck Bay - SE Corner	46.0	0.4	47.4	0.3	1.0	114.7	1.5	0.3	5.5	21.1	
Hog Neck Bay - SE Corner						110.5	3.3	0.0	~3.2	20.0	
Hog Neck Bay - SE Corner	41.6	1.1	45.3	2.4	0.0	88.2	2.2	1.2	3.6	7.2	
Hog Neck Bay - SE Corner	48.2	0.2	48.0	0.3	2.1	99.2	1.3	1.3	3.6	10.0	
Hog Neck Bay - SE Corner						99.2	4.0	0.8	~1.3	11.4	
Hog Neck Bay - SE Corner						88.7		3.4	1.7		
Hog Neck Bay - SE Corner	45.2	0.4	46.1	2.0	4.3	97.9	1.3	10.2	7.6	11.5	
Hog Neck Bay - SE Corner						98.1	2.0				
Hog Neck Bay - SE Corner						82.0	2.4	10.7		6.8	
Hog Neck Bay - SE Corner						98.1	2.4	5.8	7.9		
Hog Neck Bay - SE Corner						104.3	2.9	4.2	2.5	12.5	
Hog Neck Bay - SE Corner	47.7	0.5	49.0	2.7	8.8	108.0	1.1	7.2	2.3		
Hog Neck Bay - SE Corner						105.2	2.6	5.5	3.1		
Hog Neck Bay - SE Corner	40.9	0.8	47.0	17.7	3.7	110.0	1.0	2.5	3.1		
Hog Neck Bay - SE Corner						112.5	6.0	7.0	4.4		
Hog Neck Bay - SE Corner	45.0	0.4	46.0	1.4	2.3	111.9	1.3	1.8	1.31		
Hog Neck Bay - SE Corner						103.6	0.7	0.9	0.0	8.9	
Hog Neck Bay - SE Corner						99.2	1.3	0.0	0.0		
Hog Neck Bay - SE Corner	45.8	0.9	49.0	9.1	11.5	94.3	2.0	1.3	6.1	11.1	

Collection site	Annual growth ring height (mm)			% small ring	% large ring	Meat wt (#/kg)		% ripe	% w/ pea crabs	Water temp (°C)	% 2+ yr
	Mean	SE	Median			Mean	SE				
Hog Neck Bay - SE Corner						97.9	0.9			15.0	
Hog Neck Bay - SE Corner						91.3	2.3			15.6	
Hog Neck Bay - SE Corner						83.8	3.8			12.8	
Noyack Bay - NW corner						95.9	3.3	10.5	2.1	12.5	
Noyack Bay - NW corner	47.3	1.8	50.0	3.7	0	77.2		12.7	3.6	15.6	
Noyack Bay - SW corner						85.6	1.2	1.15	0.0	12.2	
Noyack Bay - NW corner						83.8	1.1	0.8	0.8	12.8	
Noyack Bay - NW corner	19	16.1	13.0	77.9	4.2	99.2	2.2	0.0	1.0	14.6	3.2
Noyack Bay - W side						83.3				12.8	
Robin's Island - W side (dredged)	49.3	0.6	50.0	0.0	10.5	101.4	2.2	3.4	3.4		
Robin's Island - W side (dredged)	37.6	0.8	38.6	6.4	0.6	92.6		2.5	18.4		
Great Peconic Bay - off Mattituck	25.8	1.4	19.0	50.5	0.0	121.3	4.4	2.0	0.0	~11.7	
Great Peconic Bay - off Mattituck						150.8	2.0			10.0	
Flanders Bay	35.6	1.3	36.0	9.0	2.6			2.2	0.0	7.1	