Growth, reproduction, and senescence of the epiphytic marine alga *Phaeosaccion collinsii* Farlow (Ochrophyta, Phaeothamniales) at its type locality in Nahant, Massachusetts, USA

**Abstract:** The growth, reproduction, and senescence patterns of the epiphytic marine alga *Phaeosaccion collinsii* were tracked over two consecutive seasons at its type locality of Little Nahant, Nahant, MA (USA). We investigated the potential and/or combined effects of temperature and ambient nutrient supply (NO$_3^-$ and PO$_4^{3-}$) on the phenology of this ephemeral species in its natural environment by collecting microscopic and macroscopic *P. collinsii* specimens from blades of eelgrass (*Zostera marina*) in a shallow coastal subtidal zone. Our results suggest that temperature is a strong driver of the alga’s in situ cycle and that the optimal temperature for *P. collinsii* growth and reproduction may be between 5 and 8°C, a narrower temperature threshold than previous laboratory studies on this subject have suggested. Several large winter storms also allowed us to observe the effect of physical disturbance on the integrity of the eelgrass beds and the population of microscopic and macroscopic *P. collinsii*. This study contributes the first in situ information on the abiotic conditions necessary for the successful growth and development of *P. collinsii* and a greater understanding of the life cycle of this unique golden brown alga.

**Keywords:** ephemeral algae; epiphytic algae; *Phaeosaccion collinsii*; *Zostera marina*.

**Introduction**

The growth and demography of marine plant life in coastal waters is strongly linked to fluctuating abiotic conditions in the surrounding environment (Penhale 1977, Chapman and Lindley 1980). Seasonal changes in environmental variables including temperature, light conditions, and nutrient availability correlate with the successful growth and reproduction of seaweeds, seagrasses, and phytoplankton, all of which constitute important parts of the marine coastal ecosystem (Chapman and Lindley 1980, Borum 1985, Neckles et al. 1993). Ephemeral marine epiphytes, which grow on host plants such as *Zostera marina* Linnaeus, appear during a relatively predictable and abbreviated time frame and complete their development cycle and then retreat into senescence until the following year.

Our understanding of the linkage between fluctuating environmental conditions and development of epiphytic, ephemeral marine algae is limited. Studies suggest that changes in temperature, light conditions, and/or nutrient availability may trigger the initiation and/or the decline of certain ephemeral epiphytic species (Fitzgerald 1969, Chapman and Lindley 1980, Borum et al. 1984, Borum 1985). To date, however, studies that monitor this process in situ are few (Borum 1985, Trautman and Borowitzka 1999, Reyes and Sansón 2001) with most of the available data based on laboratory studies (e.g. McLachlan et al. 1971, Chen et al. 1974, Kawai 1989). These sensitive species can be considered sentinels of climate change in the marine environment, and information about how populations vary seasonally with fluctuating environmental conditions may help to gauge how populations of ephemeral marine epiphytes will respond to changes in climate predicted to occur in the current century.
Phaeosaccion collinsii Farlow is a small, tubular golden brown species that occurs in the temperate coastal waters of New England from northern Massachusetts to Maine (Taylor 1957), as well as Greenland, Europe, and Asia (Guiry and Guiry 2015). P. collinsii is the sole member of the Family Phaeosaccionaceae and one of 32 species in the Order Phaeothamniales. This diverse family includes freshwater and marine species of unicellular, uniseriate filamentous, and monostromatic tubular morphologies; the latter two forms consist of cells embedded in a gelatinous matrix. Species are former members of the Chrysophyceae, but molecular, photochemical, and ultrastructural characteristics have placed them within the Phaeothamniales (Bailey et al. 1998, Andersen 2004, Kai et al. 2008). P. collinsii is the only member known to form macroscopic tubular thalli.

Phaeosaccion collinsii is usually found growing epiphytically on shoots of Z. marina (Collins 1900, Taylor 1957), appearing as macroscopic tubular thalli for approximately 4 weeks during spring. Nearly a century after it was initially discovered (Farlow 1882), McLachlan et al. (1971) reported the first completion of the life history of P. collinsii in culture. This study revealed a relatively simple development cycle in which biflagellate zoospores are formed asexually and released from vegetative cells of mature thalli. It also demonstrated that the completion of the life cycle was sensitive to changes in temperature, specifically that temperatures at or above 10°C have negative effects on growth and development (McLachlan et al. 1971). These findings were later verified in culture studies of a P. collinsii population from the Sea of Japan (Kawai 1989). Other research has focused on the fine structure of zoospores and cells of mature thalli (Chen et al. 1974) and analysis of pigments and other secondary metabolites (Craigie et al. 1971) in an effort to properly classify P. collinsii within the heterokonts.

With the exception of these few studies, very little is known about this alga, especially with regard to its life history in situ. In the present study, we returned to the type locality of P. collinsii to study the germination, reproduction, and senescence of this ephemeral species over two consecutive field seasons (February–April) of population growth, reproduction, and senescence. We tracked development of P. collinsii by collecting samples of Zostera weekly from subtidal transects, given the established epiphytic relationship between the two species. The data collected are principally related to (1) the abundance, size, and reproductive capacity of P. collinsii at its type locality and (2) the associated effects of environmental factors (namely, temperature, nutrient availability, and physical integrity of host plants) on the development and eventual senescence of P. collinsii thalli.

Materials and methods

The study was conducted in a nearshore subtidal site known as Dog Beach, located in Little Nahant, Nahant, Essex County, MA, USA (42°25′823″N, 70°56′107″W), the type locality of Phaeosaccion collinsii (Farlow 1882). Medium-density residential development and a road define the shoreline and mark the outer boundary of the sandy beach. The site is divided by a low-lying sandbar that is exposed at low tide and flanked on both sides by shallow Zostera marina beds (approximately -0.1 to -0.5 m MLLW). During our study, we monitored temperature continuously (HOBO Pendant Temperature/Light Data Logger 64K – UA-002-64, Onset Computer Corp., Bourne, MA, USA) and took water samples during surveys (n=5 per sampling date) to measure ambient nitrate and phosphate concentrations (μmol l⁻¹) [QuickChem FIA 8500 Autoanalyzer; Lachat Instruments; Loveland, CO, USA – detection limit: 0.014 μmol l⁻¹ nitrate (NO₃⁻) and 0.054 μmol l⁻¹ phosphate (PO₄³⁻)].

In order to estimate habitat availability and temporal variation of P. collinsii abundance, we sampled at weekly to twice-weekly intervals during two consecutive field seasons from January to April 2012 and February to April 2013 (a thick ice sheet over the site in January 2013 prevented earlier observations). The presence of Z. marina, macroscopic P. collinsii, other visible marine epiphytes, and bare space were scored at 1-m intervals along two parallel 50-m transects roughly 100 m from shore. Scores were used to calculate the proportion of shoots of Z. marina and track the appearance/disappearance of macroscopic P. collinsii. All samples of P. collinsii were found growing epiphytically on Z. marina. Shoots of Z. marina were harvested with roots and rhizome intact from five statistically derived random locations along each transect. When adequate samples of P. collinsii were not available in the immediate study area (i.e. recent storms disturbed the seagrass bed), a third location, about 120 m offshore, was used instead for additional haphazard collection of Z. marina shoots.

Specimens of Z. marina were transported from the field in plastic zip-closure bags and either processed immediately or stored in a -20°C freezer until laboratory processing could take place. In 2013, in order to interpret possible preferential settlement of P. collinsii on different areas of the host plant, inner and outer blades of the seagrass were kept separate throughout laboratory processing.

When shoots of Z. marina exhibited no visible P. collinsii growth, the front and back faces of each blade were gently scraped using a glass microscope slide that was then rinsed into a glass fingerbowl using 2 ml of filtered
seawater. All inner blades were scraped simultaneously and separately from all outer blades, and the material collected was rinsed with 2 ml filtered seawater into separate “inner” and “outer” fingerbowls per shoot. A 100-μl aliquot was removed from each fingerbowl and examined under a compound microscope at 40× magnification (Nikon Instruments Inc., Melville, NY, USA), at which point any P. collinsii basal discs were enumerated, the percent cover of P. collinsii per Z. marina shoot was calculated, and the subsamples were examined to note the presence of diatoms and other species of marine epiphytes.

When macroscopic P. collinsii thalli were present on one or more blades of a Z. marina shoot, the maximum length of P. collinsii was estimated by recording the length (cm) of the five longest thalli per shoot. Subsamples of macroscopic thalli were examined at 40× magnification to evaluate the presence and condition of P. collinsii zoospores.

In cases where zoospores were not present in freshly collected samples, thalli were placed in Petri dishes with filtered seawater and incubated in the dark for 24–48 h at 12°C in an attempt to induce zoospore release (Craigie et al. 1971, McLachlan et al. 1971, Chen et al. 1974) and thereby assess thallus reproductive maturity. The samples were examined for evidence of zoospore release by microscopic examination at 40×, using light stimulation to exploit the negative phototactic tendencies of P. collinsii zoospores (McLachlan et al. 1971).

χ²-tests were used to compare the presence of Z. marina shoots, proportion of Z. marina with macroscopic P. collinsii, and the proportion of P. collinsii that were able to produce zoospores among sampling dates and years. Analysis of variance (ANOVA) was used to compare the density of macroscopic P. collinsii abundance between study years, sampling dates, and inner versus outer blades of Z. marina (2013 only). In 2013, ANOVA was used to compare average maximum length of macroscopic P. collinsii individuals between sampling dates. Additionally, ANOVA was used to compare water temperature and nutrient concentrations in 2012 and 2013. All statistics were calculated using R version 3.0.2 (R Core Team 2013).

**Results**

Major differences in environmental variables and habitat availability were found between sampling years. The onset of spring occurred earlier in 2012, and temperatures were 2–3°C higher in 2012 during key observational periods (i.e. first appearance of macroscopic thalli and dates in which macroscopic thalli were present). It should be noted that temperatures were as much as 7°C higher in 2012 in the week preceding the appearance of macroscopic thalli in 2013 (Figure 1). Regarding nutrient availability, nitrate concentrations were almost threefold higher in 2013 (5.2±0.3 μmol NO₃⁻ l⁻¹) compared to 2012 (1.8±0.7 μmol NO₃⁻ l⁻¹; ANOVA; \( F_{1,4} = 1478.29; p < 0.001 \)). However, phosphate concentrations were slightly lower in 2013 (0.7±0.1 μmol PO₄³⁻ l⁻¹) compared to 2012 (1.2±0.1 μmol PO₄³⁻ l⁻¹; ANOVA; \( F_{1,4} = 80.06; p < 0.001 \)).

Habitat availability also differed between sampling years. While Z. marina was observed during each week sampled, the proportion of shoots (relative to bare space) was higher in 2012 (0.83±0.03) than in 2013 (0.59±0.05; \( X^2 = 984.4, p < 0.001) \). In 2013a series of major storms occurred in New England from February through March, causing coastal flooding and beach erosion in eastern Massachusetts, including the vicinity of the experimental site (A. Cryan, personal observation). This severe weather and corresponding intense wave action may have reduced seagrass density in 2013 as we observed much damage and overturn of the Zostera bed at the study site.

Microscopic P. collinsii was observable by early February (Figure 2) in both sampling years. It should be noted, however, that sampling in January 2013 was impossible due to a solid ice sheet covering the study site. Therefore, the presence or absence of P. collinsii earlier in the 2013 season is not known. Microscopic individuals
included basal discs and small independent collections of upright filaments that were not visible to the naked eye (Figures 3–4). In both years there was a notable decline in the proportion of eelgrass shoots with microscopic \textit{P. collinsii} from March into April, although this decline happened earlier in 2013 (Figure 2). Despite a higher proportion of shoots having microscopic \textit{P. collinsii} in 2012, average densities were 3.3-fold higher in 2013 compared to 2012 (ANOVA; \(F_{1,344}=3.71, p=0.05\)). However, there was also greater variation among sampling dates in 2013 compared to 2012 (\(F_{9,344}=10.04, p<0.001\)), likely due to the large amount of variation in abundance of \textit{Z. marina} across sampling dates, reflective of the frequent storms that year.

In 2013, we compared microscopic abundances between outer and inner blades of \textit{Z. marina} shoots. Although we found no significant differences in microscopic \textit{P. collinsii} density between the inner and outer blades of shoots we sampled (\(F_{1,316}=0.5819, p=0.4461\)), we noted the decline in abundance on inner blades and increase in abundance on outer blades in early March, just before the appearance of macroscopic thalli (Figure 5).

Macroscopic forms of \textit{P. collinsii} (Figures 6 and 7) were observed only in 2013. The proportion of \textit{Z. marina} with macroscopic \textit{P. collinsii} varied among sampling dates (\(\chi^2\)-test; \(\chi^2=18.70, df=5, p<0.001\)). Nearly all \textit{Z. marina} collected on March 28, 2013 had \textit{P. collinsii} present on its blades. On all other sampling dates the proportion of \textit{Z. marina} shoots with macroscopic \textit{P. collinsii} ranged from \(~20\) to \(65\)\%, with the lowest abundance observed on the last sampling date in which macroscopic thalli

---

**Figures 3–4:** Representative images of microscopic forms of \textit{Phaeosaccion collinsii}: (3), small basal discs (scale: 15 μm); (4), upright filaments (scale: 100 μm).
Phaeosaccion collinsii is observed in Little Nahant, MA, seasonally between February and April, when water temperatures in New England have warmed slightly following the chill of winter. We found temperature to be a likely driver of the completion of the P. collinsii life cycle in the field, supporting laboratory studies that previously established the association between temperature and the growth and reproduction of P. collinsii (McLachlan et al. 1971, Kawai 1989). Additionally, large differences in nutrient concentrations between 2012 and 2013 and the physical condition of the host Zostera marina after physical disturbance from major storm events may also have contributed to the success of P. collinsii. Our results suggest that P. collinsii may be more sensitive to environmental fluctuations than previously acknowledged and future climate change may negatively impact this species in its type locality.

One of the most conspicuous findings from our study was the observed lack of macroscopic P. collinsii also varied by sampling date. Notably smaller (only 2.5–3.1 cm) P. collinsii was observed during the first week of April (following a major storm) and on the last sample date. The maximum frond length observed was 5.8 cm, approximately 3 weeks after macroscopic forms appeared. During this period, average frond length of P. collinsii (1.92±0.05 cm) did not vary across sampling dates (one-way ANOVA, $F_{5,38}=0.135$, $p=0.983$).

Macroscopic P. collinsii was able to produce zoospores during the entire 2013 sampling period (Figures 8 and 9). The proportion of P. collinsii that produced zoospores (following an incubation period) generally increased over the sampling period ($\chi^2$-test; $\chi^2=13.26$, $df=5$, $p=0.021$) with nearly 100% of individuals producing zoospores on the last three sampling dates. Production of zoospores was patchy in P. collinsii individuals and did not appear to be restricted to any particular portion of the thallus (i.e. did not occur in only apical cells) (K. Benes, personal observation).

**Discussion**

Phaeosaccion collinsii is observed in Little Nahant, MA, seasonally between February and April, when water temperatures in New England have warmed slightly following the chill of winter. We found temperature to be a likely driver of the completion of the P. collinsii life cycle in the field, supporting laboratory studies that previously established the association between temperature and the growth and reproduction of P. collinsii (McLachlan et al. 1971, Kawai 1989). Additionally, large differences in nutrient concentrations between 2012 and 2013 and the physical condition of the host Zostera marina after physical disturbance from major storm events may also have contributed to the success of P. collinsii. Our results suggest that P. collinsii may be more sensitive to environmental fluctuations than previously acknowledged and future climate change may negatively impact this species in its type locality.

One of the most conspicuous findings from our study was the observed lack of macroscopic P. collinsii thalli during our first sampling season, in 2012. The 2012 season coincided with the warmest sea surface temperatures (SST) in the Northwest Atlantic in 30 years (Mills et al. 2013). McLachlan et al. (1971) found that the complete life history of P. collinsii in culture is carried out only at 5°C, and Kawai (1989) observed that saccate thalli developed exclusively at 5°C. Temperatures exceeding this value (i.e. 10°C, 15°C, and 20°C) produced poorly developed, filamentous thalli and limited zoospore germination (McLachlan et al. 1971, Kawai 1989). The absence of macroscopic thalli in 2012 could suggest that successful growth and

![Figure 5](image-url) **Figure 5:** Average density of microscopic Phaeosaccion collinsii (±SE) per square centimeter blade area of Zostera on outer and inner blades of shoots. Data are for 2013 only (n=10 per sampling date).

![Figure 6-8](image-url) **Figure 6–8:** Images of the macroscopic form of Phaeosaccion collinsii: (6), surface view of the thallus (scale: 100 μm); (7) whole thallus (scale: 1000 μm); (8), thallus releasing zoospores (scale: 150 μm).
reproduction of *P. collinsii* occur within a more narrowly defined temperature range than previous laboratory studies have reported. During our study in 2012, water temperature reached 6°C by early March and increased progressively from that point onward. Additionally, water temperatures rose to 10°C in mid-March 2012 suggesting that *P. collinsii* is very sensitive to even brief spikes in temperature above optimal thermal conditions. These data suggest that the temperature threshold for *P. collinsii* growth and reproduction may be within 5–10°C.

In 2013, macroscopic *P. collinsii* thalli were found growing epiphytically on shoots of *Z. marina* on March 25, coinciding with the first water temperature reading above 5°C (in late March 2013). Macroscopic forms persisted until temperatures rose to above 8°C in mid-April. We also found that the appearance of macroscopic *P. collinsii* was associated with a large decline in the presence and abundance of microscopic *P. collinsii* in 2013, when water temperatures rose from 4°C to 6°C, potentially indicating that the temperature increase had signalled the development into macroscopic form. These observations, combined with those made in 2012 (see above), suggest that 6–8°C is near the actual limit for *P. collinsii* growth and development into mature thalli. However, additional, more controlled studies are needed to test this hypothesis.

We also noted a possible seasonal shift regarding the location of the majority of microscopic thalli on *Z. marina* blades in 2013. Early in the season, *P. collinsii* was found on both inner and outer *Z. marina* blades (in general, more microscopic thalli were found on inner blades). Approximately 2 weeks prior to the appearance of macroscopic forms, microscopic thalli were found almost exclusively on outer blades. It is possible that this shift may be associated with *Z. marina* leaf turnover and/or potential preferential settlement by zoospores. Biomass of epiphytic communities on *Z. marina* can be on average 15-fold higher on the oldest versus the youngest leaves of a plant (Neckles et al. 1993), and the diversity and biomass of epiphytic algal species tend to be highest on the older (outer) leaves of host plants (Borum 1987, Trautman and Borowitzka 1999, Reyes and Sansón 2001). Given that the half-life of individual *Z. marina* blades is about 50 days in temperate waters (Olesen and Sand-Jensen 1994, Jernakoff et al. 1996), *P. collinsii* zoospores that settle on the inner blades up to 3–4 months prior to macroscopic development could contribute to the current season’s population.

McLachlan et al. (1971) hypothesized that settlement of zoospores onto inner *Z. marina* blades and arrested development from late spring until the following winter allows *P. collinsii* to persist year to year. Shoots of *Z. marina* at our study site had between two and five blades with the innermost blades found under a protective sheath (K. Benes, unpublished data). It therefore follows that the exposed blades in the current season would be shed by the following winter, and thus any *P. collinsii* that were residing even on the inner blades of the seagrass would apparently be sloughed off by the onset of the following growing season. McLachlan et al. (1971) noted that *P. collinsii* developed in culture from seagrass blades collected in July. However, given that zoospores lose motility at temperatures exceeding 5°C (McLachlan et al. 1971), and the overturn of seagrass blades, it remains unclear at what life-history stage and by what mechanism *P. collinsii* persists between seasons or over years when conditions for development are not optimal.

Based on our observations of zoospore production, once *P. collinsii* develops into macroscopic form, it is able to reproduce during its entire season. Following major storms, we often noted *P. collinsii* also growing on exposed roots and rhizomes of *Z. marina* once macroscopic thalli appeared (K. Benes, personal observations). This suggests that zoospores from the current season may be able to settle and develop into mature thalli within a single season.

Seasonal fluctuations in nutrient availability may also contribute to *P. collinsii* development and abundance. Nitrate concentrations were three times higher in 2013 than in 2012. These elevated nutrient conditions combined with a more optimal temperature range may have contributed to the relatively more robust population of *P. collinsii* at our study site in 2013 as compared to 2012. To date, no studies have specifically investigated the importance of nutrient availability for *P. collinsii* growth and

![Figure 9: Proportion of macroscopic Phaeosaccion collinsii collected that produced zoospores following dark incubation at 12°C.](image-url)
development. Some previous studies of other algal species have elucidated the stimulating effect of nutrient enrichment on epiphyte development (Fitzgerald 1969, Phillips et al. 1978). Other studies, however, have found no pattern of distribution of epiphytic algae consistent with nutrient enrichment (Harlin and Thorne-Miller 1981). While we cannot speculate on the relative importance of nutrients compared to temperature for \textit{P. collinsii}, exploring the possible synergistic effects of increased temperature and reductions in nutrient availability may be an important avenue for future study.

Physical disturbance of host populations of \textit{Z. marina}, i.e. damage caused by severe weather events, may impact the condition and development of \textit{P. collinsii}. In 2013, two significant winter storms (February 8–12 and March 4–9) impacted coastal Massachusetts and affected the physical condition and water temperature of the experimental site. The storms generated average wave heights (~2.00 m) in the sampling location where typical wave heights range between 0.15 and 0.60 m (National Buoy Data Center, Station 44013, Boston). During the sampling period following each storm, we found a reduction in the proportion of \textit{Z. marina} with \textit{P. collinsii} and/or density of \textit{P. collinsii} on seagrass shoots. The physical disturbance caused by the storm could have compromised the integrity and productivity of the \textit{Z. marina} beds and disturbed the \textit{P. collinsii} population.

Lastly, previous studies of \textit{P. collinsii} in culture investigated the effects of daylength and irradiance on its development. While Kawai (1989) documented no effects of daylength on \textit{P. collinsii}, McLachlan et al. (1971) noted that high light (\(\sim 100\) ft-c or \(\sim 20\) \(\mu\)mol photons m\(^{-2}\) s\(^{-1}\)) inhibited zoospore germination. McLachlan et al. (1971) suggested that both low light (\(\sim 50–100\) ft-c) and short daylength (8 h), in combination with low water temperatures (5°C), was important for completion of \textit{P. collinsii}’s life cycle. However, these environmental conditions were not tested factorially, and as such the relative importance of temperature and daylength cannot be assessed. Based on Kawai’s (1989) work and that daylength did not vary between years of our study (US Naval Observatory), it seems this factor may not be a major driver of \textit{P. collinsii}’s development.

Our study of \textit{P. collinsii} in its type locality of Little Nahant, MA, has contributed to an important body of knowledge on this epiphytic species. Documenting the \textit{in situ} effects of variable abiotic factors including temperature, nutrient availability, and physical disturbance of host plants on the successful growth and development of \textit{P. collinsii} illuminates the role of this species in seagrass ecosystems and allows a better understanding of environmental control of its phenology. Such data are also crucial for predicting how ephemeral populations may respond to changing climatic conditions in near-coastal waters as predicted over the next century (IPCC 2013). In addition to the predicted average of 4°C increase in global SST by 2100 (Meinshausen et al. 2011), increases in the frequency and severity of extreme weather events (Easterling et al. 2000) could further affect population sizes, distribution, and available habitat of \textit{P. collinsii}, as we saw in the \textit{Z. marina} beds during the intense winter storms of 2013. Data gleaned from \textit{in situ} investigations of the influence of abiotic conditions on the growth and demography of ephemeral marine algal species allow for more informed and effective mitigation of potential negative consequences on these important species caused by sustained changes in climate.

Acknowledgments: We would like to thank Dr. James Douglass for help with fieldwork and Dr. Matthew Bracken for use of field equipment and laboratory space and instrumentation. Comments from M. Dring and two anonymous reviewers greatly improved the original manuscript.

References


Bionotes

Ashley E. Cryan
Northeastern University, Marine Science Center 430 Nahant Road, Nahant, MA 01902, USA

Ashley E. Cryan is a marine scientist and educator and a specialist in algal biology and ecology. She has worked as a research assistant at Woods Hole Oceanographic Institution, Northeastern University’s Marine Science Center, and at San Francisco State University’s Romberg Tiburon Center for Environmental Studies. In 2013 she received the Physical and Life Sciences award from Northeastern University’s Center for Research Innovation for her research on harmful algal blooms and climate change in the Gulf of Maine. Ashley plans to pursue graduate study in oceanography and limnology and continue researching the effects of oceanic climate change on marine species and ecosystems.

Kylla M. Benes
Northeastern University, Marine Science Center 430 Nahant Road, Nahant, MA 01902, USA; and University of California, Department of Ecology and Evolutionary Biology, 321 Steinhaus Hall, Irvine, CA 92697-2525, USA, kbenes@uci.edu

Kylla M. Benes is a PhD candidate at the University of California, Irvine, in the Department of Ecology and Evolutionary Biology. She was awarded a MSc from California State University, Northridge, in 2006 for research on secondary succession in kelp forest algal communities. Broadly, she is interested in causes and consequences of changes in biodiversity, particularly intraspecific diversity. Currently, her research focuses on nutrient physiology, local adaptation, and population structure of intertidal seaweeds.
Brendan Gillis received a BA from Boston University and a MSc from Northeastern University's Department of Biology. His research focused on the effects of climate change on seaweed biodiversity and species interactions.

Christine Ramsay-Newton was awarded a PhD in Ecology, Evolution and Marine Biology from Northeastern University's Marine Science Center for her work on the ecology surrounding invasive seaweeds. She also received her MSc from the University of Rhode Island for her research on estuarine ecology, specifically the impacts of macroalgal blooms on salt marsh habitats. Her research interests include algal ecology, estuarine ecology, invasive species, and invertebrate ecology.

Valerie Perini is an educator with expertise in marine biology and outdoor education. She earned her Bachelor and Master of Science degrees in Biology at Northeastern University. For her master's thesis project, she worked with Dr. Matthew Bracken collecting longitudinal data documenting nutrient availability in intertidal communities in the Southern Gulf of Maine and quantifying the impacts of nutrient fluctuations on primary producers, herbivores, and community-wide nutrient cycling. Currently, as the Senior Outreach Educator at Northeastern University's Marine Science Center, Valerie leverages her dual passions for marine biology and science communication to share cutting edge marine science research with students, educators, and the general public via planning and leading outdoor education programs and public events as well as developing web content highlighting scientific research.

Graphical abstract

Ashley E. Cryan, Kylla M. Benes, Brendan Gillis, Christine Ramsay-Newton, Valerie Perini and Michael J. Wynne

Growth, reproduction, and senescence of the epiphytic marine alga *Phaeosaccion collinsii* Farlow (Ochrophyta, Phaeothamniales) at its type locality in Nahant, Massachusetts, USA

DOI 10.1515/bot-2015-0019
Botanica Marina 2015; xx(x): xxx–xxx

Research article: Completion of the life cycle of *Phaeosaccion collinsii* in situ appears to be strongly regulated by ambient water temperatures; disturbance and nutrient availability may also influence growth and development, so that climate change may negatively impact some populations of *P. collinsii*.

Keywords: ephemeral algae; epiphytic algae; *Phaeosaccion collinsii*; *Zostera marina*. 