Compiling a long-term data set based on student intertidal transect surveys at the Shoals Marine Lab, Appledore Island, ME

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Photo by E. Kuo

Introduction

Long term data describing organism distribution and abundance are valuable in assessing changes due to any number of factors, including but not limited to climate patterns, isolated or chronic disturbance events, ecological interactions, and establishment of invasive species. There is a growing body of evidence that marine ecosystems are changing rapidly in the face of these challenges -- Halpern et al. (2008) used spatial modeling to show that over 41% of ocean environments show pronounced impacts from multiple human activities. Establishing ecological baselines now may be critical to understanding these changes, but long-term data sets are rare due to the inherent difficulties involved with funding and maintaining such projects.

The Shoals Marine Laboratory (SML) has accumulated over twenty-five years of data from student transect surveys that detail the distribution and abundance of organisms in both exposed and protected rocky intertidal habitats on Appledore Island in the Gulf of Maine. SML uses the transect studies to teach research methods and focus student observations in the field; we hope that compiling the survey data will allow us to track and document changes around Appledore Island and provide a long-term dataset with baseline information to the broader scientific community. We present here a selection of data from the much greater, ongoing collection to illustrate its potential.

History of the Transect Project

SML is a summer field station devoted to undergraduate education in the marine sciences and operated jointly by Cornell University and the University of New Hampshire. The lab is located on Appledore Island, a 38.44-ha island in the Isles of Shoals, Gulf of Maine (42°58'N, 70°37'W, see Figure 1). Partially protected by neighboring islands, the coast of Appledore experiences a gradient of exposure and presents a variety of habitats that make it an ideal small-scale laboratory for comparative ecological research.

The transect project began when SML was founded and originally operated on the nearby Star Island (Kingsbury 1976)—at the time, local concern about proposed construction of an oil refinery on a neighboring island highlighted the importance of collecting baseline information. Transect records from the Star Island studies have been summarized and made available (Kingsbury 1976). When the lab began running classes on Appledore in 1974, the transect studies moved with the lab. Permanent transect sites were selected around Appledore to maximize the variety of habitats and exposures represented, (see Figure 2) (J.M. Kingsbury, pers comm). A subset of these transects are surveyed annually. Unfortunately, most of the data from these surveys exist only in paper format; transect records from classes earlier than 1982 were lost in a flooding event at Cornell, underscoring the need to curate and make these data available.

Figure 1: Landsat image of the Isles of Shoals

Figure 2: Map of Appledore Island. Transect locations are marked with red numbers, transects analyzed in this study are also circled in black.

Methods

28 permanent transects around Appledore Island are established by markers at 13.5 ft above mean low water. Students identify and record the abundance of organisms at one-foot vertical intervals above the reference markers to the upper extent of observable organisms, and below the markers as low as prevailing tide and wave conditions allow. Transects run along fixed bearings; students are instructed to avoid tide pools and to sample in areas that represent the typical slope and exposure of the transect. At each sampling elevation, three 20 cm square quadrats with a 16 square grid are placed haphazardly with their upper edge at the level to be surveyed, and all live macroscopic organisms within the quadrats are identified and quantified. Only algae with holdfasts inside the quadrat are recorded. Students identify organisms to species whenever possible and collect samples of species they cannot readily identify to key out in the lab. Organism abundance is quantified according to established standards that reflect the ecologically important parameters of a species, e.g., percent cover (both substrate and canopy) for all algae and sessile invertebrates, total count of sessile and mobile invertebrates to estimate density, and size for a few representative species. The presence of epibionts is roughly quantified by recording frequency of appearance within a grid square. Data are collected in early June and again in early August. The number of transects surveyed varies each year with class enrollment.

Students participate in two weeks of intensive instruction on species identification prior to transect work, and receive extensive, ongoing guidance for survey methods and species identification throughout the two weeks allotted for completion of the survey.

Sample Applications

To date, SML staff have digitized approximately half of the existing paper format transect records. From this subset of data, we have chosen to focus on nine transects—2, 5, 7, 15, 20, 22, 24, 26, and 28 — which are both fully representative of Appledore Island exposure regimes and have the most complete time series since 1982 (see Table 1, selected transects are also circled on Figure 2).

The graphs presented here describe several ecological patterns found in preliminary analyses -- we imply no significance in the relationships shown but hope to illustrate potential uses of the data set. We believe the transect data will be applicable to a wide variety of ecological studies, including but not limited to: tracking changes in the vertical distribution of species and groups through time (see Figure 3), monitoring the establishment of invasive species (see Table 2 and Figure 4), observing relationships between species and assemblages (see Figures 4 and 5), and recording organismal patterns with varying slope and exposure (see Figures 5 and 6).

Time Series

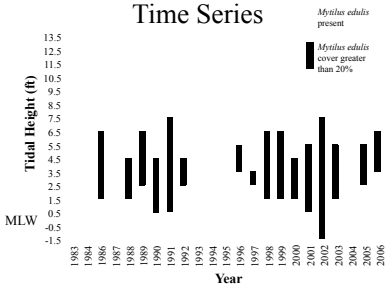


Figure 3: *Mytilus edulis* (blue mussel) shows variable abundance and vertical distribution through time. These patterns likely reflect recruitment patterns.

Table 1: Physical characteristics and data available by transect.

Transect	Average slope	Approximate fetch (nautical mi)	Relative exposure	No. years sampled 1982-2009
2	1.4	5.2	low	16
5	0.23	12	low	24
7	0.15	5.3	low	21
15	0.24	3370	high	25
20	0.16	165	high	26
22	0.23	200	high	25
24	0.24	0.21	moderate	16
26	0.14	0.5	low	25
28	0.19	5.2	low	20

Monitoring Invasive Species

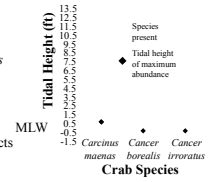
Table 2: Comparison of the years a few recent invasive species were first recorded on Appledore, in the transect data, and as common around Appledore.

Species	First recorded on Appledore	First recorded in transect data	Noted as common on Appledore
Codium fragile ssp. tomentosoides (dead man's fingers)	1983*	1988	1991*
Hemigrapsus sanguineus (Asian shore crab)	2001**	2006	present****
Membranipora membranacea (lacy crust bryozoan)	1987***	1989	1989***

*Levin et al. (2002); **B. Shulman (pers. comm.); ***Berman et al. (1992); ****personal observation.

Invasive species generally do not appear in the transect data until they are already common around Appledore, either due to misidentification or a lack of sensitivity in the study. However, the transect study does allow us to study the ecological parameters of invasive species that are already established.

Figure 4: The historic invader *Carcinus maenas* (European green crab) is the only crab species commonly found well above MLW (averages compiled from all transects and all years available).



Spatial Analyses

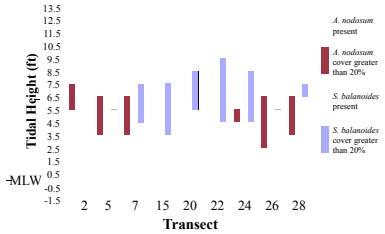


Figure 5: *Ascophyllum nodosum* (rockweed) and *Semibalanus balanoides* (acorn barnacle) show an inverse relationship in abundance varying with exposure between transects. Averages compiled from all data years available.

Figure 6: Average length of the longest *Ascophyllum nodosum* (rockweed) individual appears to vary with exposure between transects. Averages compiled from all data years available.

Next Steps

SML has shared the digitized portion of the dataset with the Gulf of Maine Research Institute (GMRI) in Portland, ME to make this portion of the dataset available to the research community for analysis and testing a wide range of hypotheses. Digitizing the remainder of the dataset remains an SML priority pending resource availability.

Effective in 2011, SML will significantly change its approach to continuing intertidal transect studies. Transect studies will be removed from credit courses that had used them as a training exercise, and the Lab will sponsor six **Transect Internships** of three weeks duration. Transect interns will be selected based on academic qualifications and previous satisfactory completion of either Field Marine Science or Field Marine Biology and Ecology (to be shortened and renamed Field Marine Ecology). Transect mentors will be faculty from Field Marine Biology and Ecology.

This change contributes to, and draws from, larger strategic curriculum adaptation at SML. Transect studies will benefit from increased focus by a small number of select interns working in close supervision with faculty mentors through review and resulting in reduced measurement and identification errors, and increased consistency in data collection. We expect that the revised approach to transect data collection will take a more proactive approach to recognizing new invasive species (see Table 2), and allow tracking of the expansion of known and newly recognized invasive species. We also expect to expand the types of data collected during transect studies to include a wider spectrum of ecological parameters, e.g. temperature loggers anchored at transect locations to quantify temperature variation between differing habitats and tidal heights.

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