EARTHWATCH INSTITUTE

CLIMATE CHANGE: SEAS TO TREES AT ACADIA NATIONAL PARK

2015

FIELD REPORT

Climate Change: Seas to Trees at Acadia National Park

2015 FIELD REPORT

Background Information

LEAD PI: Abraham Miller-Rushing

REPORT COMPLETED BY: Hannah Webber

PERIOD COVERED BY THIS REPORT: July 5, 2015-October 8, 2015

CHANGES TO:

PROJECT SCIENTISTS: Additional field staff: temporary seasonal technicians--Megan Roselli (megan.roselli@wilkes.edu), field technician, June 15, 2015-October 15, 2015. Libby Orcutt (EOrcutt11@alumni.unity.edu), field technician, May 27, 2015-November 19, 2015. Julianne Pekny (juliannepekny@gmail.com), field technician, June 8, 2015-October 15, 2015.

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Dear Earthwatch volunteers,

Wow, what an amazing first full field season we had here at Schoodic. You helped us support four research lines, all focused on different aspects of the effects of climate change at Acadia National Park and the surrounding area.

Working with Dr. John Cigliano on ocean acidification, we collected quadrat data from 13 sites and began our work on developing protocols for understanding what animals settle onto the rocky coast and when (Team 'Plate Techies' and Team 'Tuffy' were absolute champs). We also continued our work on the effects of ocean pH on snail behavior, conducted a sub-study on wave energy at the study sites, and collected data on our invasive green crab population at four sites on the Schoodic peninsula.

Working with Richard Feldman we collected insect, fruit ripeness, and bird presence data from three locations—Sundew, Alder, and Panty—around the peninsula. Climbing over hill and under scrub, fearlessly following Richard and Megan, we provided data from at least 1900 plot surveys (a massive effort!), and 360 insect trap collections! And at the end of the season we neatly removed every stake and piece of string until next summer.

One hardy crew traipsed over to Mount Desert Island to assist Sarah Nelson with her dragonfly and mercury work—contributing 40 dragonfly samples as well as water and sediment samples from two lakes in Acadia—in the pouring rain, no less. That's a lot of work, hard work. You helped us to sample sites that are normally sampled by University of Maine research staff, due to how difficult it is to reach and sample each site. We normally do not have any help in sampling these more remote sites, so the Earthwatch teams provided a valuable contribution and afforded us the opportunity to talk to the public about mercury at both higher-elevation sites and strongly wetland-influenced sites, since both of these places represent those extremes within Acadia. We were glad to have hardy, happy people helping—thanks! (Note you can follow the dragonfly mercury project on Facebook. The page is called "Six-Legged Scouts in the National Parks.")

We had an odd summer in that we did not have a lot of rainy days. On one of our few rainy days we worked on digitizing old records of wildlife from the Park's archive—including gems like this record from 1933 "Redstart—Wherever the other Warblers go, he goes, their dominoed torch-bearer."

Our goal is that data from this project will be used in developing science and resource management plans for Acadia National Park. The park is in the early stages of developing a science plan and a series of watershed restoration projects. The results from this Earthwatch project will directly inform those activities.

In all, it was a busy season from the sea to the trees—we thank you all for your contributions, and not just in the field. The conversations, the questions, the thirst for information kept us questioning our practices and methods—you may have started as volunteers but swiftly became our peers and the peer review at dinner, while walking, while star-gazing made for better practice and a very lively field season. Thank you all.

Sincerely,
Abraham Miller-Rushing and Hannah Webber

SECTION ONE: Scientific research achievements

TOP HIGHLIGHT FROM THE PAST SEASON

Mismatches: For the first time, we have a picture of the fruiting phenology of the Schoodic Peninsula's most common shrub species. Our results show that fruiting phenology was relatively synchronous across space (two sites) but asynchronous across species (two species: Mountain Holly and Huckleberry). For 2015, Mountain Holly fruit production peaked in late August while Huckleberry peaked in mid-September (Fig.1). We also recorded temporal changes in insect biomass. Interestingly, we found that insect phenology mimicked fruiting phenology (Fig. 2).

Ocean acidification: This field season we added new protocols to the project—a protocol to track mussel and barnacle recruitment (settlement plates), and a protocol to measure wave energy (clod cards) and temperature at the organismal scale (using 'robomussels' see: http://archive.onearth.org/article/a-mussel-bound-robot). These additions are exciting because a) they have the potential to tell us more about any changes in reproductive and settlement phenology, and b) adding wave energy and organismal-scale temperature allows us to relate recruitment and other patterns to the physical conditions of the environment.

Mercury: The Earthwatch crew helped collect 40 out of 400 total dragonfly samples from Acadia as part of the summer 2015 sampling. Importantly, the Earthwatch crew helped to sample sites that are normally sampled by UMaine research staff, due to difficulty of access and the time it takes to reach and sample each site. We normally do not have any help in sampling these more remote sites, so the Earthwatch crew provided a valuable contribution and afforded us the opportunity to talk to the public about mercury at both higher-elevation sites and strongly wetland-influenced sites, since both of these places represent those extremes within Acadia.

REPORTING AGAINST RESEARCH OBJECTIVES

Mismatches

1. Quantify the variability in bird, insect, and plant phenology within and across years and also across space. Are bird, insect, and plant phenologies changing over time? Specifically, we will examine breeding, migration, and feeding phenology for target birds; feeding phenology for target insects; and flowering and fruiting phenology for target plants (see methods for initial target species).2015 is the first year we quantified bird, insect, and fruiting phenology. This will serve as a baseline from which to assess longer-term, inter-annual differences. With our 2015 data, we have established that a) fruiting phenology varies among species (two most common species: huckleberry and mountain holly) (Fig. 1), b) fruiting phenology is consistent over space (two sites: "Sundew" and "Alder") (Fig. 1), c) overall fruiting phenology is synchronous with insect phenology (Fig. 2), d) fruiting and insect phenology is asynchronous with temporal variation in bird abundances (Fig. 3), and e) fruiting and insect phenology may be synchronous with temporal variation in bird diversity (Fig. 4).Earthwatch teams were instrumental in conducting the fruit counts necessary for establishing fruit production phenology. We counted the quantity of ripe fruit on seven species, of which mountain holly had the most fruit at both sites (Fig. 5). Huckleberry and bayberry also produced large quantities of fruit at the Sundew site. Interestingly, two of the rarer species, Shadbush and Rubus, had very different phenologies at the two sites while the other species were relatively more consistent (Fig. 6).With our bird banding program this year, we captured 632 individuals of 44 different species (Fig. 7). Two of the innovations we implemented with the banding program were a) collecting fecal samples and b) banding in the morning but also in the evening (4:00pm – 7:30pm). The fecal samples will be instrumental in resolving the interaction web between birds, fruit, and insects (Objectives 2 + 3). For 14 species, we collected fecal samples on at least 4 separate days (Fig. 8), which will allow us to test for temporal changes in diet composition.2. Quantify the interaction webs among birds, insects, and target plant species, and their variability in space and time. Are there years in which interactions among species pairs do not happen because of phenological mismatches? As this is the first year of data collection we cannot make statements about inter-annual variability.3. Quantify the persistence and fruit dispersal of native and invasive plants. Moving forward on objectives 2 + 3 requires analysis of the fecal samples of individuals captured in our mist-netting program. By DNA barcoding our fecal samples, we will be able to identify the insect and fruit composition of an individual's diet and how that changes through time. Furthermore, we will be able to discover whether birds forage opportunistically (i.e. consuming insects and fruit in proportion to their availability) or they are constrained in their diet choice (i.e. preferring fruit even if insects are more readily available).

Ocean Acidification

1. What is the community structure in the intertidal system and how is it changing over time? We collected data from 13 permanent sampling sites around the Schoodic peninsula. At each site we collected point-intercept data from four permanent quadrat locations (quadrat n= 52). These sites and permanent quadrats were established in 2014. While it is too early to determine if any change observed is due to ocean acidification and sea surface warming or due to natural variation, the 2014 and 2015 data will begin to establish a trend that we will build on. We will do the first analysis of community transition for each site before the 2016 field season.

2. How are physical aspects of the intertidal (e.g. pH, temperature, salinity, etc.) changing through time? Changes in intertidal temperature that affect organisms must be measured at the organismal scale. We deployed 'Robomussels', intertidal temperature data loggers that can mimic the thermal characteristics of an individual mussel, at one site in 2015. Upon later inspection we found that they had been removed. We will continue to refine our deployment methods. Additionally, Schoodic Institute has received an autonomous pH, conductivity (salinity), temperature, and dissolved oxygen sensor and data logger. We will deploy this sensor as a means to understand the general water chemistry (and seasonal changes thereof) in the waters near Schoodic peninsula.

3+4. How are the calcification rates of individual species affected by pH, and is there an affect on the on the susceptibility of these species to predation? How does pH affect important behaviors, such as predator avoidance and prey location, in intertidal organisms? We have set up a lab to study the behavioral effects of acidification and increase temperature on intertidal organisms and will continue this next year. We are working on field methods to determine calcification rates.

CHANGES TO RESEARCH PLAN OR OBJECTIVES

Mismatches

Objective 3 seeks to compare fruit dispersal between native and non-native plants. After conducting extensive surveys of fruiting species on the Schoodic Peninsula, we could not find any non-native plants. Thus, we intend to modify this objective by comparing temporal patterns in fruit dispersal for native species. We will cover branches with mesh bags to prevent fruit consumption and pair those covered branches with uncovered branches of an adjacent individual. In this way, we can quantify fruit removal rate (# fruit on covered - # fruit on uncovered = # fruit consumed) and test whether the rate changes through time and is synchronous with overall fruit availability. We will also cover branches but only at night in order to measure potential consumption by small mammal seed depredators. With help from Earthwatch volunteers we piloted the covered branch methods in 2015.

Ocean acidification

We added the following to the project to better monitor any changes due to ocean acidification and sea surface warming:

- Monitor larval settlement of barnacles (*Semibalanus balanoides*) and blue mussels (*Mytilus edulis*) using settlement plates and blue plastic mesh, oval-shaped, kitchen pot-scrubbers ("Tuffys"). As the ocean warms, it is very probable that the reproductive cycles of organisms, especially invertebrates, could be disrupted, leading to shifts in settlement time of larvae into the intertidal. Ocean acidification has been shown to have a significant effect on the larval development, which could lead to a reduction in larval settlement. Volunteers assisted with deploying and collecting the settlement plates as well as assisted with working in the laboratory to enumerate organisms found on the settlement plates (these are new tasks for the volunteers).
- Map intertidal zone using transects to determine changes in zonation patterns over time. There are no new volunteer tasks associated with this change. Volunteers continue to make and record observations.

Additionally, we collected population data on predatory green crabs (*Cancer maenas)* to better understand the predation pressure from this invasive. Understanding the population structure will allow us to better match our laboratory behavioral work with actual field conditions (Fig. 9). New volunteer tasks: Using 1m^2 quadrats volunteers collect, measure and determine the sex of green crabs at four locations on Schoodic peninsula.

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SECTION TWO: Impacts

DISSEMINATION OF RESEARCH RESULTS

Peer reviewed publications

We anticipate producing at least two peer-reviewed publications within the first four years of the project. We have not published yet.

Grey literature and other dissemination

None yet.

DEVELOPING ENVIRONMENTAL LEADERS

Students supported by the IGNITE program joined us in the field and focused almost exclusively on ocean acidification work. As a result of the fieldwork one student returned home and completed a similar study and recently presented his high school research. Another student has been volunteering at the SEA lab since her work with us and wrote her College Common Application essay on the Eartwatch expedition. An IGNITE student from 2014 decided to go to California State University-Northridge to study environmental studies because of her experience.

HSBC and National Youth Achievement Award (NYAA) Council award winners benefitted from joining us in the field.

Late in 2015 we developed a goal of connecting Earthwatch volunteers with citizen science tools that they can use in their own back yards (or communities). Thus, with our last two groups of the 2015 season we introduced volunteers to iNaturalist (http://www.inaturalist.org/), eBird (http://ebird.org/content/ebird/), Marine Debris Tracker (http://marinedebris.noaa.gov/partnerships/marine-debris-tracker), and/or Nature's Notebook (https://www.usanpn.org/natures_notebook). These are all citizen science tools that volunteers can use to record observations, track changes, or document marine debris where they live. While these tools may be well known in volunteers' communities we feel that providing training in tool use will allow our volunteers to use and share the tools with confidence once they leave Schoodic.

PARTNERSHIPS

Acadia National Park, Schoodic Institute, University of Maine. Acadia National Park provides logistical (field access logistics) as well as material support (equipment and van usage). Schoodic Institute provides field staff (especially when PIs cannot be in the field), logistics (field expedition planning and implementation), and material (e.g. cutting PlexiGlas squares for recruitment plates) support. We worked with researchers from the University of Maine on their Dragonfly Mercury Project.

CONTRIBUTIONS TO CONVENTIONS, AGENDAS, POLICIES, MANAGEMENT PLANS

- **International**
  N/A.
- **National or regional**
  N/A.
- **Local Polices or Management Plans**
  While this is our first full year it is the goal that data from this project will be used in developing science and resource management plans for Acadia National Park. The park is in the early stages of developing a science plan and a series of watershed restoration projects. The results from this Earthwatch project will directly inform those activities.

ACTIONS OR ACTIVITIES THAT ENHANCE NATURAL AND/OR SOCIAL CAPITAL

Volunteers working in the intertidal participated in shoreline clean-ups while working. We will enhance these in 2016 by adding our debris data to Marine Debris Tracker (see: http://marinedebris.noaa.gov/partnerships/marine-debris-tracker). Volunteers in the fall assisted with SeaWatch, a citizen science program that monitors the coastal migration of autumn's southbound birds.

CONSERVATION OF TAXA

Yes. We have collected population data on green crab (*Cancer maenas*), an invasive intertidal predator.

CONSERVATION OF HABITATS

We are providing baseline data on intertidal community and fruiting shrub community. We are not enhancing, restoring, or maintaining habitats.

CONSERVATION OF ECOSYSTEM SERVICES

Data from this project are being used by Acadia National Park to inform strategies to maintain relationships among birds and fruits—these relationships are critical to plant consumer relationships, seed dispersal, and bird-related tourism.

CONSERVATION OF CULTURAL HERITAGE

Volunteers engaged in transcribing historical records, from the Acadia National Park archive, that have not been easily accessible until recently. Transcribing the documents allows for researchers and manager to put today's findings into a historical context.

IMPACTING LOCAL LIVELIHOODS

Earthwatch volunteers, joining us in 2015 from July through October, directly contributed to sustained employment for seasonal employees. Schoodic Institute employs about 25 seasonal food service and hospitality workers. Schoodic Institute also employed and housed two seasonal interns in 2015. Schoodic Institute is located on a former Navy base, when the base closed in 2002 it was an economic blow to the area (an area with approximately 20% of the population living in poverty), in a state with economic growth that ranks 47th in the country.

SECTION THREE: Acknowledgements, Funding and Appendices

PROJECT FUNDING

Acadia National Park provided funding for interns who assisted with Earthwatch field teams and for vans to use as field vehicles. Schoodic Institute has provided funding for field staff to manage field preparations and support staff training (activities when there were no teams in the field). Dr. Feldman's work is funded in part by a grant to UMass—"Songbird vulnerabilities to climate change in the Gulf of Maine."

We are applying to NSF Department of Environmental Biology for funding work for 2017-2019.

ANYTHING ELSE

We enjoy working with the diverse groups of Earthwatch volunteers.

ACKNOWLEDGEMENTS

We thank Acadia National Park for their support of the work that Earthwatch volunteers are helping us with. Acadia has provided funding for Dr. Feldman's work as well as funding for the SeapHOx autonomous pH, conductivity (salinity), temperature, and dissolved oxygen sensor and data logger. We thank all of the employees at Schoodic Institute who made our field season run smoothly (especially when we needed last-minute changes to meals, or when we needed retooling of some of our field gear!). We thank the local community, especially Winter Harbor 5+10, J. M. Gerrish, and the Winter Harbor IGA for provisioning us. We thank the IGNITE program for sending us wonderful, inquisitive volunteers. We thank HSBC for sending us really hardworking and happy volunteers. We thank all of the volunteers who chose to spend their time working alongside us to help us understand what the changing climate is doing to the flora and fauna of Acadia National Park.

APPENDICES

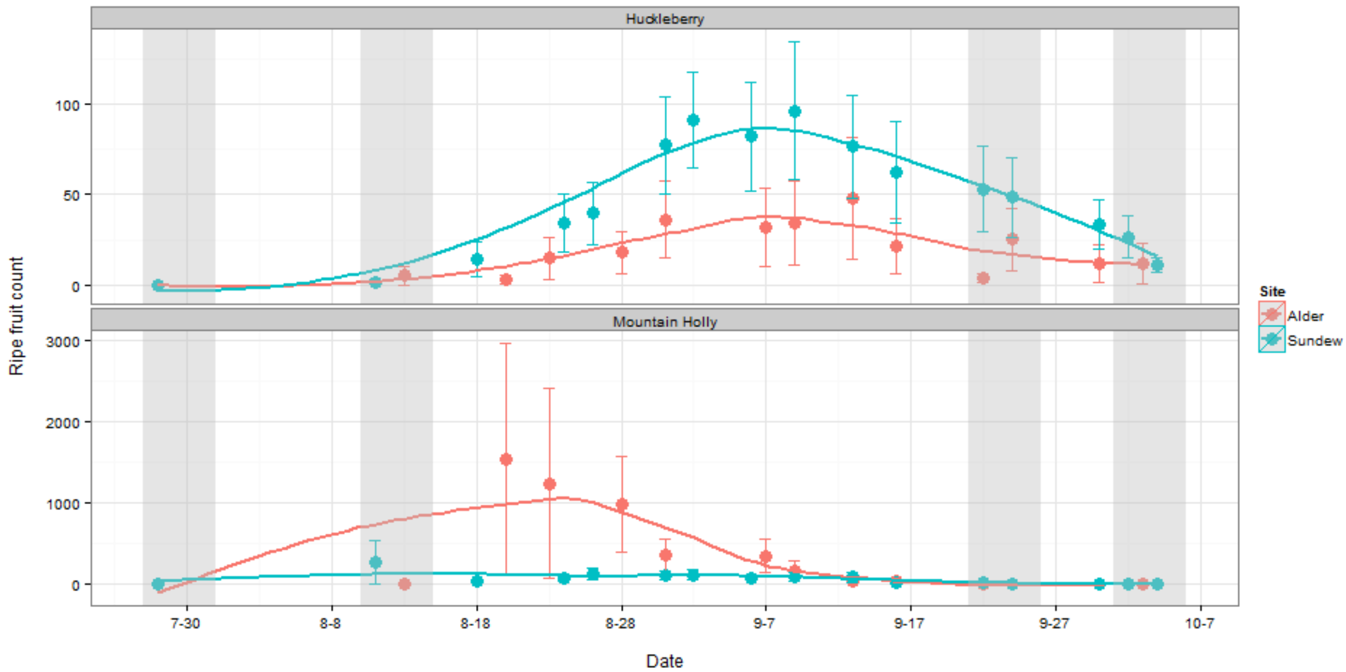

Fig. 1. Temporal variation in counts of ripe fruit for Huckleberry (top) and Mountain Holly (bottom) for two sites on the Schoodic Peninsula. Fruit counts are summed across 10- 2 m^2 subplots in each of 10 plots in each site. The data here are means and standard errors of the mean from across the 10 plots in each site. Gray bars indicate the timing of Earthwatch expedition contributions to data collection.

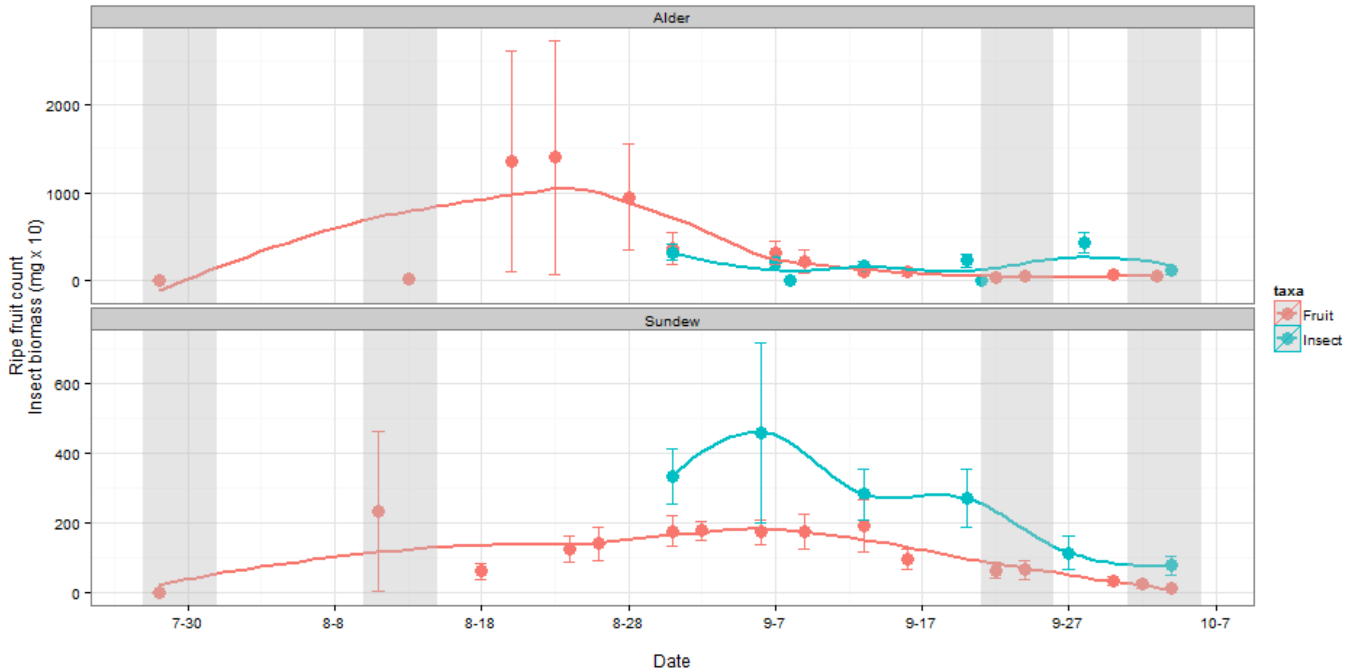

Fig. 2. Temporal variation in counts of ripe fruit for all fruiting species and insect biomass for two sites on the Schoodic Peninsula. Fruit counts are summed across 10- 2 m^2 subplots in each of 10 plots in each site. The data here are means and standard errors of the mean from across the 10 plots in each site. Insect biomass is summed across 3 hanging insect traps in each of 10 plots in each site. The data here are means and standard errors of the mean from across the 10 plots in each site. Gray bars indicate the timing of Earthwatch expedition contributions to data collection.

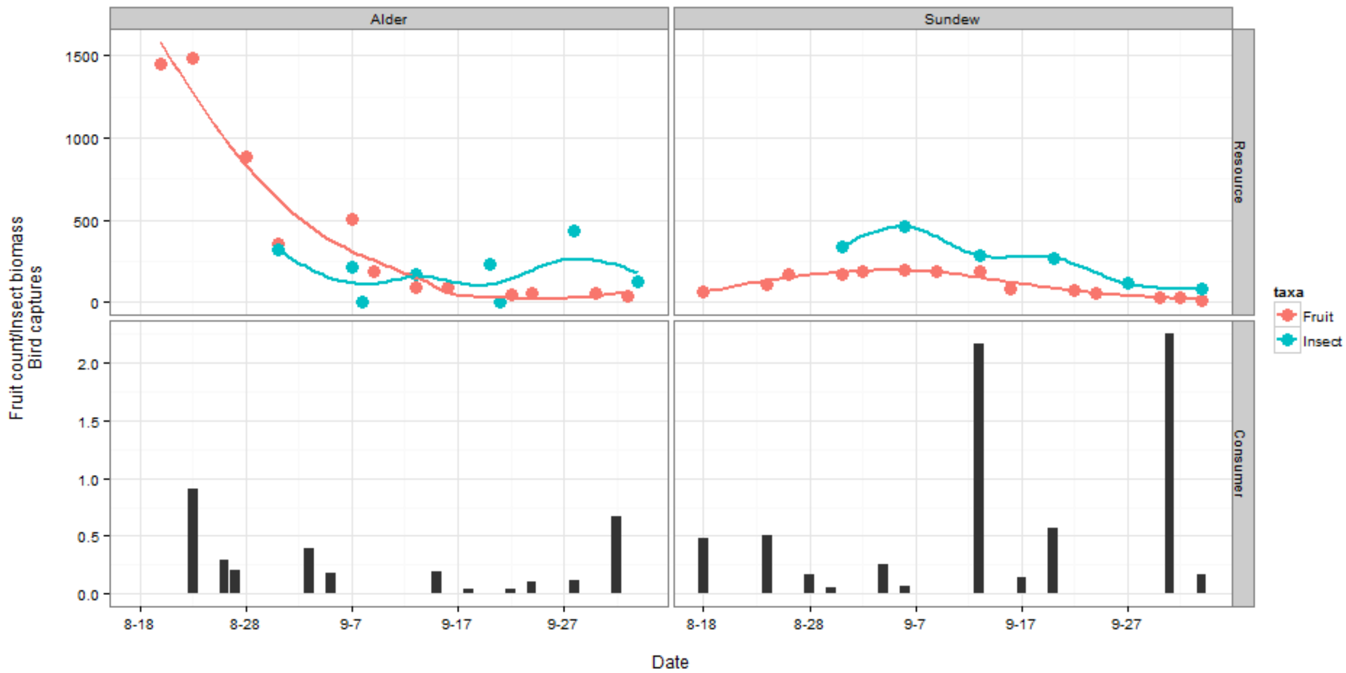

Fig. 3. Temporal variation in counts of ripe fruit for all fruiting species, insect biomass, and bird abundances for two sites on the Schoodic Peninsula. Fruit counts are summed across 10- 2 m^2 subplots in each of 10 plots in each site. The data here are means and standard errors of the mean from across the 10 plots in each site. Insect biomass is summed across 3 hanging insect traps in each of 10 plots in each site. The data here are means and standard errors of the mean from across the 10 plots in each site. Bird abundances are the total number of birds (migratory species only; n = 31) caught per day divided by the total number of hours all nets in a site were open on that day (Bird captures/hour/net).

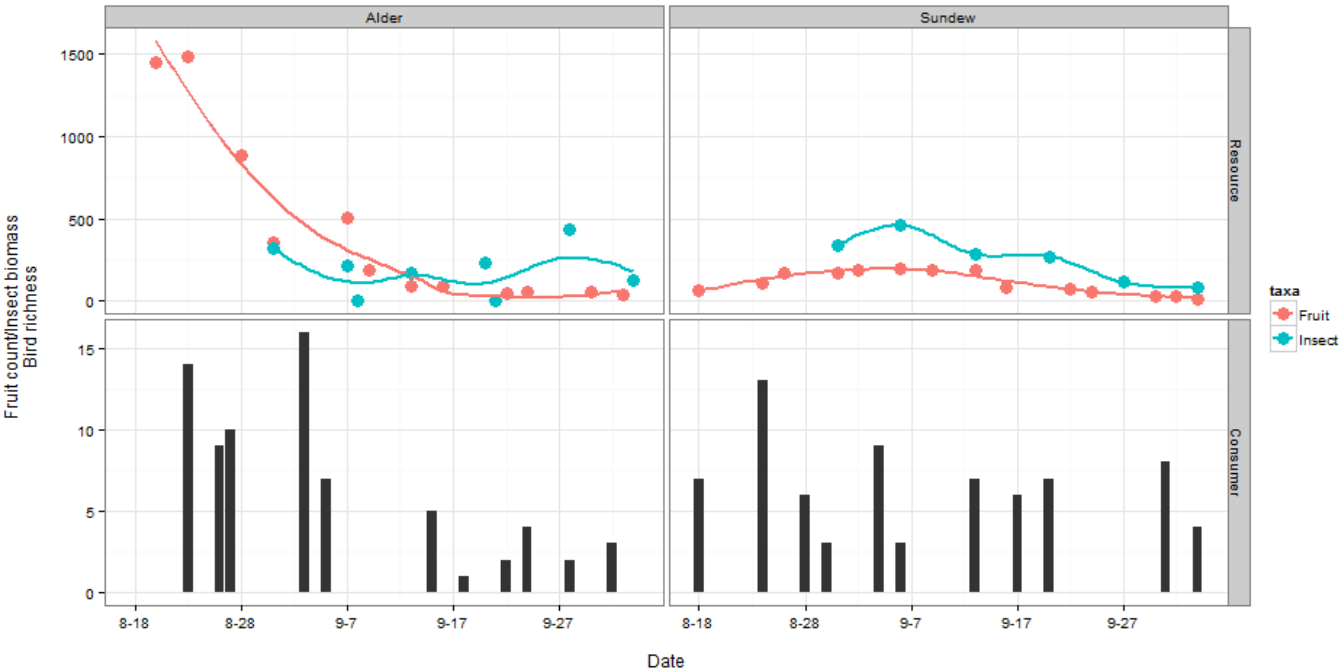

Fig. 4. Temporal variation in counts of ripe fruit for all fruiting species, insect biomass, and bird species richness for two sites on the Schoodic Peninsula. Fruit counts are summed across 10- 2 m^2 subplots in each of 10 plots in each site. The data here are means and standard errors of the mean from across the 10 plots in each site. Insect biomass is summed across 3 hanging insect traps in each of 10 plots in each site. The data here are means and standard errors of the mean from across the 10 plots in each site. Bird richness are the total number of unique bird species (migratory species only) caught per day.

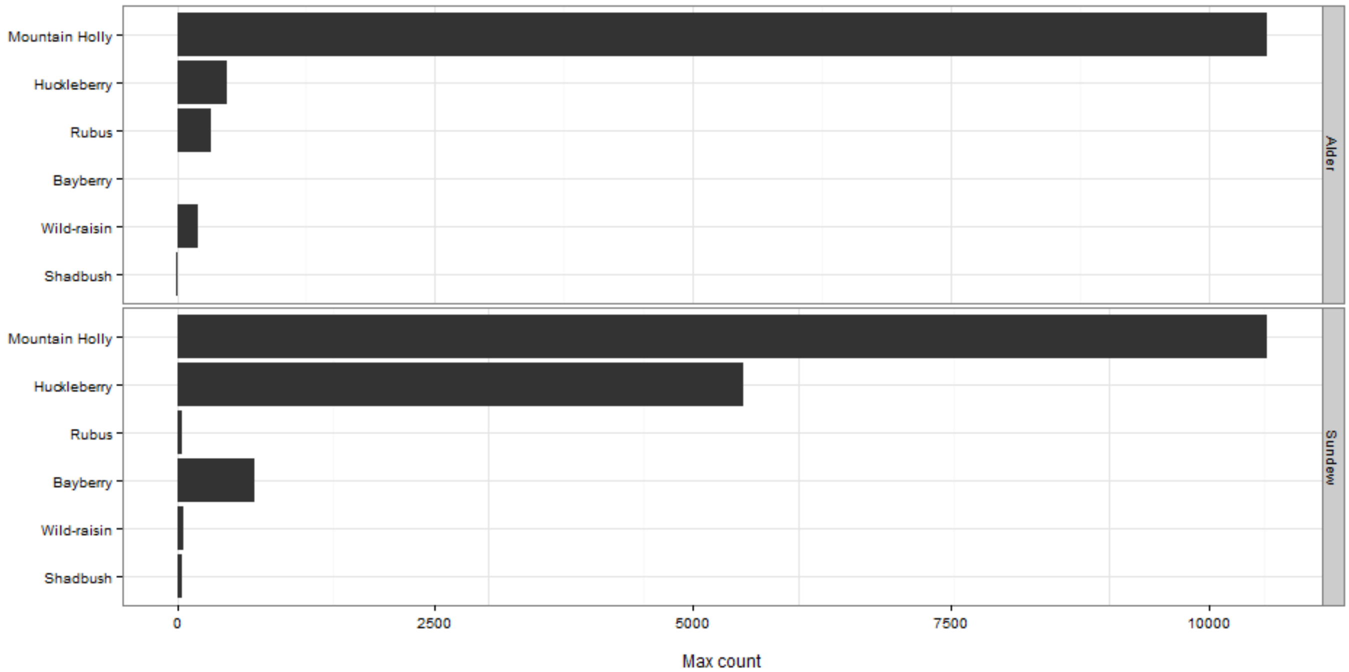

Fig. 5. Maximum number of fruit counted for each fruiting species at two sites on the Schoodic Peninsula. Fruit count is summed across 100- $2m^2$ subplots in each site. The data here are the maximum observed on one day.

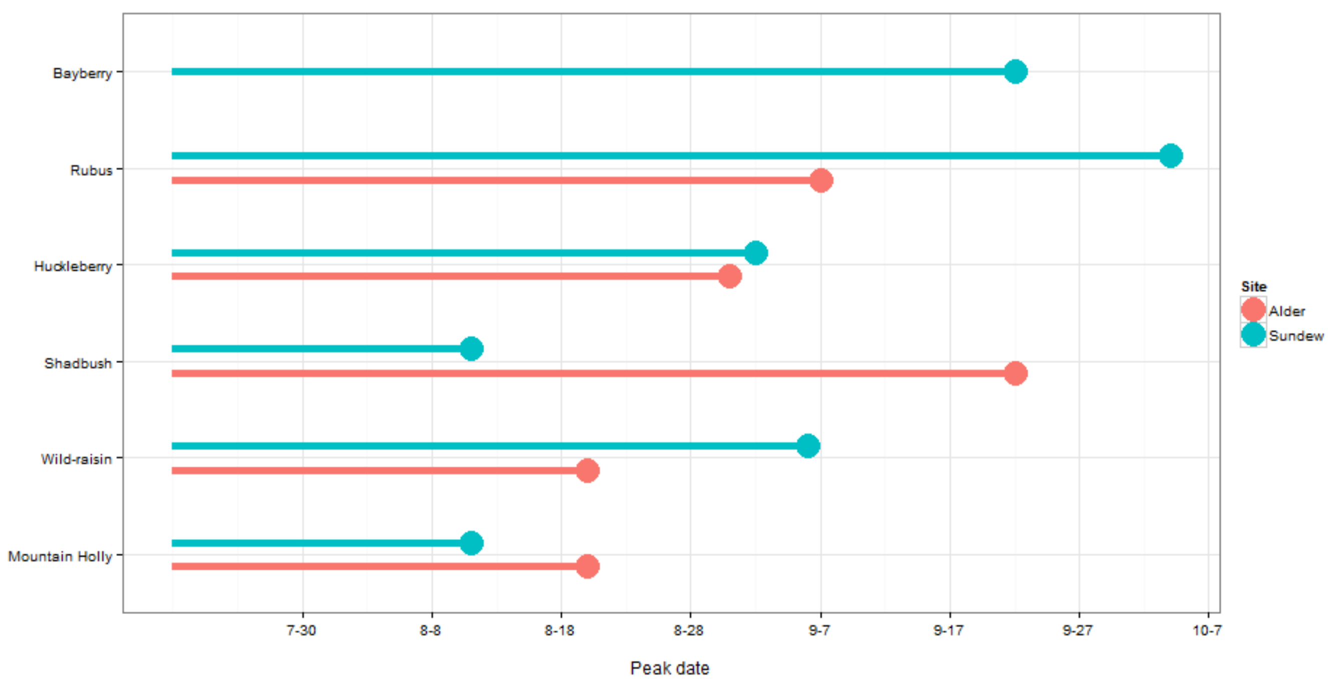

Fig. 6. The day on which the maximum number of fruit for each species was observed for two sites on the Schoodic Peninsula. Fruit count is summed across 100- $2m^2$ subplots in each site.

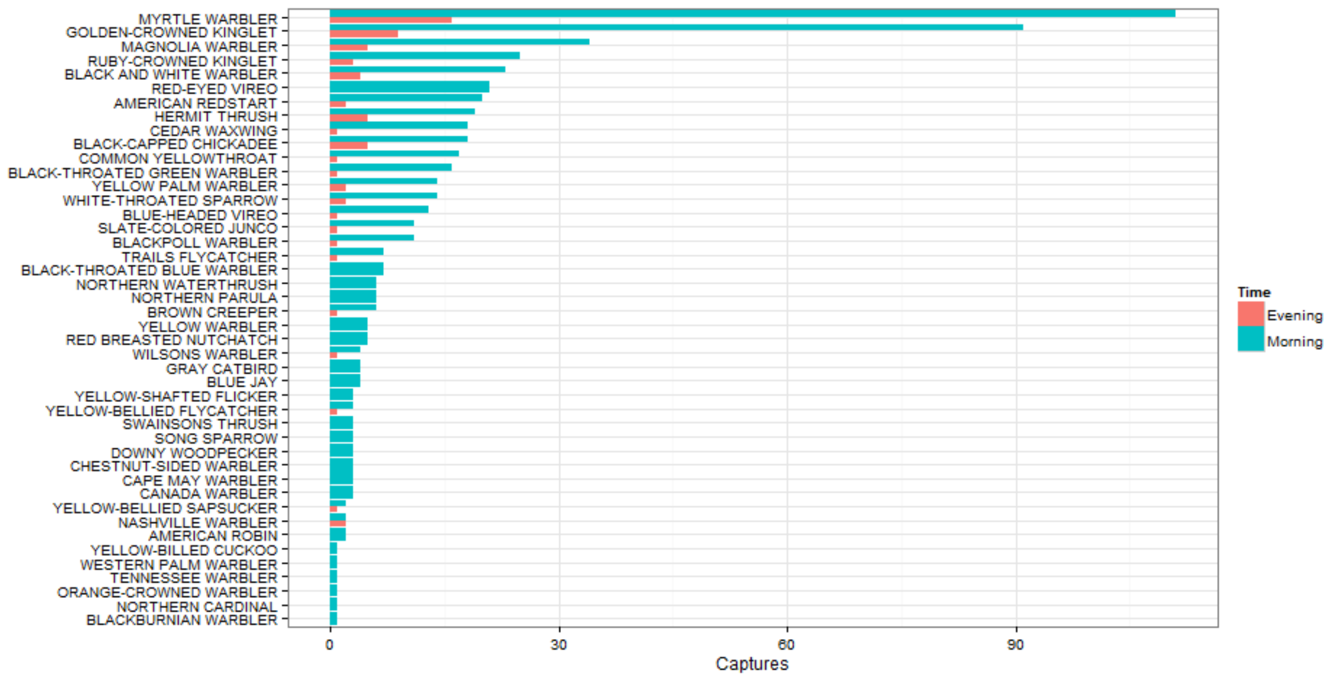

Fig. 7. The total number of captures of each bird species during the fall bird banding season. The number of birds captured in the morning (total net hours = 1438) and evening (total net hours = 443.5) are shown.

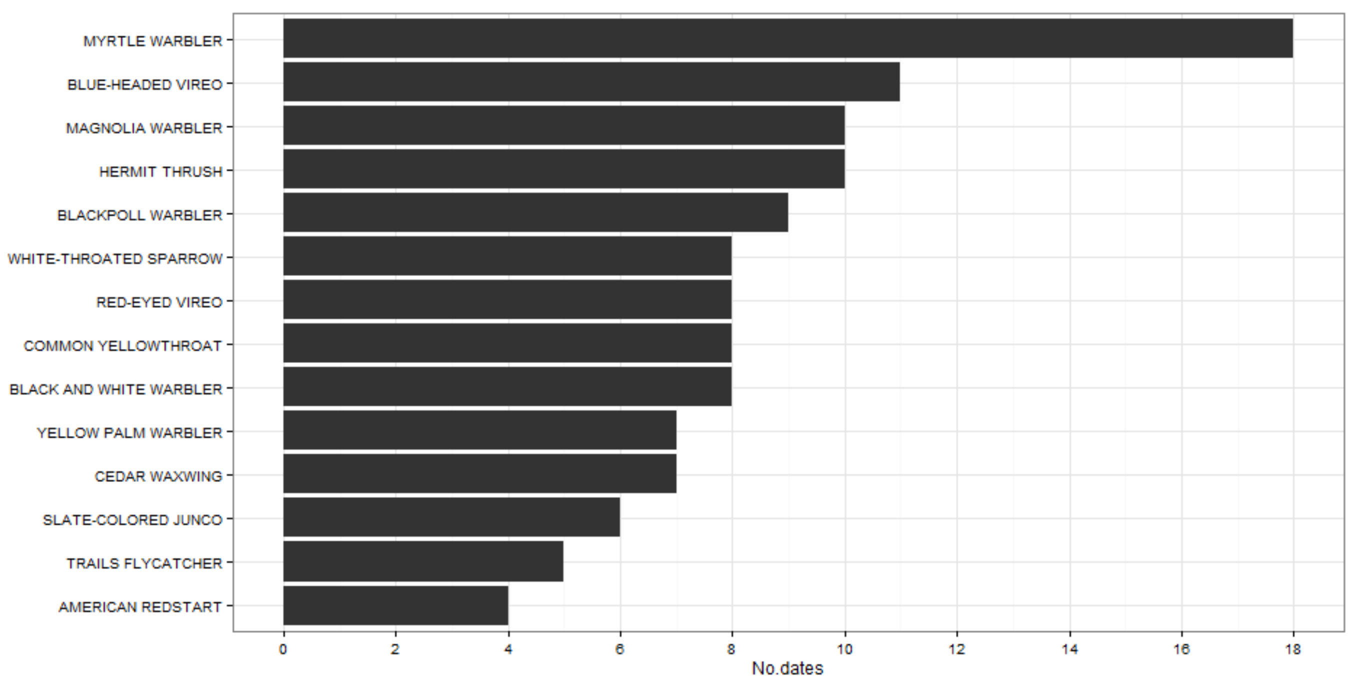

Fig. 8. The number of unique days for which each species has a fecal sample. (Only bird species with at least four fecal samples are shown).

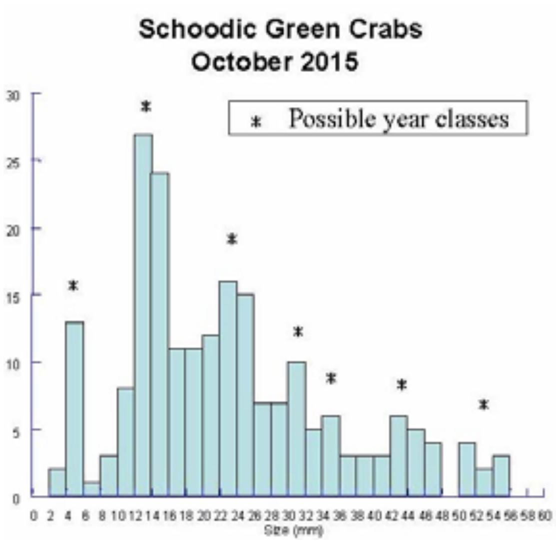

Fig. 9: Green crab population at Schoodic peninsula, Maine, early fall 2015

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