



Developing a pollinator monitoring program for Boston Harbor Islands National Recreation Area

A pilot study

Natural Resource Report NPS/BOHA/NRR—2015/950



ON THE COVER

Row one (from left): metallic green bee (*Augochlora pura*), cuckoo bee (*Coelioxys rufitarsis*), masked bee (*Hylaeus affinis*), mason bee (*Osmia atriventris*); **Row two**: a common eastern carpenter bee (*Xylocopa virginica*) at work, two volunteers and one intern on Spectacle Island sampling bees; **Row three**: a bee bowl with the day's catch of pollinators; informational sign erected at one end of a bee bowl transect; park staff at work in the lab sorting bees!

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Developing a pollinator monitoring program for Boston Harbor Islands National Recreation Area

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Natural Resource Report NPS/BOHA/NRR—2015/950

Jessica J. Rykken, Brian D. Farrell

Museum of Comparative Zoology
Harvard University
26 Oxford Street,
Cambridge, MA 02155

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Abstract

We received NPS Challenge Cost Share Funding (PMIS 159489) in FY2010 to pilot a pollinator monitoring project, focused on bees, in Boston Harbor Islands National Recreation Area. Globally, bees have been of conservation concern because both agricultural and natural ecosystems depend on these important pollinators, and accumulating evidence suggests that populations of some species are declining and geographic ranges are shifting in response to changing climates. Native bees are an ideal group to monitor on the Boston Harbor Islands because they are diverse and abundant, easy to sample with a standardized, repeatable protocol, and their taxonomy is relatively well known. Our main objectives were twofold: (1) to develop a robust, repeatable monitoring protocol with statistical power to detect relatively small changes in native bee abundance and diversity over multi-year intervals; and (2) to involve citizen scientists both in the field, sampling bees, and in the lab, sorting and preparing specimens. We set up 16 bee bowl transects on nine islands, and sampled four times during the blooming season. These efforts yielded 3,938 identified bee specimens comprising 104 species, including 23 new species records for the park. Spatial variability for bee abundance across plots was high, and in order to use this index for long-term monitoring, the sampling design may need to be modified. However, we predict that species richness will be an effective measure for detecting trends with the current design. Project participants included 10 community volunteers who contributed 326 hours in the field and lab to sample and process specimens, as well as one dedicated bee intern, and 12 NPS staff and other interns. This project successfully integrated scientific and community involvement goals, and protocols are in place to repeat the sampling for future monitoring.

Acknowledgments

We thank Marc Albert and other park staff for their ongoing support and enthusiasm for exploring and monitoring the microwilderness of the Boston Harbor Islands National Recreation Area. Staff at the MCZ, especially Amie Jones and Whit Farnum, also contributed their skills in areas such as graphic design and database management.

Fortunately, field surveys for bees are typically pleasant work, undertaken only on calm, sunny days. We thank Russ Bowles and his staff at the Division of Marine Operations, University of Massachusetts Boston for getting us out to the islands with their landing craft. Thanks also to all who helped in the field: Marc Albert, Barbara Boothby, Sheila Colwell, Liz Eddy, Meredith Eustis, Sean Kent, Jim Kilmurray, and Aya Rothwell.

As with any insect survey, running bee bowl transects generated an overwhelming amount of lab work. Thanks to all of the volunteers, interns, and park staff who sorted, pinned, labeled, and databased several thousand bee specimens: Marc Albert, Richard Armenia, Steve Cho, Elisabeth Colby, Maesen Churchill, Sheila Colwell, Erika D'Andrea, Meredith Eustis, Shannon Fadden, Marcelle Goggins, Bruce Jacobson, Josette Kimbrough, Veronica Kratman, Andy Pearson, Mary Raczek, Ann Rodman, Aya Rothwell, Sarah Waterworth, and Lowell Ray Watkins.

Bees are amazingly diverse and the process of identifying species can be challenging. We are very grateful for the generous contributions of time, skill, and effort from John Ascher, Sam Droege, Sean Kent, Joan Milam, and Michael Veit.

Introduction

The vast majority of flowering plant species rely on animal pollinators (Ollerton et al. 2011), and native bees make up an extremely diverse component of the pollinator fauna, with more than 3,600 described species in North America. Because pollinators provide such a vital ecosystem service in both agricultural and natural landscapes, their observed decline over the past decades (Biesmeijer et al. 2006) is cause for immediate concern. Dramatic declines have been well-documented and publicized for non-native honey bees (Natural Research Council 2006), but have also been observed among native bumble bees (Cameron et al. 2011), and solitary bees (Burkle et al. 2013). Potential causes for declines include habitat conversion, loss, and fragmentation, introduced species and pathogens, pesticides, and climate change, and it is probable that all of these are important drivers (Potts et al. 2010). Climate change is predicted to pose a significant threat to pollinator communities, with potential consequences including range shifts, mismatches in the phenology of plant-pollinator relationships, and population declines (Bartomeus et al. 2011; Dirnböck et al. 2011; Franzén and Öckinger 2012).

In order to measure the rate of decline for bees and other pollinators in various regions, baseline surveys and monitoring programs must be established with adequate sampling power to detect relatively small (2-5%) changes in abundance and species richness (LeBuhn et al. 2012). While resurveys of bee study sites not originally intended for monitoring can provide some information about bee abundance and diversity, the high interannual variability of these variables for bees and other insect pollinators can make it difficult to detect subtle trends. Therefore, designing a focused monitoring program with adequate sample size to detect small changes over a relatively short span of time is the preferred approach.

Another concern for monitoring programs is the monetary cost and personnel effort involved in sustaining a multi-year program (LeBuhn et al 2012). Initiating a long-term monitoring program requires a realistic assessment of the costs and hours involved for each sampling year as well as over the entirety of the program. Additionally, it is important for project managers to be aware of the level of skill required for various components of the bee monitoring process, including collecting, processing, and identifying bees, and to have access to the appropriate personnel and/or expertise for each task (e.g., citizen scientists, students, skilled taxonomists).

Native bees are beginning to receive attention in our national parks. For instance, preliminary surveys of native bee faunas have recently been conducted in 46 national park units across the United States, including Boston Harbor Islands NRA, in a service-wide study comparing bee diversity and abundance in paired transects that represent habitats likely to be vulnerable to effects from climate change (e.g., alpine meadows, coastal dunes) and more common habitats (e.g., lower elevation clearings, inland meadows; Rykken et al. 2014).

Boston Harbor Islands NRA has also embarked upon an All Taxa Biodiversity Inventory (ATBI), which focused on insects from 2005-2009, and documented 157 species of bees on a dozen small islands in an urban harbor. Building on this foundation, we wanted to develop a bee monitoring program that would have practical management application for the park, as well as rely on substantial

contributions from volunteers and citizen scientists. Native bees are an ideal group to monitor in Boston Harbor Islands NRA, because they are diverse and abundant, easy to sample with a standardized, repeatable protocol, and their taxonomy is relatively well known.

Specifically, our objectives for a bee monitoring program were to:

- Develop and pilot a sampling design with adequate power (0.9) to detect relatively small (2-5%) annual increasing or decreasing trends in bee abundance and species richness (or other metrics) if sampled every five years for ten or more years.
- Design and pilot a well-documented and easily repeatable protocol for bee collecting/processing that can be used by volunteers and citizen scientists.
- Document the number of field hours, lab hours, boat hours, equipment and other expenses required for one sampling cycle.
- Provide resource managers with a detailed implementation plan for long-term bee monitoring.
- Contribute to the ongoing Boston Harbor Islands ATBI by adding more bee diversity and distribution data for the park.

Study Area

Boston Harbor Islands National Recreation Area (NRA) comprises 34 islands and peninsulas lying within 20 km of downtown Boston, Massachusetts (Fig. 1). The islands and peninsulas sampled for bees range in size from 1.1 to 104.5 ha (Table 1). The majority of the islands are drumlins, formed by deposits of glacial till in Boston basin; a few are bedrock outcrops (National Park Service 2002). While these deposits were connected to the mainland for a time when the glaciers retreated over 12,000 years ago, sea level rise associated with glacial melting flooded the basin and isolated the drumlins as islands (Crosby 1928), and they now lie between 0.3 and 3.3 km from the mainland. Most of the intertidal areas on the islands are mixed coarse substrate such as gravel and cobble, but a few islands have sandy beaches, and some have areas of bedrock shoreline (Bell et al. 2005). Dominant vegetation communities on most islands include forest, woodland, maritime shrub, old field, and beach strand (Elliman 2005). Non-native woody and herbaceous plant species dominate many of the vegetation communities on the islands (44% of all plant species on the islands are introduced), but the dominant shrub on almost all of the islands is native staghorn sumac (*Rhus typhina*). Spectacle Island is a reclaimed landfill that was replanted in 1995-1996 and is currently a mix of open and shrubby/wooded habitats. Its north drumlin is the highest point on the islands, at 54 m. Salt marshes and brackish marshes occur on several of the islands, but freshwater is extremely scarce. The mainland surrounding the harbor comprises several towns, ranging from somewhat less developed landscapes in Hingham and Weymouth to the south of the harbor, to heavily urbanized landscapes in Boston and Winthrop, including international port facilities for shipping and air transport.

Over the past several centuries, all of the more accessible and sizeable islands and peninsulas have hosted human activities and structures. In the present day, almost all of the islands in the park are open to human visitors, but the islands vary greatly in the intensity of human traffic and impacts. Several islands (including Bumpkin, Grape, Peddocks, Spectacle, and Thompson) are serviced by public ferries between May and October. Portions of these islands and the peninsulas, World's End and Webb, are also actively landscaped (e.g., mowing, clearing brush). These islands and peninsulas receive thousands to tens of thousands of visitors per year (Table 1). The remaining islands, which do not have public ferry service, probably receive on the order of a handful to hundreds of visitors per year, but records are not available.



Figure 1. Map of 34 islands and peninsulas (shaded in gray and black) comprising Boston Harbor Islands National Recreation Area, Massachusetts, U.S.A. Islands and peninsulas shaded in black each had two bee sampling transects, except for Webb and Langlee, which each had a single transect.

Table 1. Size, isolation (distance from nearest mainland), and human visitation rates of islands sampled for bees in 2010, and names of transects located on each island.

Island	Code	Terrestrial area (ha) ³	Isolation (km)	Human visitation ⁴	Bee bowl transect codes
Bumpkin	BM	12.2	0.6	2,824	BM-BB-1 BM-BB-2
Grape	GP	21.9	0.5	3,119	GP-BB-1 GP-BB-2
Great Brewster	GB	7.5	2.3	NA	GB-BB-1 GB-BB-2
Langlee	LN	1.8	0.5	NA	LN-BB-1
Peddocks	PE	74.6	0.8	1,237	PE-BB-1 PE-BB-2
Spectacle	SP	34.6	1.9	42,019	SP-BB-1 SP-BB-2
Thompson ¹	TH	54.2	0.5	16,156	TH-BB-1 TH-BB-2
Webb Mem. ² State Park	WB	13.9	0.0	103,920	WB-BB-1
Worlds End ²	WE	104.5	0.0	51,960	WE-BB-1 WE-BB-2

¹Island connected to mainland at very low tides

²Peninsula, connected to mainland at all times

³Terrestrial area above high tide line from Bell et al. (2002)

⁴Visitor counts for 2009. Counts represent visitors arriving by ferry, charter, and private boat, except counts for WE and WB represent drive-up visitors (National Park Service 2010, unpublished report)
NA = no available data (islands without ferry service or ranger).

Methods

Sampling design

Power analysis

We used the freely accessible software program MONITOR (Gibbs and Ene 2010) to determine the minimum number of sites (i.e., replicated sample units) necessary to have sufficient power to detect relatively small (2-5%) annual increasing or decreasing trends in the abundance and species richness of bees over ten years, sampling at five-year intervals. Parameters chosen by us to run Monitor are shown in Fig. 2; the program uses simulation procedures to evaluate how each chosen parameter influences the statistical power of the sampling design.

The screenshot displays the MONITOR software interface, divided into two main panels: 'Parameters' on the left and 'Plots' on the right.

Parameters Panel:

- Survey design:**
 - Intervals: 0,5,10
 - Design type: Route regression
 - Measure type: ☒ Normal ☒ Log-Normal ☐ Presence / Absence
 - Surveys / plot / interval: 1
 - Variance type: ☒ Total ☐ Partitioned
- Trends:**
 - ☒ Deterministic / Regression - type ☐ Custom / ANOVA - type
 - Number of trends: 11
 - Minimum trend (%): -5
 - Maximum trend (%): 5
- Variance to mean relationship:** ☒ Constant CV ☐ Constant SD
- Simulation:**
 - Significance: .1
 - Number of iterations: 1000
 - Desired power level: 0.900
 - Financial cost per measure: 1
 - Number of tails: ☐ One ☒ Two
 - Rounding: ☒ Yes ☐ No
 - Counts < 0: ☒ Truncate ☐ Don't truncate

Plots Panel:

The 'Plots' panel displays a table with the following columns: No., Start value, Total variation, Sampling variation, and Process. The table contains 25 rows, numbered 1 to 25. The 'Start value' and 'Total variation' columns are populated with the value 60.00 for all rows. The 'Sampling variation' and 'Process' columns are currently empty.

No.	Start value	Total variation	Sampling variation	Process
1	60.00	60		
2	60.00	60		
3	60.00	60		
4	60.00	60		
5	60.00	60		
6	60.00	60		
7	60.00	60		
8	60.00	60		
9	60.00	60		
10	60.00	60		
11	60.00	60		
12	60.00	60		
13	60.00	60		
14	60.00	60		
15	60.00	60		
16	60.00	60		
17				
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Figure 2. Parameters and plot bee abundance/variation values entered into the Monitor program to determine the minimum number of sites necessary for adequate power to detect relatively small (2-5%) annual trends in the abundance of bees in Boston Harbor Islands NRA.

We estimated the mean number of bees collected per 30-bowl transect/plot (60) based on previous bee bowl collections in the park during the ATBI. Because we did not have a good estimate for temporal variation associated with bee bowl samples in the park (we typically sampled islands for one year only during the ATBI), we used a relatively high measure for the coefficient of variation (standard deviation/mean), $CV = 100\%$, in order to be conservative. As species richness is typically less variable than abundance, we used only abundance measures to determine the number of sites needed in our sampling design.

Results after 1000 simulations with Monitor suggested that 16 plots would provide adequate power (0.9) to detect negative or positive trends of 2-5% in the abundance of bees over 10 years (Fig. 3).

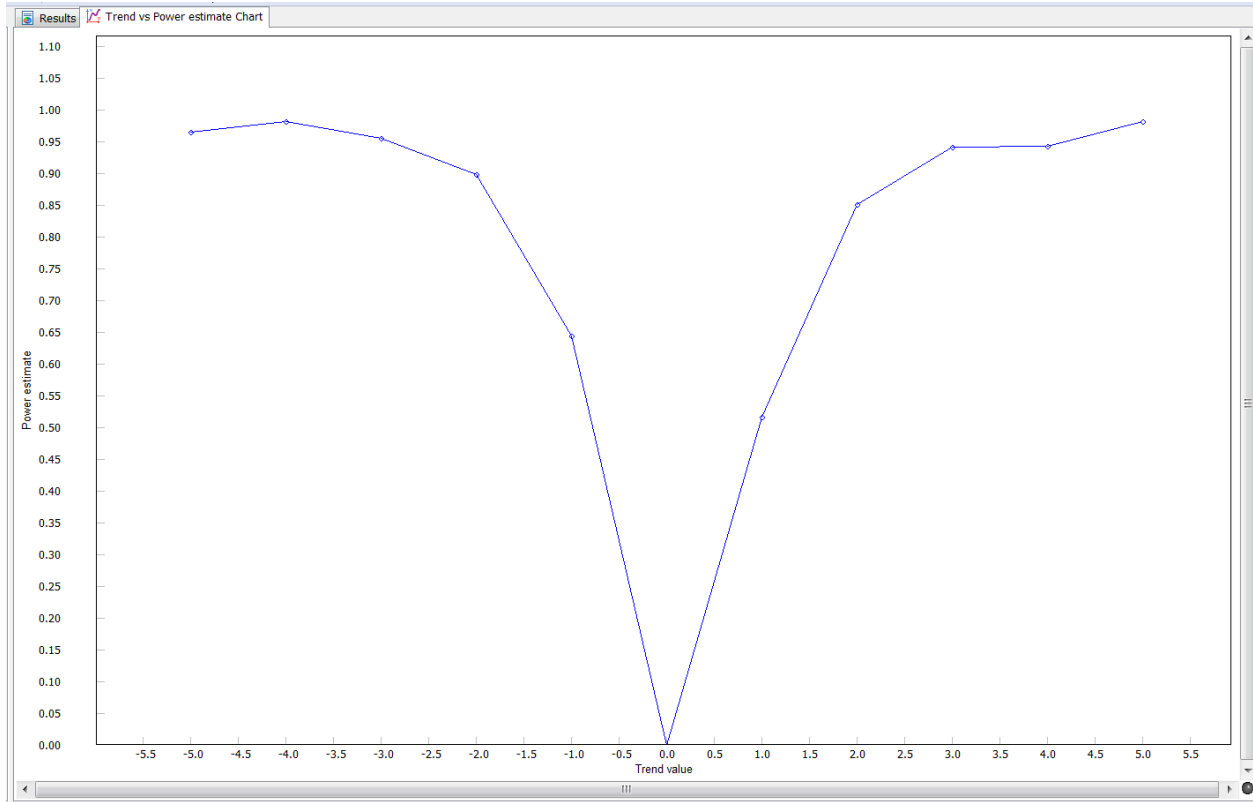


Figure 3. Trend value (i.e., percent decrease or increase in abundance of bees) versus power estimate from Monitor program, using 16 plots and the parameters shown in Fig. 2.

Replication and distribution of sample units

Guided by the results of the power analysis, we set out 16 transects on 9 islands and peninsulas in the park (Table 1). Six islands and one peninsula had two transects each, spaced a minimum of 100 m apart, while the smallest island (Langlee) and one small peninsula (Webb) had one transect each. We sampled each transect four times during the season, with the intent of timing each sampling period to coincide with the blooming of focal host plants (Table 2). Bees that are active early and late in the growing season are often host plant-specialists (e.g., on *Salix* or *Solidago*) and we hypothesized that potential mismatches in bee-plant phenology due to climate change may be more pronounced toward the beginning and end of the growing season; therefore, we intentionally biased our sampling to focus on these early- and late-season bees. Transects were relocated in consecutive sampling periods on some islands in order to place them near plants in bloom (Appendix A). Langlee Island had only one available route for a bee bowl transect, so this transect remained in the same location for all sampling periods. The four sampling periods were not intended to be independent replicate surveys, but were used to assess seasonal differences in bee abundance and richness that might influence future monitoring plans. Logistical constraints made randomization of sampling sites impractical, so inferences are limited to the sites sampled.

Table 2. 2010 sampling periods for bee bowl transects in Boston Harbor Islands NRA.

Sampling period	Focal plants in bloom	Actual dates sampled
I	Willows (<i>Salix</i>) and early blooming trees (e.g., cherry, maple)	30 April-5 May
II	Sumac (<i>Rhus</i>) and later blooming trees	3-8 June
III	Goldenrod (<i>Solidago</i>) and other composites	26-30 August
IV	Seaside goldenrod (<i>S. sempervirens</i>)	11-18 October

Sampling techniques

During each sampling period, our goal was to set up transects only on warm (~60°F or above), sunny, calm days. We were able to visit 2-3 islands/peninsulas per day, through a combination of landing craft (boat), canoe, and driving. Within the constraints of suitable weather and transportation logistics, we tried to sample within the smallest span of days possible during each sampling period (5-9 days; Table 2).

Field work was conducted by park staff (BOHA), the lead scientist (MCZ), one paid intern, and volunteers. Clear written guidance for the field protocols described below was printed, laminated, and provided to volunteers while out in the field (Appendix B).

Each sampling transect (i.e., replicated sampling unit) comprised 30 plastic cups (3.25 oz. (96 mL), 70 mm diameter at the mouth, 35 mm high), 10 blue, 10 yellow, and 10 white. These “bee bowls” were spaced 5 m apart, along a 145 m transect. Cups were filled approximately 3/4 full with a solution of 70 mL water mixed with a few drops of detergent (blue Dawn dish soap) to break the surface tension of the water. Bee bowl transects were set out by 10 am and collected no earlier than 4 pm, ensuring that they were open for a minimum of six hours during the warmest part of the day, when bees are most actively foraging. At the end of the day, contents of all 30 bowls from a transect were poured through a tight mesh kitchen strainer. The pooled insect catch from all bowls was then transferred into a 4 oz. (118 mL) Whirl-Pak® via a wide-necked (18 mm diameter) plastic funnel (100 mm diameter at mouth; Fig. 4). Ethanol (95%) and a locality label (with a shorthand sample code comprised of: bee bowl transect code, sampling period, year; e.g., TH-BB-1 IV.10) were added to the contents before sealing shut the Whirl-Pak®. Samples were then transported back to the lab and stored in a refrigerator until processing.



Figure 4. Left: Pouring the contents of a bee bowl through the strainer. Right: Transferring the consolidated specimen catch from all 30 bowls into a Whirl-Pak® bag.

Transects were set out in open, unshaded areas near blooming plants, to the extent possible. We worked under the assumption that if a bowl was difficult for us to detect (e.g., hidden in tall vegetation) then it would also be difficult for bees to detect. Transects could bend or skip short lengths of unsuitable (e.g., shaded) area to maximize productive habitat. At sampling sites in areas frequented by park visitors, we used orange survey flags to mark every fourth or fifth trap along the transect. We also marked both ends of each transect with small informational signs, describing the purpose and methods of the project (Appendix C). Photographs were taken from each end of the transect to document the site conditions. Coordinates for the start and end points of each sampling transect were marked with a Garmin eTrex® GPS unit, and these were uploaded to Google Earth to create maps for each island (Appendix A). Site photos and KMZ files for Google Earth were given to the park for permanent archiving.

A field data sheet was filled out for every transect (Appendix D). This included information about weather, GPS coordinates, a narrative description of the habitat, the times bowls were set out and collected, and details about any “casualties” (e.g., spilled or missing bowls). We also collected data on plants in bloom (presence, life form, and species if known) along ~1 m wide bands on either side of the transect. These bands were broken into 5 m lengths between consecutive bee bowls along the transect. Thus, there were 29 plant plots on one side of the transect, and 29 on the other, for a total of 58 plant plots.

At the end of each survey, additional notes and detailed field summaries were compiled to document sampling challenges and suggest ways to improve the efficiency and success of bee collecting protocols (Appendix E).

Specimen processing, curation, and identification

All lab work was overseen by the lead scientist, but we intended that the bulk of the specimen sorting, preparation, and databasing would be accomplished by volunteers and one paid intern, none of whom had prior entomological experience.

Sorting specimens

Bee bowl samples (consolidated by transect) were stored in 95% ethanol in the refrigerator until processing. Each Whirl-Pak® sample, in turn, was cut open and the contents emptied into a plastic sorting dish. Using a dissecting microscope, bees were separated from the rest of the catch. All other arthropods were sorted to taxonomic order (a simple guide to common arthropod orders was provided to assist workers unfamiliar with insect taxonomy). An experienced entomologist looked over all sorted material to check bee and order-level identifications. Non-bee “bycatch” was stored, by taxonomic order, in separate 1 dram (3.7 mL) glass shell vials or 20 mL glass scintillation vials containing 95% ethanol, together with a locality label. Vials were recorded on a sorting data sheet (Appendix F). No further taxonomic work was done on the “bycatch,” however, the vials remain in long-term storage at the MCZ (Farrell Lab), for future examination by other experts.

Washing and drying bees

Bees were transferred to a one-quart mason canning jar full of soapy water, “sealed” with a canning lid rim holding in place a square of fiberglass window screen (Fig. 5). With one hand covering the mesh, the jar was shaken back and forth for 60 seconds, agitating the bees in the soapy water. Then the soapy water was poured out of the jar, and the jar was repeatedly filled with fresh water until all soap bubbles were gone. The mesh lid was removed, and bees were transferred into a mesh strainer, then dipped into a small bowl of ethanol for approximately 30 seconds. While the bees were soaking, the jar was dried on the inside with a paper towel. Bees were then put back into the jar, along with several small wads of crushed paper towel, and the screen lid was fastened into place. A hairdryer (at high heat) was aimed into the jar with one hand, while the other hand shook the jar around, mimicking a tumble dryer. Drying was quicker for small, sparsely-haired bees (which were removed when their wings popped away from the body), but took up to several minutes for large, fuzzy bumble bees. More details (and modifications) for the bee washing and drying procedure can be found in The Handy Bee Manual, compiled by Sam Droege and others <http://bees.tennessee.edu/publications/HandyBeeManual.pdf>.

Mounting, identifying, and databasing bees

Almost all bees were pinned (sizes 1-3) or point-mounted depending on their body size (refer to Handy Bee Manual mentioned above for pinning and mounting techniques). A printed locality label was attached to each specimen (Fig. 6a). Two hyper-abundant species, *Ceratina calcarata* and *C. dupla*, were permanently stored in vials with 95% ethanol.



Figure 5. Left: Canning jar with window screen in lid to wash and dry bees. Right: Blow-drying bees.



Figure 6. (a) Locality label for specimens, showing sampling location (including sample code), sampling date, method of collection, and name of collector. (b) Determination label, showing Latin genus and species name, the name of the authority (original describer of the species), the name of the determiner (the taxonomist who identified the specimen) and the year in which the specimen was identified. (c) Specimen ID number for pinned specimen. The locality, determination, and specimen ID labels were printed in 3, 4, and 7 point font, respectively.

Prepared specimens were identified at the MCZ labs by J. Rykken and others using the online key <http://www.discoverlife.org/mp/20q?search=Apoidea#Identification>, volumes I and II of Bees of the Eastern United States (Mitchell 1960, 1962), and the Revision of the Metallic *Lasioglossum* (*Dialictus*) of Eastern North America (Gibbs 2011). A subset of bees were identified and/or confirmed by Sam Droege at the USGS Patuxent Wildlife Research Center, Beltsville, MD. Upon identification, specimens received printed determination labels (Fig. 6b). Latin names and authorities for species were taken from the most current sources available. All identified bees and any remaining unidentified bees (female *Ceratina* spp., and some female *Hylaeus* spp.) were deposited in the permanent collections of the Museum of Comparative Zoology (MCZ) at Harvard University, Cambridge, MA.

All identified bees were entered into Mantis, a relational database used for the entomology collections at the MCZ. Mantis is a free and open collections-based biological database manager created with FileMaker software (Naskrecki 2008). Each specimen or “lot” of specimens (i.e., specimens of the same species, sex, and life stage from one sampling event) was assigned a unique specimen ID number upon entry into the database, in the format BHI-##### for pinned specimens, and BHI-V##### for ethanol-preserved specimens. A third specimen label (Fig. 6c), indicating the BHI number, was attached to the pin or inserted into the vial of all databased specimens. All geo-referenced specimen data were ultimately transferred to the NPS biodiversity database, NPSpecies, in January, 2013. For more details on the databasing procedure (including quality assurance protocols) see Rykken and Farrell 2013.

Statistical analyses

We calculated total and mean bee abundance and species richness across bee bowl transects (N = 16) with 95% confidence intervals. We performed these calculations by individual seasons (sampling periods I-IV) and with all seasons lumped together.

We also evaluated our sampling design by rerunning MONITOR using all the same parameters as listed above, but replacing our previous estimates of abundance (60 for all transects) with actual transect values for species abundance and richness from the pilot study. To better estimate temporal variation, we used values calculated by LeBuhn et al. (2012) from a meta-analysis of bee pan trap studies conducted in North and South America and Europe: CV for abundance = 31%; CV for species richness = 25%.

Results

Bee sampling

Our bee collections between April 30 and October 18, 2010, resulted in 3,938 identified bees, comprising 104 species (Appendix G). Several hundred bees (*Ceratina* spp. females; *Hylaeus modestus/affinis* females) remained unidentified and were not included in analyses. Mean abundance and species richness (across 16 transects) varied between seasons (Fig. 7). April/May and late August samples yielded the most bees overall, while the mean number of bees collected in mid-October was less than 10% of the April-May sample. Mean species richness mirrored the general seasonal pattern seen in abundance, however the differences between consecutive seasons were less pronounced. Variability was very high for mean abundance values in most seasons (Fig. 7). Although the mean abundance per transect for all seasons combined (61.5) was close to the estimate we had used for determining our sampling design in MONITOR (60), variability among the 16 transects when all seasons were combined was also extremely high.

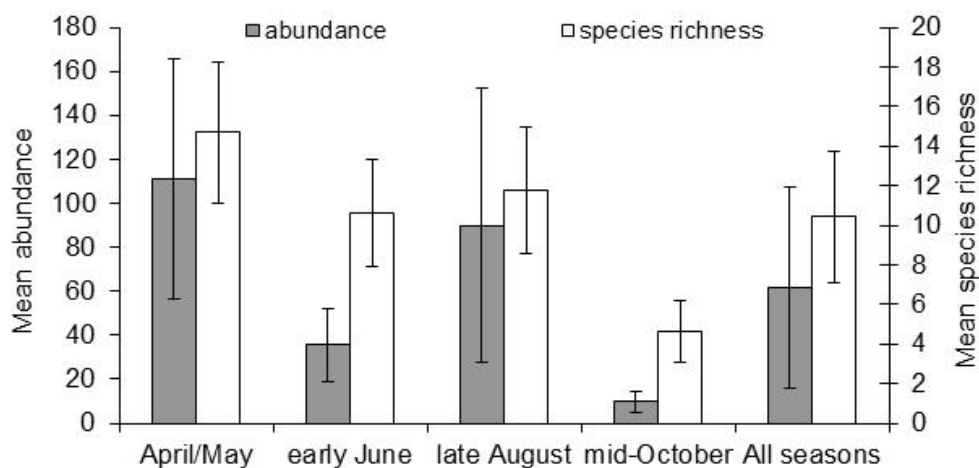


Figure 7. 2010 seasonal means ($\pm$ 95% CI) for bee abundance and species richness per transect (N = 16) and means for all seasons combined in Boston Harbor Islands National Recreation Area.

Seasonal abundance and species richness totals were broken down by genus to show seasonal patterns (Figs. 8,9). *Andrena*, *Hoplitis*, *Osmia*, and the cleptoparasitic genus *Nomada* contributed to high abundance and diversity in April/May and early June. The halictid genera *Agapostemon*, *Augochorella*, *Halictus*, *Lasioglossum*, and the cleptoparasitic genus *Sphecodes* were relatively abundant across all seasons, although their numbers dropped considerably in October. Small carpenter bees, *Ceratina*, were extremely abundant in April/May and August, and while their numbers rivaled or surpassed *Lasioglossum* in these seasons, their species diversity was far lower (2 species versus 13-21 for *Lasioglossum*). The genus *Melissodes* and its cleptoparasite *Epeolus* were collected only in August, with almost all the *Melissodes* coming from Great Brewster Island (Appendix G). The number of species shared between consecutive seasonal samples declined through the year but comprised a relatively consistent proportion (0.27-0.32) of the combined total (Fig. 9).

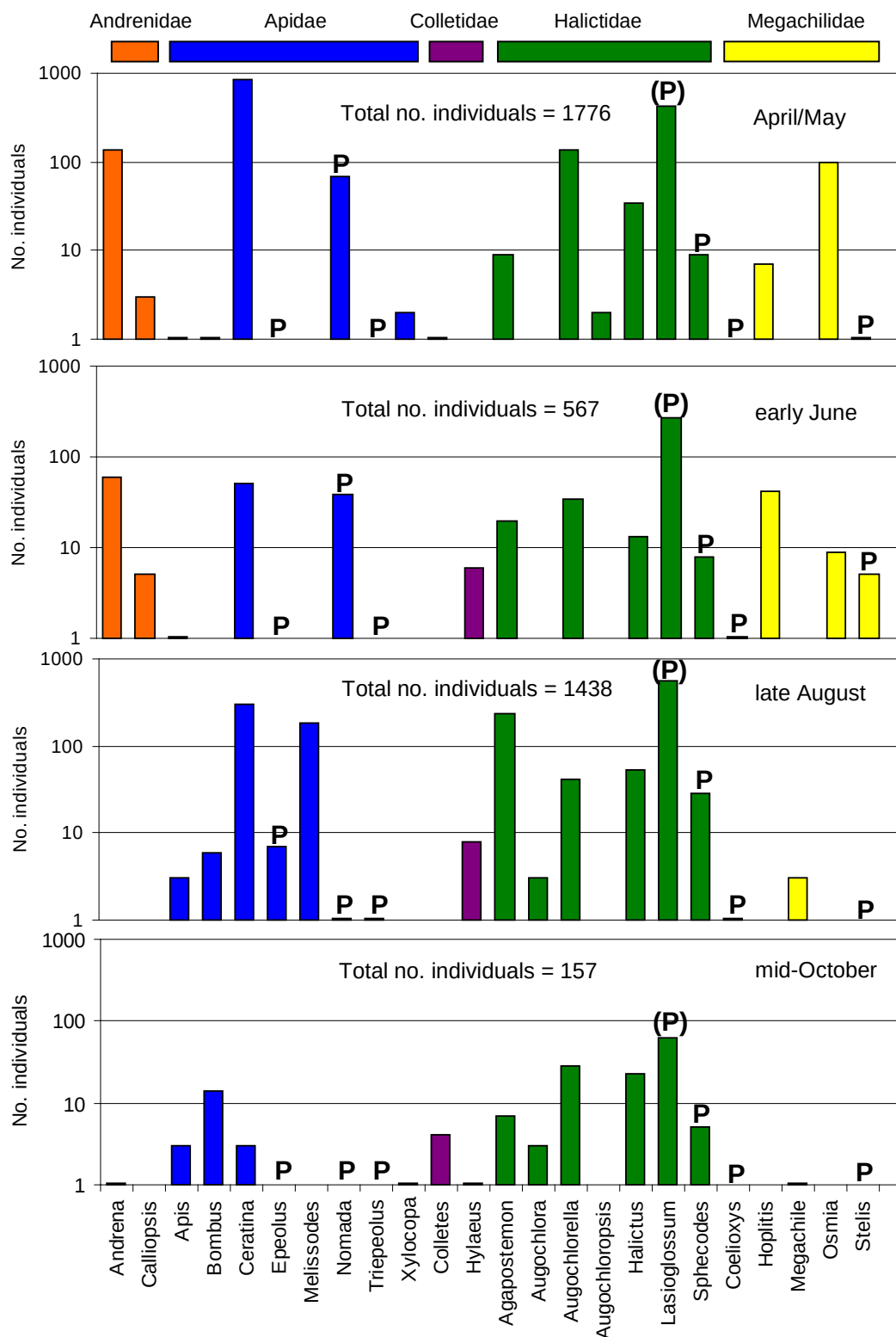


Figure 8. Total seasonal bee abundance for each genus collected in Boston Harbor Islands NRA in 2010. Genera are color coded by family. Note that y-axis is on a log scale. Counts of 1 are indicated by a minimal bar above the “1” line. Null (0) counts are indicated by the complete absence of a bar. P = parasitic genus; (P) = some species in the genus are parasites.

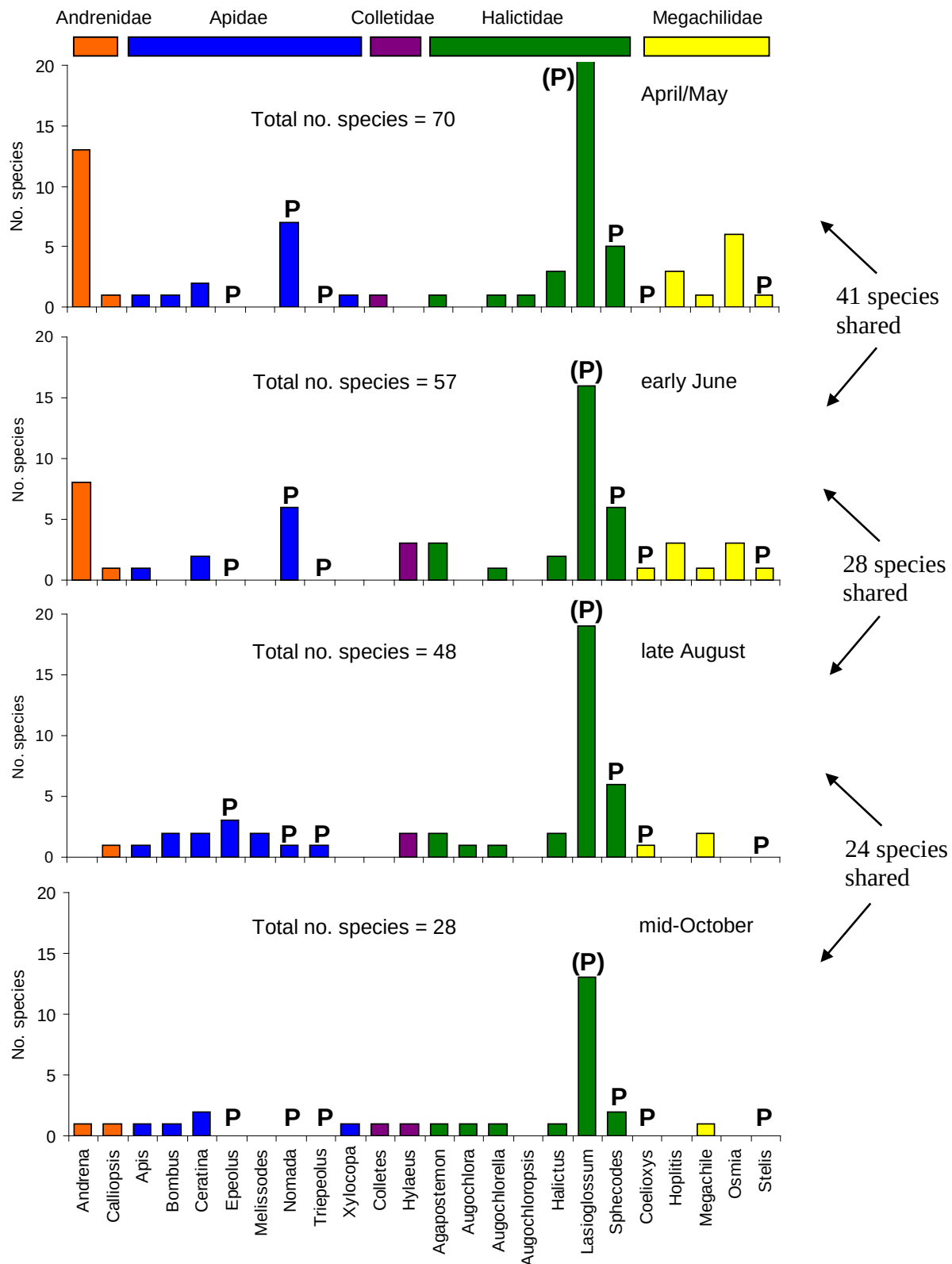


Figure 9. Total seasonal bee species richness for each genus collected in Boston Harbor Islands NRA. Genera are color coded by family. P = parasitic genus; (P) = some species in the genus are parasites.

Evaluation of sampling design using MONITOR

We reran MONITOR with plot values from raw abundance and species richness transect counts, for each season separately, and for all seasons combined. With these revised plot values, high spatial variability in seasonal and combined bee abundance across 16 transects (plots) did not provide sufficient statistical power to detect annual trends below 10%, even when alpha (α) was increased to 0.2, and desired power was decreased to 0.8. However, bee species richness from all seasons except for mid-October, as well as combined species richness, provided adequate power (0.9) to detect annual trends between 1% and 5% (Fig. 10).

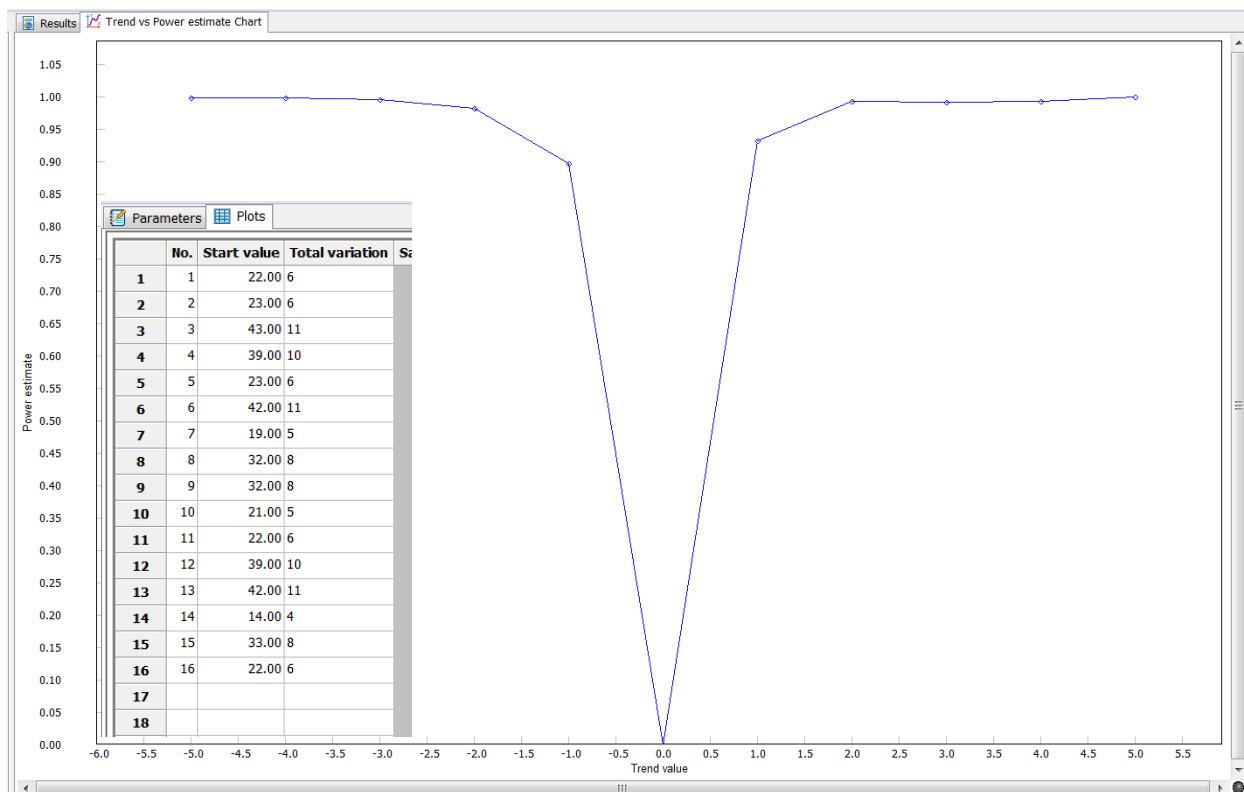


Figure 10. Trend (i.e., percent decrease or increase in abundance of bees) versus power estimate from Monitor program, using 16 plots with actual 2010 values for species richness (all seasons combined), 25% CV for each plot, and the original parameters shown in Fig. 2.

Flowering plants

The presence of flowering blooms along transects was lowest in April/May and highest in early June (Fig. 11). The dominant blooms (occurring in $\geq 5\%$ of plots along ≥ 5 transects, or present along ≥ 8 transects) for each sampling period were: April/May—*Lonicera* sp., *Taraxacum officinale*, *Malus* sp.; early June—*Rhus typhina*, *Aster* spp., *Trifolium* spp., *Rosa rugosa*, *Rosa multiflora*, *Rubus* spp., *Potentilla* sp.; late August—*Solidago* spp., *Daucus carota*, *Linaria vulgaris*; mid-October—*Solidago sempervirens*, *Linaria vulgaris*, *Aster* spp. Our April/May sample was timed slightly too late to incorporate the target willow (*Salix*) bloom, and though there were some *Solidago sempervirens* blooming in mid-October, much of it had already gone to seed, and our timing was slightly too late.

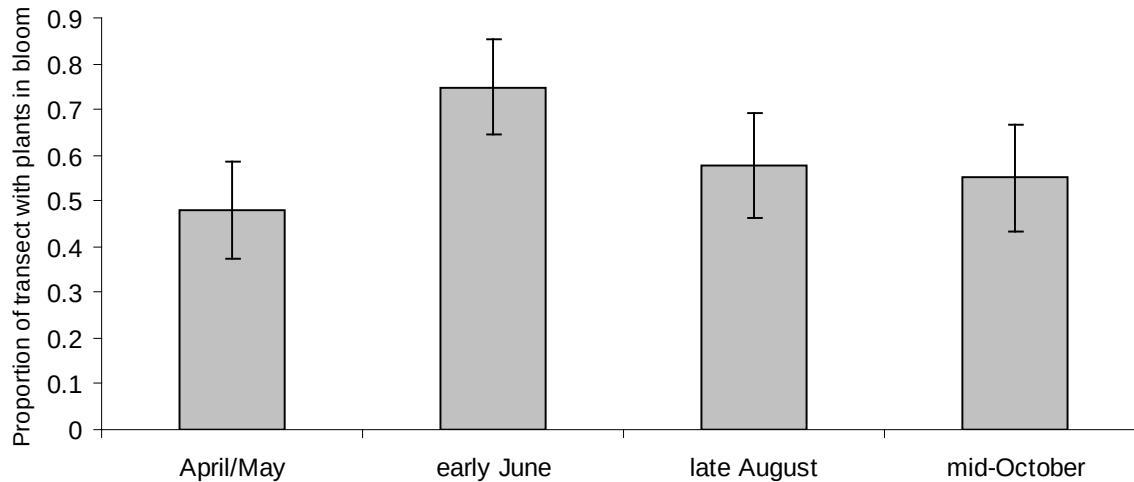


Figure 11. Mean proportion ($x/58$) $\pm$ 95% CI of transect with flowers in bloom ($N = 16$ transects) compared among four sampling dates in 2010.

Specimen sampling and processing effort and costs

In addition to one full time lead scientist (J. Rykken) and one dedicated paid intern (M. Eustis), 24 students, volunteers, NPS staff, and other professionals logged more than 430 hours with the project (Table 3).

Setting up and collecting bees from 16 bee bowl transects on nine islands and peninsulas typically required four days of field work per sampling period. The logistics of boat scheduling and adequate timing for setting up and taking down transects resulted in a morning fieldwork session (e.g., 7-11 am), followed by a midday break, and then an afternoon fieldwork session (e.g., 3:30-6 pm). The bulk of the field work was conducted by the lead scientist and paid intern, but four volunteers and three NPS staff members also participated to varying degrees (Table 3).

Lab work was split almost evenly among three main tasks: (1) sorting bee bowl samples; (2) pinning and labeling bee specimens; and (3) entering sampling site and specimen information into the database (approx. 200 hours each). Volunteers logged more than 240 hours in the lab (Table 3), and most had no prior experience with bees. Bee species were determined by trained taxonomists. The lead scientist (JR) determined 44% of the specimens (1,713), and the bee intern was trained to separate the males of three species of *Ceratina*, an extremely abundant genus in the park (1,169 identified males). Any specimens with uncertain determinations made by JR, as well nearly 1,000 unidentified specimens, were sent to Sam Droege at the USGS Bee Inventory and Monitoring Lab in Beltsville, MD for confirmation. John Ascher from the American Museum of Natural History (AMNH) in New York, NY, also determined 34 specimens.

Table 3. Break down of field, lab, and taxonomic effort by project staff, NPS staff, interns, volunteers, and students.

Worker classification	Compensation \$ = paid by project V = volunteer IK = in kind contribution	Field work (# ppl) total hours	Lab work & data (# ppl) total hours	Taxonomy (#ppl) total hours
Lead scientist	\$	(1) 112	(1; organizing, oversight, managing workflow) ~240	(1) ~200
Bee intern	\$	(1) 72	(1) 251	(1) 44
Other intern	\$		(2) 39	
Volunteer HS student	V		(3) 61	
Volunteer Coll. student	V		(1) 38	
Volunteer NPS volunteer	V	(4) 32	(2) 142	
HS student	IK		(1) 30	
Coll. student	IK		(1) 23	
NPS staff	IK	(3) 25	(8) 25	
Skilled bee researcher	V			(3) 20
Professional taxonomist	IK			(2) 16
TOTAL EFFORT:		221 hours	609 hours	280 hours

Direct costs for the project included: lead scientist (~552 hours x \$25/hr = \$13,800); paid intern hours (406 hours x \$16/hr = \$6,496); boat rental costs (70 hours x \$55/hr = \$3,850); and equipment and supplies (\$1,500).

Discussion

The pilot bee monitoring study in Boston Harbor Islands NRA was successful in its overall objective of developing and documenting a relatively simple, inexpensive, repeatable monitoring protocol with adequate statistical power to detect temporal trends of change in bee communities, similar to more global pollinator monitoring programs proposed by LeBuhn et al. (2012). It also successfully incorporated the enthusiasm and efforts of many citizen scientists (including interns, students, and park volunteers) to perform essential work. As this was a pilot study, we took care to document our approach to developing the sampling design, as well as field and lab protocols, so that our methods can be easily repeated in the future. We also tried to provide a realistic estimate of costs and labor involved in conducting the study, which will be helpful for budgeting future expenses and personnel. Most of our discussion focuses on assessments of our pilot protocols for sampling design, field work, and specimen processing, and considerations for future monitoring.

Assessment of pilot sampling design and considerations for future monitoring

Both spatial and temporal variability of measured variables influence the statistical power of monitoring programs to detect trends in populations, because the “noise” in counts can obscure the “signal” of increasing or decreasing trends (Gibbs et al. 1998). In developing our sampling design with the Monitor program, we failed to account for spatial variability in bee abundance when we assigned the same count value (60 bees, or 2 bees per bowl) for each plot (transect), as well as a constant measure of temporal variability ($CV = 100\%$). Our pilot sampling revealed that spatial variability in bee abundance across transects was so great that even with a reduced estimate of temporal variability ($CV = 35\%$, estimated from the literature, LeBuhn et al. 2012), our design did not provide enough power to effectively detect trends in bee abundance for any given season nor for all sampling periods combined.

The high spatial variability in bee abundance among transects was due, in part, to super-abundant species inflating counts on single transects or islands. For instance, 20% of the total catch from 16 transects in the April/May sample consisted of the males of one species from Great Brewster, the small carpenter bee, *Ceratina calcarata*. This species nests in the pithy stems of shrubs such as staghorn sumac (*Rhus typhina*), which is the dominant plant on Great Brewster. If *Ceratina* females had been included (they could not be identified, and thus were left out of the analyses), variability between transects would likely have been even higher. The long-horned bee, *Melissodes druriella*, was also extremely abundant on Great Brewster in late August, making up 13% of the total bee catch for that sampling period. Some of the social bees, such as the sweat bee, *Lasioglossum imitatum*, were collected in relatively high numbers on other transects.

Poorly located or disturbed transects were another factor contributing to spatial variability. For example, two transects which we installed on the beach (GP-BB-1 I.10 and BM-BB-1 II.10) caught only 5 and 4 bees, respectively, and one transect on an exposed trail on Spectacle Island (SP-BB-1 II.10) lost 11 bowls to wind and human disturbance. Weather also affected samples unevenly, as transects were sampled on different days within a sampling period, and a partially cloudy, cool, or windy day could decrease catches.

In order to increase the power of this sampling design for monitoring trends in bee abundance, various parameters could be adjusted, including: increasing the significance level (α , the probability of “crying wolf” when no trend actually exists, or type I error); decreasing the annual intervals between samples or extending the monitoring program for more than 10 years; or increasing the number of plots (transects). All of these parameters can be manipulated in the program MONITOR to get estimates of statistical power, depending on monitoring goals and logistical constraints (e.g., adequate funding for more intensive sampling).

Spatial variability among transects was lower for bee species richness, and except for the mid-October sample when catches were too low to expect to be able to detect and monitor trends (Gibbs et al. 1998), each seasonal sample, as well as all sampling periods combined, had adequate power (0.9) to detect annual trends of 1-3%, representing a cumulative decrease of 10-26% or increase of 10-34% over 10 years. Thus, species richness is likely a more feasible population index to monitor than bee abundance in Boston Harbor Islands NRA. Species turnover rates between seasons were relatively stable, less than one third of pooled species were shared between consecutive sampling periods from late April to mid-October, so that combining all seasonal samples yielded a far higher diversity of species than any one season alone, but each seasonal sample provided unique information.

Another approach to developing effective monitoring metrics is to focus on a subset of the bee community. The three most abundant and widespread species (e.g., *Ceratina calcarata*, *Agapostemon virescens*, *Augochlora pura*) made up 37% of the total bee catch across all seasons, suggesting they may be good candidates for monitoring. However, their abundances were extremely variable across transects (mean abundance for all seasons combined $\pm$ 95% CI: *C. calcarata* = 60.8 ± 44.8 ; *A. virescens* = 16.6 ± 9.4 ; *A. pura* = 14.9 ± 8.5). Introduced species are another obvious metric of interest, however, their diversity (3 species) and abundances were very low in 2010.

Sheffield et al. (2013) suggest that the functional diversity of bee populations provides a more relevant index for assessing and monitoring the health of bee communities. In particular, they propose cleptoparasites as a good indicator guild because these bees rely on healthy host populations for their survival, and they and their hosts occur across a diversity of genera and most bee families. Among cleptoparasites, adult females enter the nests of non-conspecific host species, lay their eggs in the host brood cells, and the maturing cleptoparasitic larvae kill the host eggs or larvae, then feed on the hosts' nectar and pollen provisions. In our pilot study, cleptoparasitic bees made up 25% of all bee species (26 of 104 species), an indication of a diverse and robust bee community overall (Sheffield et al. 2013). Although cleptoparasites made up a large proportion of bee diversity, their overall abundance was predictably low (Oertli et al. 2005), only 5% of the total. This made it unlikely that our sampling design would have sufficient power to detect small annual trends of change in either abundance or species richness of cleptoparasites.

Other guilds of bees that might serve as effective indicator groups for monitoring are habitat or host plant specialists. For instance, *Colletes inaequalis*, *Lasioglossum leucocomum*, and *Lasioglossum zephyrum* are all strongly associated with sandy areas, including beaches and dunes. Although we determined that bee bowl transects set out on the beach were not very productive, it is likely we

could collect many sand-associated bees in transects set relatively near to beaches. Sandy beaches may be a habitat vulnerable to effects from climate change as sea levels rise, and coastal dune bee communities have been the focus of surveys in Boston Harbor Islands NRA and other coastal parks (Rykken et al. 2014).

The presence or abundance of bee species that specialize on early- or late-blooming host plants may also be informative for monitoring because climate-induced mismatches in the phenologies of bees and their host plants may have negative consequences for pollinator-plant networks (Bartomeus et al. 2011). Many bees are spring specialists (especially in the genera *Osmia*, *Andrena*; Figs. 8,9) foraging on early-flowering plants such as willow (*Salix*), or parasitizing spring-active species (e.g., *Nomada* on *Andrena*). There are also late-summer or early-autumn specialists (e.g., *Melissodes* and its cleptoparasite, *Triepeolus*) foraging on goldenrod (*Solidago*) and asters, some of which were captured by the late August sample, but we were too late for the seaside goldenrod (*Solidago sempervirens*) bloom at most sites in mid-October.

Assessment of field and lab protocols and considerations for future monitoring

Field sampling

The seasonal timing of our sampling periods was intended to coincide with significant flowering events, but we were too late for most of the willow (*Salix*) bloom in spring, and also too late with the autumn sample in mid-October, when most of the seaside goldenrod (*Solidago sempervirens*) had already gone by, and cool, overcast weather dominated most of the sampling period. Phenology will vary year to year depending on weather (and thus must be carefully tracked in real time), but for planning purposes, one could predict that mid-April would be good timing for the first bee sample, and late September would be better for the late season sample.

Within a sampling period, the logistics of when to set out transects were challenging due to boat scheduling, weather constraints, and volunteer recruitment. A maximum of three islands/peninsulas could be visited in one day to meet the criteria of opening all traps by 10 am and closing them after 4 pm, as well as conducting vegetation surveys at each transect. Each of the sampling periods thus spanned several days, with a goal of fair weather, and three days required boat scheduling. Recruiting volunteers for full field days was difficult because of the six-hour lag in the middle of the day. It was most efficient to have three people working in the morning (scientist, bee intern, and one volunteer) and collecting all the vegetation data; in the afternoon two people could efficiently pick up the traps.

There were several important factors to consider when locating bee bowl transects. At sites that received many canine and/or human visitors (e.g., Worlds End, Webb, Spectacle) we tried to avoid sampling on weekends, and/or stayed away from foot traffic when possible. Also, some islands (e.g., Thompson and the state park islands) were mowed regularly, and it was helpful to contact staff beforehand if bee bowls were to be set out in a managed meadow. Recently mowed meadows were not generally productive because flowers were gone, and active mowing destroyed bowls!

On some islands we had confrontations with wild animals, especially breeding birds. For instance, several coastal bird species nest on Great Brewster in spring, including gulls which behaved

aggressively as we laid out bowls, and disturbed several of the bowls once we were gone. Our activities also posed a direct threat to birds in some cases, for instance, oystercatcher eggs on the beach were difficult to see and thus easily trampled when walking to and from the boat. Protecting coastal breeding bird populations during breeding season is a park priority, and thus there is a tradeoff between bee sampling in spring/early summer and disturbance to the birds.

Bee bowls did not collect much when they were positioned in shade, so it was necessary to anticipate the movement of the sun during the course of the day when setting up bowls in the morning. Bowls hidden from view in long grass were also not effective. Transects located right on the beach caught very little, perhaps because of exposure to wind, or shading from trees if bowls were pushed up above the high tide line.

Specimen processing

Lab activities (including sorting and preparing specimens, databasing) were accomplished by 19 paid interns, volunteers, and students, most of whom had little to no prior experience working with insects. With one experienced person (i.e., lead scientist or bee intern) overseeing lab activities at any given time, it was fairly simple to train people to sort and prepare insects. Databasing was a more dedicated task and fewer people were trained to do this. Most people working in the lab put in a minimum of 20 hours, however, we invited some people (e.g., park staff) to spend half a day in the lab with the primary goal of exposing them to the remarkable diversity of native bees in the park. Certainly, a smaller team of well-trained bee volunteers would be more efficient for future monitoring efforts.

This bee monitoring pilot project was a natural extension of an ongoing All Taxa Biodiversity Inventory in the park, a collaborative effort between the Museum of Comparative Zoology and the Boston Harbor Islands Partnership. As such, the pilot project benefitted from an existing alliance between the MCZ and the park, including access to a lead entomologist familiar with sampling in the park, a well-equipped lab and infrastructure set up to process park insect samples efficiently, and a wide network of bee taxonomists. For future monitoring efforts, it is possible that the park can use existing NPS staff and volunteers to conduct the bee sampling, but they will need to contract out the specimen processing, databasing, and taxonomy. LeBuhn et al. (2012) estimate that 85% of the cost (and effort) of monitoring bees is *after* bee collection, and our pilot project bears out this skewed division of cost and effort.

One way to streamline bee processing further, *if* species richness was the only variable measured for monitoring (i.e., abundance measures were dropped from the program because of the high variation), would be to document presence/absence only for species in each sample, and not keep counts of specimens within each species. However, in order to determine the identity of any but the most common species, most specimens would still need to be pinned and prepared. Cataloging efforts could be reduced significantly if only one voucher specimen per species from each sample were databased. Long-term storage and curation of the bee collection may also be simplified with fewer cataloged specimens.

An important caveat to using presence/absence data for monitoring is that bee taxonomy undergoes revision constantly, even among the most common taxa, and thus it would be wise to store *all* collected specimens with the permanent collection, even if non-voucher specimens are kept pinned or in ethanol without catalog numbers (but grouped by sample). For instance, a new eastern species of *Ceratina*, one of the most common genera collected during this study, was described in 2011, the year after our study. It is therefore likely that a sub-set of the *Ceratina* identified from this study are actually *C. mikmaqi* Rehan and Sheffield. We can presume that more taxonomic issues will arise over the lifetime of a long-term monitoring program.

Contributions to the All Taxa Biodiversity Inventory (ATBI)

Previous to the pilot bee monitoring project, the Boston Harbor Islands ATBI had documented 157 species of bees on 16 islands. The collections from the monitoring project added 23 new bee species to the ATBI database (Appendix G) and documented bees on two additional islands/peninsulas (Peddocks and Webb). New park records included ten cleptoparasitic species, including one new genus (*Triepeolus*), increasing the previous richness of cleptoparasites by 30%. Spring sampling in April/May was earlier than most previous sampling for the ATBI, and thus provided an opportunity to collect a few new early season bees (e.g., *Andrena nuda* and *Nomada cressonii*). No new non-native bees were detected, but there are seven species already known from the park (*Andrena wilkella*, *Apis mellifera*, *Lasioglossum leucozonium*, *Anthidium manicatum*, *A. oblongatum*, *Megachile rotundata*, *M. sculpturalis*). An additional benefit of continued monitoring will be to detect new exotic arrivals.

Recommendations for Future Monitoring

1. If the current sampling design is continued with similar parameters, use species richness as an index for monitoring, but not bee abundance. At the next sampling event (i.e., after five years), reassess estimates of spatial and temporal plot variability by using actual richness values from both years, and use these new plot values in the Monitor program to determine the magnitude of detectable trends.
2. Ideally, invest in several more consecutive years of sampling to further develop and assess the effectiveness of monitoring metrics other than abundance and overall species richness (e.g., abundance of common and widespread species, richness and/or abundance of cleptoparasites, sand specialists, willow specialists) and measure inter-annual variability of these metrics. Reducing the number of species included in a set of optimal monitoring metrics could reduce taxonomic efforts considerably, and thus save the program money for the long-term.
3. Adjust the timing of early and late season sampling periods to better synch with flowering of willow (*Salix*) and seaside goldenrod (*Solidago sempervirens*), respectively. Use these two sampling periods at a minimum, and add more between them if possible.
4. When locating bee sampling transects, avoid recently mowed areas, areas that may be mowed during the sampling period, long grass, direct beach placement, areas that will be in shade for a significant portion of the day, and coastal breeding bird nesting habitats. Also avoid windy, cool, cloudy, or rainy days!
5. Field work and some tasks associated with specimen processing (under direct supervision) are suitable for volunteers. There is some training involved for both field and lab work, so a smaller, dedicated work force will be most efficient.
6. The lead scientist for future monitoring efforts should be trained in bee taxonomy, or have direct relationships with bee taxonomists so that this critical component of the monitoring process does not become an obstacle to progress. Funding should be budgeted specifically for taxonomy.

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Appendix A. Coordinates, sample dates, and maps of bee bowl transects on nine islands/peninsulas in Boston Harbor Islands NRA.

Code	Date	Start latitude				Start longitude				End latitude				End longitude			
		deg	min	sec		deg	min	sec		deg	min	sec		deg	min	sec	W
BM-BB-1 I.10	4/30/2010	42	16	51.4	N	70	54	8.4	W	42	16	51.9	N	70	54	3.4	W
BM-BB-1 II.10	6/2/2010	42	16	48.0	N	70	53	48.0	W	42	16	49.1	N	70	53	44.3	W
BM-BB-1 III.10	8/30/2010	42	16	51.2	N	70	54	8.3	W	42	16	51.6	N	70	54	2.9	W
BM-BB-1 IV.10	10/14/2010	42	16	48.3	N	70	53	45.1	W	42	16	51.0	N	70	53	47.6	W
BM-BB-2 I.10	4/30/2010	42	16	54.1	N	70	54	0.6	W	42	16	51.1	N	70	53	57.8	W
BM-BB-2 II.10	6/2/2010	42	16	52.3	N	70	53	59.4	W	42	16	49.1	N	70	53	57.6	W
BM-BB-2 III.10	8/30/2010	42	16	53.8	N	70	54	0.2	W	42	16	49.6	N	70	53	57.8	W
BM-BB-2 IV.10	10/14/2010	42	16	51.4	N	70	53	58.1	W	42	16	51.8	N	70	54	4.4	W
GB-BB-1 I.10	5/5/2010	42	19	57.5	N	70	53	45.5	W	42	19	55.4	N	70	53	49.0	W
GB-BB-1 II.10	6/8/2010	42	19	58.4	N	70	53	44.5	W	42	19	55.7	N	70	53	48.6	W
GB-BB-1 III.10	8/27/2010	42	19	59.1	N	70	53	44.4	W	42	19	55.9	N	70	53	48.1	W
GB-BB-1 IV.10	10/18/2010	42	19	57.1	N	70	53	44.5	W	42	19	53.2	N	70	53	46.6	W
GB-BB-2 I.10	5/5/2010	42	19	52.9	N	70	53	50.0	W	42	19	50.3	N	70	53	49.1	W
GB-BB-2 II.10	6/8/2010	42	19	53.1	N	70	53	50.4	W	42	19	50.0	N	70	53	49.5	W
GB-BB-2 III.10	8/27/2010	42	19	53.3	N	70	53	50.1	W	42	19	50.2	N	70	53	49.0	W
GB-BB-2 IV.10	10/18/2010	42	19	53.7	N	70	53	50.1	W	42	19	50.5	N	70	53	50.3	W
GP-BB-1 I.10	4/30/2010	42	16	13.3	N	70	54	59.7	W	42	16	17.6	N	70	55	3.5	W
GP-BB-1 II.10	6/2/2010	42	16	11.5	N	70	55	13.2	W	42	16	10.0	N	70	55	18.2	W
GP-BB-1 III.10	8/30/2010	42	16	14.7	N	70	55	3.8	W	42	16	14.3	N	70	55	9.0	W
GP-BB-1 IV.10	10/14/2010	42	16	8.8	N	70	55	5.2	W	42	16	8.4	N	70	55	2.6	W
GP-BB-2 I.10	4/30/2010	42	16	15.1	N	70	55	5.6	W	42	16	14.0	N	70	55	9.8	W
GP-BB-2 I.10	6/2/2010	42	16	8.8	N	70	55	6.3	W	42	16	9.6	N	70	55	1.7	W
GP-BB-2 III.10	8/30/2010	42	16	9.8	N	70	55	22.6	W	42	16	7.8	N	70	55	28.5	W
GP-BB-2 IV.10	10/14/2010	42	16	6.1	N	70	55	14.5	W	42	16	7.1	N	70	55	12.3	W
LN-BB-1 I.10	5/1/2010	42	15	38.2	N	70	53	14.5	W	42	15	36.5	N	70	53	11.5	W
LN-BB-1 II.10	6/4/2010	42	15	38.0	N	70	53	15.5	W	42	15	37.3	N	70	53	11.3	W

Code	Date	Start latitude				Start longitude				End latitude				End longitude			
		deg	min	sec		deg	min	sec		deg	min	sec		deg	min	sec	W
LN-BB-1 III.10	8/28/2010	42	15	37.3	N	70	53	14.5	W	42	15	37.4	N	70	53	11.5	W
LN-BB-1 IV.10	10/11/2010	42	15	36.6	N	70	53	11.9	W	42	15	37.3	N	70	53	14.7	W
PE-BB-1 I.10	4/30/2010	42	17	16.3	N	70	56	48.8	W	42	17	19.7	N	70	56	46.2	W
PE-BB-1 II.10	6/8/2010	42	17	27.0	N	70	56	32.0	W	42	17	28.8	N	70	56	28.0	W
PE-BB-1 III.10	8/27/2010	42	17	24.4	N	70	56	35.6	W	42	17	28.2	N	70	56	29.3	W
PE-BB-1 IV.10	10/18/2010	42	17	48.2	N	70	55	58.5	W	42	17	49.8	N	70	56	2.7	W
PE-BB-2 I.10	4/30/2010	42	17	25.8	N	70	56	34.6	W	42	17	23.0	N	70	56	36.4	W
PE-BB-2 II.10	6/8/2010	42	17	44.1	N	70	56	5.3	W	42	17	48.0	N	70	56	4.4	W
PE-BB-2 III.10	8/27/2010	42	17	39.2	N	70	56	9.5	W	42	17	43.7	N	70	56	5.7	W
PE-BB-2 IV.10	10/18/2010	42	17	35.8	N	70	56	10.7	W	42	17	39.4	N	70	56	9.1	W
SP-BB-1 I.10	5/5/2010	42	19	36.3	N	70	59	19.0	W	42	19	38.5	N	70	59	16.3	W
SP-BB-1 II.10	6/7/2010	42	19	34.7	N	70	59	18.7	W	42	19	34.1	N	70	59	13.8	W
SP-BB-1 III.10	8/26/2010	42	19	39.7	N	70	59	10.3	W	42	19	38.9	N	70	59	16.3	W
SP-BB-1 IV.10	10/13/2010	42	19	28.6	N	70	59	7.3	W	42	19	24.7	N	70	59	8.8	W
SP-BB-2 I.10	5/5/2010	42	19	26.8	N	70	59	6.4	W	42	19	22.6	N	70	59	6.3	W
SP-BB-2 II.10	6/7/2010	42	19	33.5	N	70	54	5.4	W	42	19	37.0	N	70	59	6.5	W
SP-BB-2 III.10	8/26/2010	42	19	29.7	N	70	59	14.7	W	42	19	32.2	N	70	59	19.7	W
SP-BB-2 IV.10	10/13/2010	42	19	29.8	N	70	59	14.7	W	42	19	32.1	N	70	59	19.4	W
TH-BB-1 I.10	5/5/2010	42	18	53.6	N	71	0	40.0	W	42	18	52.8	N	71	0	35.4	W
TH-BB-1 II.10	6/7/2010	42	18	39.0	N	71	0	41.1	W	42	18	41.5	N	71	0	38.4	W
TH-BB-1 III.10	8/26/2010	42	19	14.6	N	71	0	2.5	W	42	19	15.4	N	71	0	9.2	W
TH-BB-1 IV.10	10/13/2010	42	18	58.9	N	71	0	30.4	W	42	18	54.8	N	71	0	31.2	W
TH-BB-2 I.10	5/5/2010	42	19	14.8	N	71	0	3.1	W	42	19	15.6	N	71	0	8.0	W
TH-BB-2 II.10	6/7/2010	42	18	52.1	N	71	0	31.7	W	42	18	55.9	N	71	0	32.7	W
TH-BB-2 III.10	8/26/2010	42	18	51.4	N	71	0	30.7	W	42	18	55.2	N	71	0	32.6	W
TH-BB-2 IV.10	10/13/2010	42	18	38.3	N	71	0	41.1	W	42	18	41.4	N	71	0	38.8	W
WB-BB-1 I.10	5/1/2010	42	15	34.0	N	70	55	27.5	W	42	15	35.1	N	70	55	31.2	W
WB-BB-1 II.10	6/4/2010	42	15	34.0	N	70	55	33.7	W	42	15	33.1	N	70	55	28.8	W
WB-BB-1 III.10	8/28/2010	42	15	32.9	N	70	55	25.9	W	42	15	36.3	N	70	55	27.5	W

Code	Date	Start latitude				Start longitude				End latitude				End longitude			
		deg	min	sec		deg	min	sec		deg	min	sec		deg	min	sec	W
WB-BB-1 IV.10	10/11/2010	42	15	36.3	N	70	55	22.6	W	42	15	39.7	N	70	55	24.4	W
WE-BB-1 I.10	5/1/2010	42	15	39.2	N	70	52	14.8	W	42	15	41.4	N	70	52	12.6	W
WE-BB-1 II.10	6/4/2010	42	16	0.3	N	70	52	41.3	W	42	16	4.2	N	70	52	42.3	W
WE-BB-1 IV.10	10/11/2010	42	15	55.1	N	70	52	30.8	W	42	15	57.6	N	70	52	36.2	W
WE-BB-1 III.10	8/28/2010	42	15	39.4	N	70	52	15.4	W	42	15	39.3	N	70	52	12.4	W
WE-BB-2 I.10	5/1/2010	42	15	48.8	N	70	52	20.1	W	42	15	48.9	N	70	52	15.8	W
WE-BB-2 II.10	6/4/2010	42	15	49.7	N	70	52	33.2	W	42	15	51.2	N	70	52	37.8	W
WE-BB-2 III.10	8/28/2010	42	15	42.4	N	70	52	38.1	W	missing data (see map for approx. location)							
WE-BB-2 IV.10	10/11/2010	42	15	44.9	N	70	52	32.3	W	42	15	42.0	N	70	52	35.6	W
WE-BB-3 II.10	6/4/2010	42	15	35.5	N	70	52	42.8	W	42	15	38.0	N	70	52	39.0	W

Transects marked on maps on the following pages are color coded as follows:

Yellow = May/April (I)

Red = early June (II)

Green = late August (III)

Blue = mid-October (IV)

Pins mark the ends of transects (S = start E = end), and lines show the approximate route.

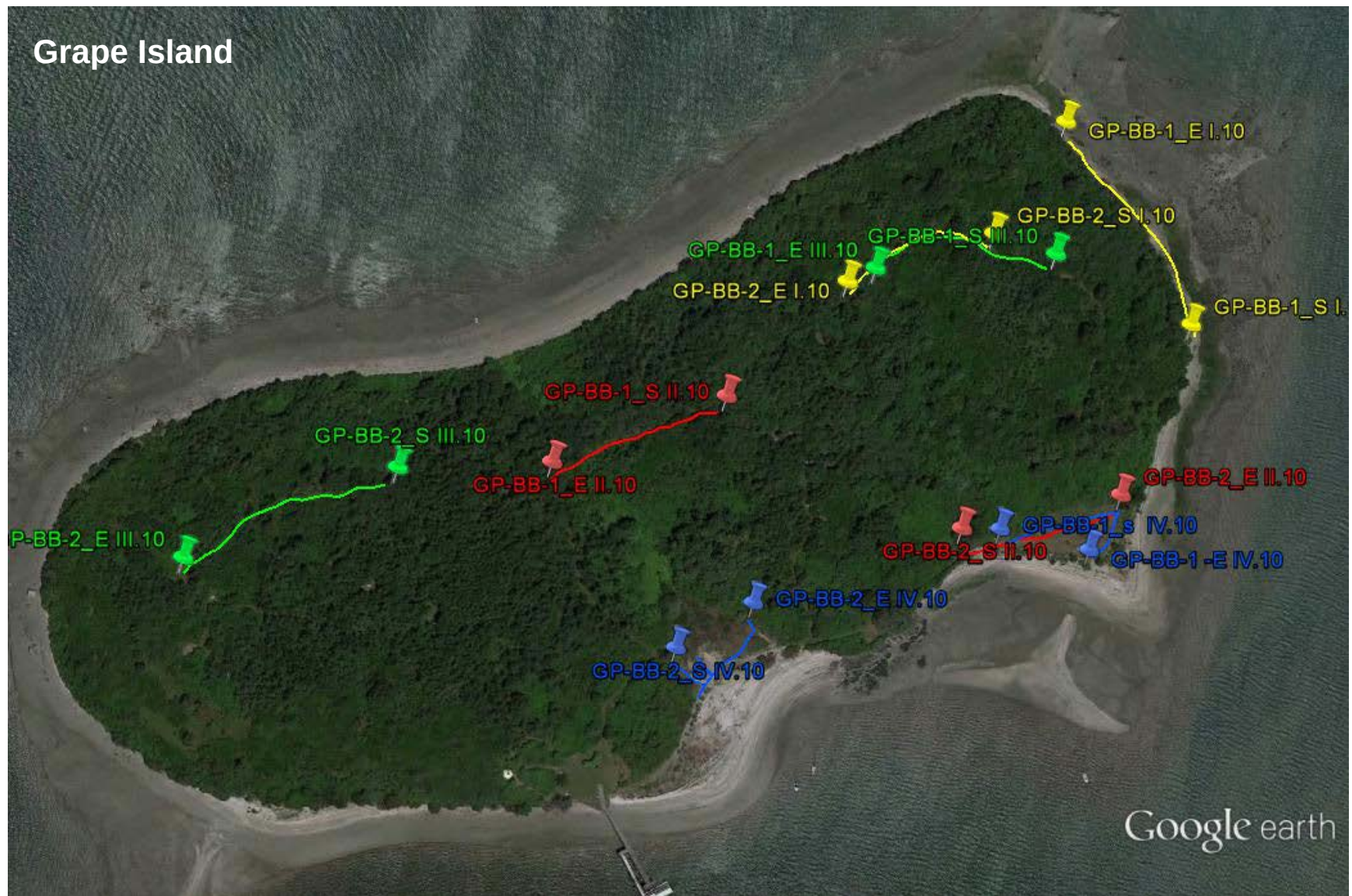
Bumpkin Island

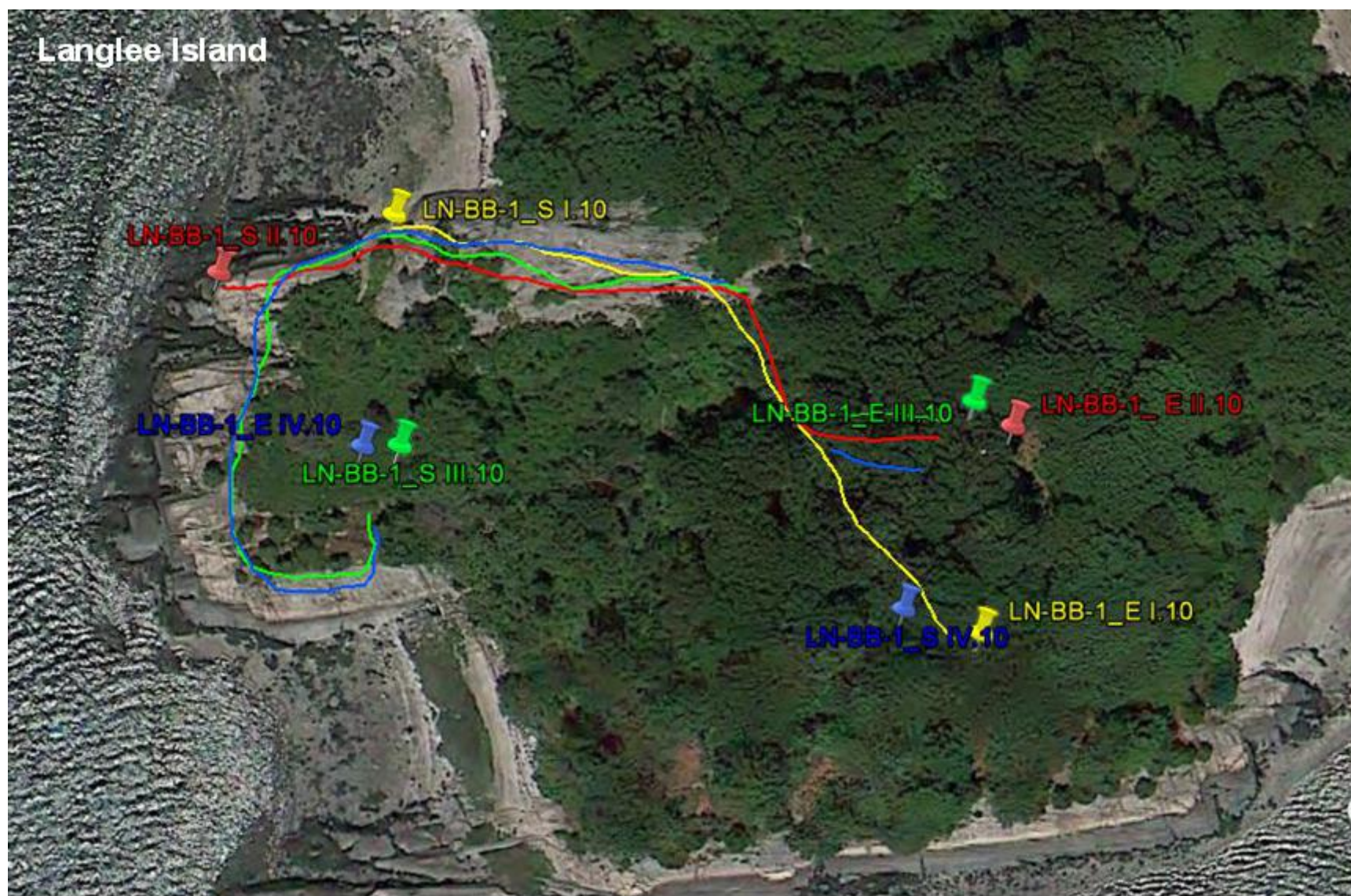


Great Brewster Island



Grape Island





Peddocks Island

north







Thompson Island



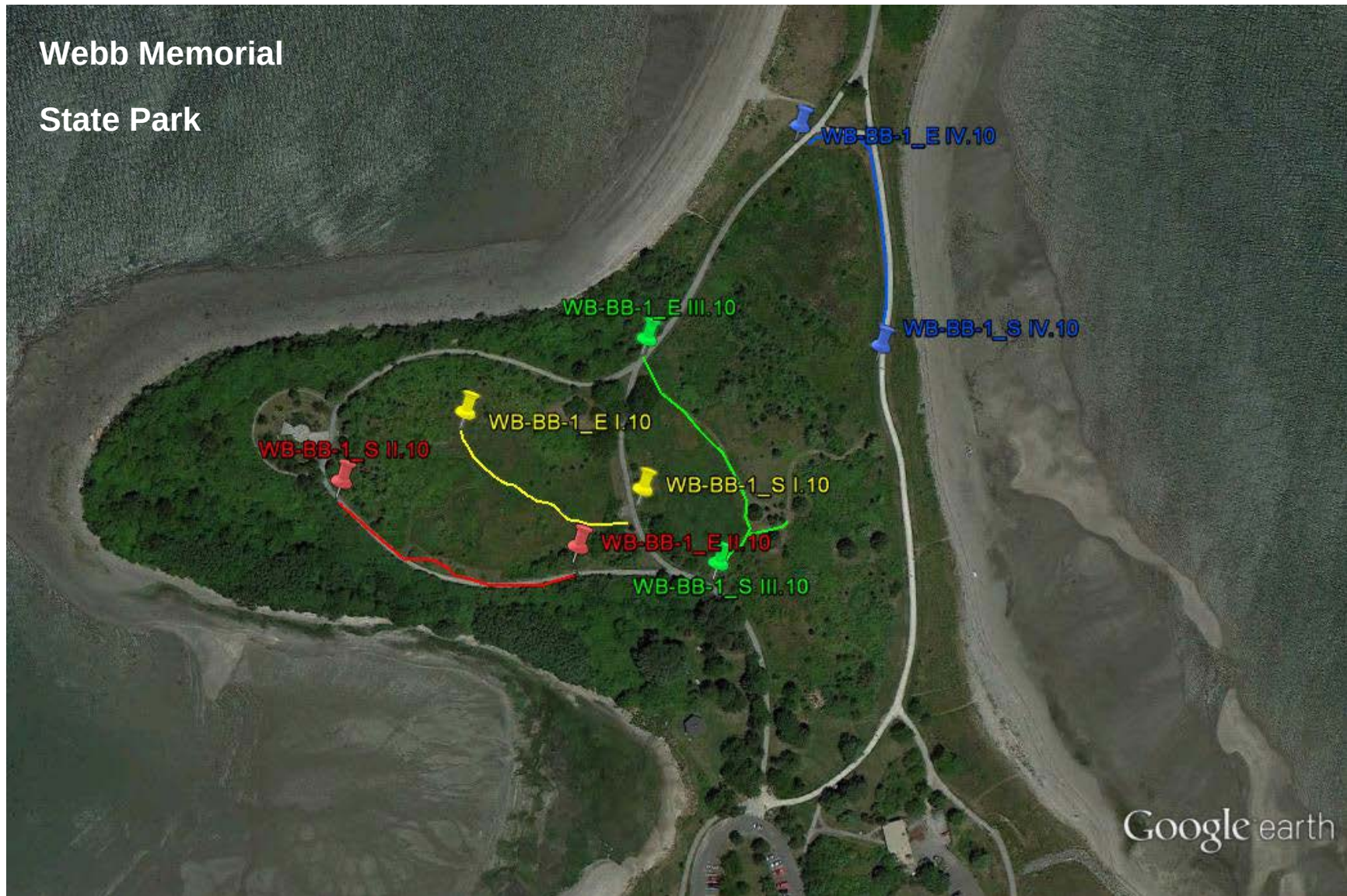






Webb Memorial

State Park





Appendix B. Field sampling protocol for setting out bee bowl transects (laminated, double sided)

Setting out bee bowls (Try to set out before 10am)

Equipment (per transect):

30 painted bee bowls (10 each color)

One half gallon water plus a few drops of blue Dawn soap

Bundle of 10+ orange flags

2 Bee monitoring signs plus stakes

Hammer & staple gun (for signs)

Camera

GPS unit

Data sheet

Pencil

Plastic or wooden squares (to put bowls on, in tall vegetation or uneven ground)

1. Check with park resource management staff regarding coastal breeding bird nesting areas. If any beach nesting areas are to be crossed, cross the gravelly upper beach very carefully, walking in a row and watching every step.
2. Mark End 1 of transect with orange flag and/or sign.
3. Fill out first three sections of data sheet, including: three parts to weather (sun, wind, temp for the day), the model of GPS unit (along with datum used), lat/long coordinates of End 1, and a general description of where the transect is located and what the habitat is like.
4. Fill bee bowl with water to about $\frac{3}{4}$ mark (not too full or insects may crawl out). Place on level ground. If grass is high, try to flatten down a small area so bowl is visible. If you can't see the bowl, chances are bees can't either.
5. Walk five paces (about 5 m) and fill the next bowl, repeat process above. Colors should alternate along transect.
6. At every 5th bowl, or if the bowl is in an odd or hidden place, mark with orange flag (also if transect bends).
7. Transect does not have to be straight, can bend to get closer to plants in flower.
8. When you reach the far end of the transect (End 2), get lat/long coordinates again.
9. Fill in the time (Time out) on data sheet, and the number of bowls set out (30).
10. Put in second bee monitoring sign.
11. Take a couple of photos of the transect.
12. Walk back along transect (or have other people do this while you are setting bowls) and record flowering plants to left and right of transect between bowls on data sheet. Look close to the transect, just a meter or two, not off in the distance. If you don't know what the flowering plant is, just record as herbaceous (H), shrub (S), or tree (T).

Bringing in bee bowls (Try to leave out until 4pm or later)

Equipment:

Whirl-Paks

Plastic funnel

Strainer

Forceps

Paper labels

Squirt bottle with ethanol

Tape

Data sheet

Pencil

Ziploc bag for collecting bowls

1. Check with park resource management staff regarding coastal breeding bird nesting areas. If any beach nesting areas are to be crossed, cross the gravelly upper beach very carefully, walking in a row and watching every step.
2. Swirl contents of bowl a little to get insects in suspension and then swiftly pour contents of bowl into strainer. If any insects remain in bowl, you can pick out with forceps if necessary (or just rap bowl on side of strainer to dislodge). Put contents of ALL 30 bowls into the strainer.
3. Once all bowls are emptied, mark down time on data sheet (Time in).
4. Note down on data sheet any bowls that were empty either because there was no fluid in them, or because they were tipped over, or trampled/eaten/missing etc.
5. Tear top off of Whirl-Pak and pull tabs to open the mouth of the bag; either blow or put your fingers inside the bag to open it up. Place the plastic funnel tip inside the bag (you can hold the Whirl-Pak and the bag securely in one hand) and then, with your other hand, rap the strainer upside down on the funnel a few times to dislodge all insects into the funnel. If there are a lot of bugs, the hole of the funnel will get clogged, but you can gently shake the funnel and they should start to move down. Washing the sides of the funnel with the ethanol squirt bottle will get the last specimens down into the Whirl-Pak.
6. Once you have all the insects in the Whirl-Pak, wash down any that are stuck to the sides of the bag so that they go down to the bottom with the rest. Then squirt in enough ethanol to cover the insects.
7. ADD LABEL. Label instructions are on data sheet. Label goes INSIDE THE BAG with the insects. Use pencil. Try to position the label so that it's readable from the outside.
8. Get all the air out of the Whirl-Pak, then fold down the wire top several times, until you have folded down to where the insects are. Bend the two ends of the wire until you can twist them together.
9. If there were any cups along the transect that could have been missed in tall vegetation or due to bends in the transect, count the bowls to make sure you got all 30.
10. Pick up flags and bundle together with tape.
11. Check over data sheet to make sure everything is complete. Don't forget to duplicate exactly what you wrote on the label in the space provided on the data sheet.

Appendix C. An example of an informational sign laminated and attached to a short wooden stake, then placed at either end of a bee bowl transect

Science in the Park: Bee Monitoring

Tracking Biodiversity in a Changing Climate

The park is participating in a national bee monitoring project as one of many efforts to detect changes in biodiversity over time. Bees were selected because they are important pollinators for many plants, are a critical link in many food webs, and are relatively easy to capture and identify.



Augochloropsis metallica

What are these painted bowls?

Researchers and citizen-science volunteers place these 'bee bowls' along 150 meter transects in the morning to attract bees and then collect them in the afternoon for identification.

How many bee species live here?

As of Spring 2010, researchers at the Harvard University Museum of Comparative Zoology have identified **154** species of native bees through the park's all-taxa biodiversity inventory (ATBI).



Project funded by National Park Service

Appendix D. Example of a data sheet for bee bowl transects (next 2 pages)

Boston Harbor Islands Bee Monitoring			Data entered?
Date:	Samplers:		
Island:	Transect (1 or 2):		
Weather: Cloud cover _____ Wind (dir. & strength) _____			
Air temp. (high projected for day) _____			
GPS coordinates (degrees, minutes, seconds) Model of unit:			Datum:
Start of transect: Lat.	Long.	Accuracy:	
End of transect: Lat.	Long.	Accuracy:	
Describe location of transect: (habitat type(s), dom. plant species in bloom (if known), grass mowed, etc.)			
Number of bowls set out:	Time set out:	Time brought in:	
Condition of bowls at pick-up ("all okay" OR # spilled, tipped over, dry, samples lost etc.):			
Label for Whirl Pak (WRITE IN PENCIL, LABEL GOES INSIDE WHIRL-PAK)			
Two letter code for island (Bumpkin = BM, Great Brewster = GB, Grape = GP, Langlee = LN, Peddocks = PE, Spectacle = SP, Thompson = TH, Webb = WB, World's End = WE)			
Trap type = BB (bee bowl, same for all)			
Transect number = 1 or 2			
Date code = I.10, II.10, III.10, or IV.10 (depending on the survey period)			
Example	TH-BB-1 III.10	(Thompson Island bee bowl transect number 1, collected during third survey period in 2010)	
More information on back side....			

Qualitative description of flowering plants next to transect:

Walk down transect from Start to End, and look an arm's length (~1m) left and right of transect. Record presence or absence of flowers in interval between one cup and the next, and also if flowers are on herbs, shrubs, or trees (can be more than one). Add any species names if known.

Cup interval	Left side	Right side
	H=herb, S=shrub, T=tree	H=herb, S=shrub, T=tree
1-2		
2-3		
3-4		
4-5		
5-6		
6-7		
7-8		
8-9		
9-10		
10-11		
11-12		
12-13		
13-14		
14-15		
15-16		
16-17		
17-18		
18-19		
19-20		
20-21		
21-22		
22-23		
23-24		
24-25		
25-26		
26-27		
27-28		
28-29		
29-30		

Appendix E. Survey notes compiled after each survey period

Notes for bee monitoring, survey I (April 30-May 5, 2010)

Survey I was intended to coincide with blooming of willow and other early flowering trees, but we missed most of this event by one to two weeks. What we did catch was predominantly: honeysuckle, blueberry, crabapple, Russian olive (TH), some cherry, barberry, garlic mustard, dandelions, mustard.

We got to three islands per field day:

- 4/30 Grape, Bumpkin, Peddocks. Setting up transects took longer than expected, 8am to 11am, as did pick up, 4:20 pm to 6pm. (actual open/close times for bowls).
- 5/1 Webb, Worlds End, Langlee. Drive up plus canoe to Langlee. 7 to 11am, 4 to 5:45pm.
- 5/5 Thompson, Spectacle, Great Brewster. 7:40 to 11:20 am, 3:45 to 5:45 pm

It would probably be better to do two islands per day in the boat, so that we can get the last transect set by 10am to maximize bowl time. It takes some time to find good places to locate the transects. Would be ideal to have all bowls out between 10am and 4pm.

Equipment worked well. Might be good to attach bee monitoring signs to stakes permanently so we don't need staple gun. Also, consider using rubber or wooden squares to flatten surrounding grass and stabilize areas of uneven ground.

Brief notes by island:

Grape - We put transect 1 on the beach, to try and get close to willows still in bloom and some other flowering shrubs/trees. But bowls caught almost nothing. They had to be shoved up under trees to avoid high tide line, so may have been too hidden. Plus, no plants on beach side.

Bumpkin - Crows messed with quite a few bowls on the central paved trail (very exposed), and either drank water (?) or tipped/pecked 11 bowls on the second transect.

Peddocks - Bowls under the full canopy on the trail did not collect bees. Perhaps next time also try paths or parade ground on 'East Head' (northeasternmost drumlin)?

Webb - One sign missing by end of day. Lots of people here on a Saturday, may be better to do this on a week day. I noticed that there was one shrub in the field in full flower that had tons of bees on it when I went to pick up the bowls, but there were hardly any bees in the nearby bowls. Did not make it to the northern part of the park, might be worth checking out next time.

Worlds End - Transect 1 in a meadow by the salt marsh got tons of bees because of the blueberries. Transect 2 did not do so well on the end that was in the tree cover. One bowl crushed (by human foot), again, weekend may not be the best day (also loose dogs).

Langlee - Hard to get out of the forest here, except up on the rocks. Low catch all around. I also disturbed some ducks off nests, and a pair of geese with goslings. Wind picked up in afternoon which

made it a little scary with the canoe. Hingham Harbor master may also be able to provide transport, esp. on a weekday when there's less going on.

Thompson - Transect 1 had long grass, so cups not very visible. Transect 2 along bluff edge of northernmost field did very well.

Spectacle - Not much in bloom on Transect 2. Placement of transects near flowering plants on north drumlin (Transect 1) was difficult due to slopes and stone walls.

Great Brewster - Grass was long, so difficult to find places to put cups on transects to make them visible. Use rubber squares or something to flatten surrounding grass? Note that the gravel beach is used by nesting American oystercatchers, and thus every step should be watched, and people should walk in a line, when crossing the beach to the vegetated interior of the island.

Notes for bee monitoring, survey II (June 3-June 8, 2010)

Survey II was intended to coincide with blooming of sumac, and later blooming trees. We were slightly early for sumac on Bumpkin and Grape, but seemed to hit it fairly well on the other islands. Other common flowering plants were: *Rosa multiflora*, *Rosa rugosa*, clover, and a variety of other flowering herbs.

We got to 2 to 3 islands per field day (with a goal of having all transects open by 10am and not closed before 4pm). We scheduled the UMass boat from 7am to 11am and 3:30 pm to 6pm—this worked pretty well:

- 6/3 (JR, ME) Grape, Bumpkin. Bowls opened 8:20 to 10:10 am; pick up, 4:25 to 5:55 pm.
- 6/4 (JR) Webb, Worlds End, Langlee. Drive up plus canoe to Langlee. Bowls opened 7:20 to 9:55 am (10:55 am for third transect on WE, see below); pick up, 4:05 to 6:35 pm.
- 6/7 (JR, AR) Spectacle, Thompson. Bowls opened 8:00 to 9:50 am, pick up 4:15 to 5:40 pm.
- 6/8 (JR, ME) Great Brewster, Peddocks. Bowls opened 8:00 to 10:15 am; pick up 4:15 to 5:10 pm.

We had two people working each day, including a volunteer, Aya Rothwell, on 6/7. Especially with a new volunteer, it's impossible to do all the vegetation survey work in the morning and still get all the transects out by 10am. So sometimes we left one or two transects to do in the afternoon. This then means that both people have to go to each transect in the afternoon, so it's less efficient. Three people would be ideal for efficiency in the morning. Two people are plenty in the afternoon.

UMass student center has wireless, so a very nice place to hang out during the day!

29 ticks on JR, picked up, presumably, on Bumpkin. ME had one. JR appears to be a tick magnet.

Data entry: We ended up entering some data from field sheets twice—once into an Excel spreadsheet, and once directly into Mantis (to generate labels). For now, we only put label information into Mantis (i.e., no notes, bowl times etc.), and entered only the lat/long for the START

of each transect. The Excel spreadsheet contains more information, but not things like weather and extra notes. We have not yet entered most of the flowering plant data.

Brief notes by island:

Grape - Foggy morning. T1 on trail on N side of island, mostly multiflora rose in bloom. Some bayberry (I think it was in bloom—hard to tell). T2 went through the meadow in southeast part of island. Not that much in flower except *Rosa rugosa* and false indigo. Saw intact fox tail (i.e., a fox's tail) in meadow at dock.

Bumpkin - Large machine running up and down main paved trail of the island prevented us from using this area for transects. T1 placed along upper edge of beach, and although there were quite a few flowering herbs, we didn't get many bees. Avoid this upper beach habitat for transect locations! T2 along a grassy trail with sumac JUST starting to come into bloom—some open, some still closed.

Peddocks - Seemed like we had good locations for both transects, even if they didn't catch lots of bees. T1 was on trail connecting SW and middle drumlins. Lots of flowering herbs and low-growing sumac. The bowls were in the shade on pick-up though. T2 in similar habitat on trail connecting north and middle drumlins. Similar plants to T1. We landed the boat at the dock and walked out, seemed fairly efficient.

Webb - Bowls set along trail on south loop. Sumac and flowering herbs fairly abundant.

Worlds End - T1 set on narrow bar between north and south drumlins. Quite windy by the afternoon—so not an ideal location. T2 on mowed trail leading south from top of Planter's Hill. Lots of the same kind of snail—not sure what but I collected some in bowls. Bumblebees on clover not going into bowls. On the way back to the parking lot I found a third site that I thought might be even better than T1 and T2, so I put in T3. Edge of field, on a mowed path with southern exposure. Lots of flowers. But in the end, not many bees.

Langlee - Nesting birds all gone. Only one place to lay this transect to keep it out of the forest, and that's along the rock outcrop on the western half of the island. Still, a few bowls go into the forest. Very few insects caught, even when bowl was next to a flowering sumac which had lots of bees on it. Less windy this time for the canoe trip.

Thompson - T1 set out on east side of meadow with high ropes course (south end of island). Dense stand of blooming sumac about 5-10 m to west. Grass pretty high, and I think we laid just 29 bowls by mistake. T2 on north side of meadow just south of restored salt marsh. High diversity of flowering herbs.

Spectacle - Put T1 on south side of North drumlin—a little sumac, clover, and other herbs. 11 bowls either dry, moved slightly, or partly crushed—animals, people, wind, combination?? T2 on another trail on east side of North drumlin and they were all in good condition on pick up. Better than last survey, but still not that productive.

Great Brewster - Gulls are nesting and protective. T1 located about where it was last time, but started slightly higher up the hill. Sumac and *Rosa rugosa*. I practically placed a bee bowl IN a gull's nest without seeing it. T2 down near where it was last time too, but reached the picnic area on the bluff via a different route up the hill. Gull nests here too. Flax still in bloom, and sumac. We were mindful on the beach about other bird nests.

Notes for bee monitoring, survey III (Aug 26-30, 2010)

Survey III was intended to coincide with blooming of goldenrod. There were several species of goldenrod in flower on most of the islands, some just barely blooming. Other common herbs in flower included queen Anne's lace, clover, vetch, butter and eggs, tansy, chickory, and other asters. Weather was good on all days—sunny, warm, not too much wind (but maybe SP had a stiff breeze).

We added 4 extra transects (2 each on Thompson and Lovells) for the national NPS bee inventory project, and left these transects out overnight so that we did not have to add extra days to the survey.

Field crew included: Jessica Rykken (MCZ), Meredith Eustis (NPS), Aya Rothwell (volunteer), Liz Eddy (NPS), Jim Kilmurray (volunteer), Sean Kent (volunteer), Steve Cho (volunteer), Barbara Booth by (volunteer).

- 8/26 (JR, ME, AR, JK--pm) Thompson, Spectacle, Lovells, Thompson. Bowls on TH, SP opened 7:50 to 10:05 am; pick up, 4:10 to 5:25pm. Bowls on LV, TH opened 11:30am to 1:40pm.
- 8/27 (JR, ME, LE--am, SK--am) Peddocks, Great Brewster, Lovells, Thompson. Bowls on PE, GB opened 8:35 to 10:05am; pick up 4:30-5:40pm. Bowls on LV, TH picked up 10:50am to 12:15 pm
- 8/28 (JR, BB) Webb, Worlds End, Langlee. Drive up and canoe to Langlee. Bowls opened 7:50 to 10:15am, pick up 4:30 to 7:30pm.
- 8/30 (JR, ME, SC--am) Bumpkin, Grape. Bowls opened 8:40 to 9:30am; pick up 4:25 to 5:30 pm.

The field volunteers worked out well. Great to have the help especially in the mornings. Two people is plenty in the afternoon if all the veg. work is done in the morning. 8/26 was a long day, with only about a 1.5 hour break between trips. The dune transect on Lovells seemed much more active than the sandy site on Thompson. We could consider dropping the Thompson “dune” site and it's control.

We have lost our volunteer force in the lab, so need to recruit more (perhaps some of the folks who help out on the islands, like Jim?). All bees from surveys II and III have been pinned up.

Brief notes by island:

Grape - Both transects on trails on north side of island. This was where most of the goldenrod was in bloom, but bowls do get shaded out for a portion of the day, no matter where you place them on the trail. If there were dense trees along the trail, I skipped over that portion of the trail and continued the transect further on when it opened up again (noted on the data sheet). So start and end points of

transect will be more than 150 m apart. There was NOTHING flowering other than goldenrod along trails. Much of the goldenrod was still in bud.

Bumpkin - T1 placed as in Survey I, in small meadow and along central, paved trail. T2 also similar to Survey I, and cups were shaded on paths for a portion of the day. Might be better to locate the transects on the main trail when possible, because it's the most open. Next time check east end of island for seaside goldenrod.

Peddocks - Located both transects between drumlins, as in Survey II. These get shaded for a part of the day. Other possible locations might have been the meadow near the dock, or the meadow before transect 2 (but need 100 m between transects). Transect 1 had tracks from some kind of wheeled vehicle (bike? Mower?). All cups had sand/gravel/grass in them, but were not tipped over. Lots of people at the cabins.

Webb - Bowls set in central meadow.

Worlds End - T1 in meadow near salt marsh (as in Survey 1); transect is forked. T2 in meadow on Pine Hill. They had just mowed the big meadows, nothing in flower there.

Langlee - Only one place to put this transect, but able to extend a little farther to the west this time, around rocks. So just a few cups in the woods near the big oak. More bees than flies, seems a good catch.

Thompson - T1 at edge of meadow on north end of island (as in Survey I). Goldenrod seemed on the way out here. T2 along edge of meadow near restored salt marsh (s side—as in Survey II). Lots of goldenrod further out in meadow.

Spectacle - Ranger Betsy Colby helped us find sites in the people mover. T1 on north side of north drumlin. A little windy. T2 on south side of north drumlin. Lots of evening primrose in the meadow nearby. Both transects had a pretty high diversity of flowering plants.

Great Brewster - Both transects where we've located them before. Mosquitoes were BAD! Clouds of them. Huge quantities of bees at pick up. The entire strainer was full of insects.

Notes for bee monitoring, survey IV (Oct 11-18, 2010)

Survey IV was intended to coincide with blooming of seaside goldenrod. In mid-September, it was just barely starting to bloom, and we postponed the survey date to mid-October (there have been lots of bees caught in previous years during the first half of October). It turns out this was on the late side for seaside goldenrod, all but a few stands were 80-90% gone by. Other herbs in flower included some other goldenrod species, white and purple asters, butter and eggs. Weather was not ideal for bees on most of the survey days. Air temperature highs ranged from high 50's to mid-60's, a few days had substantial cloud cover for part of the day, and westerly winds were strong when sampling Peddocks and Great Brewster.

Various goldenrods and asters in bloom during this survey. Most of the goldenrod was not identified to species, except seaside goldenrod, and many of the asters remained unidentified as well. Mostly

we distinguished between white, narrow-leaved asters (e.g., small white aster, or heath aster) and purple asters.

We included 2 transects on Lovells for the national NPS bee inventory project, and left these transects out overnight so that we did not have to add extra days to the survey.

Field crew: Jessica Rykken (MCZ), Marc Albert (NPS), Meredith Eustis (NPS), Aya Rothwell (volunteer).

- 10/11 (JR) Webb, Worlds End, Langlee. Drive up and canoe to Langlee. Bowls opened 7:05 to 10:00am, pick up 4:00 to 6:00pm.
- 10/13 (JR--am, ME, MA) Thompson, Spectacle, Lovells--am. Bowls on TH, SP opened 7:50 to 10:00am; pick up 4:00 to 5:15pm.
- 10/14 (JR, ME, AR) Grape, Bumpkin, Lovells-am. Bowls opened 8:05 to 10:05am, pick up 4:10 to 4:55pm.
- 10/18 (JR, ME) Great Brewster--am, Peddocks. Bowls opened 8:10 to 10:00am; pick up on Peddocks only, 4:30pm.
- 10/19 (JR) Great Brewster. Pick-up 10am.

We are close to finishing sorting/pinning survey III bees. Survey IV did not catch many bees overall, so should go quickly. I plan for Ray Watkins (volunteer) to help with bees also.

Brief notes by island:

Webb - Bowls set along trail on east side of island. LOTS of seaside goldenrod in bloom. But still not very many bees (dog walker noticed the yellow bowls caught the most insects, consistently). Don't know what the bee activity on flowers was like during the day, since I was only there early morning and at dusk, but not much in the bowls.

Worlds End - T1 in mowed meadow on east side of main walking trail, just before the sand bar. There was goldenrod (not seaside) and a few other species in bloom in the meadow, but not directly next to the transect (trying to keep bowls in open areas where they are visible), so flowers were not picked up on data sheet. The transect was shaded in the afternoon by trees lining the trail, so may be better to locate the transect in the meadow on the west side of the trail, further up the hill. T2 was in a meadow with scattered juniper trees, and more flowers in bloom near the transect than T1. Saw lots of honey bees on flowers, but none in bowls. Again, many bowls shaded in the afternoon.

Langlee - Same general location for transect. Some kind of wood aster in bloom in woods around big oak. More bees than World's End transects (!) but catch still pretty low.

Thompson - T1 at edge of restored salt marsh. Lots of seaside goldenrod plants, but only 25% in bloom. T2 in a mowed path through meadow near high ropes course on south end of island. Lots of aster here.

Spectacle - T1 went up grassy hill on north side of south drumlin. Flowering plants mostly further from transect than we record, but we kept bowls on the mowed path. T2 along south side of north drumlin, have located transects here before. Breezy.

Great Brewster - T1 on eastern shore, along marsh edge and beach, where there is seaside goldenrod. Seaside goldenrod abundant, but about 80% past bloom. T2 same general location as in last survey, not much in flower. Winds from west were strong enough that Russ did not want to return in the afternoon for pick-up. So, bowls were left out overnight and picked up the next morning. Strong winds for the whole time they were out.

Peddocks - T1 in meadow before the “neck” where we usually locate T1. It had lots of seaside goldenrod, and more still in flower here than most other places we’ve been. T2 at the west end of the “neck” between two easternmost drumlins, beginning at the edge of the (dry) marsh near cottages. Seaside goldenrod here about 75% gone by. Strong winds from the west all day.

Grape - T1 in meadow at east end of island where there was lots of seaside goldenrod (but ~90% gone by). T2 in the marsh, where most of the seaside goldenrod also gone by. T1 got many more bees, including quite a few bumblebees (usually don’t catch many large bees in traps).

Bumpkin - T1 at east end of island, not much in flower. T2 down central trail and there was more in bloom here. Day became mostly cloudy in afternoon and windier.

Appendix F. Example of an insect sorting data sheet for bee bowl transect samples

sample	date	Initials/ date when sorted	Wasps	Bark lice	Ants	Flies	Lepidoptera	Orthoptera	Beetles	Hemiptera etc.	Spiders	Springtails	Other vials (e.g., 1 x isopod)	Total # vials
BM-BB-1	IV.10													
BM-BB-2	IV.10													
GB-BB-1	IV.10													
GB-BB-2	IV.10													
GP-BB-1	IV.10													
GP-BB-2	IV.10													
LN-BB-1	IV.10													
PE-BB-1	IV.10													
PE-BB-2	IV.10													
SP-BB-1	IV.10													
SP-BB-2	IV.10													
TH-BB-1	IV.10													
TH-BB-2	IV.10													
WB-BB-1	IV.10													
WE-BB-1	IV.10													
WE-BB-2	IV.10													

Appendix G. Bees collected from 16 bee bowl transects on nine islands and peninsulas in Boston Harbor Islands NRA, Apr 30-Oct 18, 2010.

Season	April/May															
Island	BM		GB		GP		LN	PE		SP		TH		WB	WE	
Transect #	1	2	1	2	1	2	1	1	2	1	2	1	2	1	1	2
Family APIDAE																
<i>Apis mellifera</i> ¹	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
<i>Bombus impatiens</i>	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
<i>Bombus vagans</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ceratina calcarata</i>	107	45	224	128	0	45	13	37	3	19	15	2	16	3	4	10
<i>Ceratina dupla</i>	52	18	11	18	0	45	1	7	1	5	7	1	3	0	5	0
<i>Epeolus autumnalis</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Epeolus pusillus</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Epeolus scutellaris</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Melissodes desponsa</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Melissodes druriella</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nomada articulata</i> ²	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0
<i>Nomada bethunei</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nomada cressonii</i> ^{2,3}	0	0	0	4	1	3	0	0	0	0	0	0	0	0	0	0
<i>Nomada denticulata</i> ²	2	0	0	0	0	5	0	1	0	0	0	0	0	0	0	0
<i>Nomada imbricata</i> ²	0	0	0	0	0	0	0	0	2	0	1	1	1	0	3	0
<i>Nomada luteoloides</i> ²	0	0	1	0	0	2	0	1	0	0	0	0	0	0	8	0
<i>Nomada maculata</i> ²	0	1	0	2	0	1	4	0	0	0	0	0	2	0	9	1
<i>Nomada pygmaea</i> ²	1	1	0	0	0	2	0	0	0	0	0	0	0	0	5	0
<i>Triepeolus pectoralis</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Xylocopa virginica</i>	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0

¹. Introduced species

². New park record

³. Parasitic species

Season	April/May															
Island	BM		GB		GP		LN	PE		SP		TH		WB	WE	
Transect #	1	2	1	2	1	2	1	1	2	1	2	1	2	1	1	2
Family ANDRENIDAE																
<i>Andrena alleghaniensis</i> ²	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena asteris</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena bradleyi</i>	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
<i>Andrena carlini</i>	0	0	1	0	0	5	1	0	2	1	0	0	1	0	8	4
<i>Andrena carolina</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena commoda</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena cressonii</i>	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0
<i>Andrena dunningi</i>	0	0	0	0	3	2	0	0	0	0	0	0	0	0	0	0
<i>Andrena frigida</i>	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
<i>Andrena imitatrix</i>	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
<i>Andrena mandibularis</i>	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
<i>Andrena milwaukeensis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Andrena miserabilis</i>	2	0	0	0	0	1	0	0	1	0	0	0	3	2	0	0
<i>Andrena nasonii</i>	2	2	0	1	0	0	2	0	0	1	0	41	34	0	0	1
<i>Andrena nuda</i> ²	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
<i>Andrena perplexa</i>	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0
<i>Andrena vicina</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
<i>Andrena wheeleri</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena wilkella</i> ¹	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Calliopsis andreniformis</i>	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
Family COLLETIDAE																
<i>Colletes americanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Colletes inaequalis</i>	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
<i>Hylaeus affinis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hylaeus illinoisensis</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hylaeus mesillae</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hylaeus modestus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

¹Introduced species

²New park record

³Parasitic species

Season	April/May															
Island	BM		GB		GP		LN	PE		SP		TH		WB	WE	
Transect #	1	2	1	2	1	2	1	1	2	1	2	1	2	1	1	2
Family HALICTIDAE																
<i>Agapostemon sericeus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Agapostemon texanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Agapostemon virescens</i>	0	0	0	1	0	0	0	0	0	0	0	4	4	0	0	0
<i>Augochlora pura</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Augochlorella aurata</i>	13	1	38	23	0	8	2	0	4	0	1	32	0	7	2	3
<i>Augochloropsis metallica</i>	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Halictus confusus</i>	1	0	0	0	0	15	0	0	0	0	0	0	1	0	0	0
<i>Halictus ligatus</i>	3	0	1	1	0	0	0	0	0	0	0	5	6	0	0	0
<i>Halictus rubicundus</i>	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum admirandum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum albipenne</i> ²	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum asteris</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum bruneri</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum cinctipes</i> ²	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum coeruleum</i>	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum coriaceum</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
<i>Lasioglossum cressonii</i>	5	0	5	3	0	19	1	0	0	0	0	0	1	0	0	0
<i>Lasioglossum ephialtum</i>	0	0	17	8	1	11	1	8	4	3	1	8	0	0	0	1
<i>Lasioglossum hitchensi</i> ²	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum imitatum</i>	3	0	0	0	0	68	0	1	0	0	0	3	7	0	0	0
<i>Lasioglossum leucomomum</i>	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
<i>Lasioglossum leucozonium</i> ¹	0	0	0	0	0	1	0	0	0	0	0	1	3	0	0	0
<i>Lasioglossum lineatulum</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Lasioglossum macoupinense</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
<i>Lasioglossum oblongum</i>	0	0	0	0	0	3	1	0	0	0	0	0	1	0	0	0
<i>Lasioglossum oceanicum</i> ²	1	0	0	0	0	0	1	0	0	0	0	14	0	0	0	1

¹Introduced species

²New park record

³Parasitic species

Season	April/May															
Island	BM		GB		GP		LN	PE		SP		TH		WB	WE	
Transect #	1	2	1	2	1	2	1	1	2	1	2	1	2	1	1	2
<i>Lasioglossum pectorale</i>	0	0	0	0	0	0	0	0	0	0	0	3	2	0	0	0
<i>Lasioglossum perpunctatum</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum pilosum</i>	1	0	33	9	0	1	0	0	0	0	1	13	0	0	0	0
<i>Lasioglossum quebecense</i>	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum rozeni</i> ^{2,3}	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum tegulare</i>	0	0	0	1	0	2	0	3	1	1	2	0	13	1	1	0
<i>Lasioglossum versatum</i>	53	13	13	1	0	17	0	0	0	0	0	2	0	3	2	2
<i>Lasioglossum zephyrum</i>	0	0	2	6	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum zophops</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sphecodes atlantis</i> ³	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
<i>Sphecodes coronus</i> ³	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sphecodes cressonii</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sphecodes davisii</i> ³	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sphecodes galerus</i> ³	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sphecodes illinoensis</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sphecodes levis</i> ^{2,3}	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
<i>Sphecodes mandibularis</i> ³	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0
<i>Sphecodes pimpinellae</i> ³	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
<i>Sphecodes ranunculi</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family MEGACHILIDAE																
<i>Coelioxys rufitarsis</i> ³	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hoplitis pilosifrons</i>	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
<i>Hoplitis producta</i>	0	0	3	2	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hoplitis spoliata</i>	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
<i>Megachile brevis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Megachile latimanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Osmia atriventris</i>	2	0	1	0	0	3	0	3	0	1	1	0	0	1	2	2
<i>Osmia bucephala</i>	0	0	0	1	0	0	0	0	0	0	1	0	0	0	2	1

¹. Introduced species

². New park record

³. Parasitic species

Season	Late June															
Island	BM		GB		GP		LN	PE		SP		TH		WB	WE	
Transect #	1	2	1	2	1	2	1	1	2	1	2	1	2	1	1	2
<i>Osmia collinsiae</i> ²	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Osmia lignaria</i> ²	0	2	0	0	0	0	0	1	0	0	0	0	0	0	2	0
<i>Osmia pumila</i>	6	11	7	10	0	4	1	0	0	1	1	6	5	2	14	2
<i>Osmia simillima</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
<i>Stelis lateralis</i> ³	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Family APIDAE																
<i>Apis mellifera</i> ¹	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
<i>Bombus impatiens</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Bombus vagans</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ceratina calcarata</i>	0	0	7	1	0	0	0	2	0	0	0	0	1	0	0	0
<i>Ceratina dupla</i>	0	0	22	5	0	0	1	0	1	0	2	0	0	4	5	0
<i>Epeolus autumnalis</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Epeolus pusillus</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Epeolus scutellaris</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Melissodes desponsa</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Melissodes druriella</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nomada articulata</i> ²	0	0	1	0	3	0	0	0	1	0	1	17	8	0	1	0
<i>Nomada bethunei</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
<i>Nomada cressonii</i> ^{2,3}	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
<i>Nomada denticulata</i> ²	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
<i>Nomada imbricata</i> ²	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
<i>Nomada luteoloides</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nomada maculata</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nomada pygmaea</i> ²	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Tripeolus pectoralis</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Xylocopa virginica</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

¹ Introduced species

² New park record

³ Parasitic species

Season	April/May															
Island	BM		GB		GP		LN	PE		SP		TH		WB	WE	
Transect #	1	2	1	2	1	2	1	1	2	1	2	1	2	1	1	2
Family ANDRENIDAE																
<i>Andrena alleghaniensis</i> ²	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
<i>Andrena asteris</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena bradleyi</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena carlini</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena carolina</i> ²	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
<i>Andrena commoda</i>	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0
<i>Andrena cressonii</i>	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena dunningi</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena frigida</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena imitatrix</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena mandibularis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena milwaukeensis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena miserabilis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena nasonii</i>	0	3	0	0	0	1	0	6	0	0	0	23	5	0	6	4
<i>Andrena nuda</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena perplexa</i>	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Andrena vicina</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena wheeleri</i>	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena wilkella</i> ¹	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
<i>Calliopsis andreniformis</i>	0	0	0	0	0	0	0	0	3	0	1	0	1	0	0	0
Family COLLETIDAE																
<i>Colletes americanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Colletes inaequalis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hylaeus affinis</i>	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hylaeus illinoisensis</i> ²	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hylaeus mesillae</i>	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
<i>Hylaeus modestus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

¹Introduced species

²New park record

³Parasitic species

Season	April/May															
Island	BM		GB		GP		LN	PE		SP		TH		WB	WE	
Transect #	1	2	1	2	1	2	1	1	2	1	2	1	2	1	1	2
Family HALICTIDAE																
<i>Agapostemon sericeus</i>	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Agapostemon texanus</i>	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
<i>Agapostemon virescens</i>	0	1	5	2	0	0	0	0	0	0	0	7	2	0	0	1
<i>Augochlora pura</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Augochlorella aurata</i>	0	4	2	4	1	1	2	1	0	0	1	11	7	0	0	0
<i>Augochloropsis metallica</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Halictus confusus</i>	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
<i>Halictus ligatus</i>	0	0	0	0	0	1	0	0	0	0	0	1	1	0	8	0
<i>Halictus rubicundus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum admirandum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum albipenne</i> ²	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum asteris</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum bruneri</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum cinctipes</i> ²	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
<i>Lasioglossum coeruleum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum coriaceum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
<i>Lasioglossum cressonii</i>	0	2	8	2	0	0	0	0	0	0	0	0	1	0	1	1
<i>Lasioglossum ephialtum</i>	0	0	0	0	2	7	2	3	0	1	8	0	4	0	0	0
<i>Lasioglossum hitchensi</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum imitatum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum leucocomum</i>	0	0	0	0	0	1	0	0	1	2	0	13	0	0	1	0
<i>Lasioglossum leucozonium</i> ¹	0	1	0	0	0	3	0	0	1	1	2	0	1	0	0	0
<i>Lasioglossum lineatulum</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum macoupinense</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum oblongum</i>	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
<i>Lasioglossum oceanicum</i> ²	0	0	0	0	0	0	0	0	0	0	0	4	2	0	0	0
<i>Lasioglossum pectorale</i>	0	0	0	0	0	0	0	0	0	0	2	10	4	1	0	1

¹Introduced species

²New park record

³Parasitic species

Season	Late June															
Island	BM		GB		GP		LN	PE		SP		TH		WB	WE	
Transect #	1	2	1	2	1	2	1	1	2	1	2	1	2	1	1	2
<i>Lasioglossum perpunctatum</i> ²	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
<i>Lasioglossum pilosum</i>	0	0	30	8	0	2	0	0	0	0	1	2	2	0	0	0
<i>Lasioglossum quebecense</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum rozeni</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum tegulare</i>	2	3	0	0	0	1	0	2	5	0	3	16	0	4	2	0
<i>Lasioglossum versatum</i>	1	12	0	0	0	62	0	0	0	0	0	0	0	0	1	6
<i>Lasioglossum zephyrum</i>	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0
<i>Lasioglossum zophops</i> ²	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
<i>Sphecodes atlantis</i> ³	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
<i>Sphecodes coronus</i> ³	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
<i>Sphecodes cressonii</i> ^{2,3}	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
<i>Sphecodes davisii</i> ³	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
<i>Sphecodes galerus</i> ³	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sphecodes illinoensis</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sphecodes levis</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sphecodes mandibularis</i> ³	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
<i>Sphecodes pimpinellae</i> ³	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sphecodes ranunculi</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Family MEGACHILIDAE																
<i>Coelioxys rufitarsis</i> ³	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hoplitis pilosifrons</i>	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0
<i>Hoplitis producta</i>	1	5	1	4	2	2	0	3	6	0	0	3	3	0	0	0
<i>Hoplitis spoliata</i>	0	0	4	0	0	1	0	1	1	0	0	0	1	0	1	0
<i>Megachile brevis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Megachile latimanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Osmia atriventris</i>	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
<i>Osmia bucephala</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Osmia collinsiae</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

¹. Introduced species

². New park record

³. Parasitic species

Season	Late August															
Island	BM		GB		GP		LN	PE		SP		TH		WB	WE	
Transect #	1	2	1	2	1	2	1	1	2	1	2	1	2	1	1	2
<i>Osmia lignaria</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Osmia pumila</i>	0	0	0	0	0	0	1	2	0	0	0	0	2	0	0	0
<i>Osmia simillima</i>	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
<i>Stelis lateralis</i> ³	0	0	2	1	0	1	0	0	1	0	0	0	0	0	0	0
Family APIDAE																
<i>Apis mellifera</i> ¹	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	0
<i>Bombus impatiens</i>	0	0	1	0	0	0	0	0	0	1	0	0	0	3	0	0
<i>Bombus vagans</i>	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ceratina calcarata</i>	2	1	103	93	14	5	25	20	2	2	3	13	5	0	0	0
<i>Ceratina dupla</i>	0	2	0	0	8	2	0	2	0	0	2	0	0	0	0	0
<i>Epeolus autumnalis</i> ²	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0
<i>Epeolus pusillus</i> ^{2,3}	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
<i>Epeolus scutellaris</i> ^{2,3}	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Melissodes desponsa</i>	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Melissodes druriella</i>	0	0	106	75	0	0	0	0	1	0	0	1	0	0	0	0
<i>Nomada articulata</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nomada bethune</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nomada cressonii</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nomada denticulata</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nomada imbricata</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nomada luteoloides</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nomada maculata</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nomada pygmaea</i> ²	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Tripeolus pectoralis</i> ^{2,3}	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Xylocopa virginica</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family ANDRENIDAE																
<i>Andrena alleghaniensis</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena asteris</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

¹Introduced species

²New park record

³Parasitic species

Season	Late August															
Island	BM		GB		GP		LN	PE		SP		TH		WB	WE	
Transect #	1	2	1	2	1	2	1	1	2	1	2	1	2	1	1	2
<i>Andrena bradleyi</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena carlini</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena carolina</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena commoda</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena cressonii</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena dunningi</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena frigida</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena imitatrix</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena mandibularis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena milwaukeeensis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena miserabilis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena nasonii</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena nuda</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena perplexa</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena vicina</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena wheeleri</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena wilkella</i> ¹	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Calliopsis andreniformis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family COLLETIDAE																
<i>Colletes americanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Colletes inaequalis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hylaeus affinis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hylaeus illinoisensis</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hylaeus mesillae</i>	0	0	0	1	0	0	0	2	2	0	2	0	0	0	0	0
<i>Hylaeus modestus</i>	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family HALICTIDAE																
<i>Agapostemon sericeus</i>	0	0	0	3	0	0	0	0	0	1	0	4	0	0	0	0
<i>Agapostemon texanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

¹Introduced species

²New park record

³Parasitic species

Season	Late August															
Island	BM		GB		GP		LN	PE		SP		TH		WB	WE	
Transect #	1	2	1	2	1	2	1	1	2	1	2	1	2	1	1	2
<i>Agapostemon virescens</i>	1	2	36	46	0	1	0	0	6	18	19	23	51	18	4	7
<i>Augochlora pura</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
<i>Augochlorella aurata</i>	0	0	15	16	0	0	0	0	2	0	0	2	0	0	4	3
<i>Augochloropsis metallica</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Halictus confusus</i>	1	0	4	2	0	0	0	7	2	0	0	0	4	0	0	0
<i>Halictus ligatus</i>	1	0	6	1	0	0	0	1	1	1	0	0	17	0	4	1
<i>Halictus rubicundus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum admirandum</i>	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	0
<i>Lasioglossum albipenne</i> ²	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum asteris</i>	0	0	7	4	0	0	0	0	0	0	0	0	2	0	0	0
<i>Lasioglossum bruneri</i>	0	0	2	0	0	0	0	3	1	0	0	0	0	0	1	0
<i>Lasioglossum cinctipes</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum coeruleum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum coriaceum</i>	1	2	1	0	1	0	0	1	0	0	2	3	2	0	3	2
<i>Lasioglossum cressonii</i>	1	0	15	10	1	1	0	2	0	0	0	1	6	0	4	0
<i>Lasioglossum ephialtum</i>	0	0	46	20	0	1	0	8	0	11	3	7	0	0	1	0
<i>Lasioglossum hitchensi</i> ²	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0
<i>Lasioglossum imitatum</i>	0	0	0	1	0	0	0	0	3	0	0	0	52	1	0	0
<i>Lasioglossum leucocomum</i>	0	0	1	0	0	0	0	0	0	0	0	4	0	0	0	0
<i>Lasioglossum leucozonium</i> ¹	0	0	2	2	0	0	0	0	6	10	2	1	3	3	0	0
<i>Lasioglossum lineatulum</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum macoupinense</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum oblongum</i>	0	0	1	0	0	0	0	4	0	0	0	1	0	0	0	0
<i>Lasioglossum oceanicum</i> ²	1	0	0	1	0	1	0	1	3	0	0	4	2	0	2	0
<i>Lasioglossum pectorale</i>	0	0	0	1	0	0	0	0	0	0	0	2	3	0	0	0
<i>Lasioglossum perpunctatum</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum pilosum</i>	0	0	74	32	0	0	0	1	1	1	2	5	0	0	0	0
<i>Lasioglossum quebecense</i>	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0

¹Introduced species

²New park record

³Parasitic species

Season	Late August															
Island	BM		GB		GP		LN	PE		SP		TH		WB	WE	
Transect #	1	2	1	2	1	2	1	1	2	1	2	1	2	1	1	2
<i>Lasioglossum rozeni</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum tegulare</i>	7	3	2	0	0	0	0	12	14	4	0	0	3	1	1	2
<i>Lasioglossum versatum</i>	9	0	0	0	3	0	0	0	4	0	0	0	0	1	3	5
<i>Lasioglossum zephyrum</i>	0	0	15	20	0	0	0	0	0	0	0	9	1	0	0	0
<i>Lasioglossum zophops</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sphecodes atlantis</i> ³	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
<i>Sphecodes coronus</i> ³	0	0	1	15	0	0	0	0	0	0	0	0	0	0	0	2
<i>Sphecodes cressonii</i> ^{2,3}	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
<i>Sphecodes davisii</i> ³	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
<i>Sphecodes galerus</i> ³	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
<i>Sphecodes illinoensis</i> ^{2,3}	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sphecodes levis</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sphecodes mandibularis</i> ³	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sphecodes pimpinellae</i> ³	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sphecodes ranunculi</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family MEGACHILIDAE																
<i>Coelioxys rufitarsis</i> ³	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
<i>Hoplitis pilosifrons</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hoplitis producta</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hoplitis spoliata</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Megachile brevis</i>	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
<i>Megachile latimanus</i>	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
<i>Osmia atriventris</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Osmia bucephala</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Osmia collinsiae</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Osmia lignaria</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Osmia pumila</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Osmia similima</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

¹. Introduced species

². New park record

³. Parasitic species

Season	Mid-October															
Island	BM		GB		GP		LN	PE		SP		TH		WB	WE	
Transect #	1	2	1	2	1	2	1	1	2	1	2	1	2	1	1	2
Family APIDAE																
<i>Apis mellifera</i> ¹	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0
<i>Bombus impatiens</i>	0	1	0	1	10	0	1	1	0	0	0	0	0	0	0	0
<i>Bombus vagans</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ceratina calcarata</i>	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
<i>Ceratina dupla</i>	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Epeolus autumnalis</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Epeolus pusillus</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Epeolus scutellaris</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Melissodes desponsa</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Melissodes druriella</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nomada articulata</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nomada bethunei</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nomada cressonii</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nomada denticulata</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nomada imbricata</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nomada luteoloides</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nomada maculata</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Nomada pygmaea</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Tripeolus pectoralis</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Xylocopa virginica</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Family ANDRENIDAE																
<i>Andrena alleghaniensis</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena asteris</i>	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
<i>Andrena bradleyi</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena carlini</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena carolina</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena commoda</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

¹Introduced species

²New park record

³Parasitic species

Season	Mid-October															
Island	BM		GB		GP		LN	PE		SP		TH		WB	WE	
Transect #	1	2	1	2	1	2	1	1	2	1	2	1	2	1	1	2
<i>Andrena cressonii</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena dunningi</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena frigida</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena imitatrix</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Stelis lateralis</i> ³	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena mandibularis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena milwaukeensis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena miserabilis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena nasonii</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena nuda</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena perplexa</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena vicina</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena wheeleri</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Andrena wilkella</i> ¹	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Calliopsis andreniformis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family COLLETIDAE																
<i>Colletes americanus</i>	0	0	0	0	0	0	0	0	3	0	0	0	1	0	0	0
<i>Colletes inaequalis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hylaeus affinis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hylaeus illinoisensis</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hylaeus mesillae</i>	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
<i>Hylaeus modestus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family HALICTIDAE																
<i>Agapostemon sericeus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Agapostemon texanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Agapostemon virescens</i>	0	0	0	1	1	0	0	3	0	0	0	0	2	0	0	0
<i>Augochlora pura</i>	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
<i>Augochlorella aurata</i>	0	0	0	1	0	0	12	2	0	1	0	1	7	0	2	2

¹Introduced species

²New park record

³Parasitic species

Season	Mid-October															
Island	BM		GB		GP		LN	PE		SP		TH		WB	WE	
Transect #	1	2	1	2	1	2	1	1	2	1	2	1	2	1	1	2
<i>Augochloropsis metallica</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Halictus confusus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Halictus ligatus</i>	0	1	0	0	2	0	0	0	0	4	1	3	9	0	1	2
<i>Halictus rubicundus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum admirandum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum albipenne</i> ²	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum asteris</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum bruneri</i>	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0
<i>Lasioglossum cinctipes</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum coeruleum</i>	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
<i>Lasioglossum coriaceum</i>	0	0	1	1	0	0	3	0	0	0	0	0	0	0	0	0
<i>Lasioglossum cressonii</i>	0	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0
<i>Lasioglossum ephialtum</i>	0	2	0	1	3	1	1	0	0	1	1	8	1	0	0	0
<i>Lasioglossum hitchensi</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum imitatum</i>	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
<i>Lasioglossum leucomomum</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
<i>Lasioglossum leucozonium</i> ¹	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum lineatulum</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum macoupinense</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum oblongum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum oceanicum</i> ²	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
<i>Lasioglossum pectorale</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum perpunctatum</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum pilosum</i>	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
<i>Lasioglossum quebecense</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum rozeni</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum tegulare</i>	3	2	0	0	0	0	2	2	0	0	0	0	0	0	0	3
<i>Lasioglossum versatum</i>	0	0	0	0	5	0	0	3	0	0	1	0	0	0	0	0

¹.Introduced species

².New park record

³.Parasitic species

Season	Mid-October															
Island	BM		GB		GP		LN	PE		SP		TH		WB	WE	
Transect #	1	2	1	2	1	2	1	1	2	1	2	1	2	1	1	2
<i>Lasioglossum zephyrum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Lasioglossum zophops</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sphecodes atlantis</i> ³	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sphecodes coronus</i> ³	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sphecodes cressonii</i> ^{2,3}	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
<i>Sphecodes davisii</i> ³	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0
<i>Sphecodes galerus</i> ³	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sphecodes illinoensis</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sphecodes levis</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sphecodes mandibularis</i> ³	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sphecodes pimpinellae</i> ³	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sphecodes ranunculi</i> ^{2,3}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Family MEGACHILIDAE																
<i>Coelioxys rufitarsis</i> ³	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hoplitis pilosifrons</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hoplitis producta</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hoplitis spoliata</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Megachile brevis</i>	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
<i>Megachile latimanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Osmia atriventris</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Osmia bucephala</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Osmia collinsiae</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Osmia lignaria</i> ²	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Osmia pumila</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Osmia simillima</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Stelis lateralis</i> ³	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

¹ Introduced species

² New park record

³ Parasitic species

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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National Park Service
U.S. Department of the Interior



Natural Resource Stewardship and Science

1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

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