Introduction to a Special Issue—Boston Harbor Islands National Recreation Area: Overview of Recent Research

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A Brief History of Surveying Biodiversity at the Boston Harbor Islands

The only drumlin archipelago in the United States, the Boston Harbor Islands National Recreation Area (BHI) is comprised of 34 islands and peninsulas distributed across a gradient from protected embayments in the inner harbor to the exposed outer harbor periphery. The islands are the ancestral homeland of the Massachusett people since the glacial retreat, and have been subject to intensive alterations since the arrival of Europeans in the 17th century. All of the larger forested islands were initially cleared by colonists for fuel and building material, and used for agriculture. Later they were developed for a wide variety of institutional uses including waste treatment (e.g., Deer Island), quarantine facilities and hospitals (Bumpkin, Deer, Gallops, Long, and Rainsford islands), coastal defense fortifications (Gallops, Georges, Long, Lovells, Outer Brewster, and Peddocks islands), lighthouses and navigation aids (Little Brewster, Long, and Lovells islands), and educational institutions (Rainsford and Thompson islands). These human-caused disturbances and associated human transport of species through the busy Boston Harbor have resulted in the vegetation being comprised of >50% non-native species (Elliman 2005), posing a primary threat to native plant biodiversity (e.g., Pauchard and Shea 2006, Vilà et al. 2011). The islands support multiple upland and coastal habitats characterized by diverse natural communities that can tolerate coastal stressors, and provide important breeding habitats, in particular for colonial nesting waterbirds. As highlighted by Creasey (2021) and others, understanding the diversity and stressors that may act on these habitats is crucial for park managers to be able to conserve the authentic natural and cultural resources. For this reason, an inventory and monitoring program was established by the National Park Service in 1996 to document diversity and changes to habitats and ecosystems (Fancy et al. 2009). At the BHI, the first inventories took place in 2001, focusing on breeding birds (Paton et al. 2005); bryophytes and lichens (LaGreca et al. 2005); Lepidoptera (moths and butterflies); Odonata (dragonflies and damselflies), and Cicindelinae (tiger beetles) (Mello 2005); and vascular plants (Elliman 2005). These initial surveys were followed by a terrestrial invertebrate All-Taxa Biodiversity Inventory (ATBI) from 2005 to 2010 (Rykken and Farrell 2013).

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Biological inventory and research at the BHI has steadily continued as part of an ongoing opportunistic ATBI, complemented by multiple focused projects. For example, Nolfo-Clements and Clements (2015) captured the native *Peromyscus leucopus* (Rafinesque) (White-footed Mouse) and *Microtus pennsylvanicus* (Ord) (Meadow Vole) by short-interval trapping. Variation in animal densities among years was attributed to food availability and the presence of predators. Clark et al. (2011) collected 18,000 ants (Hymenoptera, Formicidae) across 10 islands of the BHI and revealed 4 new species records for Massachusetts including 1 species that had not yet been reported in the US: *Myrmica scabrinodis* Nylander. Davidson et al. (2011) conducted a carabid beetle (Coleoptera, Carabidae) inventory on 13 islands and found >6000 specimens representing 128 species. Of these, 7 were new state records for Massachusetts, again including 1 species, *Laemostenus terricola terricola* (Herbst), that was new for the country.

Some of the results from surveying studies at the BHI were utilized in testing widely known ecological hypotheses. By continued trapping of the White-footed Mouse, Nolfo-Clements et al. (2017) revealed that adult mice on Bumpkin and Peddocks islands were significantly larger in body size compared to mainland mice—in line with the island rule (Lokatis and Jeschke 2018, Van Valen 1973), which states that smaller species exhibit gigantism on islands (and vice versa; larger species are dwarfed on islands). In addition, both the ant (Clark et al. 2011) and vascular plant (Elliman 2005, Long et al. 2009) surveys found that species richness increased with island area and decreased with island isolation, consistent with the theory of island biogeography (MacArthur and Wilson 1967). However, the effect of isolation was significantly stronger for native plants, and as a result exotic species represented a higher proportion of the plant community on islands farther away from the mainland (Long et al. 2009). The carabid study (Davidson et al. 2011) also found a clear relationship between species richness and island area, although Calf Island and Grape Island were outliers with many more species than expected for their relatively small size.

Recent Biological Research at the Boston Harbor Islands

This special issue complements Northeastern Naturalist Special Issue 3 (2005) and begins with 2 contributions about the terrestrial invertebrate All-Taxa Biodiversity Inventory. Rykken and Farrell (2018a) report on the abundance and distribution of native and non-native beetles (Coleoptera) across 15 islands and peninsulas. The authors discuss introduction pathways for the 105 non-native species documented at the BHI and why the islands may be attractive to them. The second article presents the full results of the invertebrate ATBI, which resulted in the collection of ~160,000 specimens of which >76,000 have been identified and databased thus far, representing 1732 species and morphospecies (Rykken and Farrell 2018b). Eleven species of beetles (Coleoptera), bugs (Hemiptera), and ants (Hymenoptera, Formicidae) were new records or first published records for the state of Massachusetts, 3 were new country records, and 5 were newly documented for North America.

Since December 2012, Haelewaters and collaborators have conducted a fungal inventory at the BHI. Haelewaters et al. (2018) present a preliminary checklist of fungi that includes 172 species in 123 genera, 62 families, 24 orders, 11 classes, and 2 phyla. Since the publication of the checklist, 3 species found at the BHI have been formally described: *Orbilia renispora* (Shao et al. 2018), *Trochila bostonensis* (Gómez-Zapata et al. 2021), and *Xylaria finismundoensis* (Vandegrift 2021). Next, Nolfo-Clements (2018) presents the results of mammal monitoring through camera trapping, visitor sightings, and animal-sign surveys and discusses differences in presence and moving behaviors between smaller and larger mammal species. Johnson and Gates (2019) present the first BHI data on the only lineage of mammals that has evolved the capability of true flight: the bats. Six bat species are reported, including 2 species impacted by white-nose syndrome—*Myotis lucifugus* (Le Conte) (Little Brown Bat) and *M. septentrionalis* (Trouessart) (Northern Long-eared Bat), which is listed as threatened under the Endangered Species Act, along with evidence of bat roosting and foraging on the islands. Through long-term acoustic monitoring, the authors also found that season has a significant effect on activities of bats.

The next 2 manuscripts in the issue are fungus-themed articles, each focusing on a poorly studied order of fungi. Screening the BHI collection of Carabidae housed at the Harvard Museum of Comparative Zoology (Rykken and Farrell 2018b), Haelewaters et al. (2019) reveal 13 records of ectosymbiotic Laboulbeniales fungi, including 2 new country records: *Laboulbenia clivinalis* Thaxt. and *L. egens* Thaxt. The BHI reports of *L. flagellata* Peyr. from 11 hosts in 5 genera triggered morphometric and molecular phylogenetic analyses, and the authors present data to validate the hypothesis that *L. flagellata* is a complex of multiple species. In his contribution, Vandegrift (2021) focuses on Xylariales fungi and provides data for 26 species and varieties in 16 genera across 5 families. One of them, *Xylaria finismundoensis*, is formally described based on material from World's End peninsula and provides the first evidence of a saprotrophic lifestyle within a clade previously only known as endophytes.

Matassa and Hitchcock (2021) present the result of a 1-day intertidal bioblitz at multiple islands. Two low-tide sampling events, one by experts-only and the other by both experts and public participants, resulted in the identification of 132 vertebrate, invertebrate, and macroalgal species. The authors compare and discuss results from the expert-only vs. public bioblitzes for species richness and patterns of biodiversity within and among islands. Finally, Trocki et al. (2021) present data resulting from the first 12 years of monitoring of coastal breeding birds in the BHI, including assessment of trends in annual counts and comparison of boat-based counts and ground-based nest surveys. This long-term study will continue in order to improve our understanding of how breeding bird populations respond to environmental changes in Boston Harbor as well as to provide recommendations about management strategies.

In all, this special issue presents the work of 24 researchers from 22 institutions across 7 countries. The data collected during the multiple research projects presented

here will be used to map species distributions across habitats and islands/peninsulas and to help park management prioritize actions towards the conservation and restoration of BHI habitats and ecosystems. In addition to professional scientists dedicated to their research, the public has been increasingly involved in ecological and environmental studies (Bonney et al. 2014, Silvertown 2009). This is also the case at the BHI. Park managers, in collaboration with scientists, organize bioblitzes and photoblitzes, and citizen scientists are actively encouraged to submit observations to iNaturalist (http://www.inaturalist.org) during these and other events such as the annual City Nature Challenge. In a quickly changing world, conservation and management strategies require such rapid ways to deliver high-quality data; it is clear that these "citizen science" initiatives quickly generate an important pool of data for the documentation of biodiversity, study of ecological patterns, and conservation of species and sites. (e.g., Lowman et al. 2019, Parker et al. 2018).

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