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Biodiversity Survey of Artificial Reefs in Lake Allure, Quarryville, Pennsylvania

Elefteria Papavasilis

Abstract

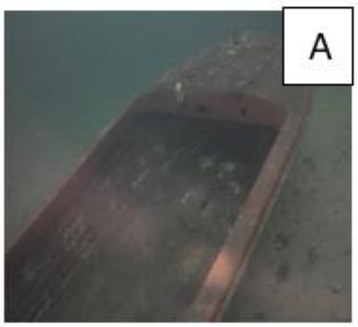
Lake Allure in Quarryville, Pennsylvania provided a unique opportunity to contribute to our understanding of the development of artificial reefs in inland freshwater lakes. An investigation was conducted from October 2021 to November 2022 to analyze the microinvertebrates and periphyton (the material growing on submerged surfaces in freshwaters) growing on the artificial reefs. This study sought to answer the question of whether the community composition on the reef sites was significantly different and whether depth and month were significant factors in the development of these artificial reefs. Statistical analyses revealed that the Shallow and Artificial Reefs are not significantly different. However, the presence of heterotrophs on the Shallow Artificial Reef Site indicates that the warmer and shallower water is a catalyst for a faster rate of ecological succession than that of the Deep Artificial Reef.

Introduction

Human-made artificial structures, such as metal vessels and concrete modules, are frequently deployed as artificial reefs on the seafloor to create reef habitats (Becker et al. 2018). Artificial reefs are important to natural resource management because they provide habitat and recreational opportunities. However, caution must be exercised when planning the implementation of reefs because artificial reefs are not one-size-fits-all for habitat enhancement and should be considered strategically based on location; specific scientific assessments and resource needs to maximize benefits of the habitat (Paxton et. al. 2020). Reefs should be installed only after physical and biological surveys of the water by trained personnel (Prince et al. 1977).

While the goal of artificial reefs is to provide a habitat for natural resources, ecological succession must be taken into consideration as the presence of targeted species, such as commercially sought-after fish, will not inhabit the reef until suitable and sustainable food is present. Hard reef substrate enhances the surface area on which fouling organisms (organisms that attach to floating objects) can settle and anchor to better withstand currents and the destructive force of storms. Over time, the resulting increase in biomass enriches the surrounding water column, and sediments promote the growth of infauna and colonization by filter-feeding invertebrates and provides food sources for reef-associated invertebrates (Harrison & Rousseau, 2020). In lentic environments, algae are most often the dominant primary producers and are responsible for carbon fixation and sequestration of essential nutrients, such as nitrogen and phosphorus, which then become available to consumers (Vadeboncoeur et al. 2002). As such, algae are critical ecosystem components of both nutrient cycles and food webs in lakes.

Methods



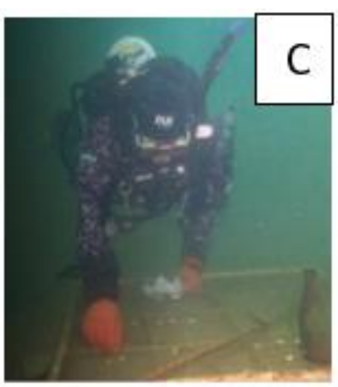


Figure 1. In May 2021, two boats were sunk in Lake Allure and 24 settling plates were placed within one-meter square grids in August 2021. From November 2021 to October 2022, 4 monthly dives were conducted where the artificial reefs were photographed, videotaped, and four settling plates were removed from each reef to identify and count the organisms growing on the reefs. In total, 88 settling plates were collected. **A)** The shallow boat in 11.6 meters of water. **B)** The deep boat 21.3 meters of water. **C)** Author collecting settling plates from the shallow boat and placing them into 30ml plastic scintillation vials. **D)** A subset of three wet mount slides were made from each settling plate for a total of 264 slides analyzed at 200x magnification for this study. Organisms were identified to phyla using taxonomic keys. Each subset of 3 slides per tile were added together for analysis in R Software.

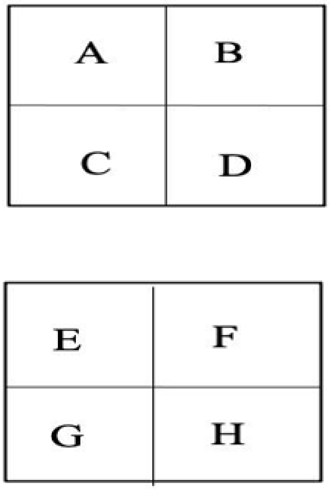
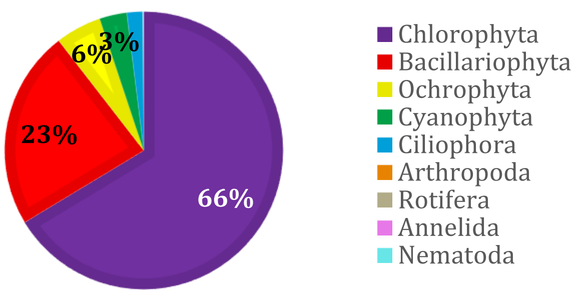


Figure 2. One meter PVC grids were divided into 4 quadrats. The Shallow Boat consisted of quadrats A, B, C, and D whereas the Deep Boat consists of quadrats E, F, G, and H. Within each quadrant, 12 settling plates were positioned for a total of 48 sample plates in each grid.

Results



Shallow Reef

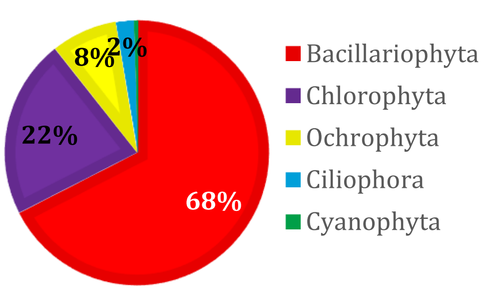
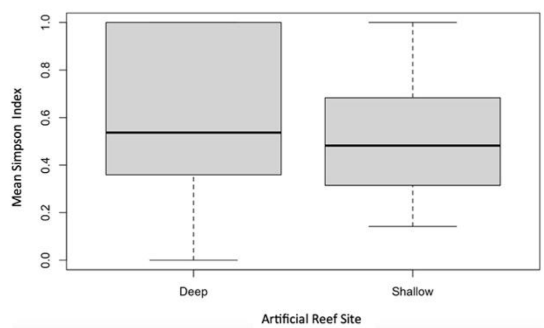


Figure 3. Pie charts of the phyla of the Shallow and Deep Artificial Reef Sites of Lake Allure. Only phyla with five or more individuals were represented in this study. The phyla are listed from most to least common for each artificial reef site. Heterotrophs such as Arthropoda, Rotifera, Annelida, and Nematoda comprise less than 1% of the Shallow Artificial Reef and are nonexistent on the Deep Artificial Reef. Autotrophs such as Chlorophyta, Bacillariophyta, Ochrophyta, and Cyanophyta dominate the community composition of both artificial reefs with Chlorophyta dominating the Shallow Artificial Reef at 66% and Bacillariophyta dominating the Deep Artificial Reef at 68%.



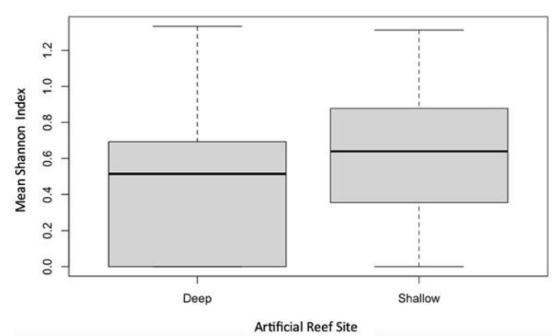


Figure 4. Simpson Index of the Deep and Shallow Artificial Reef Sites analyzed with ANOVA. The two depths do not differ with

respect to the Simpson Index ($F_{1, 66} = 1.9879$, $p = 0.1633$).

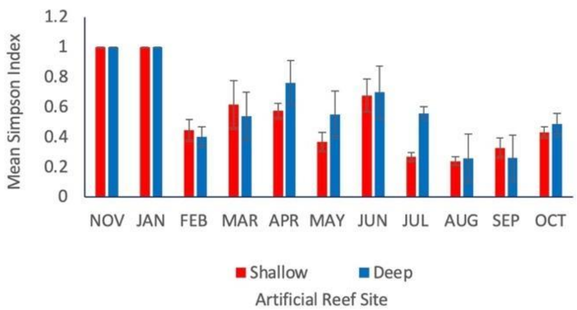


Figure 6. Mean Simpson Index of the Shallow and Deep Artificial Reef Sites across the months. The interaction between month and reef site is not significant ($F_{10, 66}= 0.8944$, $p = 0.1633$), but there is a significant main effect of month on the Simpson Index ($F_{10, 66} = 14.4853$, $p <0.0001$).

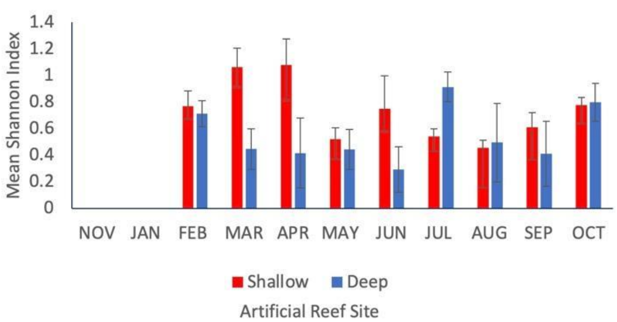


Figure 7. Mean Shannon Index of the Shallow and Deep Artificial Reef Sites. The interaction between month and reef site is significant ($F_{10, 66}= 2.2690$, $p = 0.02376$), and there is a significant main effect of month on the Shannon Index ($F_{10, 66} = 7.5909$, $p <0.0001$).

Discussion

Communities on the Shallow and Deep Artificial Reefs differed because of variations in trophic levels represented at the phyla level. Heterotrophs including Ciliophora, Arthropoda, Rotifera, Annelida, and Nematoda were present on the Shallow Artificial Reef whereas they were absent on the Deep Artificial Reef (Figure 3). Primary producers dominated both reefs with Chlorophyta dominating the Shallow Artificial Reef at 66% and Bacillariophyta dominating the Deep Artificial Reef at 68%.

Although the shallow and deep reefs did not differ with respect to the Simpson Index (Figure 4), the shallow reef did have a greater Shannon Diversity Index compared to the deep reef (Figure 5), which suggests that rare species may be more different between the reefs than common species are. Both reefs varied in their diversity indexes across the months (Figures 6 and 7). This is not surprising because species' thermal distributions are rarely symmetrical, which suggests that we should expect the probability of the presence of different species to change at different rates, even over relatively narrow temperature ranges (Flanagan et al. 2019). The Shallow Artificial Reef had a temperature fluctuation of 13.9℃ and the Deep Artificial Reef had a temperature $fluctuation\ of$ 8.9℃. Presence of heterotrophs on the Shallow Artificial Reef and their absence on the Deep Artificial Reef could indicate that ecological succession is taking place at a faster rate in these warmer and shallower waters. This study can be used for future planning, implementation, and management of artificial reefs in freshwater inland lakes.

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