Memo:

To: Rob Williams, Brittney Rodgers (SLELO PRISM)

From: Andrew Tucker, Gust Annis, Lindsay Chadderton (The Nature Conservancy, Great Lakes Project), and Erick Elgin (Michigan State University extension)

Date: December 17, 2021

Subject:	**Port of Oswego 2021 aquatic plant survey results**

Background

This memo reports on the methods and results of an aquatic plant survey conducted in Oswego harbor and lower Oswego River on August 25, 2021. The survey was undertaken as part of the Invasive Aquatic Plant Surveillance in New York Great Lakes Ports project, through a funding opportunity (F20AP00244) from US Fish and Wildlife Service (FWS) to the Oswego County Soil and Water Conservation District, on behalf of the Finger Lakes - Lake Ontario Watershed Protection Alliance (FLLOWPA) for New York State Aquatic Nuisance Species Management Plan implementation. Oswego was one of three priority sites (with Irondequoit Bay and Buffalo Harbor) surveyed in 2021 as part this project and is among the highest risk sites in the Great Lakes basin for non-native aquatic plant introduction (Tucker et al. 2020).

Methods

Survey design generally followed recommendations from Trebitz et al. (2009) and Hoffman et al. (2016), including random selection of sample sites to facilitate evaluation of detection rates and optimization of sampling efficiency. The survey area encompassed roughly 324 acres. Sample units (100 m^{-2}) were overlaid on the survey area in ArcGIS. A stratified survey design was employed for sample unit selection with grid cells in the survey area attributed as shallow (<6m) or deep (>6m) based on cell centroids overlaid on depth layers created in ArcGIS 10.8.1. Sample units (i.e. grid cells based on cell centroids) were randomly selected using the Create Spatially Balanced Point tool in ArcGIS, with 3:1 ratio of shallow to deep sites (Figure 1).

The survey was conducted August 25, 2021. At each sample unit, plants were collected with rakes or observed visually and recorded. The rakes were double headed 14-tine rake heads attached to approximately 50 feet of 3/8” braided polypropylene rope. The survey targeted submerged, floating, and emergent taxa. All observations were from the shoreline lakeward to the maximum depth in any grid cell. The shoreline was defined as the land/water interface (i.e. the boundary between aquatic and riparian or wetland conditions). Plants were only recorded when observed in water. The location of a sample unit was occasionally adjusted away from the a priori random location selected in ArcGIS to sample adjacent areas where field observations indicated presence of macrophyte beds. In general, four evenly spaced and discrete stations were surveyed within each sample unit (e.g. the four corners of the grid cell). At each station a rake was tossed 5 – 10 meters from each side of the boat (i.e. four rake tosses), allowed to sink to the river/harbor bottom, and slowly retrieved. In instances where the fourth rake toss resulted in collection of a species not observed in the previous three tosses, subsequent rake tosses were made until no new species were collected.

Plants were identified to species in the field by a trained taxonomist (Erick Elgin, Michigan State University Extension). When specimens could not be identified in the field (e.g. when identification required scrutiny of morphological features under magnification) the plant was retained and identified to species (or lowest possible taxonomic group) on shore. Plant specimens were retained for vouchering and deposited with the herbarium at SUNY Oswego. The total number of species collected at each sample location was tallied for data analysis. Water depth at each sample location was recorded from the boat mounted sonar unit. GPS coordinates, plant species observed, and water depth at each sample station were recorded electronically in the field to an iPad (connected to a Bluetooth enabled GPS receiver) using Collector for ArcGIS.

Descriptive statistics (e.g. species richness measures by site and depth) were compiled. For analysis, species richness was calculated as the aggregate from the four stations comprising each sample unit. Species richness measures were mapped in ArcGIS 10.8.1.

A nonparametric estimator, iChao2, was used to estimate total species richness (S_{est}) based on sample-based plant incidence data. The iChao2 estimator uses the frequencies of species detected one, two, three, or four times to estimate the number of undetected species (Chiu et al. 2014). The S_{est} value was calculated using the R-based web application SpadeR (Chao et al. 2015).

To quantify the effort required for high-probability nonnative species detection, estimates of the number of samples required to obtain a near-total (95%) or total (100%) census of the plant species present were derived. S95% and S100% values were estimated in the R-based web application iNext (Chao et al. 2016) using the nonparametric method proposed by Chao et al. (2014), which calculates the number of samples required to detect some proportion of the asymptotic sample-based species richness estimator, S_{est}.

Results

Twenty-two species (or lowest identifiable taxonomic unit) were collected from across 16 sample units (Table 1; Figure 2). Two taxa could only be identified to genus level (Chara and Wolffia spp.). The four most common species are native to the basin, including *Ceratophyllum demersum, Elodea nutalli, Heteranthera dubia,* and *Vallisneria americana*. Six species are non-native to Lake Ontario. The most common non-native species were *Myriophyllum spicatum* (Eurasian watermilfoil), found at nearly 40% of sample sites, and *Trapa natans* (Water chestnut), which was detected in 19% of the sample units. Most non-native species were uncommon, with detection in no more than 1 of the 16 sample sites. All non-native species are known to occur elsewhere in the Great Lakes Basin, with the exception of Trapa natans which has only been found in Lake Ontario but was already known from Oswego.

Species richness varied across the site (Figure 3). An average of four species were detected per sample unit, and at one site 15 species were observed. For 50% of the sample sites no plants were detected (Figure 4). Species rich sites (>4 species) included Oswego marina, boat ramps at Wright's Landing Marina and W Bridge St, and shallow areas adjacent to the Oswego Yacht Club and Breitbeck Park. Plants were more frequently detected in shallow versus deep sites (Figure 5). The average depth of sites with no plant detections was 13 ft.

The estimated total species richness (S_{est}) for the survey area from sample-based incidence data, with 95% confidence interval, is 37 [30,53], which suggests that roughly 60% of the species present at the site were detected in the one-day survey (Figure 6). The species-effort relationship suggests that an additional 22 units of sampling effort are needed to detect 95% of the true species pool at the site (Table 2). The model predicts that an additional 79 samples are needed to detect 100% of the predicted species richness, which would be equivalent to sampling about 40% of the total area. Future sampling that targets shallow sites with the highest observed richness measures, including points of entry, could help to refine the rarefaction-based estimates of total species richness and would increase confidence that the full complement of rare aquatic species, including any novel non-natives, have been detected.

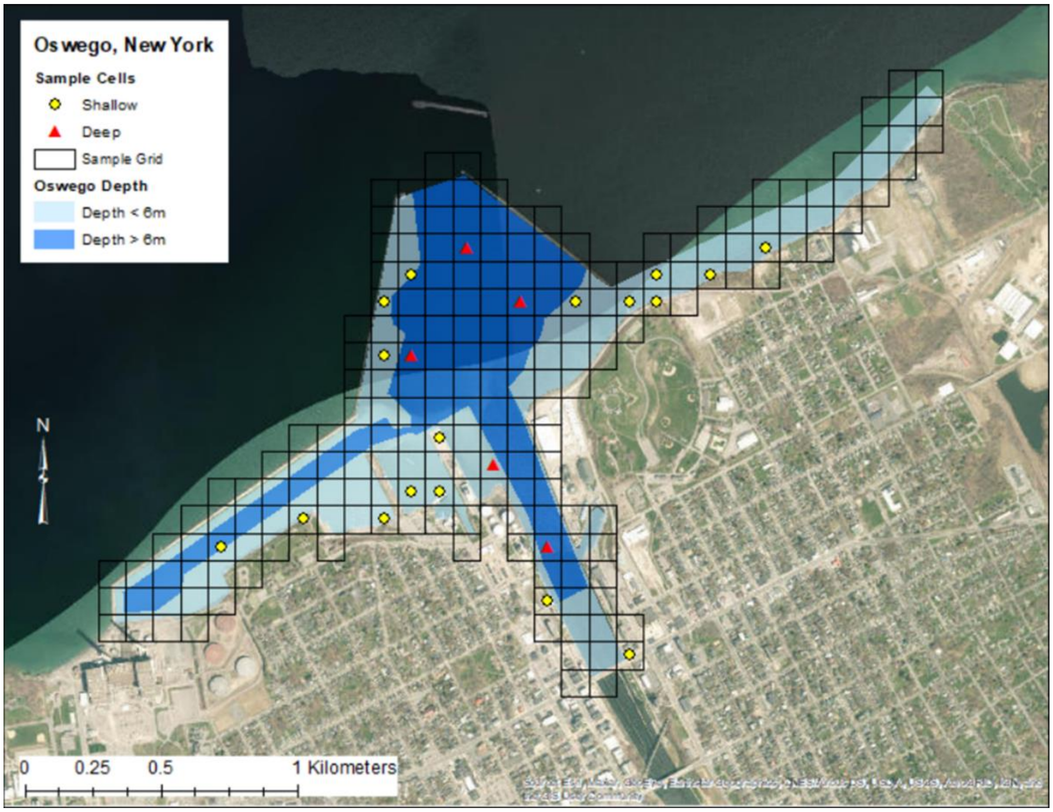

Figure 1. Survey area for Port of Oswego showing randomly selected sampling units (yellow = shallow; red = deep) overlaid on the 100m sample grid.

Figure 2. Survey area for Port of Oswego showing sample locations overlaid on the $100m^2$ grid.

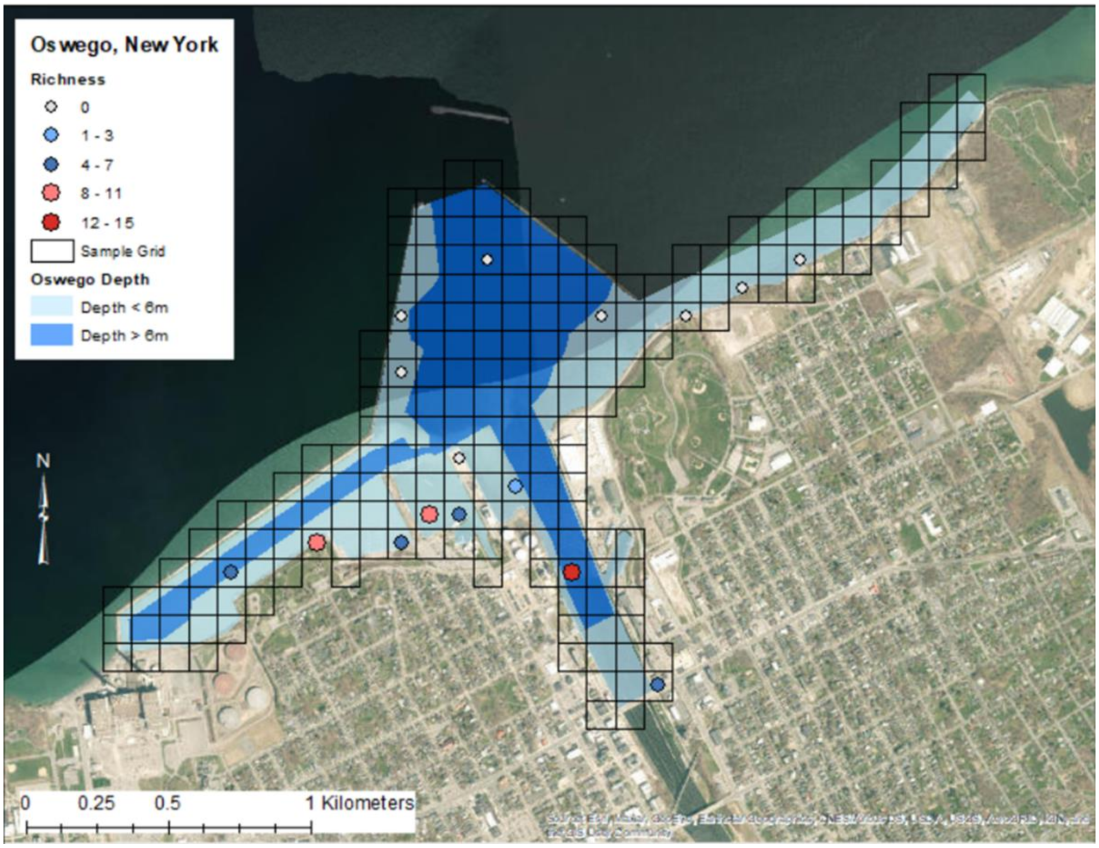

Figure 3. Species richness measures from August 2021 survey of Port of Oswego.

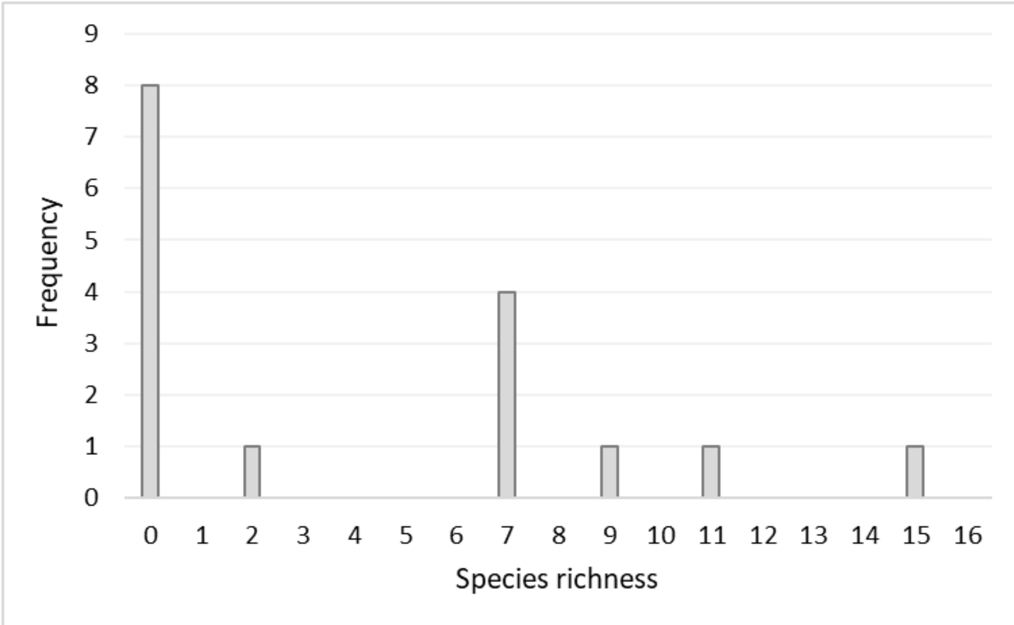

Figure 4. Frequency histogram showing species richness across sample units.

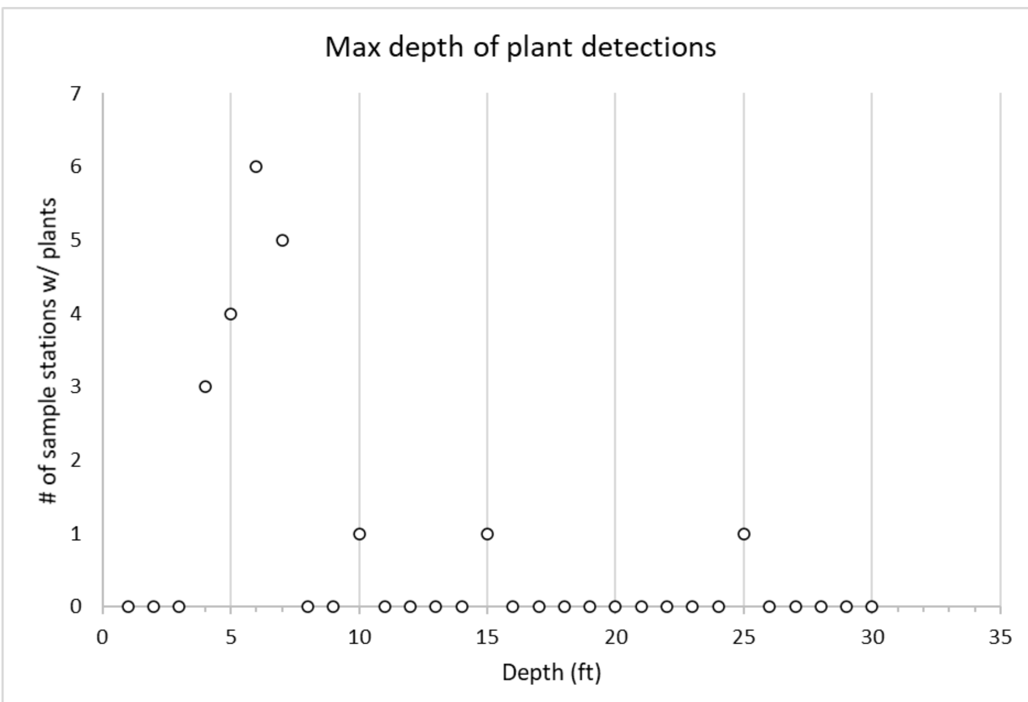

Figure 5. Scatter plot showing number of sample stations where plants were detected as a function of depth.

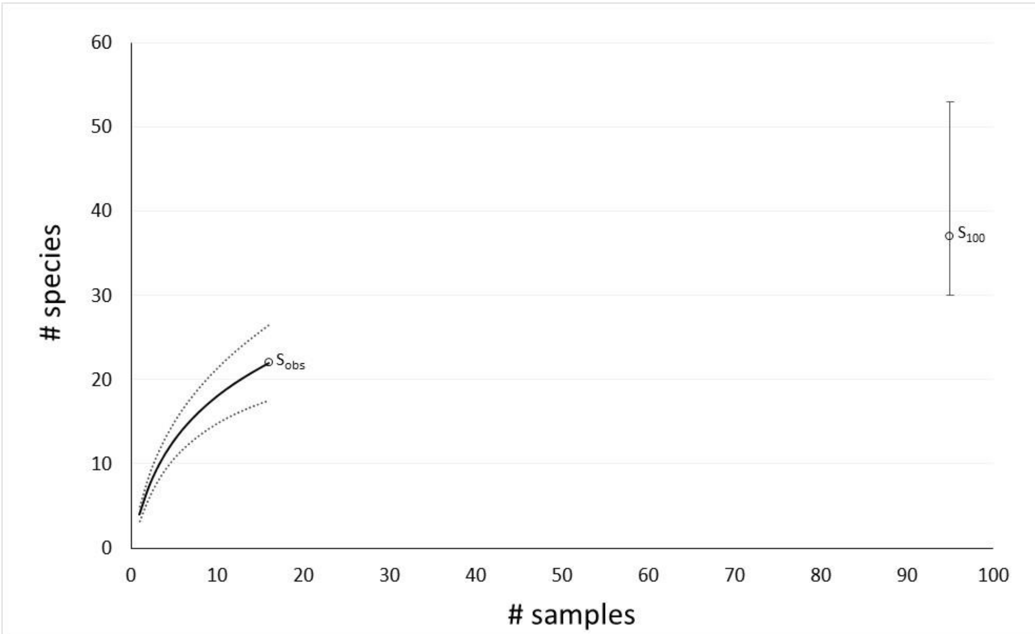

Figure 6. Species-effort curve (solid line) and its 95% confidence interval (CI; dashed lines), showing the average increase in species with each additional sample taken based on a random re-ordering of sites. The number of observed species is indicated (S_{obs}). The level of effort required to sample the estimated species total (S_{100}) is also included (error bars show 95% CI).

Table 1. Species list for Port of Oswego aquatic plant surveys, Aug 25, 2021. (*) indicates non-native species. Occupancy is calculated as the percentage of sample units where the species was observed.

Species	Occupancy
Ceratophyllum demersum	50
Elodea nutallii	44
Heteranthera dubia	44
Vallisneria americana	44
Myriophyllum spicatum *	38
Lemna turionifera	19
Potamogeton pusillus	19
Potamogeton richardsonii	19
Spirodela polyrhiza	19
Trapa natans *	19
Lemna minor	13
Lemna trisulca	13
Potamogeton perfoliatus	13
Chara spp.	6
Hydrocharis morsus-ranae *	6
Najas minor *	6
Nitellopsis obtusa *	6
Potamogeton crispus *	6
Potamogeton nodosus	6
Potamogeton zosteriformis	6
Stuckenia pectinata	6
Wolffia spp.	6

Table 2. Survey data and sampling completeness statistics for Oswego aquatic plant survey. Number of incidences is the tally of all plant detections across all sites sampled. Unique species are those species only detected in one sample unit. Duplicates were detected in exactly two sample units. S_{est} is the estimated true species richness at the site with 95% confidence interval shown. "A'ddl effort" is the additional number of sample units that would need to be sampled to detect 95% (S_{95}) or 100% (S_{100}) of the predicted total species pool.

Variable	Oswego
№ sites sampled	16
№ species detected	22
№ incidences	65
Uniques	9
Duplicates	3
S_{est} *(95% CI)*	37 (30, 53)
A'ddl effort S_{95}	22
A'ddl effort S_{100}	79

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