# Survey of the Distribution and Abundance of Nurdles and Microplastics in Long-Term Monitoring Zooplankton Samples from Lake Champlain

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## Introduction

**Microplastics**

- Microplastic is defined as a plastic particle <5 mm in diameter (Dris et al. 2015).
- Microplastics can be classified further based on type (e.g., fragment, film, fiber, foam, and pellet) and polymer type (Eriksen et al. 2013).
- Microplastics were documented within the freshwater Laurentian Great Lakes (Eriksen et al. 2013). These findings reported greater densities of microplastics in Lake Erie around urban centers with high population densities.

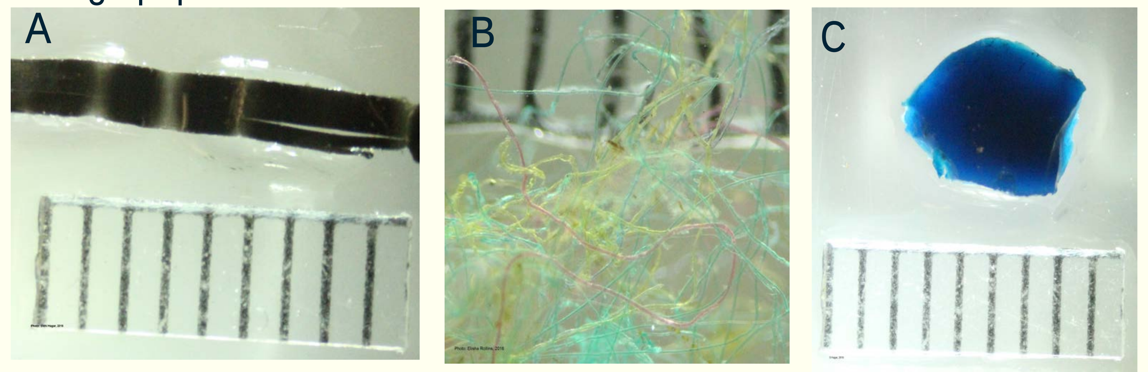


Fig. 1. Photographed (mm scale) under dissecting microscope: A) black film, B) Multicolor fiber cluster, C) blue plastic fragment.

**Nurdles**

- Nurdles are a type of pre-production plastic used in industrial settings. They serve as raw materials in the making of larger-scale plastic products. They can be up to 5 mm in size and are often cylindrical in shape (Ellison 2007).
- Nurdles can degrade over time (sunlight, mechanical) and be consumed by microorganisms such as zooplankton (Ellison 2007, Cole et al. 2013).

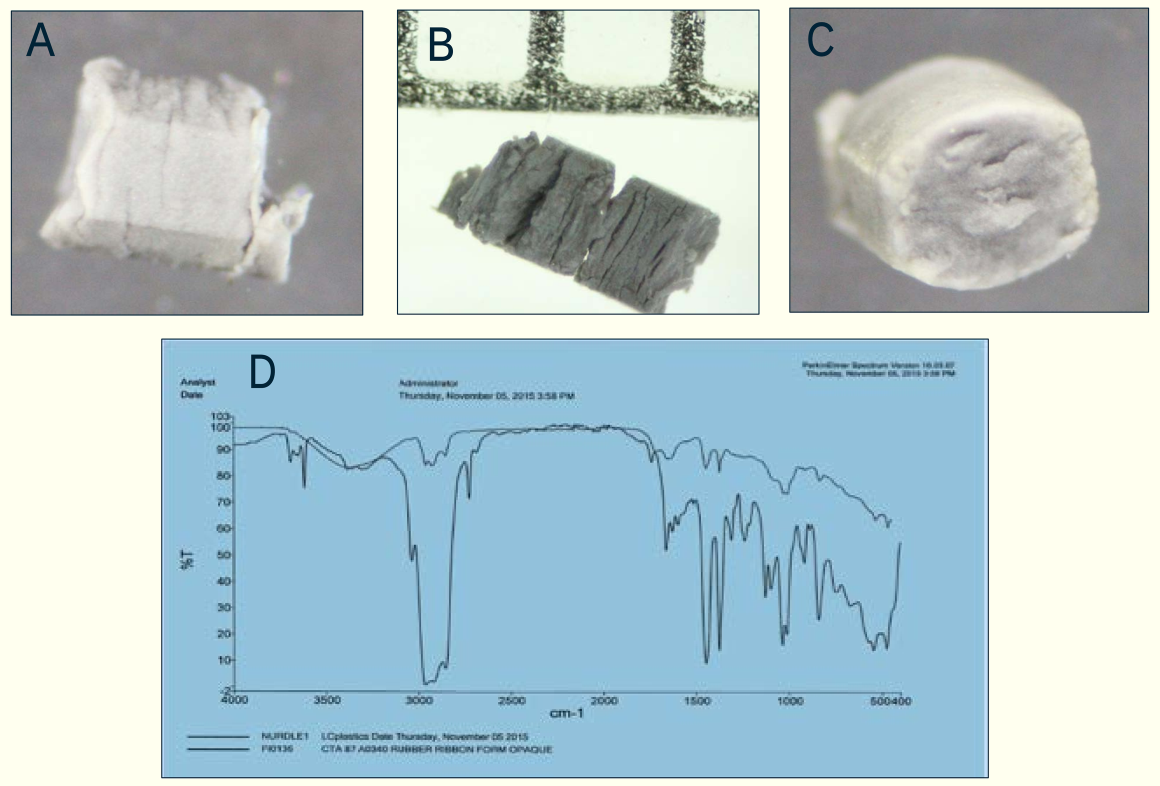


Fig. 2. A-C) Nurdle photographed (mm scale) under dissecting microscope D) Fourier Transform Infrared (FTIR) of nurdle representing polyisoprene rubber ribbon composition.

## Lake Champlain Long-Term Monitoring Sites

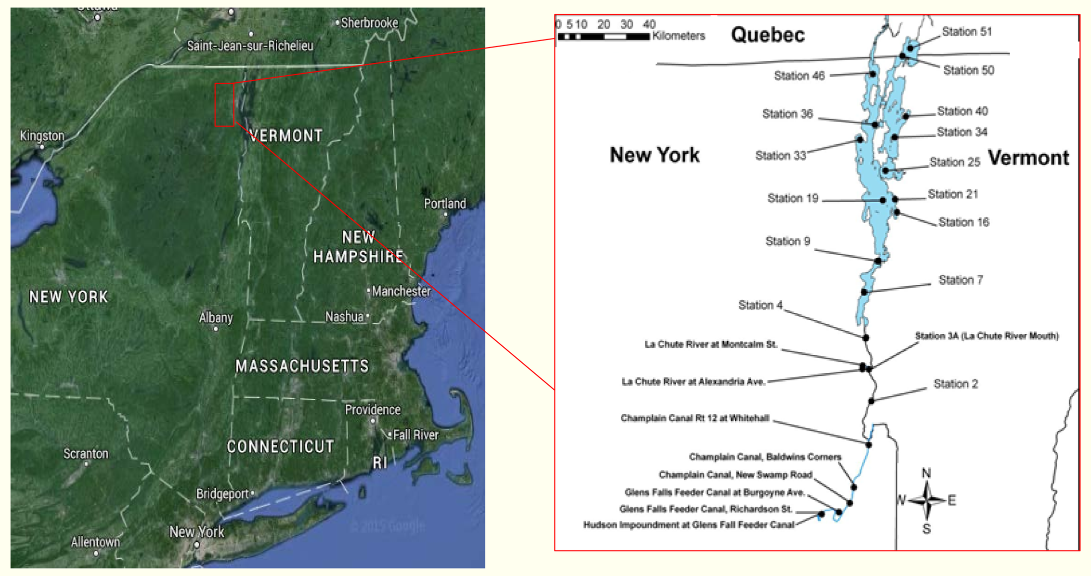


Fig. 3. Lake Champlain relative to New York and Vermont (Google Map). Location of LCRI long-term monitoring sampling stations.

## Goals and Hypotheses

- To quantify the abundance and map the spatial distribution of microplastics and nurdles in long-term monitoring samples.
- Density of microplastics and nurdles will be higher adjacent to industrial centers.
- The majority of microplastics will be of the fiber type.

## Field Methodology

**Zooplankton Long-Term Monitoring (LTM)**

- Zooplankton samples were collected 2X monthly by vertical plankton (30 cm-153 um, 50 cm-250 um nets) tows. Depth varied by site.
- Net rested approximately 30 seconds 1m above benthic sediments (at deep sites) before retrieval.
- Net retrieval rate was 1 m/s. Tow depth (m), tow type, station, date, and identification number, were noted on each sample.
- Nets were hose rinsed to wash organisms into the cod end until 125 ml sample bottle was ½ full. Cod end was removed; screen cleaned using a spray bottle.

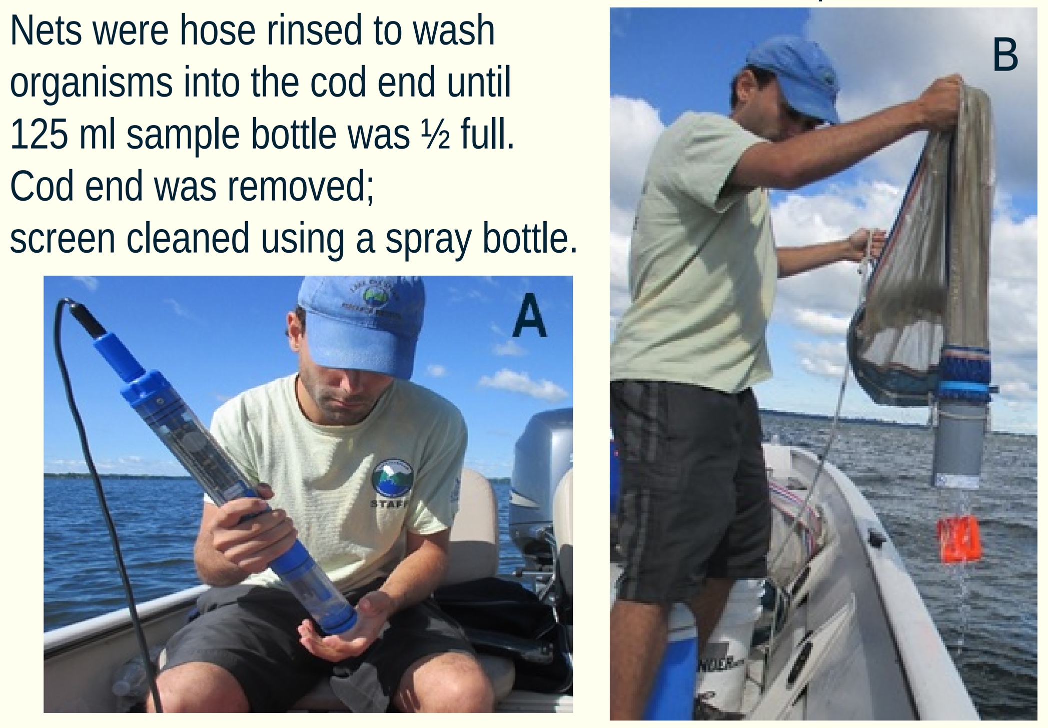


Fig. 4. A) M. LaMay using the Sonde water quality probe, B) Retrieving plankton tow at LTM site.

- Buffered 10% formalin-sucrose-rose bengal solution was added to sample in water to bring volume up to the bottle shoulder resulting in a 1% formalin solution (approximately 2.5% formaldehyde).

## Laboratory Methodology

**Nurdle sample processing:**

- Zooplankton samples were homogenized (n = 2265).
- The entire sample was placed in a beaker.
- Nurdles were quantified and stored in vials.
- Fourier Transform Infrared Spectroscopy (FTIR) was used to characterize nurdle polymer type.

**Microplastic sample processing:**

- Zooplankton samples were homogenized.
- 20 ml aliquot extracted from the 160 ml sample.
- Sample is placed in a grid-bottom Petri dish, microplastics quantified grid and values extrapolated.
- Conversion totals based on sample depth and net size (n = 1308 samples) – canal and epilimnion samples not included.

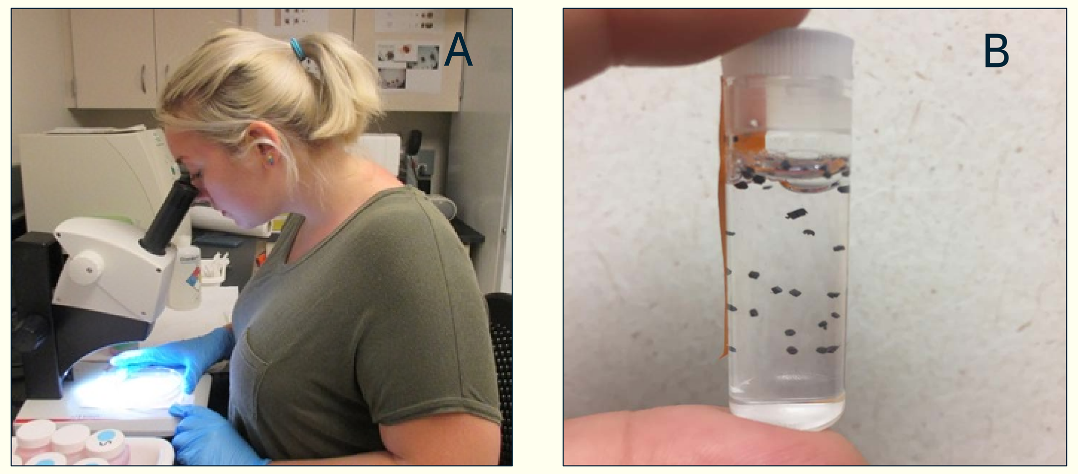


Fig. 5. A) L. Austin examining nurdle sample, B) nurdles in an LTM zooplankton sample.

## Abundance & Distribution of Nurdles & Microplastics

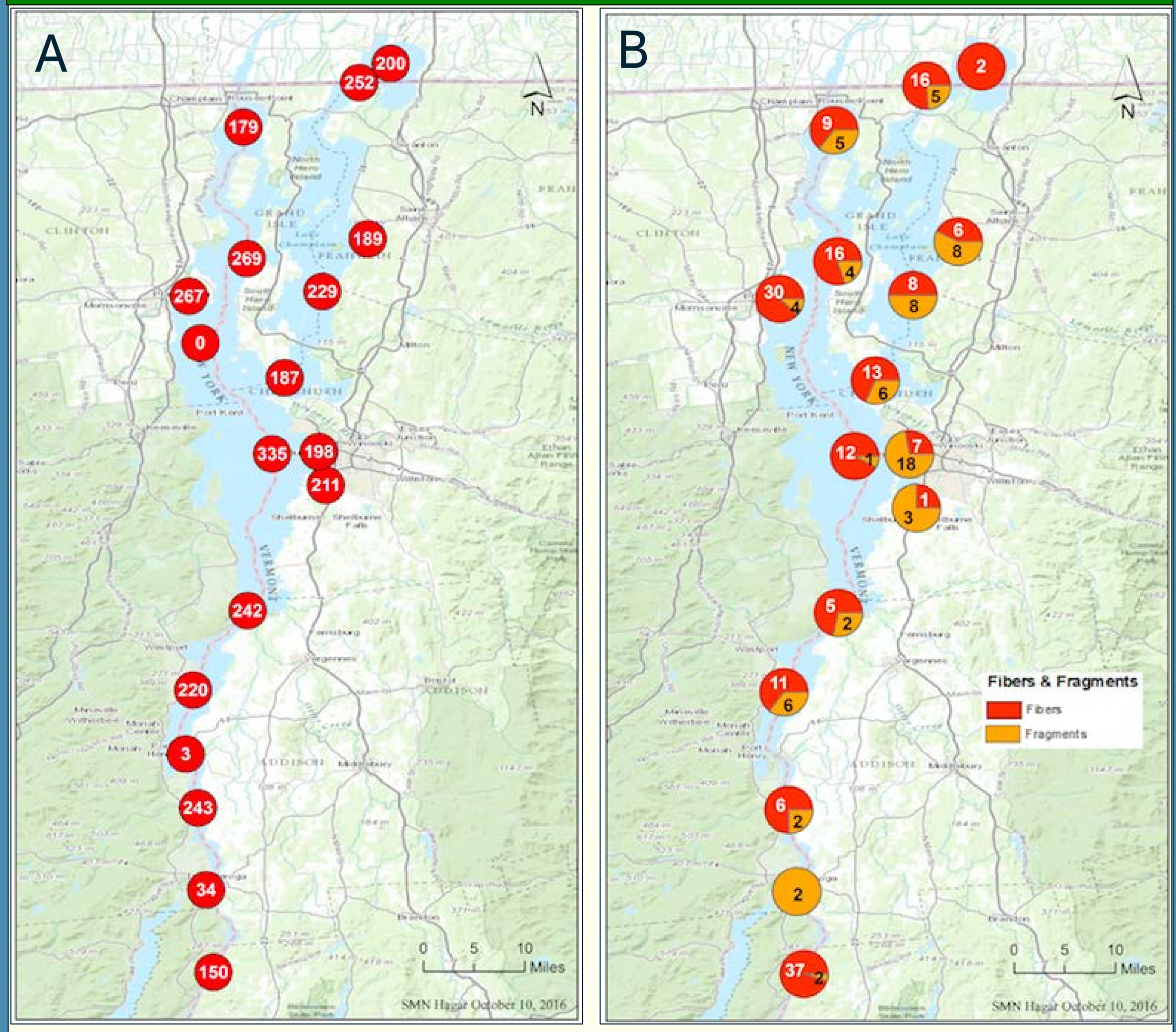


Fig. 7. A) Total nurdle abundance and distribution at LTM sites (n = 2265) samples processed,
B) Total fiber and fragment abundance and distribution at LTM sites. Maps were made using symbology quantities proportional symbols (nurdles) and pie charts (microplastics) in ArcMap V. 10.2.2.

## Densities & Spatial Distribution of Nurdles

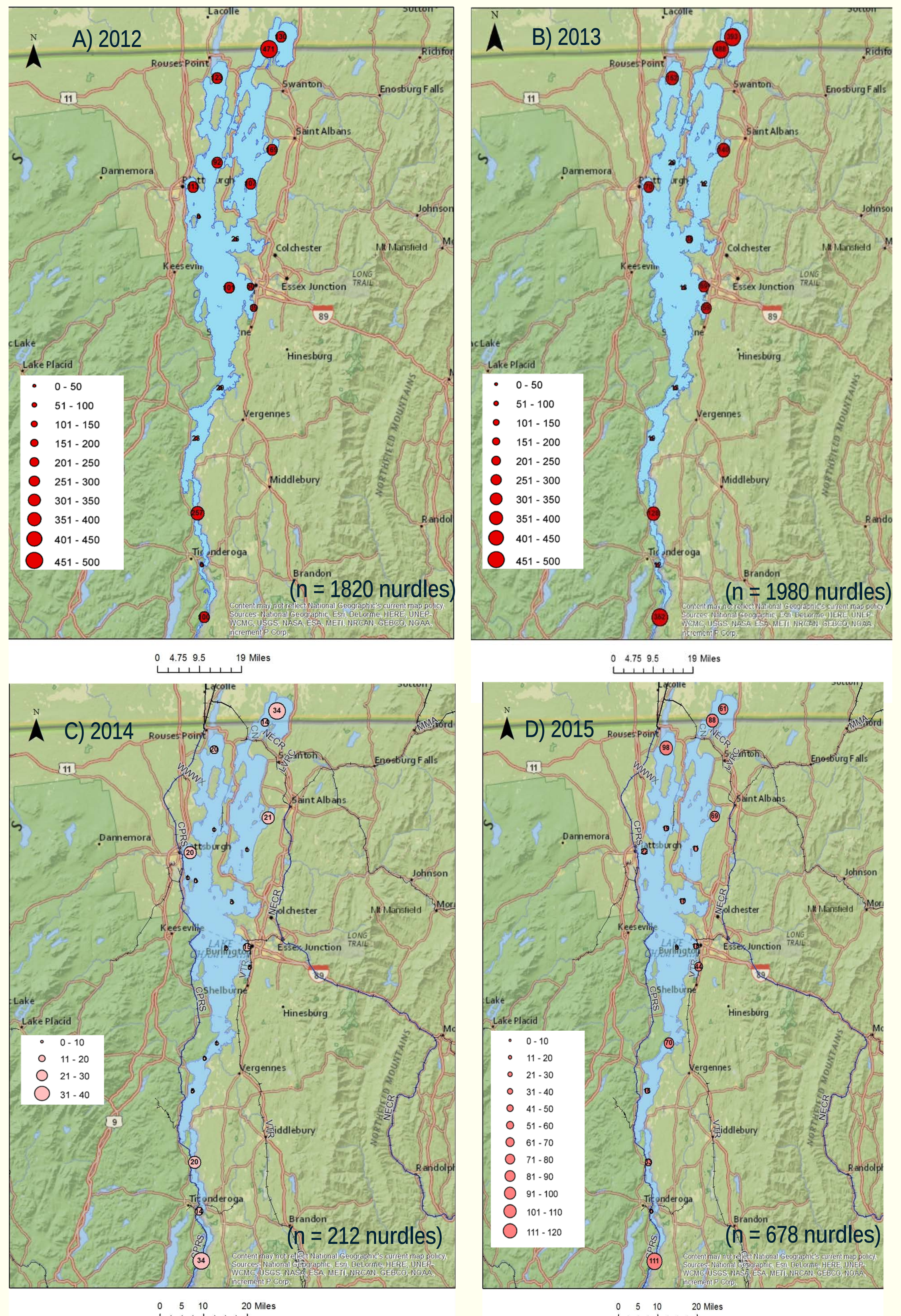


Fig. 7. Spatial distribution of nurdle densities (n/ m$^3$). Note: 2010-2011 (n = 0 nurdles, n = 269 samples). A) 2012 (n = 404 samples), B) 2013 (n = 258 samples), C) 2014 (n = 159 samples), D) 2015 (n = 486 samples). Red and pink hoves represent high and low density scale. Samples processed do not include canal or samples (differing sampling method) and samples without depths.

## Results and Discussion

- Of the total 249 microplastics found, 201 were FIBERS 3,455 nurdles (n = 2265) samples
- The greatest microplastic and nurdle densities occurred at stations located at Missisquoi and other bays, as well as north of Ticonderoga in the southern narrow lake reaches (Fig. 8).
- Twice as many nurdles were found in 2012-13 as compared to 2014-15.
- Nurdle abundance peaks in 2012.
- Microplastic (fiber) abundance peaks in 2015.
- Annual density maps scale absolute abundance to volume of water sampled, adjusting for nurdles at deep sites (e.g., station 19).

**Suggestions have been made:**

- High densities NORTH are in isolated and limited flow bays (e.g., Missisquoi Bay), which may suggest local source.
- Plastic manufacturing near waterways may release raw materials into freshwaters (Rehse et al. 2016).
- High densities SOUTH may result from canal-lake/lock system.
- Increasing densities at urban centers surrounding the lake (e.g., Plattsburgh, Burlington) may be associated with industrial sites.
- Watershed-wide increases may reflect the 100-year flood April 13-June 19, 2011; peaked May 5, 2011 103.27 ft > sea level.
- Hurricane Irene (Aug 28, 2011)
- Wind currents may explain current trends.

**Underlying Concerns:**

- Microplastics may be highly toxic as they are prone to absorbing aqueous contaminants (Setälä et al. 2014).
- Microplastics can be ingested by aquatic species such as zooplankton, fish, turtles, waterfowl (Cole et al. 2013, Browne et al. 2007), as well as humans.

## Future Directions

- Continue processing historical zooplankton samples.
- Overlay historical and current industrial site maps in proximity to the Lake Champlain Basin to identify potential industrial use sources.
- Consult with local industry to determine what raw material (polyisoprene?) is used in plastic manufacturing at local sites.
- Develop depth survey to determine which portion of the water column particulates reside.

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