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

Student Researcher: Susan-Marie Nadeau Hagar
Faculty Mentor: Danielle Garneau, Ph.D., Eileen Allen, GIS Coordinator
Center for Earth and Environmental Science
SUNY Plattsburgh, Plattsburgh, NY 12901

Introduction

- First noted in freshwater systems in the Laurentian Great Lakes (Driedger, 2015, Erikson et al., 2013).
- Microplastics are a category of plastic particles defined as <5mm and may include, but are not limited to fibers, fragments, beads/ pellets, foams, and films (Filella, 2015).
- Characterization occurs based on size and surface characteristics (Filella, 2015).
- Particulate polymers are identified as either lightweight (e.g., polypropylene and polyethylene) and heavyweight (e.g., PET, PVC). Weight dictates where they reside in water column.

What are nurdles?

Nurdles are a type of pre-production plastic. They are plastic beads or strands that can be easily transported and can be melted quickly and evenly. Nurdles can be used to manufacture virtually any plastic item.

Fig. 1. Nurdles. *Photos courtesy*: Gabriella Doud

Table 1. Nurdle origins from: Study to Quantify Pellet Emissions in the UK. Bristol, United Kingdom. Eunomia Report (Cole and Sherrington, 2016).

Industry Sector	UK figures		Scotland Figures*	
	Weight, tonnes (min-max)	No. of pellets, billions (min-max)	Weight, tonnes (min-max)	No. of pellets billions (min-max)
Production	25 – 250	1.3 – 13	3.8 – 37.5	0.2 – 1.9
Transport+	32 – 320	1.6 – 16	4.8 – 48.0	0.2 – 2.4
Processors	48 – 480	2.4 – 24	7.2 – 72.0	0.4 – 3.6
Waste Management	0 – 4	0.0 – 0.2	0.0 – 0.6	0.0 – 0.03
TOTAL pellets lost	**105 – 1054**	**5.3 – 53**	**15.8 – 158.1**	**0.8 – 7.9**

*estimated 15% of total in UK, based on relative proportion of chemicals industry.
+'Transport' includes losses at other facilities that handle pellets between production and final use (e.g. intermediate storage)

Goal and Hypothesis

To quantify the abundance and map the distribution of microplastics and rubber nurdles in long-term monitoring samples.

→ Abundance of microplastics and nurdles will be higher adjacent to industrial centers.
→ The majority of microplastics will be of the fiber type.

Lake Champlain Long-Term Monitoring Sites

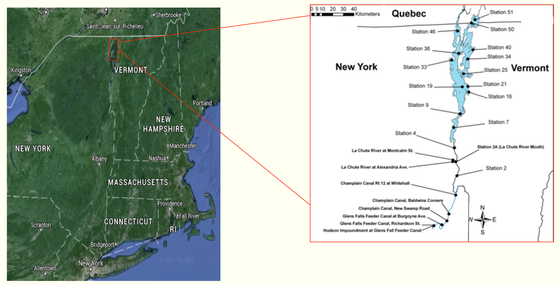

Fig. 2. Lake Champlain relative to New York and Vermont (Google Map). Location of LCRI long-term sampling stations.

Field Methodology

Zooplankton Sampling for Long-Term Monitoring

- Zooplankton samples were collected by vertical net (30cm diameter, 153um mesh) tows beginning just above the sediments to the water surface.
- Net rested for approximately 30 seconds at the benthos before retrieval.
- Net retrieval rate was 1m/s. Tow depth (m), tow type, station, date, and identification number, were noted on bottle.
- Nets were hose rinsed to wash organisms into the cod end. Cod end was removed and screening cleaned using a spray bottle.
- Wash cod end until 125ml sample bottle is filled ½ full (approximately 65 ml).
- Organisms were narcotized with 10-15 ml of cold club soda or ½ of an antacid tablet.
- After 5min buffered 10% formalin-sucrose-rose bengal solution was added to bring volume up to the shoulder to create a final approximate 5% formalin solution concentration (approximately 2.5% formaldehyde concentration).

Laboratory Methodology

Nurdle sample processing:

- Zooplankton samples were homogenized (n = 400).
- The entire sample was placed in a tray.
- Nurdles were quantified and stored in vials.
- Fourier Transform Infrared Spectroscopy (FTIR) was used to characterize nurdle polymer type.

Microplastic sample processing:

- Zooplankton sample was homogenized.
- A 20ml aliquot was extracted from the 160ml sample.
- Sample was placed in a grid-bottom Petri dish (evenly distributed).
- Microplastics were quantified in the grid and values extrapolated.

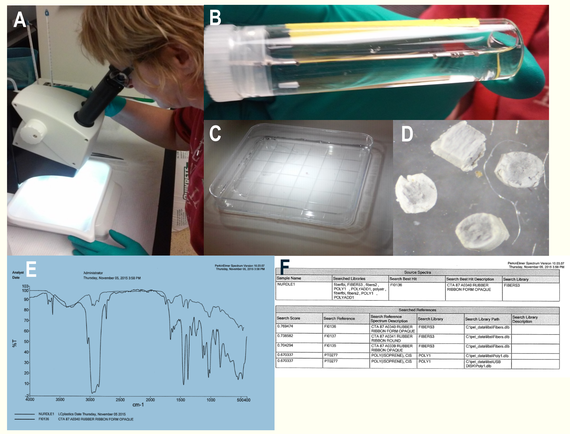

Fig. 3. **A)** Quantification of nurdle sample, **B)** nurdle sample, **C)** gridded Petri dish of sample, **D)** nurdles under magnification, **E)** FTIR of nurdle, **F)** Polymer characterization of nurdle.

Nurdle and Microplastic Distribution Maps

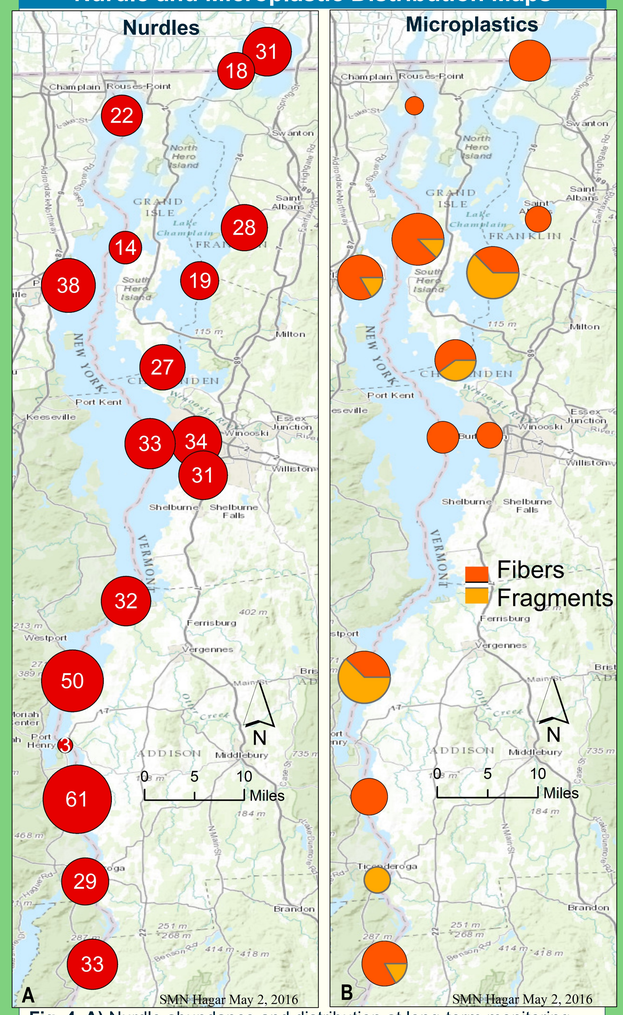

Fig. 4. A) Nurdle abundance and distribution at long-term monitoring sites, **B)** Fiber and fragment abundance and distribution at long-term monitoring sites. N = 400 samples.

- Maps were made using symbology quantities proportional symbols (nurdles) and pie charts (microplastics) in ArcMap V. 10.2.2.

Vertical Distribution of Nurdles and Microplastics

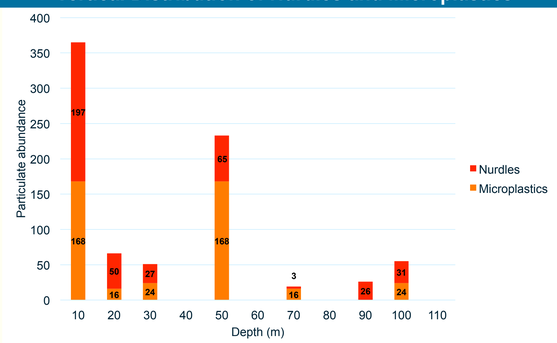

Fig. 5. Distribution of nurdles and microplastics by depth from surface.

Results and Discussion

- **Nurdle distribution** is highest at the southernmost end of Lake Champlain, as well as Shelburne and Missisquoi Bays (Fig. 4A).
  → High abundances correspond with Whitehall and Ticonderoga, both sites historically associated with industry.
  → **Nurdles and micoplastics** were primarily found at **0-10m** and **40-50m** depth (Fig. 5).
  → Depth of particulate is important, as susceptible organisms are distributed throughout the water column.
- **Microplastic distribution and abundance** is highest at the mid-section of the lake, as well as Missisquoi Bay and south of Westport
  → **Fibers** were the dominant microplastic type (Fig. 4B).
- Research has shown microplastic bioaccumulation up the food web in filter feeders, zooplankton, fish, and waterfowl (EPA, 1995; Syberg et al. 2015), and humans (Cauwenberghe, 2014).
- Microplastics are known to leach out plasticizers (e.g., phthalate, BPA)(Bergmann 2015) and absorb toxins (e.g., heavy metals, pathogens)(Bergmann 2015).

Future Directions

- Continue processing historical zooplankton samples.
- Identify date of first presence of nurdles in samples.
- Survey for presence of microplastics up the food chain.
- Perform stomach content analysis at fishing tournaments to assess presence of fishing debris (e.g., plastic lures, line, rope).

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