SUPER HI-CAT: Survey of Underwater Plastic and Ecosystem Response between Hawaii and California

Tara M. Clemente, Jeffery A. Ernst, Allison A. Fong, Brett D. Updyke, Donn A. Viviani, Kimberley A. Weersing, Benjamin R. Wheeler II, Angel E. White and David M. Karl

Objectives and Methods

The objective of the Center for Microbial Oceanography Research and Education (CMORE) SUPER HI-CAT cruise was to locate and sample the microbial communities and biogeochemical properties associated with the Pacific plastic patch between Honolulu, HI and Port Hueneme, CA. Sampling was conducted from the R/V Kilo Moana between August 25th – Sept. 5th, 2008 (Figure 1a). During the transit, we occupied a total of 15 CTD/Trawl/Optics stations and 15 underway (UW) stations to look at various biogeochemical parameters en route to CA (Figure 2).

Hydrographic and biogeochemical data were collected to characterize the upper 150m water column at discrete depths (5m, 15m, 25m, 45m, 75m, and Deep Chlorophyll Maxima or DCM) using a CTD rosette sampler (Figure 1b). Table 1. UW stations were sampled using the ships uncontaminated seawater system. A Manta Trawl was used to map the surface horizontal distribution of plastic (Figure 3a). Plastic samples were then size fractionated into the following size classes; 5mm and larger, 2mm – 5mm and 0.2 – 2mm (Figure 4). All three size fractions were then sub-sampled to measure Chlophyll a and ATP concentrations, to estimate Gross Primary Production (GPP) and Respiration (R) and to preserve samples for subsequent genomic analyses. A LISST and HYPERPRO radiometer were used to characterize particle size distribution and optical properties of the upper water column (Figure 3b).

Water Column Hydrography and Biogeochemistry

Plastic Biogeochemistry

Figure 8 (left). Super HI-CAT plastic concentrations from surface Manta trawls (pieces/m^2) relative to the August sea surface temperature field (C°).

Table 1. Biogeochemical parameters measured during the SUPER HI-CAT cruise.

<table>
<thead>
<tr>
<th>Event</th>
<th>Parameter Measured</th>
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<tbody>
<tr>
<td>CTD and UW Stations</td>
<td>Salinity, DO, pH, Nitrate, NO3, NO2, PO4, Si, Chl a, Chl b, Chl c, Chl d, Subsurface, Chl a, Chl b, Chl c, Chl d, ATP, NDF, Particulate C, N, P, S, DNA/PHA, DNA, N, and ATP Environmental and Optical station (CTD only)</td>
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<tr>
<td>Manta Trawl</td>
<td>Chlophyll a ATP, Particulate ATP, DNA, siRNA, RNA, Chi a, ATP (CD)</td>
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Figure 7. Variation in near-surface ocean plankton metabolism (μmol O2 L-1 d-1) at stations along the transect. Gross Primary Production (GPP), Net Community Production (NCP) and Respiration (R) for near surface waters along the transit.

Figure 9. Variation in near-surface microbial biomass (line graph) and microbial biomass associated with plastic particles of different size categories (bar graph) as measured by (a) chlorophyll a and (b) ATP content.

Figure 10. Metabolic rates (μmol O2 L-1 d-1) from plastic particles. Left plot represents rates derived from plastic pieces > 5mm; right plot represents rates derived from plastic pieces < 5mm.

Figure 11. Microscope used to sort and examine plastic collected by the Manta Trawl.

Figure 12. Large pieces of plastic debris seen floating by the R/V Kilo Moana during the cruise.

Figure 13. A plastic buoy covered with barnacles creating a new habitat for marine organisms.

SUPER Summary

- Particle concentrations integrated over the top 0.5 m of the water column along the transect ranged from 0.17 - 1.85 x 10^6 plastic fragments km^-2.
- Particle abundance was not coincident with the region of highest plastic concentrations. Particle abundance and size distributions were roughly similar for all stations, except for stations UW2 and UW14 which showed increased particle abundance and a shift in the size spectra.
- Total microbial biomass as measured by chlorophyll a and ATP content were highly variable across the transect (2.5 to 4 fold range, respectively).
- Chlorophyll a and ATP concentrations associated with plastic provided proof that microorganisms colonized the plastic particles.
- Higher concentrations of Chlorophyll a were found associated with the 5mm and above size classes suggesting some microorganisms may favor larger particles.
- Measurements of Gross Primary Production (GPP), Net Community Production (NCP) and Respiration (R) revealed high community metabolic rates on plastic particles in the two larger size classes.
- Rates of NCP in seawater were close to zero (GPP=R), whereas microbial assemblages associated with plastic debris were demonstrably autotrophic suggesting the presence of phytoplankton enriched biofilms.

Education and Outreach

As well as providing an exciting opportunity to launch new research initiatives, the SUPER cruise also afforded numerous opportunities for education and outreach. In addition to communicating our science with media outlets, outreach and education products were created including a short film, a daily weblog, and a set of classroom lessons on marine debris (http://story.soest.hawaii.edu/cruises/super/index.htm).

Acknowledgements

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