UNIVERSITY OF CALIFORNIA, SAN DIEGO

Gyre Plastic: Science, Circulation and the Matter of the Great Pacific Garbage Patch

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy

in

Communication

by

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The Dissertation of Kim De Wolff is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

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TABLE OF CONTENTS

Signature Page iii

Table of Contents iv

List of Figures vi

Acknowledgements ix

Vita xii

Abstract of the Dissertation xiii

Introduction
Knowing "Things that Matter" in the North Pacific 1
A Global Environmental Problem as Matter of Concern and Care 5
Circulation as Methodology and Site 8
Words that Matter 14
Plastic Oceans of Waste and Wonder 18
Chapter Maps 20

Chapter 1
Pacific Currents: Plastic and Water Circulating with Science 25
Plastic in *Nature* and *Science* 29
Enter the Gyres 38
The Garbage Patch Concept 44
From Tools to Pollution 49
Plastic Marine Debris Science 55
Conclusion 62

Chapter 2
Trash Island: The Materiality of Things That Aren't There (But Could Be 65
Elusive Traces: The Stuff of Headlines 70
Dismissive Encounters: Rational Skepticism 81
Corrective Encounters: Reshaping Truth 91
Constructive Encounters: Building on Trash Island 102
Myth/Mis-/Missing: The Generative Potential of Material Absences 111

Chapter 3
Witnesses in the Garbage Patch: Intersections of Humans and Plastic at Sea 114
Pacific Crossings 118
Becoming Witnesses "On a boat, looking for plastic" 122
Corrective Encounters in and with a Garbage Patch 131
Plastic Witnesses and Forms of Doubt 141

The Vast Continuity of the Sea 144
Conclusion 146

Chapter 4
Diverging Models of Science and Activism: Plastic Knowledge in Motion 149
Collecting Gyre Samples for Science and Education 153
Trajectory 1: Making Knowledge in the Laboratory 160
Trajectory 2: Making Knowledge Public through Demonstration 166
Trajectory 3: Escaped Plastic and Missing Knowledge 172
Conclusion 176

Chapter 5
Plastic Species: Tangled Naturecultures in the Plastisphere 179
Entanglements in and with Science 182
Tangles of Waste and Life at Sea 185
"Plastic versus everything else": Separation as scientific knowledge 188
"Dangerous Species": Separation as public knowledge 193
The Matter of Belonging 201

Conclusion 206
Science, Activism and Matters of Care 208
For Further Research 211
How to Live Responsibly with Plastic 213
Plastic is not solid waste 214
Plastic evades control 215
Plastic deserves more power, not less 215

References 217

LIST OF FIGURES

Figure 0.1: ……..... 1
A floating ‘island’ of plastic objects and an ocean surface sample of ‘plastic soup.’

Figure 0.2: ……..... 17
Map of major currents and accumulation zones in the North Pacific Ocean. Source: NOAA.

Figure 0.3: ……..... 20
Provisional map of the chapter ‘ingredients’ and their respective circulations.

Figure 1.1: ……..... 42
Munk’s model of gyre currents in the North Pacific.

Figure 1.2: ……..... 46
Ingraham and Ebbesmeyer’s map locating a ‘garbage patch’ in the Eastern vortex of the North Pacific Subtropical Gyre. Beachcombers’ Alert 2002.

Figure 1.3: ……..... 48
Nike shoe, rubber duckie, hockey glove and salmon illustrate circulation in the North Pacific Subpolar Gyre from Alaska Fisheries Report on OSCURS, 1997.

Figure 1.4: ……..... 53
Cover of January 2001 Environmental Science and Technology. Takada’s article, “Plastic Pellet Transport of Toxics in Ocean Environments” is on the cover.

Figure 1.5: ……..... 54
Plastic pellet sample from Israel. One of hundreds in the IPW archive.

Figure 1.6: ……..... 61
Wood drifter in the lab and weathered float recovered from Kamilo Beach. Photos by the author.

Figure 2.1: ……..... 82
Image from “Hyperbole and the North Pacific Garbage Patch” presentation by Angelicque White.

Figure 2.2: ……..... 91
Captain Moore and Gyre Sample 2002.

Figure 2.3: ……..... 102
WHIM Architecture’s rendering of Recycle Island in the middle of the North Pacific Subtropical Gyre.

Figure 3.1: ……... 117
Replica “Crossroads of the Pacific” sign at the Pearl Harbor Visitor Center. Photo by the author.

Figure 3.2: ……... 121
Stepping aboard the Sea Dragon in Honolulu. Photo by Laura De Wolff.

Figure 3.3: ……... 122
Labeled diagram of the 72 foot racing boat and gyre traveller, the Sea Dragon. From the Pangaea Explorations website.

Figure 3.4: ……. 130
Holding the wheel in calm seas, the world off-kilter as the boat slants with the wind.

Figure 3.5: ……. 134
Typical macrodebris: a black fishing float with an attached community of gooseneck barnacles.

Figure 3.6: ……. 136
The Sea Dragon approaches the heart of the high pressure zone. Photo by the author.

Figure 3.7: ……. 139
Staging science at sea. Marcus poses for Jin with the manta trawl in the background.

Figure 3.8: ……. 143
View of the horizon from the boat in the garbage patch. Photo by the author.

Figure 3.9: ……. 146
Map of Algalita sample sites between 1999 and 2011. July 2011 scientific sample locations are red dots, and education sample locations are large yellow dots.

Figure 4.1: ……. 154
The ‘suitcase’ manta trawl. Photo courtesy Rob Johnson.

Figure 4.2: ……. 156
Sample Collection: deploying the manta trawl; looking into the cod end of the high-speed trawl; bottled ‘gorilla’ sample. Photos by the author.

Figure 4.3: ……. 157
The mixed plastic and marine life contents of the “gorilla trawl” education sample. Photo by the author.

Figure 4.4: ……. 162
Pieces of a single North Pacific Gyre sample, fully sorted, weighed and labeled. Photo by the author.

Figure 4.5: ……. 167
Algalita's education coordinator walks visitors through plastic pollution issues with samples close at hand.

Figure 4.6: ……. 172
Goldstein's (2012) representation of increasing microplastic concentrations in the North Pacific Subtropical Gyre.

Figure 5.1: ……. 184
Ghost net with reef fish and human, as encountered on the North Pacific Expedition in July 2011. Photo courtesy of the Algalita Marine Research Institute.

Figure 5.2: ……..… 186
Velella velella from ocean surface sample. Photo by the author.

Figure 5.3: ……..…… 188
Ocean surface sample sorted into plastic and plankton at the University of Hawaii Hilo. Photo by the author.

Figure 5.4: …… 190
Two salps with plastic fragments (and a tiny crab). Courtesy of the Algalita Marine Research Institute.

Figure 5.5: …… 194
The California Coastal Commission "Cig Egret" poster promotion coastal cleanup day in 2005.

Figure 5.6: …… 197
"The Most Dangerous Species in the Mediterranean" poster by the Catalan Water Agency.

Figure 5.7: …… 202
Method 'Ocean Plastic' soap bottle (fine print clarifies only 10% ocean and post-consumer recycled materials). Photo by the author.

Figure 5.8: …… 203
Dale Selvam with the crate of coastal reef fish in North Pacific Ocean. Photo courtesy of the Algalita Marine Research Institute.

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Kim De Wolff was the sole author of all material in this dissertation, and all materials listed below that have been published, submitted to journals, or are being prepared for submission.

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ABSTRACT OF THE DISSERTATION

Gyre Plastic: Science, Circulation and the Matter of the Great Pacific Garbage Patch

by

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In global oceans, circulating current systems called gyres concentrate floating plastic waste into garbage patches far from land. This dissertation describes how the Great Pacific Garbage Patch accumulating between California and Japan comes to matter as an environmental problem and public concern at the turn of the 21st century. It draws on participant observation, interviews, historical and textual analysis to "follow" plastic

as it circulates – with water, images, people, knowledge and marine life – from the ocean, through laboratories and beyond. By tracing the intersecting trajectories of multiple materials, I take a problem often blamed on activist exaggeration or media misrepresentation and show how the garbage patch emerges with a diversity of collective practices. The production and sharing of knowledge not only shapes the garbage patch, but also the kinds of solutions and care that are possible in return. For some, the garbage patch becomes a solid 'trash island' twice the size of Texas in need of cleanup; for others, a whole new realm of inseparable associations between synthetics and life called the plastisphere. Plastic, however, continues to escape from these attempts to measure, know, cleanup and otherwise control it, challenging the cultural and political foundations of science and ecology. I argue that caring for the ocean requires responding to plastic in all its natural-cultural relationships, as it transforms humans and environments alike.

Introduction
Knowing "Things that Matter" in the North Pacific

Figure 0.1: A floating 'island' of plastic objects and an ocean surface sample of 'plastic soup.'

There is a garbage patch growing in the North Pacific Ocean where plastic travels without humans, moving with currents of wind and water to accumulate far from land. It is prominently reported by major media outlets as a solid, even continental form made entirely of trash. Some say it is an island twice the size of Texas. Yet the garbage patch is invisible to satellite imagery, and even those venturing through it on a boat are not always sure they are actually there. Some insist they have seen photos of the island, while others wonder why they have not. I wanted to see for myself this problem that appears at once as a circulation and the product of circulations: plastic travelling with currents to the far reaches of the sea, but also with images, researchers, boats, knowledge and marine life all in motion. Rather than investigating whether the trash island is 'real' or not, I examine how the accumulation known as the Great Pacific Garbage Patch becomes a matter of concern: something that 'matters' both in the sense of having a physical form, and in the

sense that it is something people care for, whether as a bounded trash island or a problem far more tangled and amorphous.

"Garbage patch" is the popular term for areas where floating waste collects in the middle of giant circulating current systems called 'gyres' that define patterns of surface movement in global oceans. Plastic makes its way to the ocean by floating down rivers and off beaches, washing down storm drains, and occasionally, being dumped intentionally from ships. Since plastic is so common and so durable, it makes up the vast majority of materials in garbage patches (NOAA 2014a; Thompson et al. 2004).[1] Synthetic plastics are polymers, made of extremely long repeating chains of chemical units with bonds too strong or too unfamiliar to be broken down by organisms. Susceptible to sunlight rather than digestion, plastic *photo-* rather than *bio-* degrades into ever-smaller pieces without disappearing completely into component parts, a process made even slower in seawater (Andrady 2011). In the ocean, floating plastic becomes a multiple threat: through the entanglement of marine life caught by larger objects like lost fishing nets and six-pack rings; through the ingestion of plastic as marine life treat items including lighters, bottle caps and smaller fragments like food; and as a vector for toxins, where even the tiniest 'microplastic' pieces have a tendency to both leach chemicals into and concentrate toxins from the surrounding seawater.[2] Many of these toxins, with

[1] I use the singular term "plastic," when speaking of the common cultural category that lumps together a large class of solid synthetic materials. It is important to note that plastic is not a single substance, and that not all plastics float in seawater. There are thousands of types of plastic, far exceeding the seven recycling categories (based on most common use) molded on the bottoms of bottles and other packaging (American Chemistry Council 2014; MacBride 2012).

[2] Plastic production involves taking oil or natural gas and super heating it until chemical bands are rearranged in a process called "cracking." Chemical additives included during production alter material properties, making a diversity of plastics that are, for example, harder, more flexible

ominous modern acronyms DDT, PCBs, BPA are endocrine disruptors capable of tricking hormones and rejigging reproductive systems in even the smallest dose (Freinkel 2011). For these reasons, and with emphasis on their potential economic consequences, the United Nations Environment Program (UNEP) named "Plastic Debris in the Ocean" among major emerging global environmental challenges in 2011.

Though the first published scientific reports of plastic in the open ocean date to the early 1970s, it is only in the last decade that garbage patches have become the stuff of national headlines and international discussion. The popularization of the issue is due, in no small part, to the work of a number of nonprofits determined to draw attention to the presence and possible dangers of plastic in the ocean: Algalita, Project Kaisei, Surfrider Foundation, Sea Education Association, and 5 Gyres among others.[3] I conducted much of my fieldwork with Algalita,[4] a small marine science and education organization based in Long Beach, California whose founder Captain Charles Moore is often credited with 'discovering' the Great Pacific Garbage Patch in the mid-1990s. The organization continues to raise awareness about ocean plastic pollution by producing and sharing

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or fire-resistant (American Chemistry Council 2014). These additives do not always stay attached. The off-gassing of potentially toxic additives called phthalates (also endocrine disruptors) is responsible for new car smell and the aroma given off by new shower curtains, table cloths and other consumer goods (Freinkel 2011).

[3] This list is based on the organizations most commonly referenced in my fieldwork. It is also very similar to those mentioned in a literature review by Scripps Institute of Oceanography professor James Leichter (2011).

[4] The official name of the organization changed several times during the course of my research, from Algalita Marine Research Foundation to Algalita Marine Research Institute, and again to Algalita Marine Research and Education. For consistency and simplicity, I use the common denominator "Algalita" as my shorthand. The word "Algalita" was intended as the Spanish for "little algae," in reference to coastal restoration projects prior to the focus on plastic. The organization's research vessel was later named the "*Alguita*," bearing the correct Spanish, but the original name stuck.

knowledge about it. “We’re trying to know things that matter,” Moore explains, “and know them on a wide scale, and combat this notion that the observations of citizens are not useful in understanding the world” (Moore, personal interview, 2012). Focusing on specific material problems in the world that demand care – “things that matter” – by conducting research and making it public becomes a form of activism.

But with increased attention from public and academic scientists, the garbage patch seems to take on multiple forms: what the “thing” is and how and why it “matters” become questions themselves. Concerned members of the public come to care for something decidedly solid: a floating landfill signaling consumer excess and the troubling human capacity to alter even the most distant environments. For those conducting research and traveling through the accumulation zone, the garbage patch appears far more amorphous and dispersed: small plastic participles, toxins and the odd recognizable object suspended in seawater and even home to marine life. Attempting to provide a measured, and more “accurate” picture of what is happening at sea, they bring experiences, samples and reports back to land, even suggesting new metaphors like “plastic soup” to circulate in the island’s place. Despite these efforts many people, as recounted by long-time plastic pollution researcher and activist Marcus Eriksen, continue to insist on the existence of a frightening island, adamant that the garbage patch is a solid problem in need of cleanup at sea:

> We bring this information to land, and sometimes people that have not been out here will deny the facts we bring to them. I’ve had people argue with me, no there’s an island out there, I’ve seen a video, I’ve seen the photographs, I’ve read an article. I say, well, this is my third time being out there, fourth time being out there and it doesn’t exist. (Eriksen, personal interview, 2011)

Scientists and activists alike are surprised by the tenacity of the solid manifestation of the problem, wondering how it can endure even in the face of direct experience and good science; or, conversely, for a continued lack of concern for microplastic fragments and associated toxins. Seeking explanations, marine scientists point out what they see as egregious examples of media misrepresentation, blaming journalists and activists for exaggeration or simply getting it wrong. But are island and soup all the same, others ask, as long as they "fuel the fires" of change? If people care, if they are convinced to act, does the shape of the problem matter?

I argue that the materiality of environmental problems does matter. As I traveled with plastic around and across the North Pacific Ocean conducting research over the course of three years, I began to see how the physical characteristics of the garbage patch and forms of care are connected, how nature and culture, plastic and oceans, are all inextricably entangled in their many circulations. Instead of evaluating practices and representations as right or wrong, this dissertation shows how they are part of culturally specific engagements with material worlds that become foundations for the kinds of responses that are possible in return.

A Global Environmental Problem as Matter of Concern and Care

One of my main goals in studying the garbage patch is to investigate materiality in the emergence of a global environmental problem. I want to understand how plastic pieces are made to matter for publics, and made to matter in forms as different as a potentially habitable island is from thin toxic soup. In science and technology studies, to "know things that matter," is to be part of ongoing ethico-political processes that bring

worlds into being.[5] Substance and meaning, what is and what is to be done, do not emerge and cannot be studied in isolation: "The way STS presents things doesn't split affects of concern and worry from the staging of their lively existence" (Puig de la Bellacasa 2011: 88). For me, questions about the garbage patch's material existence are questions about how to know and care for it.

Following Latour, I approach the garbage patch as a "matter of concern" (Latour 2004; 2008), not as a bounded object that already exists floating in isolation, but as a 'thing' given in experience and by associations.[6] In outlining matters of concern, Latour distinguishes them from matters of fact, bits of 'objective' reality presented with a stable existence independent of human relations and construction, like the measured density of plastic particles on the ocean surface. Matters of concern, in contrast, are what results when seemingly self-contained matters of fact are no longer allowed to stand for themselves, but are situated within a "whole scenography" of human and nonhuman relations (2008: 39). To matter in this sense is to be caught up with interests, to matter for actual people at specific times and places. A garbage patch becomes a thing with the power to "gather" diverse actors to the remote reaches of the North Pacific in the pursuit of plastic and knowledge about it.[7] Power, then, is not only found in human struggles, but

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[5] As Karen Barad describes of posthuman performativity, "The world is an ongoing open process of mattering" (Barad 2003: 817). I also take inspiration from Annemarie Mol's "ontological politics" (1999) and Michelle Murphy's (2006) conceptualization of "materialization."

[6] Where representationalism assumes the presence of bounded objects already in the world awaiting description, for STS, things (and here I mean in the always entangled Heidegger-through-Latour sense of things) do not pre-exist material configurings of the world (Barad 2007: 47).

[7] Latours conception of gathering rests on Heidegger's distinction of "things" as sites that draw together in opposition to "objects" that stand alone outside of relationships. Whereas objects are

is located in the diversity of materials, spaces and practices that produce knowledge (Bennet 2010; Joyce 2003; Mukerji 2009).[8]

The vast majority of existing research about ocean plastic pollution is directed toward the production and evaluation of matters of fact. As I carried out my fieldwork, scientists and members of nonprofits would ask me, in voices tinged with frustration, why people did not listen, or care more about the truth. These questions were posed, it seemed, with hopes that as a communication scholar I might offer social facts that would help to more accurately transmit scientific ones, all with the good intention of encouraging understanding and effective solutions. I understand communication, however, as part of – rather than what comes after – culturally situated practices and processes of knowing; mediation, whether as a movement of plastic or a movement of words, always involves transformation. The island endures along with the cultural and political conditions of its emergence.

I am, like those I worked with, very much interested in forms of responsibility and care that emerge as the garbage patch shapes human relationships with the ocean, but I follow these concerns through focusing on the materiality of gyre plastic rather than by evaluating the accuracy of representations. As such, this project takes up Latour's

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simply 'there,' things have complicated qualities and are entangled with all kinds of issues. Matters of fact and matters of concern correspond to object and thing respectively.

[8] Following actor-network theory, a key tenet of matters of concern and a major contribution of STS has been recognizing the diversity of actors, including nonhumans, in constituting practices and producing knowledge. I understand materiality as relational: plastic waste and synthetic chemicals, whether in landfills, ditches or the ocean, come from the communities that surround them, and are therefore part of networks or assemblages of people and things (Callon 1986; Latour 1992; 2007; Law & Hassard 1999). This approach suggests that plastic materials are not only 'meaningful' but also the literal 'stuff' of social practices and the material foundations of political regimes (Bennet 2010; Cronon 1991; Joyce 2003; Mukerji 2009; Shove et al. 2007).

challenge to "devise another powerful descriptive tool that deals this time with matters of concern and whose import then will no longer be to debunk but to protect and to care" (2004: 232). I take further cues from feminist science studies scholars who emphasize how ontologies are not only relational and political, but ethical as well. Here care is not simply a synonym for concern; it invokes an active conception of "doing and intervening," practices of car*ing* and respons-*ability* (Haraway 2008; Puig de la Bellacasa 2011: 89). The garbage patch, whether measured or imagined, emerges not only in relationships, but entangled with possible actions and solutions. Feminist approaches also direct attention to neglected things, to what becomes invisible or excluded in practices of knowing (Murphy 2006; Star 1991). Efforts to simply clean plastic from the ocean, for example, fail to account for the marine life that has adapted to flourish with plastic, or the way plastic continues to escape and travel despite attempts to regulate its movements. I argue that caring for the ocean requires awarding more power to plastic in all its relationships as it transforms humans and environments alike.

Circulation as Methodology and Site

The garbage patch is not a stable entity anchored with coordinates and facts, and as I tried to follow it my research site became circulation itself: the tangled trajectories of all kinds of moving materials.[9] Gyre plastic is a matter of concern because it is matter in motion connecting ocean ecosystems with cultures of consumption and waste. Studying a garbage patch through material processes and practices demanded an approach capable of

[9] As such, my fieldwork stays close to the narrower definition of multi-sited ethnography "in/of the world-system" (Marcus 1995; 1998), meaning not simply having more than one site, but focusing attention on the movements and connections between.

following a diversity of actors, both human and nonhuman, as they circulated around and across the North Pacific Ocean. My approach builds from two main traditions: the science and technology studies imperative to "follow the actors" in the production and circulation of knowledge (Latour 1988; 2008), and anthropological attention to the "biographies" or trajectories of material things to understand global cultures of circulation (Carse 2014; Kopytoff 1986; Marcus 1998).[10] In practice, this involved a combination of participant observation at sea and on land, interviews, and media analysis. Since I am interested in the power of materials as they transform and are transformed, I travelled physically with gyre plastic wherever possible, spending time on boats, walking beaches, working in labs and conducing interviews in person.

I began my fieldwork on Algalita's North Pacific Expedition, sailing through the heart of the garbage patch in July 2011. In an extreme introduction to participant observation, I learned to steer a 72' sailboat in near-gale conditions, to cook meals for thirteen in a tiny kitchen, and to help collect scientific samples a thousand miles from land. I wrote extensive fieldnotes documenting daily activities including the interactions of diverse participants and resulting discussions of plastic pollution. These observations were supplemented with photographs and video footage of more complex processes, such as scientific sample collection and technical explanations of sample contents. I noted the differential treatment of scientific and education samples, and began to sense the

[10] In STS, this invovles sticking as closely as possible to the many participants and practices in the production of knowledge, whether through ethnographic or historical analysis (Latour 1988; 2008). I bring this approach in line more specifically with recent work in anthropology focused on the global through "the entanglement of circulating things with the specificities of place and attendant emphasis on both flow and form" (Carse 2014: 391). Brignign these two traditions togather, allows me to emphasize how things, and not just human relationships are transformed in global processes.

struggles of the crew as they negotiated between scientific precision and the challenges of working on a racing sailboat; their experience of a visually elusive Garbage Patch and the desire to instigate change. These intense three weeks spent working in close quarters as part of a team not only allowed me to see how plastic pieces are observed, sampled and experienced in and as a garbage patch, but also to forge lasting relationships with people and materials. From this starting trajectory in the middle of things (geographically, socially, and metaphorically), my research then spiraled outward in several directions.

I spent a total of six months conducting participant observation at the Algalita laboratory and office, observing how gyre plastic further 'travels' through science and education projects. My participation on the expedition and willingness to work (unpaid) facilitated access, but my research flourished even more so with the organization's incredible generosity in sharing everything from media archives and board meeting notes to candid expressions of organizational and individual strengths and weaknesses. With ocean plastic pollution garnering international attention, this was a somewhat transitional period for Algalita, as directors considered how to proceed beyond "raising awareness." At the office, I was privy to such programmatic discussions while helping with activities ranging from minor administrative tasks such as entering contact information and editing, to helping design a marine debris education video and kit for Los Angeles area classrooms and supervising an undergraduate intern. With the office staff in the midst of coordinating an upcoming two-part expedition through the Western North Pacific and the potential debris field from the 2011 Japan Tsunami, I was able to observe the kind of preparation involved from the organization's perspective.

During this time, I spent one or two days a week at Algalita's laboratory where I learned to process samples collected at sea into measured data. On request of the research staff, I created a Zotero database of scientific publications related to marine debris and plastic pollution that was both tagged and sortable by key terms, authors and dates. I met a rotation of volunteers, and on occasion helped lead activities for visiting student groups and filmmakers, noting differences between the arrangements of spaces, activities and priorities at the office versus the lab. I also accompanied Algalita office and lab staff to a host of public events: talks given by founder Captain Charles Moore at the Aquarium of the Pacific in Long Beach and the Ocean Institute in Dana Point; presentations led by the education coordinator in Los Angeles area classrooms and at the Plastic Ocean Pollution Solutions leadership training youth summit in Venice Beach; even taking a tour of the Puente Hills Landfill and participating in California Coastal Cleanup Day. On many of these occasions, I spent considerable time interacting with members of the public, called on to staff the Algalita table and answer questions about ocean plastics and my experience at sea. Sharing rides to and from events through Southern California traffic, I enjoyed many extended casual conversations about Algalita people and projects.

While I did ethnographic work in Long Beach, the specific samples I helped collected at sea travelled with expedition participant and marine ecologist Hank Carson to a laboratory at the University of Hawaii, Hilo for analysis. In spring of 2012 and again in 2013, I headed across the Pacific to see how they were fairing. I spent a week with marine debris researchers and undergraduate assistants, helping to process samples, and learning about using scanning electron microscopes to study the forms of life that live on plastic. These trips to Hawaii helped me understand how plastic samples are transformed

in an academic setting. I looked at how samples are used to measure, map and monitor accumulations of plastic pollution, translating plastic bits into written knowledge, and I observed particularly interesting discussions of the uneasy relationship between university science and activism, as researchers worried that advocating specific changes would undermine their credibility as researchers.

Given limited resources, Algalita relies on the skills and expertise of affiliated researchers, many of whom I interviewed along with other key actors in ocean plastic science and activism. This included, among others, physical oceanographers modeling flows of debris; analytical chemists measuring toxins; the Pacific marine debris coordinator at the National Oceanic and Atmospheric Administration; authors of prominent popular and scientific articles on the garbage patch; and members of numerous nonprofits (Algalita and 5 Gyres in Los Angeles, Sustainable Coastlines and the Hawaii Wildlife Foundation in Hawaii, Washed Ashore in Southern Oregon, Japan Environmental Action Network and Surfrider Foundation Japan in Tokyo). Traveling to conduct these interviews in person, I was privileged to demonstrations of computer models and laboratory practices, and to simple observations of the newspaper clippings and personal collections of plastic flotsam accumulating in offices, homes and labs. I combined many of these visits with trips to local beaches, sometimes on my own, but more often in conjunction with beach cleanup, art and research projects. Walking shorelines of Hawaii, Oregon, California, and Northern Japan, digging in the sand and gathering waste allowed me to experience firsthand the many fates of plastic pieces that escape waste management and sample collection.

The devastating events of the March 2011 Japan tsunami began to unfold just months before I began my fieldwork. Massive waves that claimed thousands of lives also washed an estimated 5 million tons of debris out to sea (Ocean Conservancy 2014c). As these lost objects made their way across the Pacific, the tsunami increasingly became part of Algalita's work, and, by association my own. I spent the first five months of 2013 living in Japan, where I interviewed key figures in nonprofit and scientific communities, participated in tsunami debris forums, and visited disaster-impacted communities. Though I set out to study plastic rather than people, I found myself in emotionally demanding conversations with those who had lost their possessions, their homes and in some cases, their families. These difficult experiences helped me rethink questions about origins and responsibility in ways that extend far beyond the scope of my dissertation.

Throughout my travels near and far, I wrote copious fieldnotes, took thousands of photographs and acquired a growing collection of plastic curiosities (aka garbage). In addition to conducting interviews, I relied on analysis of historical, scientific and media texts to "follow" gyre plastic to times and places I could not visit myself.[11] As I circled the North Pacific by plane, boat and train, on foot and through texts, I began to notice the tendency for my investigation to loop around and intersect in unexpected ways. Interviewing a Japanese analytical chemist in Tokyo, I was shown San Diego State University and Algalita mugs, gifts delivered in person by two other participants in my study. I dove into the history of mathematical models of ocean currents, searching for

[11] Given the proliferation of published material over the last decade, I focused my study on three main areas: 1) scientific publications, media coverage, and displays specific to the July 2011 North Pacific Expedition; 2) early documentation of ocean plastic research and reports of plastic pollution in the ocean; and 3) prominent mainstream media coverage of the Great Pacific Garbage Patch.

where the first scientific report says plastic in the Pacific only to land at the Scripps Institute of Oceanography a few miles from my home. Flying to Hawaii for the second time, gazing down on the sea far below, I realized I was making giant physical laps of the Pacific in the same direction as gyre currents. This realization helped me finally understand exactly what I meant by "following."

Words that Matter

There were many times where the material politics of words made themselves explicit in my research. But nowhere was this more evident than in the tensions between the terms *marine debris* and *plastic pollution* as they surfaced at the Fifth International Marine Debris Conference in Honolulu, an event hosted by the National Oceanic and Atmospheric Administration (NOAA) and the United Nations Environment Programme (UNEP) in March 2011. Tensions at the conference coalesced around the "Honolulu Commitment," a two-page document meant to codify agreement and cooperation among the many government, corporate and nonprofit stakeholders in attendance. It generated just the opposite effect. As recounted by Algalita's President, Bill Francis, the draft version circulated at the beginning of the conference had a surprising omission: it made no mention of plastic. Francis poured over the titles for the over six hundred papers to be presented at the conference and found that close to seventy percent made arguments directly addressing plastic. As he explained in frustration, "the fact is, something like 70% of marine debris is in fact plastic, and to ignore especially in light of UNEP calling it an emerging issue, to me just seemed ludicrous" (Bill Francis, personal interview, 2012). Others too, like Plastic Pollution Coalition co-founder Daniella Russo, began to

sense that something was amiss. Even the official vocabulary of event organizers and sponsors exhibited a calculated avoidance of the words plastic and pollution, especially in combination. Plastic, Russo noted, was one "Who Must Not Be Named" (Russo 2011a; 2011b). What was going on?

Marine debris, the term of choice for scientists and government officiates, evokes the apolitical bent of objective description and the guarded authority of entities like NOAA. By the final Honolulu Commitment definition, marine debris can consist of "any anthropogenic, manufactured or processed solid material, irrespective of its size, discarded, disposed of or abandoned in the environment" (UNEP 2011). This broad definition leaves space for other kinds of things like tin cans and wooden shipwrecks that need to be addressed by policy and other efforts. But this very inclusivity allows the phrase to be mobilized in attempts to separate the material from the problem, particularly in ways that distance responsibility from specific products and organizations. The conference, it so happens, listed as its two major sponsors none other than Coca-Cola, a company thoroughly entangled in disposable plastic production, recycling and greenwashing, and the American Chemistry Council (ACC), the trade industry association for plastic producers.

Not all marine debris is plastic; but, as Francis, Russo and even UNEP point out, most of it is. To speak more specifically of plastic pollution then is to keep the matter with the concern, to name a problem that demands action. The incommensurability of these approaches leaves its traces in the Honolulu Commitment. After many hours of negotiation at conference working sessions, the editors agreed to make note of the relationship between marine debris and plastic pollution. This concession was bartered in

exchange for allowing the plastics industry to mention their work on a plan for reducing the amount of pollution. The final document makes a single reference to "plastic debris," followed by a much longer qualification "recognizing that other materials also constitute marine debris" (UNEP 2011).

The politics of words was not limited to conference deliberations; it permeated everyday practices at Algalita, especially challenging for a nonprofit that aims to raise awareness while maintaining a reputation for scientific accuracy. Writing a script for an education video, Algalita's education coordinator wondered where to begin. She worried plastic pollution was "too activist," but that marine debris seemed to be "what the government uses." Moreover, it was too general a description for Algalita's activities that are unapologetically focused on plastic. Algalita, she felt, was "right in the middle," with a tendency to switch back and forth between the two. This tendency is maintained (perhaps unintentionally) in the final cut of the education video, which begins with "plastic," but is distributed as part of a "marine debris science" education kit. With my actor's categories in tension and flux, it was becoming clear that I would either need to take sides or come up with my own terms.

By *garbage patch*, I mean one of the many accumulation zones of floating waste in the open ocean. Though not without detractors, garbage patch is the term most commonly used by journalists and the public. I discuss in detail its origins in Chapter 1, and some of its limitations in Chapter 2. There is a common tendency to conflate the waste with the *gyre*, the relatively stable patterns of currents and weather, which I call where possible, by their full names. A garbage patch is shaped by and located in a gyre,

but at least in scientific terms, it is not the gyre itself. To put this into practice with an example, take Figure 0.2, a map of the North Pacific provided by NOAA:

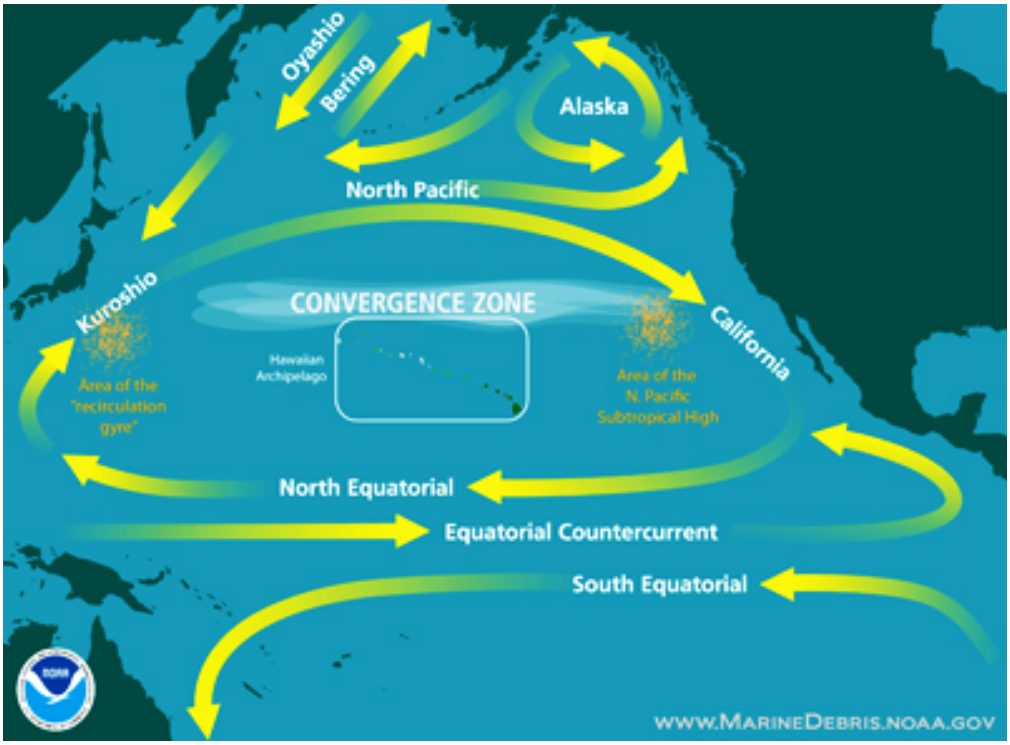

Figure 0.2: Map of major currents and accumulation zones in the North Pacific Ocean. Source: NOAA.

The arrows trace the movements of the major ocean currents, with those encircling Hawaii constituting the *North Pacific Subtropical Gyre*. For simplicity, educators and journalists often locate the garbage patch in the 'middle' of this system without being too specific, but NOAA's map demarcates two distinct 'areas' of accumulation. The one to the east, between Hawaii and California and labeled "Area of the N Pacific Subtropical High," corresponds with the infamous *Great Pacific Garbage Patch*.[12]

[12] Not only does the map not mention a garbage patch, but the bottom right corner directs audiences to NOAA's "marine debris" resources, a website that attempts to contain the "garbage patch" with scare quotes.

I locate my own plastic politics with the terms *gyre plastic* and *ocean plastic pollution.* By gyre plastic, I emphasize the importance of circulation and movement for plastic materials, and my relationship to them. At the same time, I have narrowed my focus (at least for this dissertation) from *all* plastic in the ocean to plastic that travels great distances across and around the Pacific. When I use the term ocean plastic pollution, I refer to a constellation of matter and concern, but I also take sides: I do very much believe that there is an alarming amount of plastic in global oceans and that we need to do something about it.

Plastic Oceans of Waste and Wonder

The garbage patch floats at the nexus of coupled histories of consumer culture and ocean environments. By following plastic in its multiple circulations, and approaching them as matters of concern, I aim to cut across the persistent divides of nature and culture, science and social science ways of knowing. More specifically, I complicate western cultural traditions positioning the ocean in similarly binary terms of promise and wonder, or wasteland and threat (Hagood 2013; Helmreich 2009).

In the mid-twentieth century, as modern plastic products infiltrated spaces of everyday life, so too did a passion for all things oceanographic. Rachel Carson's *The Sea Around Us* (1951), in particular, imparted a sense of aquatic wonder and ecological aesthetic to human relationships with the ocean. Yet, as Amanda Hagood (2013) argues, the lessons of Carson's work tended to enter the home as object of consumption and alongside assumptions that marine-military and marine-scientific expansion was part of the narrative of progress. Interest in the sea emerges as "both a desire to connect with the

earth and the imperialist environmentalism of the industrial economy" (Hagood 2013: 73). This ecological "sense of wonder" co-existed with assumptions that the sea was an unlimited resource and dumping ground, so vast as to be immune to human intervention. By the late 1950s, as Barthes was declaring plastic a "miraculous substance," a source of endless possibility (1972: 97 [1957], Carson began rethinking earlier claims about an ocean exempt from human influence by detailing the threats of nuclear waste to the seas (Alaimo 2012: 486). In the 1960s and 1970s, the promise of plastic was also increasingly plagued with doubt, as encapsulated in the consumer disillusionment of *The Graduate*, and Barry Commoner's ecological critique of synthetic plastics interrupting natural order (Meikle 1997). By the beginning of the 21st century, cultural understandings of plastic had shifted from the miraculous to the mundane and even dangerous; and the ocean from invincible to endangered.

The tendency to approach the ocean through a "duality of wonder and waste," however, endures.[13] In studying the multiple becomings of the garbage patch as it comes to matter, I join STS and environmental humanities scholars striving to understand the ocean in its many mediations, moving beyond the twentieth century legacy of the ocean as either sublime or threat/ened (Helmreich 2009). These studies turn to media ecologies, multi-species relationships, and even seawater itself in interrogating nature-culture relations and aquatic environmental futures (Alaimo 2012; Hayward 2010; Helmreich 2009; 2011). Here I am concerned with the transformative capacities and generative

[13] It can be found, among other places, in the lyrical prose of Deborah Cramer's (2002) *Great Waters*, in the myth of a plastic trash island as resource to be reclaimed or made habitable by humans (Chapter 2).

potential of gyre plastic, as it offers new possibilities for understanding human relationships with oceans.[14]

Chapter Maps

Each of the five chapters that follow focuses on one of the many material "ingredients" that, in their associations with plastic, constitute the Great Pacific Garbage Patch as a matter of concern: water currents; island absences; people on boats; knowledge; and marine life. Their respective trajectories trace multiple patterns of movement, circulating sometimes together as with fish taking shelter under a plastic crate in the open seas, at other times circulating apart, as with attempts to sort and classify samples as they move to and through in the laboratory. Together, they map the many becomings of plastic waste as a garbage patch and in the production and sharing of knowledge about it.

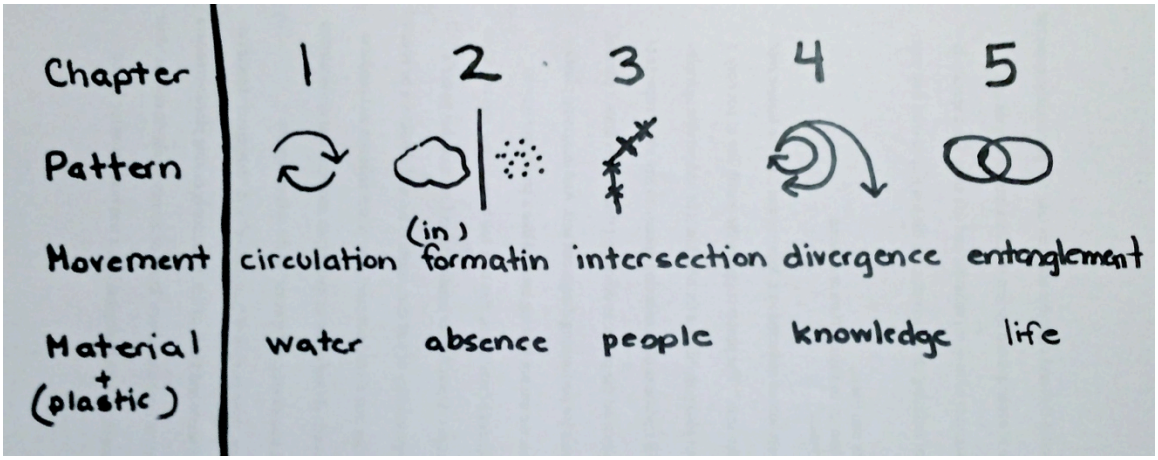

Figure 0.3: Provisional map of the chapter 'ingredients' and their respective circulations.

[14] This project can also be situated among growing intest in waste and discard studies more generally (Giles 2007; Strasser 2000). In tracing trajectories of lost and discarded plastic, I join others attending to afterlives in the biographies of things (Guins 2014) and the ethos of wate in consumer culture (Hawkins 2005).

In Chapter 1, "Pacific Currents: Plastic and Water Circulating in Science," I trace the convergence of ocean currents and gyre plastic as objects of scientific study in the late 20th century. I draw on a systematic analysis of the scientific literature on marine debris and ocean currents, and where possible, interviews and fieldwork with those involved from around the North Pacific. Though scientific research documents plastic in the open ocean in the early 1970s, plastic must be understood to circulate together with ocean currents (and without humans) before there can be a garbage patch. I complicate the popular narrative of Great Pacific Garbage Patch "discovery" by showing the much more gradual processes that enable gyre plastic to be encountered and studied as a problem in its own right. As gyre plastic transforms from an overlooked or simply aesthetic blemish to a global concern, it marks the transformation of human relationships with synthetic materials and with the sea.

The garbage patch, however, is perhaps best known not as an object of scientific study, but as a trash island of immense proportions solidified by the mainstream media. In Chapter 2, "Trash Island: The Materiality of Things that Aren't There (But Could Be)," I describe how multiple forms of the garbage patch come to circulate as a problem (or not) in news coverage about it. Approaching trash island not as a misrepresentation, but as a case of missing materiality, I extend media analysis through interviews with key figures and a focus on interactions with the presence/absence of plastic at sea. In doing so, I develop an analytical framework of dismissive, corrective and constructive encounters to describe different kinds of attempts to solidify the material form of the garbage patch as myth, as plastic soup and as island-to-be respectively. I argue that the

very form and existence of a plastic problem is inextricably connected to forms of care, pointing to the enduring power and generative potential of both trash island and material absence more generally.

It is in the shadows of trash island that I head to sea, departing from Honolulu on Algalita's July 2011 North Pacific Expedition. Chapter 3 "Witnesses in the Garbage Patch: Intersections of Humans and Plastic at Sea," documents my experience sailing through the gyre in the company of thirteen scientists, activists, journalists and curious members of the public interested in seeing the garbage patch with "their own eyes." The movements of humans on a boat cut a line across gyre currents, intermittent encounters with plastic pieces and sample sites become intersections marked with points on a map. Despite assumptions that a twice-Texas sized garbage patch would be self-evident, seeing a plastic problem without seeing a trash island requires all kinds of work of which science is only a small part. Plastic becomes a garbage patch (or not) as we become witnesses through collective practices of running the boat, learning to see plastic, and reconciling the presence of tiny plastic fragments encountered by the narrow slice of our travels with the enormity of the ocean we do not see. Though seeking the reality of the problem in the corrective encounters of direct experience, the multiple forms of the garbage patch do not resolve neatly into a single "true form" of the problem.

Where Chapter 3 focuses on intersections at sea, Chapter 4, "Diverging Models of Science and Activism: Plastic Knowledge in Motion," traces split trajectories after the expedition. I link processes of collection at sea to the possibilities for some plastic's future travels. Drawing on participant observation in the separate spaces of Algalita's laboratory and office, I trace the divergent pathways of gyre plastic samples as they are

measured into scientific data and enlisted in projects of demonstrating plastic problems to the public. Yet gyre plastic continues to escape for human plans to know and contain it on a global scale, challenging traditions of locally bounded laboratory studies in STS, and models of garbage patch science and management more generally.

Of the many things I learned at sea, none had more lasting impact on the direction of the project than the term "Plastisphere" and the communities it describes where marine life and plastic meet. In Chapter 5, "Plastic Species: Tangled Naturecultures in the Plastisphere," I move from circulation as divergence to circulation as entanglement. Exploring the "plasticity" of the category of 'species,' I document attempts to disentangle assemblages of natureculture at Algalita's laboratory where sample sorting involves deciding what gets counted as life (not plastic) and what does not (plastic). I then consider public education campaigns featuring warnings about dangers plastic bottle "fish" and other plastic-crossed creatures, paying particular attention to assumptions about whether plastic species should or should not meet. I argue that the 'danger' of garbage patch relationships lurks not in associations but in the very categories used to understand and live with forms of plastic and forms of life. Here belonging and responsibility emerge with kinds of materials, and gyre plastic becomes ecology: not only matter out of place, but matter of life and death.

Plastic can now reportedly be found not only floating in all the world's oceans, but frozen into arctic ice sheets, and embedded in a new kind of conglomerate rock (Corcoran et al. 2014; Obbard et al. 2014). As I finish writing this dissertation, the international Anthropocene Working Group deliberates whether or not we are now living in a distinct geological epoch defined by human intervention on a planetary scale

(Sample 2014). This dissertation offers possibilities for rethinking the cultural and political foundations of science and ecology in the face of unprecedented global environmental challenges.

Chapter 1
Pacific Currents:
Plastic and Water Circulating with Science

According to a widely circulated narrative, Captain Charles Moore discovered the Great Pacific Garbage Patch by chance in 1997. Sailing home to California after a boat race in Hawaii, he took a little-travelled shortcut through the wind-starved doldrums in the North Pacific. Fuel reserves dwindling, boat slowed to a crawl, Moore began to notice an alarming amount of plastic waste floating in the surrounding waters; scatterings of consumer objects and synthetic fragments that seemed to stretch endlessly to the horizon. Where the wind failed to propel the boat, the encounter with trash so far from land compelled Moore to redirect nonprofit Algalita and his own work toward marine plastic pollution research and education. While he did not, as he now clarifies often and with great emphasis, find an island, a mountain, or a vortex of plastic, he did begin to bring public attention to marine plastic pollution. So the story goes.

Though Captain Moore's discovery is often cited as a key moment in garbage patch history, it is far from the first encounter between humans and plastic in the ocean. But where others sailed through the same area without noticing plastic, or even recorded observations only to dismiss the problem as aesthetic, Moore saw pollution that demanded action. In this chapter, I position his tale as one of many intersections of circulating humans, plastic, concerns and currents in the Pacific. The chapter is populated by oceanographers and plastic fragments, but also by beachcombers, analytical chemists, Nike shoes and papyrus rafts. Their encounters involve all kinds of accidents and contingencies —equipment fails, shipping container spills, shortcuts that are not — but

they also mark a much more gradual transformation of the place plastic in the ocean and the ocean sciences.

Shifting emphasis from discovery to circulation helps open up histories of science to diverse actors and to potential understandings of movement as transformation. I take cues from historians that approach the emergence of modern science through the circulation and encounters of people and things. Harold Cook (2007) links science to commerce rather than religion, connecting changing ideas and the exchange of stuff in global Dutch trade of the 16th and 17th centuries: "the so-called scientific revolution resulted from movements in the world and in persons, leading to countless efforts to find out matters of fact about natural things and to ascertaining whether that information was accurate and commensurable" (Cook 2007: 81). As the careful observation and exact description of material goods for trade become a way of knowing nature, the movements of goods and collection of specimens do no simply accumulate knowledge, but change how knowledge is made and what it means. Kapil Raj (2007) also argues that diverse actors are transformed as learning and trading are intertwined in the gathering and transformation of objects and the exchange of 'facts.' Taking circulation itself as the very site of knowledge formation, Raj 'relocates' the making of modern science from European laboratories to material practices and encounters in South Asia. This emphasis on circulation points to "the *mutable* nature of the materials – of the men themselves and of the knowledges and skills which they embodied – as also their transformations and reconfigurations in the course of their geographical and/or social displacements" (Raj 2007: 21). Such approaches leaves space for both objects and people to be transformed through the observation, gathering and exchange of material things and facts.

Though by no means commensurate with the specificities of Dutch empire or early modern science, shifting focus from narratives of individual "chance discovery" (Moore and Phillips 2011) to all kinds of material relationships with the sea helps show the conditions that allowed Moore's observations to become transformative where others were not. This is a story of the changing place of plastic in the ocean sciences, from a chemically inert material for (often disposable) instruments and a tool for mapping currents to a bioactive substance as object of study in its own right. In the process, the presence and movements of consumer plastic goods become associated with ocean currents and are even used to study them. This is also the watery part of the story of how plastic acquires the capacity to not only accumulate, but to "gather" (Latour 2004) diverse actors to the middle of the ocean, whether in pursuit of scientific knowledge or an elusive trash island. If Cook and Raj[15] are concerned with the movements of goods, gyre plastic qualifies as the movement of what Ulrich Beck (1992) calls 'bads,' modern risky things with the capacity to escape attempts to know them.

In the first section of this chapter I tell the stories of three scientific publications often cited as the origins of studies of plastic marine debris in the open ocean, where science starts to take note of floating synthetics in the early 1970s: in the Pacific, Elizabeth Venrick's sightings of plastic bottles and other consumer goods published in *Nature* in 1973; in the Atlantic, Thor Heyerdahl's accounts of oil clots and other synthetics in the Atlantic shipping lanes published in *Biological Conservation* in 1971; and Edward J. Carpenter and K. L. Smith's characterization of plastic pellets and

[15] I also take inspiration from William Cronon's (1991) descriptions of the transformative market relations and flows of material goods – lumber, grain, meat – connecting city and country, nature and culture alike.

fragments collected in the Sargasso Sea published in *Science* in 1972. None of these researchers set out, at least initially, to find plastic or study pollution, yet they produced the first records in the academic literature. Positioning their 'discoveries' as encounters between humans, plastic and oceans, helps make sense of why they were able to see plastic where others did not. While both identifiable objects and small plastic fragments make themselves visible to researchers, they do not have a particularly transformative impact on ocean sciences at the time.

The following sections detail the transformation of ocean currents and later ocean plastics into objects of modern science. I show how "Garbage Patch" accumulations of plastic waste were first predicted in 1980s and 1990s, as mapped and modeled gyre currents get caught up with the movements of equally modern plastic consumer waste, especially in the North Pacific. As plastic becomes a tool for the study of currents for oceanographers in North America, an analytical chemist in Japan shows that moving plastic pellets also transport toxins as they circulate. These movements of plastic, with currents and with chemicals, challenge assumptions about the material's status as an inert solid. They also show how movements of gyre plastic 'gather' new communities, and potentially transform how ocean science is done.

This chapter is based on interviews with key actors, analysis of the scientific literature, and readings of primary and secondary texts. It is assembled from fragments and bits, from pieces of my own encounters doing fieldwork around the edges of the Pacific, at sites as close as a bike ride to the nearby Scripps Institute of Oceanography, and as distant as a laboratory tucked in the far corner of the Tokyo Agricultural University. Though many actors travel great distances, the story itself circulates,

returning like ocean currents to points where it has started, if not in the same way. The chapter begins on a boat in the middle of the Pacific, where a group of researchers has travelled to study ocean ecosystems outside the reaches of human influence; it ends some 40 years later, on a boat at almost the exact same coordinates, where a group of researchers has travelled to study just how far human influence has reached.

Plastic in *Nature* and *Science*

Dr. Elizabeth Venrick, biological oceanographer and research professor at the Scripps Institute of Oceanography, has a distinguished career studying pelagic ecosystems, the surface communities of the open ocean. She specializes in phytoplankton, the microscopic plant-like organisms that form the foundation for all life in the ocean, and began conducting fieldwork in the 1960s when few women went to sea.[16] Venrick is far less well known as the lead author of a very short article that happens to be the first scientific publication to note consumer plastics in the middle of the Pacific Ocean. It is with hopes of learning more about this plastic publication that I have rolled down the hill from the UCSD main campus on my bicycle for a visit to her office. The power has gone out, and as we sit in the dim daylight among the organized clutter of decades of research, speaking humbly but surely, she tells of a cruise that did not go as planned some 40 years before.

In August 1972, Venrick was a young post-graduate student at Scripps, part of research expedition C'BOG sailing far out in the Pacific to study plankton communities.

[16] In Laura Harkewicz's lengthy oral history detailing Venrick's career and time at Scripps there is no mention of plastic or her article in *Nature* (Venrick 2005).

At the time there were already concerns about global chemical pollutants, especially with artificial nutrients causing nearshore plant communities to thrive to the point where they deprived other ocean life of oxygen. Wanting to understand natural communities, research expeditions like C'BOG headed to the open ocean precisely to avoid problems of contamination plaguing coastal areas as a result of human processes and products. But weather and equipment were not cooperating. Riding the tail end of a hurricane, a combination of engine trouble and a broken winch meant research could not proceed as planned. As they motored back to land, there was little to do but gaze out at the now calm seas. Until they began to see all kinds of stuff floating where it did not belong.

It started off casually: "Guess what I saw today." Then the crew established a 'junk log' to pass the time. Venrick still has the original rules sheet, neatly penciled on a piece of card covered in strips of now-yellowed tape for waterproofing. It instructs participants to observe for a minimum of 15 minutes continuously, while looking for "non-endemic surface debris." The log itself, which she also produces from her filing cabinet in the original, has columns for recording the date and time of the observation, the ship's speed and additional comments, "barnacles attached" reads one box. Their log records the unexpected sightings of "1 red rubber thong," a "coffee can" and an "old balloon." Upon their return, Venrick and colleagues described a sea surface "littered with a startling array of man-made objects, even 600 miles from the next major civilization (Hawaii) and outside the major shipping lanes" (Venrick et al. 1973: 271).

Venrick wrote up the results of their observations, with the cruise tech guy, two graduate students, and Chris Platt (who is now working with the National Science Foundation) as co-authors. They sent the work off to *Nature*, where to their surprise, it

was not only published, but without revisions. The resulting article, "Man-made Objects on the Surface of the Central North Pacific Ocean," now reads as strangely prophetic. While the log was not specific to plastics, they take care to emphasize the synthetic objects that account for two-thirds of the sightings, distinguishing them from glass fishing floats which they reason, can claim a historical and aesthetic place in the sea. This is followed by a striking conclusion cautioning that "unless we find adequate means of disposing of our plastic products soon, we can anticipate that the 'Wynkin Blykin and Nod' of our children will set sail into a plastic sea, accompanied by all the 'no-deposit — no-return' products of our technology" (Venrick et al. 1973: 271).

But at the time the article and its publication were rather tongue-in-cheek. On closer inspection, it looks a bit strange sharing a page with a report about "Induced Nucleophilic Substitution," and Venrick explains that at the time *Nature* was publishing series of humorous short pieces (she recalls another about dangling ropes in black holes). While based on actual observations and calculations, the joke is in extrapolating from a very small sample size of 53 total observations to the entire surface of the sea. Most impressively, the authors use the sighting of a mere six plastic bottles and the ratio of bottles to fishing floats to estimate a total of 5 million bottles floating in the Pacific, by their most "conservative estimate." Venrick, notes with a laugh, that this remains her only work to be published in the prestigious journal (she does have her plankton research published in the equally respected *Science*).

Though Venrick's report is the first from the Pacific, it is preceded by several middle-of-ocean trash reports from the Atlantic. Venrick herself had recently read about Thor Heyerdahl, Norwegian ethnographer of *Kon-Tiki* fame, spotting synthetics in the

middle of the Atlantic in 1969 and 1970. He too had not intended to study pollution, synthetic or otherwise. When Heyerdahl and team set sail from Morocco on a papyrus raft, the *Ra I* in 1969, they set out to test ancient Egyptian design on the open seas. By crossing the Atlantic, they hoped to demonstrate the possibility of early contact between old and new worlds, not to demonstrate the presence of synthetic materials in the middle of the ocean. But leaning over to brush his teeth one morning in early June, Heyerdahl started to see lumps of what looked like asphalt, sticky synthetic 'oil clots' (also known as tar balls). Moving much slower and closer to the water that usual for vessels following this route, and in remarkably calm weather, "pollution observations were forced upon all expedition members due to its grave nature" (Heyerdahl 1971a: 164).

Shocked that the Atlantic was polluted even way out in the middle, the team reported "a rich flotsam of non-organic material of rather homogenous appearance and undoubtedly resulting from modern commercial activity," almost equidistant from the coasts of Africa and America (Heyerdahl 1971a: 165). The *RA I*, unfortunately, started to disintegrate soon after, sinking the boat, but not their spirits. The team set out again 10 months later on the *Ra II*, this time, with pollution in mind and plans to record daily sightings of floating waste in the Atlantic. Though the resulting scientific publication in *Biological Conservation* focuses on oil clots, they also note sightings of plastic bottles, squeeze tubes and other synthetic consumer goods (Heyerdahl 1971b).

These observations were especially shocking because they stood in such vivid contrast to what Heyerdahl saw twenty-four years earlier crossing the Pacific on the *Kon-Tiki*, a balsa wood raft that was effectively moving just as slowly and as close to the water as the papyrus crafts. In his best selling account of the *Kon-Tiki* adventure,

Heyerdahl writes of a sense of oneness between raft and sea, and of a sublime separation from the troubles of developed human worlds, of which there are no material traces to be found:

> We saw no sign either of a ship or of drifting remains to show that there were other people in the world…. To us on the raft the great problems of civilized man appeared false and illusory –like perverted products of the human mind. Only the elements mattered. And the elements seemed to ignore the little raft. Or perhaps they accepted it as a natural object, which did not break the harmony of the sea but adapted itself to current and sea like bird and fish. (Heyerdahl 1984 [1950]: 96)

Two decades later in Atlantic, the *RA* voyages are redefined by ocean pollution he could not ignore. Encounters with synthetics were particularly jarring in juxtaposition with the initial *Ra* mission, which like the *Kon-Tiki,* was meant to establish the possibility for long distance human travel by challenging the accepted capacities of ancient design and *natural* materials: balsa, bamboo, hemp and papyrus. As Heyerdahl explained to *Life* magazine: "I started out this voyage to get a glimpse into man's past but I got just as much a glimpse into man's future" (Moore 1971). Worried about ocean pollution that was no longer "a mere offense to human aesthetics," Heyerdahl shared his findings with the United Nations, in hopes of changing policies regulating waste dumping and oil tank cleaning at sea.

Just over a year after the *Ra* expeditions, in January 1971, Woods Hole Oceanographic Institute (WHOI) scientists Edward J. Carpenter and K. L. Smith were working in coastal waters of Niantic Bay off New England, assessing the possible impacts of a nuclear plant on the near shore marine communities. And they noticed a large number of strangely uniform plastic spheres in their samples (Carpenter et al. 1972). Carpenter admits that they had likely encountered the pellets before without

noticing them, but the especially high density in Niantic Bay — 20 pellets per cubic yard of water — made them harder to miss. Then in September 1971, the same pair were aboard the 210-foot research vessel *Atlantis II*, studying communities in the Sargasso Sea. They were going about their usual research business, using a surface-skimming net with a one meter opening to collect samples of the marine life among the mats of sargassum seaweed that give this area its name. In these routine samples, they began to notice plastic fragments, tiny pieces gathered together by the fine mesh of their plankton nets. Unlike the plastics in the nearshore samples, these pieces were highly varied in color and shape, suggesting multiple origins. Investigating further, they realized that though oil clots (which they also saw from the *Atlantis II*) had received some attention thanks to Heyerdahl and team, the presence of synthetic particles had not been reported in the scientific literature.

Like Heyerdahl and later Venrick, Carpenter and Smith also noted the presence of identifiable items – jewelry, syringe shield, cigar holder, button snap – but their report in *Science* is the first published work to focus on what are now called 'microplastics' in the open ocean. Carpenter and Smith describe two kinds of pieces as most common in their samples: hard white cylindrical spheres, and jagged edged fragments that are 5 millimeters or less in diameter. Though their small sample size of only 11 net tows for a whole ocean limits generalizations (no statistical jokes here), their study sets up many of the questions that continue to shape studies of plastics in the ocean. The New York Times coverage of the issue reports "countless' pieces of plastic in the Atlantic, but Carpenter and Smith's protocol borrowed from plankton studies involved setting up the conditions for doing just that: counting and weighing all the tiny pieces in their samples in order to

understand how much plastic might be out at sea and how widespread it might be, tasks that researchers continue today. Carpenter and Smith note the presence of diatoms and other microorganisms on the fragments, confirming that communities live on the surfaces of even the tiny pieces, suggesting possible population increases for certain species, noting the kinds of plastic-life relationships that now figure in studies of rafting and the plastisphere (Chapter 5). Their relatively short article also manages to outline possible relationships between toxins, plastics and marine life, identifying plastics as the possible source of PCBs in the water.

Why, in a relatively short span of time do three separate research projects produce reports of synthetic pollution in the middle of both the Atlantic and Pacific Oceans? Venrick suggests, like Carpenter and Smith, that with increasing plastic production and by the early 1970s floating plastic reached a kind of critical mass that was simply more noticeable than before. Both Heyerdahl and Venrick mention exceptional relationships between crew and the sea surface: Heyerdahl traveling low and slow for weeks on end, Venrick traversing unusually calm weather and seas. In each case there is an element of precedent: Heyerdahl's ability to compare with the *Kon-Tiki*; Venrick having read Heyerdahl's report from the Atlantic; And Carpenter and Smith's nearshore samples. What I believe is most important, however, is the very possibility of seeing gyre plastic as pollution. This comes not only from the technical possibility of visibility at sea–whether because of prevalence or providence–but from steadily growing material doubts about the 'wonders' of plastic and a burgeoning environmental movement accompanied

by anti-littering campaigns. Plastic, in short, was also accumulating a bad reputation on land.[17]

But the trajectories connecting floating plastic to land remained a mystery. At the time of publication in 1972, Carpenter and Smith were still working to figure out the origins of the strange spheres, which they soon learned are industrial pre-production pellets (or 'nurdles'). But where the uniformity of the near shore spheres pointed to a single source (likely a local factory), pellets and fragments from the open ocean appeared to be of diverse resin types and likely disparate origins. Still, local human actions seemed to be the most likely explanation: the dumping of trash or cleaning of ship's tanks directly in the open ocean. In all three cases, however, it is precisely the opposite – objects and bits appearing so far *removed* from human activity – that makes the presence of plastic in the open ocean remarkable. Since the *Kon-Tiki* was far outside the shipping lanes, travelling for over three months without encountering a single ship, whereas the *Ra* travelled directly in the Atlantic shipping lanes, proximity to humans seemed a likely explanation for two very different experiences of the open seas. Heyerdahl describes immediately looking up for a ship upon his first encounter with the oil clots, assuming that they must have a nearby human source. Though he is surprised when said ship fails to materialize, he continues to point to human agency, condemning the "continued indiscriminate use of the world's oceans as dumping ground for durable human waste" (Heyerdahl 1971b). Carpenter and Smith were less convinced of the link between shipping lanes and the presence of plastics, noting that plastics were spread over a huge

[17] For a thorough account of how the promises of "modern" plastic give way to material doubts over the course of the 20th century, see Chapter 8 of Jeffrey Meikle's (1997) wonderfully comprehensive cultural history *American Plastic*.

area, only the southernmost part of which overlapped with commercial activity. While they did consider dumping of waste from cities and ships as the likely origins, they questioned how directly this was happening, noting that the closest large city – New York – was over 900 kilometers away. Venrick also noted that observations took place well outside shipping lanes. It is precisely the distance from human commerce, communities and practices – from the makers, users and discarders – that makes gyre plastic worthy of occupying column space in prestigious scientific publications.

Their reports, however, do not offer alternative explanations for how plastic travelled to such remote reaches of the seas. In a brief survey of the marine plastic scientific literature, SIO oceanographer James Leichter comments that none of these early accounts call upon ocean currents to explain areas of extreme pollution; they do not connect the presence of plastic in the open ocean to circulating gyre currents. This is true of the scientific publications. A popular news report covering the research at the time, however, does suggest a link between the concentration of floating plastics and gyre currents. After describing Carpenter and Smith's encounter with plastics, the article then offers the following description of a Sargasso Sea that "lies in the middle of circular currents that create a low whirlpool effect, concentrating floating objects toward the center" (Rensberger 1972). If only by juxtaposition, there is a sense that patterns of ocean circulation, as well as human circulation, play a role in the movement and accumulation of plastic.

Despite observations of high concentrations of plastic in surprising locations, the resulting articles received limited attention from the scientific community or the public. Heyerdahl presented his observations to the United Nations, where they slowly trickle

toward changes in ocean dumping policies, while Carpenter quietly settled his concerns about plastic pellets in coastal waters directly with the plastics industry (Meikle 1997). Venrick continued to study phytoplankton communities, mostly remembering her article as 'the one she got in nature." The question of the relationship between plastics and PCBs in the water is left largely unaddressed, not returned to in full force until a mid 1990s surge in concerns about endocrine disrupting chemicals. At the time, Venrick explains, no one realized that plastic was a pollutant in the bio or chemically active sense. In other words, what they encountered was 'matter out of place,' not a potentially toxic substance. The plastic was considered an aesthetic affront, the ocean equivalent of roadside litter. Its status as such was based on a cultural sense of which materials belong at sea and which do not. Heyerdahl argues for a 'natural' relationship between balsa raft and sea, and Venrick even suggests that glass floats have an achieved status of belonging at sea. Interestingly, she explains this difference between glass and plastic in historical terms of a long-established presence in the ocean, not by appealing to material properties of endurance or chemical reactivity. Like glass, plastic was assumed to be effectively inert. Objects might entangle wildlife, but as noted in the publication, plastic was "unlikely to enter the food chain and threaten human welfare" (Venrick et al. 1973: 271). Though fragments and PCBs were observed in the Atlantic, researchers in the Pacific were not really thinking about the larger objects breaking down, and they were certainly not imagining plastic as shifting accumulations of chemicals and marine life with the capacity to move with currents across seas.

Enter the Gyres

In the early 1970s then, multiple groups of humans somewhat independently meet plastic materials where least expected. But for most part, these are encounters with pollution in a limited aesthetic sense and researchers do not officially call upon ocean currents to explain what they have found. If matter is out of place, humans have misplaced it. This was not because of a lack of knowledge of large systems of ocean circulation. The same processes that concentrate floating objects in the Sargasso Sea, were understood to create similar circulating systems in the North Pacific, South Pacific, South Atlantic and Indian Ocean 'gyres.' Though these patterns had been described in the 19th century, named gyre systems only appear as recently as the 1950s, after physical oceanography is firmly established as a mathematical science.

In *The Fluid Envelope of our Planet*, historian Eric L Mills chronicles the transformation of the ocean sciences from a field based on observation and common sense to a mathematical science concerned with modeling and prediction. Mills locates the height of this process in the 60-year period between the 1890s and the middle of the 20th century, but first ocean currents had to become objects of modern science. Despite a wealth of seaman's lore about surface currents and wind patterns, ocean currents were rarely depicted in renaissance maps of the sea. The ocean was an obstacle to cross or source of wonder, but not itself an object of systematic inquiry. Moreover, currents aiding in rapid navigation, like the North Equatorial Current identified by Spanish sailor Berdardo de la Torre in the Pacific in 1542, were not understood in relationship to return flows. Though these large-scale currents began to appear on navigation maps in the late 17th century, it was scholars and not mariners that proposed a system of ocean circulation at the time of the scientific revolution. Circulating patterns of water movement must

exist, they reasoned, as otherwise flows of water would leave empty space in their wake (Mills 2009: 4). Writing on the 'motion of the ocean' in 1677, Dutch scholar Isaac Voss described a single continuous system where "all the waters of the Ocean turn around in a circle, and return to the same point from whence they departed," with each ocean following a similar pattern, proceeding clockwise in the Northern and counterclockwise in the Southern hemispheres (2009: 17). Voss attributed the system to atmospheric circulation, in particular the regularity of the trade winds, which mariners had long connected to the direction of surface currents. For over two centuries that follow, arrows continued to mark current directions on maps, but few scholars agreed or even speculated upon their causes and mechanisms (2009: 10).[18] With theories of fluid dynamics applied to studies of electricity, the atmosphere and ether, it seemed that pretty much everything except the ocean was being studied mathematically at the time.

It is in late 19th century Scandinavia that quantification spills out from laboratories into the ocean, and common sense loses out to mathematical simplification and the hope for prediction (Mills 2009: 6). At the time, biologically trained marine scientists were having trouble explaining the distribution of fish and their food, especially variation in the seemingly declining cod fishery, a subject of much government concern (Finley 2011). A zoologist did notice that cod roe are pelagic: they inhabit the surface of

[18] In the 1830s, Alexander von Humboldt, approaching the whole earth as interconnected physical systems, that proposed it was not wind alone, but all kinds of mechanisms including polar cooling and variations in density that effected water movement. More importantly, Humboldt was convinced that nature could be revealed and systematized through measurement. In Mills account, Humboldt's synthesis gives way to a lively debate over the causes of ocean circulation between physiologst W.B. Carpenter's general theory of polar cooling-based vertical circulation and clerk James Croll's calculations of wind-driven surface circulation. For Mills, this is the last significant debate about ocean circulation waged in common sense and simple calculation.

the open ocean where they are subject to the whims of currents. The fisheries science emerging at this time coincides with the application of dynamic analysis of cyclonic air systems from meteorology to ocean currents, connecting both surface and deep water movements, wind direction and water density, and later, the rotation of the earth (Mills 2009). As mathematical theories of fluid motion come to replace direct observations of water movement, they also form the basis for the modern management of ocean ecosystems (Finley 2011).

These new methods do not travel seamlessly. Multiple introductions of mathematical ocean science happen before they take hold in North America. On the Pacific coast, this happens in La Jolla, at the Marine Biological Association, now Scripps Institution of Oceanography (SIO), with physicist George F. McEwan translating Scandinavian papers and applying mathematical approaches to North American waters in the first decades of the 20th century (Mills 2009:193-195). With physical oceanographer Harold U. Sverdrup at the helm from 1936, SIO was clearly invested in dynamic oceanography. His field-defining textbook *The Oceans*, published in 1942, is evidence of oceanography solidified as a distinct science. But emphasis on gyre circulation comes still later (there is no mention of 'gyres' among the equations and text in *The Oceans*), in Sverdrup's 1947 publication accounting mathematically for wind driven currents and the Coriolis effect: how the rotation of the earth shapes trade winds curving away from the equator. But where the focus at the flourishing Woods Hole Oceanographic institute on the East Coast looked to the open ocean, work at Scripps had a tendency toward local, coastal environments, such as the California current, and Sverdrup worked with an open-ended model that did not include Asian landmasses. His former student, Walter Munk, is

the one that adds a western coastal boundary to the model that ocean gyres are accounted for quantitatively in a simplified rectangular ocean abstraction. The resulting circulating patterns – clockwise (anticyclonic) in the Northern and counterclockwise (cyclonic) in the Southern Hemisphere, are systematically applied to all oceans for the first time (Mills 2009). What comes to be known as the Great Pacific Garbage Patch corresponds with the 'wind-spun vortex' on the eastern edge of Munk's model (Figure 1.1). There is another, if less well-known, accumulation zone associated with the western boundary vortices.[19] It is only after they have been made calculable, that they are classified and named the North/South Atlantic and Pacific Subtropical Gyres respectively.

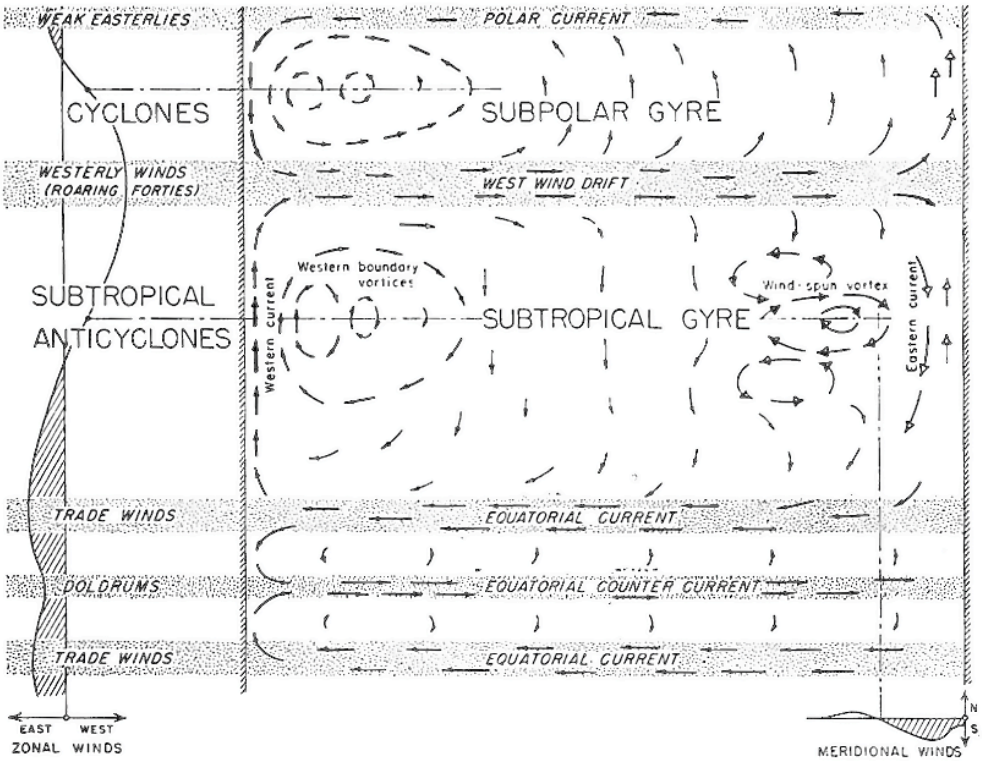

Figure 1.1: Munk's model of gyre currents in the North Pacific.

[19] There are current debates about whether the Eastern and Western garbage patches should be considered separate entities or are better understood as a single zone (as in the Japanese version of garbage patch, the *gomi berulto* or garbage belt) (Carson, personal interview, 2013).

In Mill's intellectual history-of-a-science, it is science alone that emerges altered by these processes. Concluding that "The ocean is largely unchanged, but the science that studies its circulation has been transformed" (Mills 2009: 286), Mill's ocean is separated from ways of knowing it, and, with the certainty of the rotating earth, remains immune to human influence. Yet an ocean explainable by mathematics, measured in numbers rather than described in words, is not the same as the ocean as obstacle to be crossed or the ocean as source of wonder that Mill introduces near the start of his narrative; it *is* an ocean transformed, one made not only calculable, but manageable in particular ways. For contemporary physical oceanographers, it is now possible to imagine the ocean as a kind of abstract surface, the interface between wind and water rather than something full of life (Hafner and Maximenko, personal interview, 2011). Models for currents and the desire for predicting flows at sea are not just abstractly 'better' knowledge; they are very much tied to the fates of fish and the desire to control ocean processes for human ends. As Carmel Finley (2011) argues, for example, the rapid decline of fish stocks in the 20th century is a direct result of attempts to manage them through the calculation of maximum sustainable yield, predicting the number of fish that can be safely caught while maintaining healthy populations. The models, Finely explains, have a tendency to become increasingly divorced from what is happening out at sea while at the same time justifying actions that radically alter what is happening there.[20] From the perspective of the ocean's diverse actors, the cod roe and other creatures decimated by modern management, the ocean is physically transformed in return.

[20] See also Apphun 2009, for an account of management and classification transforming the environment it is meant to protect.

The Garbage Patch Concept

On a dark summer's day in July 2012, with low cloud and moody weather characteristic of this corner of the continent, I visit Jim Ingraham at his ocean view home on Whidby Island, an hour's drive north of Seattle. Ingraham is a physical oceanographer who trained at the University of Washington and specializes in computer models for objects drifting in the North Pacific. Though officially retired since 2004, he is still active in the beachcomber community and is currently working to track the path of debris from the March 2011 Japan tsunami. I'm hoping for a demonstration of Ocean Surface Current Simulations (OSCURS) and the story of how a model meant to track fish got caught up with plastic.

Ingraham was very involved in the development of OSCURS while working for the National Oceanic and Atmospheric Administration (NOAA) and the Alaska Fisheries Center in the 1970s. OSCURS uses US Navy weather data going all the way back to 1901, and, indebted to experiments and models developed in Norway, it is a direct descendant of Scandinavian mathematical techniques. Like them, it was intended to understand the impact of ocean variability on fish populations, in this case, salmon in the Bering Sea. OSCURS is a retrospective model, meaning that it can predict where seawater a specific point (say the mouth of the Columbia River) may have been six months previously, or, adding wind to the equation, suggest the path an object likely followed (Ingraham 1997). But all this was rather specific to water and fish.

Until January 1991, that is, when an armada of Nike shoes began washing up on the shores of Vancouver Island and soon after, the Oregon Coast. Curtis Ebbesmeyer, a

Seattle-based oceanographer and avid beachcomber, was eating lunch at his parents' house when his mother handed him a newspaper clipping covering the Nike invasion. Ebbesmeyer promised he would look into it. Though shipping losses are secretive business, Nike's transportation department was surprisingly forthcoming, confirming that 5 shipping containers of shoes – a total of 78,932 sneakers – fell off cargo vessel *Hansa Carrier* some eight months earlier in a May 27th storm mid-journey between Korea and Los Angeles (the contents of another 16 containers lost at the same time remain a mystery). And since each Nike is stamped with a unique identification number (Purchase order ID or POID) it would be possible to trace shoes back to specific containers and point of entry into the Pacific (Ebbesmeyer and Scigliano 2010). With this critical data in tow, Ebbesmeyer contacted a colleague from his University of Washington days, Jim Ingraham. Between the time and coordinates of the spill and the location of each beached shoe they could correlate OSCURS with the movements of actual objects at sea.

While ocean current models like OSCURS are made, in part, by researchers throwing things in the ocean on purpose, first bottles and later satellite trackable drifters,[21] Ingraham was particularly attracted to the challenge of predicting the movements of actual floating shapes in comparison to the abstractions of generic scientific drifters. Streamlined objects, for example, will travel faster, as will those that sit higher in the water as they catch more wind (the model calculates these variations as a 'windage' factor). Floating soul-up with shoe-bodies acting as rudders, left and right shoes have a tendency to take different paths (a divergence even more pronounced with

[21] In this sense, Mills (2009) perhaps draws too strong a line between observation-based and mathematical oceanography, which continues to rely on observations and instruments at sea.

hockey gloves). Though the Nike shoes first inspired Ebbesmeyer and Ingraham to use container spills of consumer goods to understand circulations at sea, they are most famous for studying an epidemic of 'rubber' duckies, part of a set of plastic 'Floatee' brand bath toys, a sea-worn blue turtle sits perched on the computer tower in Ingraham's home (Hohn 2011). These lost and found plastic consumer goods have the advantage in sheers numbers and length of their travels compared to satellite drifters usually deployed in the hundreds, rather than tens of thousands, and trackable only for a matter of months rather than years.

But even with such large data sets, ocean currents are extremely variable, making object paths hard to predict. Ingraham plays a colorful computer animation of the paths of the Floatee toys migrating around the Pacific, some washing up on coastlines, others making laps with the gyre currents. "Anything could happen out there" he says, pointing to the middle of the ocean North East of the Hawaiian Islands where lines marking toy trajectories tangle into messy knots.

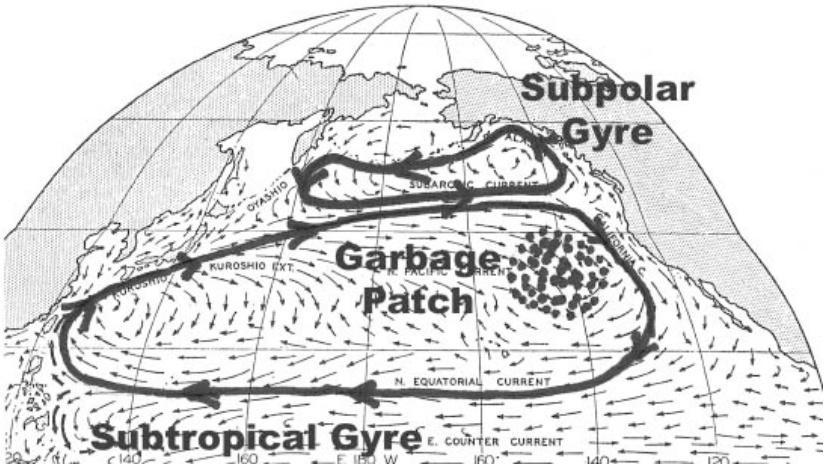

Figure 1.2: Ingraham and Ebbesmeyer's map locating a 'garbage patch' in the Eastern vortex of the North Pacific Subtropical Gyre. Beachcombers' Alert 2002.

He is pointing at an area of the North Pacific Subtropical Gyre, where OSCURS as

"accidental debris tracker" honed on the calculated trajectories of buoyant plastic goods, predicted a zone of accumulation where durable debris could recirculate for over a decade (Ingraham 1997). An area that Ebbesmeyer dubbed the "garbage patch." Another team of researchers led by Day working for NOAA and the University of Alaska had made similar predictions based on surface samples of microplastics collected in the Pacific during the 1980s linking synthetic debris and gyre currents. In addition to noting dense concentrations of plastic particles in the Japan Sea, they inferred somewhat awkwardly (and with less fanfare and popular media coverage) that "the generally convergent nature of water in the North Pacific Central Gyre should result in high densities there also" (Day and Shaw 1989: 261). But in the mid 1990s,[22] the garbage patch remained conceptual accumulation; a theoretical place where floating debris might congregate with massive circulating ocean currents.

Just a few years later, Captain Moore is trying to make sense of his 1997 trash encounter, and realizes that he has 'discovered' something that scientists had known for quite some time: the North Pacific Subtropical Gyre (Moore and Phillips 2011: 48). The area he found coated with floating plastic already had a name based on the circulating currents that give shape to the flows of water, and researchers had predicted that flotsam might gather there. Though Day had made similar predictions, and Carpenter and Smith had encountered plastic pellets in the Atlantic decades earlier, it was Ebbesmeyer's garbage patch with its consumer object associations that spoke directly to Moore's experience of plastic in the ocean. Describing his own 1997 experience in an article for

[22] Ebbesmeyer and Ingraham presented the first map labeled 'garbage patch' at the 1995 International Marine Debris Conference (Ingraham, personal interview, 2012)

Natural History, Moore writes:

> as I gazed from the deck at the surface of what ought to have been a pristine ocean, I was confronted, as far as the eye could see, with the sight of plastic. It seemed unbelievable, but I never found a clear spot. In the week it took to cross the subtropical high, no matter what time of day I looked, plastic debris was floating everywhere: bottles, bottle caps, wrappers, fragments (2003: 46)

While Moore counts fragments among the debris, his reports of recognizable objects had a particular affinity with Ingraham and Ebbesmeyer's project and the consumer goods that helped define flows of debris in the Pacific, physically and conceptually, a decade before a trash island appears in the popular media. If the garbage patch was only a concept, it was a concept established with help from mass spills of floating shoes, bath toys and hockey gloves. Recognizable consumer goods, that, in the company of salmon, continue to illustrate a 1997 report on OSCURS.

Figure 1.3: Nike shoe, rubber duckie, hockey glove and salmon illustrate circulation in the North Pacific Subpolar Gyre from Alaska Fisheries Report on OSCURS, 1997.

Borrowing both garbage patch concept and coordinates, Moore charted an Algalita expedition to gather scientific samples in the garbage patch in 1999, with Ebbesmeyer and Ingraham hoping to further correlate their computer model with movements of actual

objects. “If you see any debris looking much the same as sneakers, toys,” wrote Ebbesmeyer, “I’d appreciate an email so that Jim and I may update our trajectory” (Ebbesmeyer 1999). With Moore setting out to gather samples from the garbage patch, Algalita’s plastic project was designed from the start, to connect models and plastic, image and ocean.

As Day, Ebbesmeyer, Ingraham and Moore link plastic concentrations to the gyre, they open up the possibility of linking accumulations to ocean circulation, not just human agency as those had emphasized before them. Plastic, as iconic duckies and swoosh-marked shoes, was travelling with currents not with people. Beached Nikes also sparked public interest, as they gathered journalists and scavengers, beachcombers and scientists to the shore. As the mystery of plastic’s presence at sea shifts to understanding its movements, consumer goods become tools for physical oceanography, a means for studying currents.

From Tools to Pollution

Across the Pacific in a Tokyo Metropolitan University laboratory, analytical chemist Dr. Hideshige Takada was doing seemingly unrelated research on “Persistent Organic Pollutants,” or friendlier sounding “POPS” for short, a class of long-lasting synthetic environmental contaminants. They include the DDT of Rachel Carson’s *Silent Spring* infamy, the Bisphenol-A or BPA many plastic bottles and toys now make claims to be free of, and a whole range of other pesticides and fire retardants. They also include the PCBs that Carpenter and Smith found with pellets. In the late 1990s there was a lot of public interested in these substances because of their potential to act as endocrine

disruptors: chemical compounds that mimic hormones and mess with reproductive systems among other things, even in very small doses.

In 1998 Takada was busy researching concentrations of POPs in seawater, when he was approached by a colleague who had a hunch that plastic pellets washed up on Japanese beaches – the very same kind of industrial feedstock Carpenter and Smith had analyzed[23] –might be contaminated with POPs. Working in policy and governance, rather than analytical chemistry, she did not have the techniques to investigate. Takada had never seen or even heard of pellets at this point, and he was admittedly rather skeptical that they contained toxins. But he did have the technique to find out for certain, and passed a sample of the beached pellets along to his student for analysis. When the student returned with the results, Dr. Takada was so surprised he immediately asked if the student had made a mistake. She had not. The steep spikes on the graph printout were no anomaly: the plastic pellets contained high levels of pollutants.

When I interviewed Takada at his office, now in the Environmental Science building at the Tokyo Agricultural University, I asked why he had been so surprised. Takada replied that he is not sure, giving evidence instead for why this should not really have been so unexpected at the time. He explained that since both plastics and POPs are oil-based synthetics with a water-hating affinity it makes sense that they would stick together, and also noted that he encountered pellets at a time of accumulating evidence

[23] Also known as 'nurdles,' pre-production pellets are the industrial form of plastic, shipped to factories where they are melted and molded into more familiar objects. Round bead-shape easily poured, almost like a liquid, mobile, they have a tendency to get loose. Spilled at factories or by container load when lost at sea, pellets roll and float way to the ocean and can routinely be found on almost any beach around the world if you know what you're looking for.

showing that plastics were not inert as previously assumed. As evidence, Takada pulled a book from one of the many packed shelves lining a long wall in his office. It is his personal copy of *Our Stolen Future*, a popular book on endocrine disruptors published in 1996.[24] He opens it to Chapter 8, "Here, There. And Everywhere," where the authors recount the tale of encounters with endocrine disrupting chemicals in plastic laboratory equipment. This was something that cell biologists found rather unexpectedly at the Tufts Medical school in Boston, home to a long-running project comparing plastic beakers of breast cancer cells treated with estrogen to control groups of untreated cells. During routine monitoring in December 1987, one of the researchers observed the unexpected and very troubling rapid proliferation of the cells, not only of the treated ones, but of the control group as well. This was cause for much alarm, a clear sign of contamination capable of jeopardizing the integrity of the research project in its entirety.

The project was put on hold for increasingly infuriating months as researchers attempted to isolate the source of the problem. After eliminating other possibilities, they traced the interference to the plastic beakers and tubes, chosen for this work because they were believed to be nonreactive with hormone-like substances. Sure enough, their manufacturer confirmed a change in the containers ingredients, but refused to disclose the name of the substance in question on grounds of protecting trade secrets. Several additional months of laboratory work later, the researchers isolated the mysterious guilty substance: endocrine disrupting nonylphenol (Tanaka et al. 2013). At almost the same time, a team of researchers at the Stanford University School of Medicine, traced

[24] *Our Stolen Future* (1996) was written in collaboration between Theo Colborn, a chemist studying endocrine disruptors; Diane Dumanoski, a reporter and science writer; and Pete Myers, with a background in national and international environmental policy.

unexpected estrogen effects to BPA in polycarbonate laboratory equipment, again only noting the effects – which occurred at very low concentrations – because they happened to be working with estrogen sensitive cells (Colborn et al. 1996). These research disrupting chemicals changed not only the kinds of materials used in the laboratory, but how plastic was approached and understood more generally by the scientific community: "The plastic, which they had always regarded as a benign, inert substance must contain chemicals that can cause significant, worrisome changes in human cells. Far from inert, the plastic appeared biologically active" (Colborn et al. 1996: 93).

Still, at the time Takada, had been extremely skeptical that tiny plastic balls from Japanese beaches would contain these substances. The highly controlled environment of a lab, after all, is hardly commensurate with the enormity of ocean-sized bodies of water. Takada and graduate students at his Laboratory of Organic Geochemistry began a series of experiments and analysis that continues today. First, to confirm that pollutants were not already in the plastic but came from the surrounding seawater, a graduate student submerged samples of virgin PCB-free pellets in highly contaminated Tokyo harbor.[25] The pellets adsorbed a remarkable amount of toxins within the first two days. The resulting paper, calculating that just five pellets could represent the toxins in 100 liters of seawater, was featured on the front cover of prestigious journal *Environmental Science and Technology* in 2001 (Mato et al. 2001). Recognizing the potential of plastic pellets as tools, Takada began the Japanese Pellet Watch in 2001, analyzing samples of beached pellets collected and sent to the lab from around Japan. While bottle caps or other

[25] Though Carpenter and Smith noted the co-presence of pellets and PCBs in 1971, they did not determine the source of the toxins.

consumer waste may have been dropped by beachgoers directly, pre-production pellets are far more likely to have spent considerable time at sea. Plastic pellets make an especially attractive monitoring tool because they do not require preservation like mussels or unwieldy transportation like water samples, two common alternatives. In contrast, participants with little specialized training or knowledge can pick pellets off a beach, put them in an envelope and drop them in the mail. These advantages make pellets particularly conducive to a large-scale analysis projects.

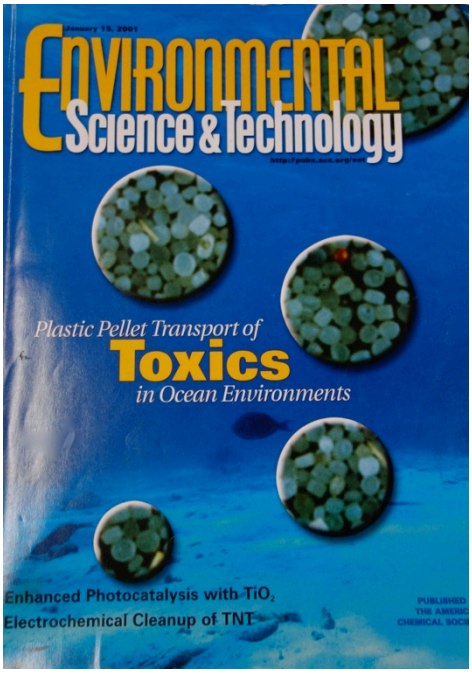

Figure 1.4: Cover of January 2001 Environmental Science and Technology. Takada's article, "Plastic Pellet Transport of Toxics in Ocean Environments" is on the cover.

In 2005, Dr. Takada made a first international call for pellets at a Los Angeles marine debris conference, organized by none other than Captain Moore. From the start, the International Pellet Watch attracted diverse citizen science participants, artists, school children and their teachers, in addition to those with extensive formal scientific training. In return for sending one hundred pellets, the more yellowed the better (discolored pellets

contain the highest concentrations of extra chemicals), participants received analysis results and an explanation commensurate with their level of scientific knowledge. Communicating the results is a very important part of the project for Dr. Takada who for years has personally written emails, working out how to explain the results – in English – using language appropriate to participants' levels of scientific training.

Figure 1.5: Plastic pellet sample from Israel. One of hundreds in the IPW archive.

International Pellet Watch was established to measure POPs in seawater. Like shoes and toys used to understand ocean currents, plastic was a tool for those doing analysis of something else, a medium for monitoring seawater where toxins themselves were the pollution. But many of those collecting and submitting pellets had a rather different perspective: they saw plastic itself as the pollution. The pellets then served as boundary objects, a site where rather distinct ways of understanding plastic overlapped enough to allow collaboration between diverse groups of actors (Star & Griesemer

1989).[26] But more than that, the movements of the pellets, with ocean currents, with toxins, and through the postal system and analysis process, formed new relationships between an analytical chemistry laboratory in Japan and diverse publics often more concerned about the plastic itself than the POPs. And these relationships transformed the scientific project. Through the accumulated impact of conversations with members of activist communities and concerned citizens (some of who themselves travel to Tokyo), Takada decided that the Pellet Watch project needed to include plastic itself as pollution: "the public attention and public interested affected me. And I changed my mind" (Takada, personal interview, 2013). In recognition that both plastics and POPs are considered pollution at the lab, I am gifted a desk calendar sent as a thank you to participants, titled with project's current public message: "No single-use plastic!" The cover displays an image of two bottle caps, a zipper-lock baggie, disposable plastic drinking cup and plastic glove, all neatly arranged against a dark backdrop as if waiting for analysis.

Plastic Marine Debris Science

By the late 1990s plastic had become a material doubly in motion: it travelled with currents across vast distances, and it was itself a fluid material. Plastic might be a solid but not one that is stable or inert. Captain Moore starts learning to do and write science, organizing expeditions and learning stricter protocol from sample collection of micro, not only macro debris in the Pacific. When Algalita's research on the distribution

[26] This is not, of course, without complications. Participants sometimes send pellets that are too white and new to produce results, or package samples in plastic bags that may cause further contamination.

of microplastics in the North Pacific gyres gets published in the peer-reviewed *Marine Pollution Bulletin*, he is surprised that his findings do not immediately lead to change (Moore and Phillips 2011). Moore continues to share what he has seen and learned with pretty much anyone who will listen, presenting at Rotary Clubs, getting a few lines of coverage small local Long Beach newspapers. Though the problem gradually gains momentum, picked up by mainstream popular media (see Chapter 2), marine ecologists and others within academic remained incredibly skeptical, if taking any interest at all.

In April 2008, Marcus Eriksen, Algalita's education coordinator and repeat gyre expedition crew, was invited to give a talk at Scripps Institute of Oceanography in La Jolla. I have heard multiple reports of what ensued from those directly involved, needless to say the audience response was rather critical, with persistent questioning of sample size and how the research was conducted. Among those in attendance was SIO graduate student, (now Dr.) Miriam Goldstein. Though clearly not speaking for Scripps as a whole, Goldstein had pointed out her concerns with the scientific merits of Algalita's research – everything from a lack of formal training as oceanographers to the size of Algalita's vessel and winch relative to Scripps' much larger capacity – in January, well in advance of the presentation. I do not believe the questioning was meant to be mean-spirited; like Goldstein's (2008) blog post, all those I have spoken with at SIO have great respect for Algalita and give the organization credit for both drawing public attention to ocean plastics and framing key scientific questions. But the combination of academic cultures of rigor and skepticism and activist cultures of making-do and optimism generated a measure of animosity between Algalita and Scripps.

But they also generated a new level of curiosity about open-ocean plastic for Goldstein who had enrolled at SIO with the intention of conducting research on pollution in local tide pools. When I interviewed Goldstein in her office in Sverdrup Hall (named for none other than the SIO director famous for mathematical accounts of ocean currents in the 1940s and 1950s), she explained being captivated by the issue of gyre plastics, but in delving into the scientific literature found "very little scientific information" on plastic marine debris, and none by Scripps with "one minor exception." Changing the focus of her studies, Goldstein proposed a research expedition funded through the University of California Ship Fund to investigate further. Not only was the proposal successful, but Goldstein herself was appointed chief-scientist for the resulting SEAPLEX (*Scripps Environmental Accumulation of Plastic Expedition*) voyage, a rare opportunity for a student.[27] The exception was none other than Elizabeth Venrick. Leaning of the upcoming cruise, she dug up a copy of her *Nature* article, walked down the hall to the office of Professor James Leichter who was overseeing the expedition, where she triumphantly placed the article on the desk and announced that he had been scooped.

With ocean plastic pollution now moving from a popular media issue to an object of academic research at a prestigious institute, the SEAPLEX was charted to address a knowledge gap teeming with myth-busting potential. Whether or not they were setting out to prove Algalita wrong, to show that plastic was not such a grave concern, setting out on the three-week voyage in 2009, the project team worried about what they might find, if anything at all. As Goldstein explains:

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[27] SEAPLEX received funding for an additional week at sea courtesy of Project Kaisei

> We seriously had no idea. One of the questions people kept asking us (and by people we mean advisors), was how are you going to find the plastic? How are you going to know when you see it? And we were just like we don't know…. I quite frankly though we would be going out for three weeks and we wouldn't find anything and we would kind of sadly go back, except for maybe not sadly: proving a negative doesn't really mean anything… Because it's really hard to find stuff in the ocean. It looks all big and blue and the same but you lose stuff all the time. (Goldstein, personal interview, 2012)

Though the ocean was big and blue, plastic, to Goldstein's surprise, was not at all hard to find. The team encountered far more than expected:

> And that's what shocked me the most actually, it's what shocks scientists who work in the open ocean a lot too, although it's something that is very hard to communicate to nonscientists, but the shocking thing is that it's easy to find, and that it's so even, that it's everywhere. And when I tell scientists that once you just starting going west you're just going to hit it and you can't miss it, they're like, what? No, that's crazy. (Goldstein, personal interview, 2012)

In one of the publications resulting from the voyage, Leichter (2011) described the initial results as "largely confirmatory of other prior sampling," including that done by Algalita. In doing so, however, he continues to draw a line between the "observational" work of Algalita and Scripps science. Leichter credits Algalita with "providing compelling observational evidence of the nature and scale of the plastic debris in the Central North Pacific and in framing many of the relevant scientific questions" (2011: 252), whereas Scripps is the first to bring quantitative mathematical (read scientific) methods to the issue.[28] But again, there was some luck involved, weather and current conditions in 2009

[28] And an example of the "important roles that outreach and advocacy groups can play both in initiating and fostering scientific investigations of environmental problems and in delivering compelling images and information to the public and media outlets." (Leichter 2011: 253). What follows somewhat problematically implies the benefits of such 'outsourcing' of the costly preliminary research at sea.

meant that the middle of the gyre was further north than usual, conveniently due west of San Diego.

Scripps was not the only academic institution to addressing plastic marine debris. The SEA program, based out of Wood's Hole Oceanographic Institute continued to collect samples in the Atlantic and Pacific Oceans. Similarly, various nonprofit and activist organizations focused on ocean plastic proliferate. Project Kaisei, (Japanese for "ocean planet"), a US-based nonprofit is founded in 2008 to investigate the feasibility of recovery and recycling, in part, as a response to Algalita and Captain Moore's insistence that cleanup was impossible (Humes 2012). Marcus Eriksen breaks from Algalita to found 5 Gyres along with fellow activist and educator Anna Cummins, doing much to emphasis the global reach of plastics far beyond the North Pacific. Others, like the Surfrider organization, adopt ocean plastic pollution as a new focus. David de Rothschild, polar icecap crossing modern day 'explorer,' finds a new causes in the United Nations report on plastic in the ocean. Working from the premise that a media stunt or something dramatic was needed to spark change (de Rothschild 2011: 18), he turned to Heyerdahl and the Kon-Tiki as a model. After several years, many material and other trials later, de Rothschild sets sail in 2010 from San Francisco Bay for Australia on a boat of plastic bottled christened the "Plastiski." Among the crew of filmmakers, activists and sailors, is Olav Heyerdahl, Thor's grandson. With the Plastiki, like its balsa wood predecessor, only able to sail downwind, people and plastic waste move together with the currents of the Pacific.

As plastic becomes a somewhat legitimate topic of academic sciences,[29] there are signs of further changing relationships to plastic from within the ocean sciences. Marine ecologist Dr. Hank Carson, a postdoc teaching a very popular undergraduate marine debris classes at the University of Hawaii Hilo, regularly took groups of students to Kamilo beach, the famously plastic-covered shore a few hours' drive south. There they collected samples for a variety of projects and tried to trace the origins of some of the objects based on the writing, plastic containers from China, Taiwan, Japan, and more mysteriously, one from Turkey that had not likely floated from there directly. Carson, however, was also noticed distinctly local things washing up, containers marked Hawaii dairy, but also more perishable pineapple tops that could not have travelled far. He decided to conduct a more systemic investigation to understand local currents around Hilo, Hawaii's second largest city and the nearest urban center, with the possibility of establishing pathways of local responsibility for some of the trash washing up on Kamilo beach.

Breaking from a long tradition of purposely throwing disposable plastic in the ocean in pursuit of knowledge,[30] Carson made a point of very deliberately *not* using plastic to understand currents. Instead, he acquired a branding tool and made his own set of drifters from wood as "fake plastic" he jokes:

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[29] As I detail further in Chapter 2, all researchers I have interviewed, even those with careers dedicated to marine debris, list plastic pollution after problems climate change, ocean acidification, and overfishing in raking the most pressing issues for the ocean. I have also heard reports of the difficulty of acquiring grant funding for plastic research from organizations such as the National Science Foundation.

[30] There are growing efforts in marine biology and oceanography to retrieve equipment and use more sustainable materials. (Monterey Bay Aquarium 2011).

> It just seemed like that would be a not responsible to throw 1600 pieces of plastic in the ocean in order to study plastic. And it's funny, because like many things, plastic would be the ideal material. We could get the longer range, they wouldn't degrade, I'm sure there would be some recoveries maybe in a year in the Philippines or Japan or something like that, which would be cool but doesn't really get at my question. That's sort of known, it would be very interesting result to demonstrate that Hilo something in Hilo does go on to pollute somewhere else. The wood blocks I doubt will last that long, they will break down (Carson, personal interview, 2012)

Plastic, though in many ways a physically "ideal material," is deemed inappropriate based on the project's topic and the scope of its questions, which do not extend as far as more durable plastic might travel. The floats are square, about four inches across and two thick, stained a bright red. Each is numbered and branded with the follow message:

HELP UNDERSTAND CURRENTS
AROUND HAWAII
REPORT THIS DRIFTER TO
UH HILO BY EMAIL
hilodrifter@gmail.com
808-937-4289 MAHALO

Figure 1.6: Wood drifter in the lab and weathered float recovered from Kamilo Beach. Photos by the author.

Hoping the floats, well, float, and that the call to help is answered, Hank dropped 1600 blocks in large batches around Hawaii. And many people do find and report the floats. The drifters return as data, but their movements also produced something less expected: a

community of people interested in marine debris. People that found the red blocks were drawn into the project, "they've been pulled in to thinking about it, pulled in with interest and then you start talking about why you did the study, marine debris in general." Here wood-as-fake-plastic is not only a tool for data production, but evidence of the capacity of objects to gather diverse actors into new kinds of communities, relationships that start new kinds of circulations. Carson began email correspondence with an elementary school on Maui where a student had recovered a drifter, working out the path the blocks might have travelled step by step with the students. This connection between Maui, with a county wide plastic bag ban, and Hilo became evidence become part of the evidence Carson and students successfully presented to the Hilo City council in support of a bag ban. The project also gained the attention of local media, and of other scientists interested in his technique. The branding tool itself takes to traveling, shipped to oceanographers at the University of Hawaii, Manoa in Honolulu, and more blocks get made and released. Carson describes what happens as "guerilla outreach," where rather than giving more formal presentations, found objects themselves draw members of the public to the issue. On my return to Hilo a year later, taxi drivers, waiters, and hotel staff are quick to tell me about the new policy when I explain the reason for my visit.

Conclusion

In July 2011, I step onto a boat in Honolulu about to depart on a three-week Algalita research expedition through the North Pacific Gyre. Our trajectory is charted for almost the same coordinates where Venrick encountered plastic some 40 years before. But the ocean we are about to sail, the people I travel with, the scientific projects we

support, plastic itself, have all been transformed. Like the International Pellet Watch community connected by samples, or those drawn in to conversations about local pollution and marine debris research by red floats, we too have been "gathered" by the movements of material things; people, boats, instruments drawn by the promise of plastic to the middle of the ocean. It is not only expectations or intellectual history that have shifted. Relationships with plastic and the ocean have been changed by encounters with shoes and bath toys, tar balls and pellets. Not only do we expect to find plastic, we expect plastic that has traversed great distances with currents rather than with people.

The legacy of these encounters is, like ocean currents themselves, quite variable. The most optimistic devise plans where ocean currents themselves become part of the solution, harnessing water circulation to filter plastic from the sea, or hoping the ocean will simply clean itself given time. Others are more cautious in embracing the implications of plastic-ocean circulations. Takada's original results, that plastic pellets can attract pollutants at a staggering one million times concentration of the surrounding seawater, still stand. But it only with his most recent publication, after fifteen years of research, that he is finally convinced the toxins he has been tracing all over the world can move from plastic into animal tissues directly and potentially enter the food chain.

The ocean does not change for everyone. Venrick is amazed at what has happened since, but in the 1970s finding plastic so far from land did not really change her research or the way she saw the sea. Though it was found in a place scientists went to study 'natural' communities, the plastic was at such a low background level that it was too rare to been seen as a problem. Indeed, it was something you would not see at all if you weren't looking for it or did not have the right sampling techniques, she explains. Taking

only small water samples, Venrick never again notices plastic in her subsequent research or samples. She believes that the open ocean was and still is the best place for plankton research, even if it is not perfectly free of human influence. But near the end of the interview Venrick looks over the singe-page paper copy of her article, one of the originals. She rereads the last sentence about “setting sail into a plastic sea,” and smiles quietly to herself at the largely unremarked prescience of the words.

Chapter 2
Trash Island:
The Materiality of Things that Aren't There (But Could Be)

Spelled out in bold font with the science section authority of no less than the *New York Times*, the November 9th, 2009 headline seems irrefutable: "Afloat in the Ocean, Expanding Islands of Trash." That journalist Lindsey Hoshaw has just returned from an expedition through the garbage patch in the North Pacific makes the trash island report all the more real. And the *New York Times* claims are in good company. *Time Magazine* describes a "swirling mass of plastic debris twice the size of Texas," human impact on the ocean so severe "You can literally see the result" (Walsh 2008) The garbage patch is crowned "The World's Largest Landfill" by *Discover* amidst calls to recognize it as "the 8th continent" (Kostigen 2008). Visible. Solid. Massive. The collective account does not shy from specifics. As reported by *ABC News*, the *San Francisco Chronicle*, and even *Oprah*, among countless others, the garbage patch spans hundreds of miles, is one hundred meters deep, and weighs 3.5 million tons (Berton 2007; Bonfils 2008). It is, following the most recited descriptor, twice the size of Texas. Or, in all its regional variations, "as large as Central Europe" (Pravda 2004), with a "footprint as large as France and Spain combined" (WHIM 2014), even "twice the size of America" (Daily Mail 2008). This floating mass growing in the North Pacific Ocean, northeast of the Hawaiian Islands is surely impossible to miss. But despite general agreement on its location and the proliferation of claims about its size, no one can find it; not on Google Earth, not after weeks at sea. The trash island is not there.

In response, some call for images as evidence, or in their absence, deny ocean plastic as a problem in any form. Others work tirelessly to promote what they see as more accurate facts and representations about plastic pollution. Though reputable sources like the *New York Times* have since shifted their descriptions to a less solid sounding "plastic soup," the garbage patch-as-trash-island continues to dominate public understandings of plastic ocean pollution and continues to inform the kinds of solutions that seem possible. In this chapter I position trash island as a case of missing materiality, where knowledge, images and even schemes to build it, continue to circulate in the absence of island encounters at sea. This approach allows me to shift focus from evaluating the accuracy of representations and facts, to considering what trash island does and how it continues to have power as people navigate plastic presences and island absences. These constitutive encounters show that trash island is not simply a 'metaphor' with 'material effects,' but rather, is performative: it shapes the world in its own image.

In each of the chapter's three main sections, I describe what is missing – a problem, scientific knowledge, trash island – and how what is missing matters. These different encounters with trash island are caught up with questions of care, credibility and the practicality of solutions. Under what circumstances do distinctions between modes of caring about plastic pollution come to matter? Posing this question allows me to emphasize the commitments that are common across academic, nonprofit and journalist communities, despite the often-apparent antagonisms among groups that care. This allows me to escape from focusing on controversy alone, opening up a space to point out how scientific research and island myth worked together to bring attention and give shape to the issue. Plastic pollution does sometimes emerge as the object of scientific inquiry,

and the island as the object of the myth and fancy of media an activist exaggeration. But this is not a simple story of the triumph of scientific knowledge over misconception, or progress toward ever 'better' representations (for what and for whom?). Despite valiant attempts to uncouple plastic pollution from trash island, (and later from tsunami debris and the remains of Malaysia flight 370), encounters with ocean plastic continue to take shape in the shadow of the island, real and not, present and absent, materialized and otherwise. How this happens shows that care and matter are inextricably connected, not only in theory (Puig de la Bellacasa 2011), but in the sea.

As a case of missing materials, trash island offers a much needed empirical addition to the emerging STS literature coalescing around problems and politics of absences. Much of this work has taken the form of conceptual organization. Jennifer Croissant (2014), for example, lays out a taxonomy of absences in an attempt to create conditions for more systematic comparison across cases. But rather ironically, detailed empirical cases themselves appear to be missing. It is, after all, rather difficult to study knowledge that is not made or not shared (Frickel 2014).[31] With trash island, however, knowledge *is* present; it's the material thing that is lost at sea. All kinds of facts circulate about the size and shape of the island in the mainstream media, and are dissected in terms of accuracy by scientific and activist communities concerned with plastic pollution. Some people talk about, go looking for, or event attempt to build trash island, while others express their frustrations with misrepresentation and how trash island obscures the path to solutions. While other studies of absences, most notably in anthropology (Bille et al.

[31] See Londa Schiebinger's *Plants and Empire* (2007), for an account of missing people and ideas.

2012), consider the continued influence of missing things,[32] they focus on things that once were there but are no longer: people, possessions, and places disappeared in disasters or other unfortunate circumstances. These kinds of lost objects are an example of what Scott Frickel (2014) calls relative absences, a category that covers things (including knowledge) that used to be, things that are hidden, or are now somewhere else.[33] In contrast, he uses absolute absences to describe "things that are not there or anywhere else and probably never were" (2014: 88). Trash island cuts across these spatial and temporal distinctions: it simultaneously never was, is still missing, and may yet come to be.

Though reported as such in the mainstream media, trash islands, and plastic pollution more generally (as outlined in chapter 1), are not simply floating around awaiting 'discovery.' Like other scientific objects, trash island emerges (or not) in processes of becoming, as part of relationships that make it real or not (Daston 2000; Murphy 2006). In tracing how trash island comes to be, my approach resonates with historical ontology. In tracing the production of trash island as missing, it also demands emphasis on *non*-existence. Michelle Murphy's version of 'materialization' is helpful in

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[32] While Latour's (1992) "missing masses," famously pointed to materiality so overlooked in linguistic turn inflicted social science, these anthropologists show how absent things are manifested in everyday practice and feeling: "Absence is therefore not just a theoretical concept implied as the default logical antonym to presence; it is also the corporeal, emotional and sensuous phenomenon articulated in discretely concrete, political, and cultural registers" (Bille et al 2012: 4). This is not just missing materials, but the missing made material.

[33] Puig de la Bellacasa (2014) conceptualizes ontological absence in terms of collective care. In her case, soil is the "dismissed infrastructure of the bios," something that is everywhere, but rarely noticed. It is relatively absent, invisible to, or made invisible by those who do not wish to see it. Where Puig de la Bellacasa focuses on the consequences of how soil becomes an object of knowledge, as soil itself is transformed in the movement from absence to presence, trash island is an excellent case for exploring the implications of how an object passes back in to invisibility, and how it continues to live on as a relative presence by those who wish to keep seeing it.

part because she considers not only how a phenomenon can become something "people could say, feel, and do something about" (2006:7), but especially because she is equally concerned with how phenomenon at the same time come to be imperceptible in ways that preclude action. In her case, for example, the production and maintenance of uncertainty about whether "sick building syndrome" is real or imagined becomes grounds for shirking responsibility for workers' illnesses.[34] Similarly, expert knowledge of a missing trash island can become grounds for the wholesale dismissal of the 'problem' of plastic pollution.[35] Objects and relationships with real consequences are in danger of passing into invisibility (Puig de la Bellacasa 2014).

In chapter one, I showed how the garbage patch concept emerged from models of gyre currents, shipping container spills and unexpected encounters at sea. This chapter takes up how the plastic pellets, fragments, duckies and sneakers coalesced into a trash island mass. Like the theoretical shift from representation to mattering, the chapter moves from media coverage about trash island to actual schemes for cleaning the sea of trash and building islands out of it.[36] In the first section, I survey some of the media coverage

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[34] Murphy tends to position multiplicity as an answer in her analysis, noting that it has vague 'consequences' but without pushing further. I take multiplicity as a starting point, not the end, and want to take sides – I do not want plastic to pass (back) into invisibility.

[35] Olga Kuchinskaya (2014) describes how not only radiation but its consequences are made and kept invisible in processes and practices of producing knowledge about the aftermath of Chernobyl.

[36] This chapter draws media analysis together with interviews with key actors, and observations over the course of my fieldwork in California, Oregon and Hawaii. I trace the emergence of the plastic pollution 'island' through systematic searches of Access world news database for "garbage patch," "plastic soup" and various combinations of "trash/plastic/garbage + island," checking the results against Algalita's extensive media archive. I regularly, if less systematically monitored Google image search results for the same terms between 2011 and 2014, and took note of which images and stories recirculated through popular social media. This is combined with interview data and observations of key actor's own explanations of why trash island is so compelling and enduring.

that helped to establish and popularize the trash island concept in the mid to late 2000s, and recount my own failure to track down an elusive first image of a floating garbage mountain. In following sections, I describe in more detail three kinds of constitutive encounters with trash island: what I call dismissive encounters, corrective encounters, and constructive encounters. *Dismissive* encounters are where the missing island and missing images of it become grounds for debunking the issue of plastic pollution in the ocean in its entirety. No further scientific knowledge is needed, as the ocean is not filling up with plastic. *Corrective* encounters describe a variety of attempts to produce and share what is considered more accurate, scientific, knowledge about plastic ocean pollution. Corrective encounters treat the conception of trash island as a kind of ignorance about the 'true' state of ocean plastic pollution. *Constructive* encounters describe efforts to make trash island a real physical entity. Here problems of knowledge, whether as undone science or the inaccuracies of myth, are far less important than the missing island itself. Confronted with the lack of trash island, cleanup projects attempt to make trash island out of ocean plastic in proposed solutions. In the final section, I return to the relationships between forms of matter (as nothing, as soup, as island) and forms of care (for something else, with good science, by cleaning up). I argue that through encounters trash island assumes a generative potential that is at once material, political and ethical as it comes into being as a presence or as an absence.

Elusive Traces: The Stuff of Headlines

I interview Captain Moore, sitting at the galley table aboard Algalita's Research Vessel, the *Alguita,* where it is moored on Naples Island, Long Beach, conveniently

across the street from his house. We have been talking about the history of plastic pollution science and activism, and the emergence of the garbage patch term. My next question, and what I so desperately want to know, is who was the first to call the garbage patch a trash island? To my surprise, Moore points to "foreign papers," specifically *Pravda* and proceeds to describe a captivating image of a "Matterhorn looking mountain," an artists conception of a floating trash heap. Soon after the interview, I search media archives and am pleased to find that Moore's tip checks out – the earliest mention of a floating trash island does appear to be in *Pravda Online*, February 24th, 2004. The short article, "'Trash Island' discovered in the Pacific Ocean," takes its content in turn from an article in German National Geographic equivalent *Geo* that describes a 'carpet' of plastic in the ocean. How the carpet turned into an island remains a mystery of English-German-Russian-English translation.

The "Matterhorn looking mountain" image, however, is nowhere to be found. A tiny, pixelated thumbnail of a pile of blurred something adorned with yellow caution stripes, is all that remains. The image currently links to a 2007 trash island article in Pravda, mountain picture not included. Hoping that the image might be preserved in print, I asked the UCSD library for help finding a paper copy of the article in Russian, with hopes of tracing down trash mountain. But in an act of academic triage, I was redirected to the Scripps Institute of Oceanography librarian. Despite clearly explaining that I was trying to track the *metaphor* of trash island, the librarian quickly cautioned me not to trust Pravda's story, providing a link to a "more authentic and scientific source" – the Scripps SEAPLEX project headed by Leichter and Goldstein. Upon clarification, the librarian joked that she should have replied with her communication hat on, not her

Scripps one. Though no closer to the image, I realized that I had just glimpsed the kinds of processes where well meaning people erase myths with 'truth' and 'better' representations, leaving only incomplete traces in their wake.

Though I have yet to find the original island image, in the months and interviews that follow, I encounter a handful of articles referenced over and over, as I ask plastic pollution scientists and activists about the origins of trash island. I will briefly consider three of the most often referenced, in order to give a sense of how trash island emerged as a media object in the mid 2000s: the "Altered Oceans," series appearing in the *Los Angeles Times* in 2006, positions ocean plastic as part of a more general crisis at sea, drawing attention to the issue but without mentioning trash islands; the "Toxic: Garbage Island" series by *ViceTV* documents the problem at sea, directly confronting the absence of an island; and finally, I return to Lindsay Hoshaw's piece that opens the chapter, "Afloat in the Ocean, Expanding Islands of Trash," striking because of both where and when it appears – the science section of the New York Times in 2009. I pay particular attention to the 'stuff' headlines are made of, considering slippery terminology, encounters with plastic, and the possibility of blatant exaggeration. Though I point to institutional pressures of journalism and the difficulty of distances between land and sea, media sensationalism and misrepresentation are by no means sufficient explanation for emergence or enduring power of trash island.

Written by Kenneth Weiss for the *Los Angeles Times*, "Altered Ocean" is a Pulitzer Prize-winning multimedia series, published in five parts between July 30th and August 3rd, 2006 (Weiss and McFarling 2006). Covering the "crisis in the seas," the series depicts struggles for survival in an ocean no longer invincible to human

intervention, surveying irreversible, global changes that "alter" the very chemistry of the sea. "What happening here," the narrator explains as divers futilely pluck seaweed off a now dead coral reef, "is another example of slow environmental decay sliding into a self-perpetuating collapse. The results are fundamental changes to the ocean." Among the creatures and sites that sound the alarm for the state of the seas–red tides, marine mammal die-offs, fatally damaged coral reefs, dead zones reduced to jellyfish and bacteria – is a "Plague of Plastic that Chokes the Seas." Here synthetic materials sit as one of five major threats to ocean ecosystems.

Weiss does not ever mention a trash island, yet the series sparks a spate of phone calls and emails to Algalita proposing island cleanups and other seemingly fantastic schemes. What about the series invites such solid solutions? First, the article uses the term 'garbage patch' to describe the accumulation of plastic in the North Pacific. As several informants pointed out, like pumpkin and other kinds of patches, a garbage patch sounds both earthy and bounded. A "plague of plastic that chokes the seas" definitely sounds thick enough to impede circulation. This association is further encouraged by familiarity with landfills as Weiss dubs the garbage patch "the world's largest dump," comparing its size to yet another bordered territory: Texas, only bigger. Second, these linguistic tropes, present in ocean plastic media coverage before, but especially after "Altered Oceans," are supported by images implying that ocean plastic is something decidedly solid. In the accompanying video vignette, an animation of a "clockwise swirl of plastic debris," depicted as a rotating whirlpool of dense, dark splotches cuts to an image of debris piled up on Midway Atoll, the main ingredient appears to be familiar bottles. Through juxtaposition, the dense accumulation of a beach is mapped onto the

open ocean, the abstraction of the "swirl" materialized as recognizable objects piled up on solid ground. Plastic is shown similarly concentrated in almost every other image circulating with the article: a colorful heap of plastic chunks in the stomach of an albatross chick; the layers of fishing nets, consumer objects stranded on Hawaiian beaches; an undulating blanket of garbage, plastic and otherwise, making its way down the Los Angeles River to the sea. It is from the LA river, not the Pacific, that the online version of "Plague of Plastic" appears to draws its cover image: a cropped close-up of disembodied doll head laying among plastic soda and juice bottles, woody debris giving away its coastal location, as small pieces of organic matter would not outlast the trip to the gyre. Weiss has personally encountered plastic concentrations, but at the edges of the gyre; only a single visual – Captain Moore swirling a jar of tiny plastic bits suspended in seawater – is an image from the open ocean.

Though Weiss carefully focuses on the mechanisms of accumulation and the impact of plastic on water and wildlife, his article still sets up something solid. Readers are encouraged to link their own lives to a distant problem through the travels of familiar consumer objects, ever-present plastic bottles and bags. These objects, and trash island itself, are a kind of charismatic megafauna for the anthropocene. Though they may not be cute and fuzzy like their animal counterparts, bags, bottles and trash island similarly "serve as symbols and rallying points to stimulate conservation awareness and action" (Heywood 1995). Plastic bottles and bags, however, are immediately recognizable as problems to a public familiar with cleanup and recycling as appropriate solutions. Focusing on larger, visible objects may do a lot for awareness, but solid problems encourage solid solutions not meant to address toxins or microplastics at sea.

Where Weiss reported from the edges of the North Pacific, *Vice Magazine* is among the first media outlets to encounter plastic in the middle of the gyre itself. In 2007, a film crew of three age twenty-something hipsters, including now online editor Thomas Morton, joined Captain Moore on the *Alguita* sailing through the garbage patch from Long Beach to Honolulu in 2007. The result is a three-part internet TV series about their experiences that appeared online in April 2008. The Vice team engage directly with the trash island concept; they position the island as potential "urban myth," and weave a narrative around embarking on a journey to investigate. If you focus on the headlines "Toxic: Garbage Island" is a story about the garbage patch as trash island. If you watch carefully, enduring strings of expletives, the documentary tells a story of going out in search of trash island and confronting its absence.

The documentary begins with establishing shots of the open ocean; the red and green sails of the *Alguita* against clear sky; and a close up of conspicuously blue water. A voiceover of Captain Moore proclaims "Every reporter changes the story. Just like every scientist changes what he's observing, every reporter is changing that story." Standing on the boat, Moore peers through binoculars at what careful editing reveals as a pod of dolphins rather than a trash island. As an opening, Moore's words serve as disclaimer for everything that follows: they too have edited a story in the course of doing their job. The irony does not appear to be lost on the producers, who later quote novelist Graham Green: "reality in this century is not something to be faced." The documentary then locates the 'source' of trash island in the media, showing its presence in an accumulation of headlines. They also hint that Captain Moore's initial descriptions of encountering

"plastic bags and bottles and consumer products as far as the eye can see" have contributed to the sense of something very solid to be found at sea.

Setting out, it appears the team had not quite reconciled themselves to the fact that the garbage patch may be as elusive as the 'reality' they, as representatives of a new century, do not wish to face. Though the team began with repeated statements about being on their way to see "garbage island," their concerns about what they are not seeing increase with each day at sea. After a week on the boat, the *Vice* team's excitement gives way to boredom, whining, and worries they won't find anything after all. Their concerns are exacerbated as they amass clues about what matters in the ocean, wondering aloud why Moore makes such a production of stopping the boat to retrieve a single plastic bottle. "But aren't we going to a whole island of plastic bottles?" Meredith points out, before categorizing the hunt for trash island as a "Moby Dick situation." In the absence of the island, the team wonders if plastic pollution is a problem at all.

That they were expecting a "trash dump," and that they did not find something that fit these expectations is made explicit. "I think in my mind, and probably in Meredith and Thomas's, we were eventually going to arrive somewhere. We were going to get to the place where this is where all the trash is," explains the cameraman. Trying to reconcile the garbage island quest with tiny plastic 'sparkles' stuck to their skin after diving, with fragments swirling in sample jars, with tales of invisible toxins, they do concede that there is a problem in the ocean: "I came here expecting to find like a trash dump, pieces in the water you could pull out, but instead what I got was an even ruder awakening." And this rude awakening carries through to final reflection by Morton: "If

we've ruined the ocean what chance to we have for land? Or for our fucking selves for that matter?"

Even in the details of the documentary, the team finds ways to keep the myth alive. Their experiences are constantly defined against the garbage island, which at various points gets explained as "there" but in a different or even "invisible" form, or in metaphysical terms, as Morton muses: "garbage island is less a physical place, and more a state of mind. At some point we all find our garbage islands." Through these shifting forms "the patch," as they take to calling it, remains a destination, a place they are waiting to arrive so they have more to do. When they do get there, however, the documentary gives very little explanation of the collection process where surface samples gather the concentrated contents of a large area of the ocean surface (more like football field than soup can amount of ocean) look like water samples, as if the jar was simply dipped in the ocean beside the boat. "It's the composition of the ocean now," explains Morton, holding a jar of plastic soup to the camera.

Confronted with this new version of the 'problem,' the team seems equally (or even more) concerned with the need for a 'glamour shot.' Moore patiently explains once again that the garbage is spread out. But still the cameraman pleads, "we just need the big shot." And the article accompanying the video implies that they have found just that. Morton muses about being tired of environmental controversies, and attempts to weigh impossibly complicated evidence and opinion:

> sometimes you just want something huge and incontrovertibly awful to come along for everybody to agree on. Something you can show anyone a picture of and go, "See? We're fucked." Well, I have just such a thing. There is a Texas-size section of the Pacific Ocean that is irretrievably clogged with garbage and it will never go away. And I have seen it with

> my own eyes. Case closed. Oh, you want to hear more? OK, fine. (Morton 2008)

Further down, Morton admits that he thought there would be a concentrated mass, and that this is not the case. But this disclaimer appears far from the "Garbage Island" headlines and assertions of seeing it with his "own eyes."

The disjuncture between headline and story, images and text are all the more explicit in the 2009 *New York Times* article about trash islands. Its author, journalist Lindsey Hoshaw, in many ways repeats the trajectory experienced by the *Vice* team, traveling on the *Alguita* through the garbage patch with Moore in 2009. And Hoshaw too expected to find islands and experienced something quite different. As she explained in an interview "I expected to see, I think what a lot of people would expect, I expected to see a lot of trash all mounded together, a lot more like a floating landfill in the middle of the ocean. And that's not what it's like at all" (Hoshaw 2013). But again the sea visible empty of islands fills samples with tiny fragments, "I was shocked by how small the pieces were. I was shocked that so many pieces were so tiny and that everything was degrading so quickly." Hoshaw crowd sourced funding for the expedition just after starting a journalism graduate program at Stanford, [37] and headed to sea with an article promised to the *New York Times* in return, her first big article for a national publication.

The text of the resulting *New York Times* article beings with familiar objects, "Light bulbs, bottle caps, toothbrushes, Popsicle sticks," and it does use the term "garbage patch" with all its troubling associations. Hoshaw also writes, from the start, of

[37] The campaign, on then new website spot.us (introduced to Hoshaw when its founder gave a presentation for her journalism class at Stanford), received a lot of attention, sparking discussions of the future of journalism, as Hoshaw summarizes "is it the equivalent of a journalist trying to beg with a virtual tin cup, or is this something that's really great?"

"tiny pieces of plastic, each the size of a grain of rice," and takes care to describe how the pieces break down into fragments that are dispersed across an area, not constituting an island, "twice the size of Texas." When I ask her to describe plastic at sea she similarly speaks of "tiny confetti-sized pieces," comparing its distribution to taking "a waste bin of trash and dumping it in an Olympic sized swimming pool." And she agrees with Algalita's descriptions: "I think Captain Moore really has it right when he talks about it as a floating plastic soup. It does look like that; it's little pieces of confetti – plastic minestrone." How, then, does a journalist who has visited the gyre herself, who set out to write an article that conveys the "facts and details," who speaks of dispersed fragments end up with her name attached to headlines about expanding floating trash islands?

The short explanation is that someone at the *Times* chose the headline because it was "compelling." As Hoshaw explains, "Something about that word island, and something about a floating island of trash just seems so strange and so bizarre and so otherworldly that it immediately gets other people's attention." The choice of headlines, however, happens despite a series of exchanges where Hoshaw, emphasizing that she has seen what is "really" there, attempted to clarify that the ocean plastic pollution problems was not in island form:

> We would go back and forth about the article, and they would show me what the headline was and I would say, nyuh, it's not really and island. This is kind of how it is. And in the end they ended up running with it anyways. So yeah, that's something that's I think adding to the whole eighth continent or you know floating landfill, that's not helping. I think it's only natural to want to galvanize people to action, to really convey to people how serious this is, so it's easy to jump to those metaphors, but in this case that's not true. And that was the one thing about this article that I would say if I could take back I absolutely would. (Hoshaw, personal interview, 2013)

Though Hoshaw readily admits that the headline is "unfortunate," that it is something she wishes she could "take back," the disjuncture between headline and content points to material-ethical tensions between the desire to "galvanize people to action" and commitments to the "truth." This is especially evident when I ask about the images accompanying the article, the editors' selection of those submitted by Hoshaw. These published images, I point out, are all with one exception of a handful of fragments of larger objects: a fish making its home in a caulking tube, a netball, a huge chunk of polystyrene, plastic jug, bottle, barrel and fishing float. Her explanation for these images, which she does not find troubling:

> Because if you just jump in the water and take a photo of what you see, you may see a couple confetti-sized fragments, but you might not see anything and how do you use that to convince people that this garbage patch is real? You don't. (Hoshaw, personal interview, 2013)

Like the editors' choice of headline, these images of bigger pieces are "compelling," attracting readers and convincing them that ocean plastic is something to care about. Hoshaw's candid evaluation suggests that the best approach to sharing what is "real" is not always through brute faithfulness to the facts. While the island is clearly too much of a stretch for Hoshaw, there is a sense that people need to be drawn in, made to care about the problem before you can explain the problem in all its intricacies.

Together, these three examples and my search more generally only hint at the origins of ocean plastic in trash island form or why it remains so powerful. Instead of locating a single source, I have pointed to a set of rather ordinary challenges of science and environmental communication: the slipperiness of garbage patch language; the desire for something spectacular; not having control over headlines. In the case of trash island,

the pressure to tell a story that is simultaneously "compelling" and "true" is exacerbated by the distance between the open ocean and people's everyday experience. The authors do their best to bridge this distance with metaphors and recognizable consumer objects, but the space that remains is big enough to grow an island. This physical distance is the embodiment of the 'gap' between representation and reality, between stuff in the ocean and stuff in people's heads. The problem that follows is in how it is told, a problem of words and images rather than of plastic in the sea. Assuming some inherently 'better' or 'accurate' representation is possible denies the inseparability of matter and care, objects and knowledge of them.

In the sections that follow, I instead trace three kinds of encounters with ocean plastic and show the entangled forms of matter and care that emerge with them: where knowing and caring are part of very material becomings (becoming absent). In doing so, I can't help but keep returning to Moore's opening quotation from *Toxic: Garbage Island,* where "all reporters change the story." The ever-irreverent team from *Vice* may have intended a kind of reflexivity or were perhaps simply absolving themselves of responsibility for the problem or their version of it. Yet there is something enduringly compelling about the way they allow myth to haunt the story without resolution, as the narrative they weave ensures that their encounters with plastic can only happen in the shadow of trash island.

Dismissive Encounters: Rational Skepticism

Dismissive encounters describe experiences with trash island that lead people to believe that the garbage patch is not a problem at all, producing skepticism about the

extent of plastic pollution in the ocean. The missing island or missing evidence of one becomes the basis for downplaying or even rejecting the whole issue. In dismissive encounters, people are more invested in showing that there is *not* an island than in addressing whether the plastic that *is* there poses a threat. Though dismissive encounters serve industry goals, some of those who dismiss the trash island are established ocean researchers who have failed to encounter trash islands or even plastic waste in all their years of sampling at sea. While concerned with the ocean more generally, these researchers cannot resist the temptation to draw attention to the 'gap' between their research and public understanding, presenting claims about the garbage patch as hyperbole and arguing for the ontological absence of trash island. Making present absent through dismissive encounters however, is to tinker with the interstices of visibility, existence and care for the ocean as the missing island has a tendency to mollify a public that takes the lack of a trash island is good news for the ocean. At the same time, concern about plastic dismissed along with the myth of the island undermines the credibility of organizations like Algalita and threatens the pursuit of further knowledge about ocean plastics.

Dismissive encounters are exemplified by the images of blue ocean circulated in the name of the garbage patch: gently rippled surface of a deep blue sea, lighter blue sky and a scattering of fluffy clouds. What is *not* present matters the most, that plastic is not immediately visible in any form. Figure 2.1 is borrowed from the title page of a PowerPoint presentation titled "Hyperbole and the North Pacific Plastic Patch," given to me by biological oceanographer, Dr. Angelicque White.

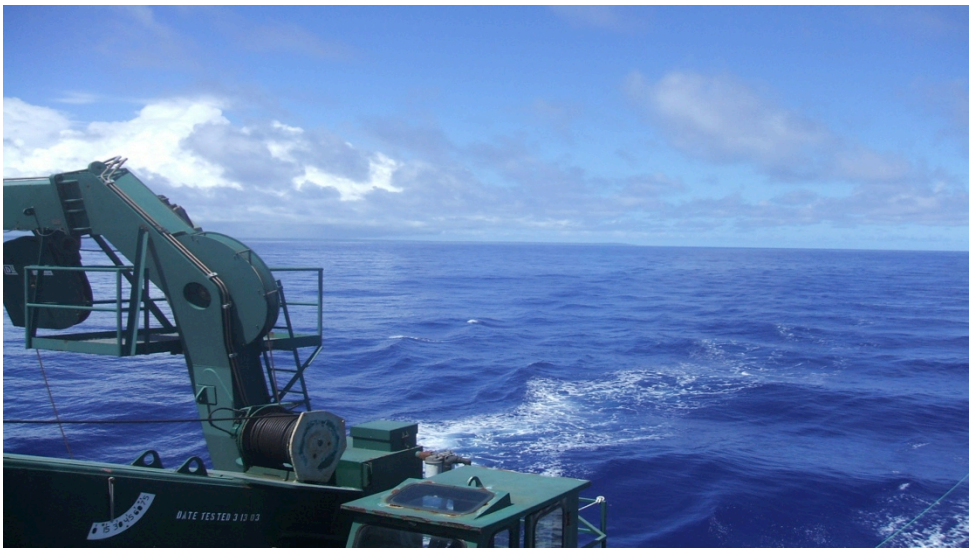

Figure 2.1: Image from "Hyperbole and the North Pacific Garbage Patch" presentation by Angelicque White.

The green metal winch system, used to raise and lower sampling equipment on a large research vessel occupies the bottom left corner of the image, imposing the stamp of science on the blue seascape. A wake of white bubbles evokes movement toward the open ocean, as the mostly unseen ship passes out of the frame and away from what upon closer inspection appears to be a thin sliver of shoreline.

This section explores dismissive encounters through the work and words of Dr. Angelicque White, whose name is often invoked as the voice of dissent by those seeking to direct attention away from problems of plastic pollution. White is an Assistant Professor in the College of Earth, Ocean and Atmospheric Sciences at Oregon State University, and her much cited claims about ocean plastic appeared in a January 4th, 2011 university press release, provocatively titled "Oceanic 'garbage patch' not nearly as big as portrayed in the media." Quoting White, the press release positions measured scientific calculation against media sensationalism:

> There is no doubt that the amount of plastic in the world's oceans is troubling, but this kind of exaggeration undermines the credibility of scientists…. We have data that allow us to make reasonable estimates; we don't need the hyperbole. (Oregon State University 2011)

Through the report, White continues to systematically dispute the major facts circulating about the garbage patch, arguing that it is at most only a fraction the size of Texas, that there is no evidence it is growing exponentially, and that "there are no tropical trash islands out there," especially not the kind that could be seen from space or efficiently cleaned up. The press release leaves little doubt about the conclusions, giving White the final word: "if there is a takeaway message, it's that we should consider it good news that the 'garbage patch' doesn't seem to be as bad as advertised" (Oregon State University 2011).

Given this hard science verging on pro-plastic stance, I arrange a meeting with White at her office on the Corvallis campus with some trepidation, bracing myself for my own potentially dismissive encounter. Who is she? I wonder, and what interest does she have in contesting the issue? Surely she must be some variation of the climate change skeptic type conservative, possibly with corporate ties. Instead, I find a passionate researcher and teacher, with a genuine sense of care for the sea grounded in a deep respect for scientific methods. White is clearly prepared to talk about the issue, a PowerPoint introduction to her research at the ready. A newspaper article about the recent arrival of a large Japanese dock lost in the tsunami on the Oregon coast sits on her desk. But I am not the only one making assumptions, and my visit as a Communication graduate student is interpreted as a quest for the big 'T' Truth by following data to its source. If White is by no means the voice of the plastics industry, she is a voice of reason,

committed to undoing irrational public responses with rational science: asking questions, thinking critically, and evaluating the evidence.

While almost anyone can be dismissive of plastic pollution by stating that it doesn't exist or isn't important, dismissive *encounters* require the rigorous skepticism of an academic scientist, and most importantly, one who has encountered a lack of plastic at sea. You cannot confirm the absence of trash islands from your office in Corvallis or standing on a beach a thousand miles from the middle of the gyre. The word "plastic," however, is conspicuously absent among the titles of White's academic publications. She begins our meeting by walking me through images of *trichodesmium*, a kind of ocean bacteria that look like spikey orange orbs close up, the usual object of her research. The press release the press release is the result of pouring over existing publications, including Algalita's, rather than gathering her own data. "So you came to different conclusions with the same data?" I ask. "The *same* conclusions" she corrects, explaining that it is only the interpretation that differs. White's interpretation, and the possibility of it becoming a dismissive encounter are grounded in the authority of experience at sea. White explains that she has done literally a thousand net tows for her own plankton research and has never once found plastic in the samples. When pressed to explain, she admits that her net tows are generally quite short and take place north of the area where plastic tends to congregate. White did also participate on a Center for Microbial Oceanography Research and Education plastic research expedition at sea in 2008. Even when looking specifically for plastic, she was surprised at just how little was out there, and that plastic was not visible from the boat deck. Coupled with relatively low concentrations even in net tow samples, she wondered at the time, whether they were

actually in "the patch," as she calls it. Her explanation for this encounter with the lack of plastic, is not that they missed it, but that activists have misled the media. White walks me through an extensive PowerPoint on the topic, not so subtly titled: "Hyperbole and the North Pacific Plastic Patch." She does not shy away from naming names, tracing the much repeated suspect claims – an ocean with "more plastic than plankton," "a landfill," "twice the size of Texas," that weighs "3 million tons" – back to direct quotes by Captain Moore.[38] The presentation ends with a teaching moment about identifying "media hype," by tracing the origins of scientific claims.[39]

It is the move from no island to no problem that makes what would otherwise be an especially rigorous form of correction or myth busting into a dismissive encounter. In the press release, White concedes that the amount of plastic in the ocean is indeed "troubling." On her website, she further clarifies the implications of a lack of Texas-sized floating trash island: "This is not to say that the issue of plastic in the ocean should be dismissed, rather the problem is more complex and enigmatic than that conveyed by the imagery of a cohesive patch spread out over a few remote locations." Yet her claims get taken up to do just that: to dismiss the problem, and not just the problem of a trash island. There is a slippage where the nonexistent island is equated with the absence of a real ocean plastic problem. A smaller garbage patch, one that is not solid or visible from space, many conclude, must be good news for the ocean. The encounter begins with White at sea, but only becomes fully dismissive when framed as such in the media. This

[38] Moore, in turn credits oceanographer Curtis Ebbesmeyer with the Texas-sized comparison, at least in the *Vice TV* documentary.

[39] At the same time wants White explicitly wants to mobilize public attention for issues she thinks really matter, but happen to be less visible and less charismatic than trash islands.

happens somewhat unintentionally as an effect of journalistic conventions as the press release is reproduced with little modification or presented as a 'second' side to the issue, but also intentionally, as the press release becomes evidence supporting explicitly pro-plastic positions.

I first came across White's name in an *Earth* magazine cover story about tracking plastic waste (DiGregorio 2012). The issue came out in January 2012, just as I began fieldwork at Algalita's office where I was given a one of the organization's complimentary copies. The article focuses on the scientific work of studying plastic in the ocean, with Captain Moore and Algalita featured prominently, positioned among the first organizations to raise awareness about the problem. The author does an especially good job emphasizing the complexities if the problem: plastic breaking down and sinking, the ever-moving currents, the uneven distribution of floating materials. But as I read, a concerned-looking Algalita staff member points to short section halfway through, that begins "not everyone is convinced that the Great Pacific Garbage Patch contains as much plastic as Moore and his team calculated." The few paragraphs that follow point to skepticism about the amount of plastic in the ocean, emphasizing the difficulty of addressing the question and the lack of funding for doing so. The source, of course, is White; her claims arranged as counterpoint to an article that would otherwise be completely dedicated to the details of actually carrying out ocean plastic the research.[40]

[40] As another example of White positioned as a 'second side,' see "Berkeley City Council to consider moving forward with plastic bag ban" (Morris 2011).

In the majority of cases, however, the press release is simply reproduced with few, if any alternations.[41] When modifications do happen, journalists tend to frame the report as either the latest word on the garbage patch, or as yet more science discredited by other science. But usually it is only the headline that changes noticeably: "'Great Garbage Patch' in the Pacific Ocean not so great claim scientists," in *The Telegraph* (Alleyne 2011); "Giant floating trash pile not so big after all, prof. says" in the *Seattle Post Intelligencer* (Ho 2011); "Claims island of plastic waste twice the size of Texas is floating in the Pacific are 'false'" in the *Daily Mail* (2011). The cumulative effect, that neither garbage patch or trash island is "so great," diminishes problems of garbage patch pollution more generally. A small or nonexistent garbage patch becomes good news for the ocean.

In some cases, the press release claims are very intentionally used as dismissive encounters, and even to explicitly defend the continued use of disposable plastic. In a provocative example, Mark Gunther, author of a business and sustainability feature on *Greenbiz* and regular contributor to *FORTUNE*, leverages White's measured scientific caution "In defense of the plastic bag" (Gunther 2011). Constructing a pro-plastic manifesto to counter a tide of plastic bag bans and taxes, Gunther juxtaposes White's expertise as an ocean scientists who has been there against alarmist claims about the problem courtesy of Oprah:

> Whether Oprah has actually seen the garbage patch is anyone's guess. But Angelicque "Angel" White, an assistant professor of oceanography at Oregon State, participated in one of the few expeditions solely aimed at understanding the abundance of plastic debris in the Pacific. He [*sic*] says

[41] This is common practice in science journalism (Lewis et al. 2008) in part because journalists must cover fields far broader than their areas of scientific expertise (Murcott 2009).

> the claim that the "Great Garbage Patch" between California and Japan is twice the size of Texas is flat wrong.[42] (Gunther 2011)

Again, the dismissive encounter is grounded in not only the authority of academic science, but in experience at sea; White is not only a professor, but one who has participated on an expedition through a scare-quoted "Great Garbage Patch." Gunther borrows this experience as evidence that "plastic pollution of the oceans probably isn't as bad as you think."

In person, White seems to agree that plastic problems are not so dire (though I have not asked about her stance on plastic bags in particular), arguing that there are still areas of the ocean largely unpolluted by plastic. Far more troubling, are the activist hyperbole and media hype. And they do more than create state-sized problems from dispersed fragments; they provide grounds for dismissing the credibility of nonprofits, media outlets and scientists alike. Trying to reduce the amount of plastic in the world at any cost, is what White calls "activism with blinders," a slippery slope to distortion, hyperbole and lies. White is adamant that the people working for Algalita are "not scientists." In her powerpoint presentation, the large green winch of Real Science present in the image above, is juxtaposed against the much smaller equipment on the *Alguita* as if intentionally emphasizing institutionalized disparities. Though members of Algalita do have experience at sea, they do not posses the requisite skepticism and are "undermining the credibility of scientists." The implication is that caring on grounds of anything other than the best knowledge (read accurate science), is detrimental to not only the 'cause' but also to scientific projects more generally.

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[42] It is worth pointing out the gender slippage here in the presentation of scientific expertise, holding a male Dr. White up against a female African-American Oprah.

With the slippage from no island to no problem, the future of scientific research on the topic is uncertain. In the absence of trash island there is no need for solutions, like cleaning the sea, and there is little need for further knowledge of something nonexistent, or, at best, greatly exaggerated. Surprisingly, not a single person I interviewed over the course of the project – founding members of plastic pollution focused nonprofits included – listed ocean plastic among the top three threats for the ocean. In the *LA Times* Altered Oceans series, plastic appears as the fourth, among five parts; and even Marcus Erikson, co-founder of 5 Gyres, listed climate change, ocean acidification and overfishing before plastic. For White, plastic does not even place among the top ten global environmental problems, as she rattles off a list of ocean acidification, overfishing, eutrophication, and land use including oil, nuclear and broader pollution problems.[43] Yes, there is some plastic in the ocean, but White continues, we cannot fix all of this and need to weigh the risks. When it comes to distributing scarce resources, plastic does not seem to rank at all. White is not at all funded for her plastic work, and would not even know who to ask as the usual sources, NSF and NOAA will not fund microplastic research. Other ocean scientists reported similar difficulties getting funded, with graduate students warned specifically against pursuing ocean plastic research should they wish to be hirable in academia after graduation. Dismissive encounters with ocean plastic as a 'real' object of scientific inquiry are transformed into an absence of future knowledge about it.

[43] Eutrophication is where excess nutrients from sewage runoff cause algae blooms that in turn starve other forms of life of oxygen. Ocean acidification is where the ocean absorbs elevated levels of CO2, chemically changing properties of water to detriment of many life forms, especially coral reefs.

Together, these processes are attempts to transform the relative presence of trash island – as a myth, as something in need of care – into an essential absence, something that does not and has never existed. Despite White's obvious skepticism about the extent of an ocean plastic problem, her encounter with the missing island only becomes a truly dismissive encounter in the hands of others. The power to generalize from the experiences of scientists at sea to a lack of plastic pollution lies, in part, in the media framing. But dismissive encounters work to untangle these relationships, producing distinctions between scientific (skeptical) and activist (with blinders) modes of caring. For White, caring about the wrong things or in the wrong way is worse than not caring in the first place as it undermines the credibility of not only the organization making claims, but the whole project of science. Problems of caring for trash island extend beyond the topic of plastic, for example, as 'science discredited by other science' becomes science not worth listening to at all. Just as academic scientists trace the sources of questionable claims to activists whose science is compromised by activist concerns, nonprofits point then to the media in turn. But attention focused on who is responsible for the myth of trash island and showing it does not exist is attention diverted from the question of what to do about plastic. With dismissive encounters, the question of how to care becomes a question of whether anyone should care. The missing trash island becomes a missing plastic problem.

Corrective Encounters: Reshaping Truth

Corrective encounters describe processes where people attempt to replace the myth of trash island with what they see as a more accurate understanding of plastic

pollution. The trash island becomes a representation that is problematic because it does not convey the true form of ocean plastic pollution, and believing trash island exists becomes a kind of ignorance about the ocean. In corrective encounters, people are most invested in reshaping concern generated by trash island, rather than dissipating attention entirely. This imperative to correct public understanding of ocean plastic problems is shared by members of both the activist and academic communities, though they do not always go about it in the same way. As with dismissive encounters, the authority to correct begins with experiences at sea; those who have 'been there,' engaging in myriad projects aimed at getting the facts out by sharing the truth about ocean plastic and bringing samples back with them. Here too, there is a desire to reconcile representations with reality, but also an understanding of the need to do so while maintaining public concern. Corrective encounters are often motivated by the desire for practical solutions, ones that do not begin with assumptions of solid islands. Care for plastic pollution the right way, and meaningful change should follow. But corrective encounters point toward the difficulty of making an island absence while maintaining plastic presence.

Figure 2.2: Captain Moore and Gyre Sample 2002. Photo by the author.

Corrective encounters are exemplified by the images of 'plastic soup' circulated as samples of the garbage patch: glass jars filled with bits and pieces of colorful plastic suspended in murky liquid. The island may be absent, but plastic is definitely present. In Figure 2.2, Algalita founder Captain Moore himself holds up a sample as evidence. The plastic in the jar looks nothing like an island. It is broken into little pieces, no bottles or bags in sight. The solid pieces that do appear are suspended in liquid, presumably seawater. Upon closer inspection the plastic is mixed up with now-dead sea life, most conspicuously a small lanternfish. The gloved hands, open jar and background seascape give the impression that the contents have just been scooped from the surrounding waters. Moore presses the sample toward the camera, as if to say, there is an ocean plastic problem and here is a piece of it. I told you it was not an island.

This section explores corrective encounters through Algalita's attempts to assert the existence of an ocean of plastic soup in place of a trash island, and through the 'myth busting' project of Miriam Goldstein, a young oceanographer at the Scripps Institute of Oceanography. This is a specific example of more general concerns, expressed by almost everyone I have interviewed, about the limitations of "garbage patch" as a descriptive term. It is far too terrestrial, bounded and solid; a garbage patch too easily coalesces into trash island. As the National Oceanic and Atmospheric Administration (NOAA) website explains, "while often used by the media, it does not paint an accurate picture of the marine debris problem in the North Pacific ocean." NOAA does not offer a catchy replacement, "concentrations of marine debris" is not exactly the stuff of headlines. Moore on the other hand has tried to replace garbage patch, a term he always credits to Ebbesmeyer, with "a swirling sewer" and even "a superhighway of trash" connecting two

"trash cemeteries" (Hohn 2008). In place of a trash island more specifically, Moore offers plastic soup, a term he is not afraid to claim as his own.[44] In his book, *Plastic Ocean*,[45] separating trash island from plastic soup is among the first orders of business:

> Let it be said straight up that what we came upon was *not* a mountain of trash, an island of trash, a raft of trash or a swirling vortex of trash – all media-concocted embellishments of the truth. It would become known as the Great Pacific Garbage Patch a term that's had great utility but, again, suggests something other than what's out there. It was and is a thing plastic soup, a soup lightly seasoned with plastic flakes, bulked out here and there with "dumplings": buoys, net clumps, floats, crates, and other "macro debris" (Moore and Phillips 2011: 4).

Here, in the first chapter titled "Plastic Soup," Moore blames the trash island myth on "media embellishment," but he also opens up space for the "utility" of garbage patches, and perhaps even for trash islands by association. In corrective encounters the missing trash island is not good news for the ocean. It is problematic because it does not map onto "what's out there."

Corrective encounters require a connection to the open ocean, whether through the experience of someone who has been there, or through interactions with samples and images brought back from the gyre. As such, corrective encounters can happen directly at sea as expedition participants, who may or may not count themselves as scientists, travel through the accumulation zone and confront plastic fragments. They can also happen indirectly at education and media events back on land. Armed with gyre samples, Algalita's education coordinator, for example, gains the authority to assert the form of the

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[44] The first mention of "plastic soup" in the media does indeed appear as a direct quote from Captain Moore in a local newspaper staff report about Algalita receiving a large water pollution research grant. "It's a plastic soup in the ocean," Moore said (Daily Breeze 2002). Every article that follows with mention of plastic soup mentions Moore in some capacity.

[45] The title of the Japanese edition translates to "Ocean of Plastic Soup."

problem without having sailed through it herself. Showing and describing plastic soup only becomes part of corrective encounters when used to confront the trash island or other misleadingly solid versions of the problem. Corrective encounters also depend on a public that brings the trash island with them, providing the concern that demands reshaping.

It is this replacement of the absent trash island with other kinds of knowledge about present plastic that turns acts of dispelling myths into corrective encounters rather than dismissive ones. This happens through a combination of reappropriation, as common tropes are clarified, and substitution, where new forms and metaphors are offered in their place. Engaging directly with problematic assumptions about the size and solidity of the garbage patch, Moore integrates the now much-circulated claims into his interviews and presentations. At the Aquarium of the Pacific in Long Beach, Moore tweaks the twice-the-size-of-Texas claim for a full auditorium. It is not a trash island twice the size of Texas, he clarifies, rather the area we were *sampling* is roughly twice the size of Texas. Though Moore has said some questionable things over the years, the only times I have caught him uttering the words "trash island," whether in newspapers, online, or during my fieldwork with Algalita, are to say it does not exist. Or at least not yet: "Well, you know, it's been referred to as a "trash island," but really, what we're trying to do is stop it from becoming a trash island**.** It's a dispersed congregation of our debris from civilization, mostly plastic, and it's breaking into small fragments," Moore tells NPR (2008). At the Ocean Institute in Dana Point, Moore lines the evidence up on tables, a sample jar from each of the five major ocean gyres. For Algalita's education coordinator, these jars are the key to helping the public move from the island metaphor toward what's

really out there: “the best way to get somebody to understand is to have a physical sample with you, to kind of like shake it up and show them that it’s more of a soup” (Allen, personal interview, 2012).

Corrective encounters are not limited to the domain of nonprofits. When I interview Miriam Goldstein, a graduate student at Scripps Institute of Oceanography, she confesses to being an avid mythbuster: “When I started working on this I was so enthusiastic about correcting all the misconceptions and really trying to get out the word about the truth, you know, and like really engaging these misconceptions” (Goldstein, personal interview, 2012). Goldstein’s research project was shaped by trash island as she initially wondered why no one at Scripps had seen it or had evidence it did not exist, and then, set out to remedy what she found to be an absence of academic science about ocean plastic more generally. In addition to her scientific research Goldstein devotes energy to tracing the origins of images circulated as “trash island” (her ‘favorite’ which she has dubbed “canoe man” turns out to be a stock photograph of waste-congested Manila harbor), and thoroughly disputing popular claims. She points her collaboration on an article for i09 as a successful example (Newitz 2012). “Lies You’ve Been Told about the Pacific Garbage Patch,” reads the title; underneath a single tag files it under “DEBUNKERY.” The article introduction carefully emphasizes Goldstein’s status as a marine biologist and her experience on several research trips through the garbage patch, adding that she has “even swum in it.” The remainder of the piece counters each well-known myth (“There is a giant island of solid garbage floating in the Pacific”), with hard fact (“There are millions of small and microscopic pieces of plastic, about .4 pieces per

cubic meter, floating over a roughly 5000 square km area of the Pacific. This amount has increased significantly over the past 40 years").

While Goldstein takes direct aim at trash island and associated cleanup solutions, she is not afraid to speak of the "ubiquity" (as opposed to White's scarcity) of plastic encountered in the North Pacific, or to call the gyre a "trash magnet" on record (Reilly 2010). Here debunking myth does not sink the issue with the island, but opens up space for the substitution of 'better' knowledge, a set of facts for every myth. In her TEDx talk, "How I learned to stop worrying and love the garbage patch," Goldstein (2013) sets up a narrative of heading out to sea after hearing about the trash island, but then not finding it. The accompanying image is that of nothing but blue sky, blue sea dismissal, where "ocean looks pretty much like blue ocean." Rather than leaving it there, she points out (as White does in her longer presentation, but less so in the press release), what you see when you "look closer," showing a top-down image of blue ocean surface with twenty-three plastic fragments encircled in white making the plastic visible to the audience. Both Goldstein and Algalita position their best scientific facts in a way that is intended to produce trash island as nothing more than popular misconception, and they both provide plastic alternatives: Goldstein, the image of dispersed but very present fragments,[46] and Algalita, an ocean of soup.

Dishing up plastic soup, however, proves to be far easier than convincing the public that the island is not there. One metaphor does not simply replace the other in a linear progression toward better representations. Moore, in fact, was describing an ocean

[46] Goldstein similarly holds up jars of surface samples as evidence and even occasionally uses the comparison to plastic soup.

of plastic soup and showing people samples of it in 2002, at least five years before stories about trash island proliferate. More than ten years later, after full hour presentations about plastic soup, I listen as audience members continue to ask completely serious questions about cleaning up the island. Though I have had my share of conversations with people that insist that trash islands do exist, I still find myself wondering how someone can sit through an entire presentation about microplastic and toxins, plastic in the bodies of tiny sea life, and suggest a giant aquatic vacuum as a remedy. For Algalita's education coordinator, it is the media "twist" on the issue that makes the island so difficult to explain away. "It's been out of Charlie's [Moore's] control, everybody's. And they attach the trash island and all of that to it, and it's hard to get people away from that almost romantic vision of what's out there." Algalita's director agrees,

> It's interesting and it's frustrating because you don't even know what's going to get printed after you've done an interview. And it seems to me that they always go back to the island, trash island, garbage patch, twice the size of Texas – those quotes that you're trying to get them away from, but they're still going back to the same things (Francis, personal interview, 2012)

There is a shared sense that media coverage is "getting better than it was," that public awareness of plastic soup is increasing. [47] More reputable media outlets start to take up "plastic soup," or rather drop the trash island talk. By May 2011, *New York Times* Green Blog asks "How to Rid Seas of Plastic Soup?" (Wassener 2011).

[47] "When I first started talking about the issue we were misquoted, there were things in it that just weren't accurate" (Francis, personal interview, 2012). Goldstein agrees, "When I started working on this I was so enthusiastic about correcting all the misconceptions and really trying to get out the word about the truth, you know, and like really engaging about these misconceptions. And I think we have made progress….Yes, I think really the plastic soup idea has really gone more into the public awareness so that's good" (Goldstein, personal interview, 2012).

Others, however, are simply unwilling to engage in corrective encounters. Goldstein confronted Greenpeace over an animation purportedly demonstrating the drift of pollution in the Pacific Trash Vortex. You do not have to look very closely to see something peculiar – the lines and arrows demarcating flows that begin at sea continue to move over land, down into California's Central Valley and up through the interior of British Columbia. When Goldstein pointed what she sees as a particularly egregious yet easily fixed conflation of air and water, the organization replied that is was "good enough" for their purposes. Years later, the air model of ocean plastic circulation still stands.[48] For Goldstein the model is "completely ridiculous," for making such a rudimentary mistake, but it is especially frustrating because in letting it stand, Greenpeace is "ruining their good name." Goldstein was similarly disappointed in the *New York Times* trash island article. As she explains in a blog post on the SEAPLEX website:

> Widespread misinformation, as is so common regarding plastic in the North Pacific, serves no one – not activists trying to ban plastic bags, not plastic manufacturers trying to develop ocean-degradable products, not groups developing methods to stop plastic pollution. Our role as scientists is to find out truths about the world, and to interpret and explain them (Goldstein 2011)

Again, scientific accuracy is inseparable from credibility, the legitimacy of the organization evaluated by the legitimacy of their facts.[49]

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[48] And it is still there, as of June 15, 2014. http://www.greenpeace.org/international/en/campaigns/oceans/fit-for-the-future/pollution/trash-vortex/

[49] Algalita, while subject to much critique, is lauded by both White and Goldstein for taking critiques and improving over time.

While Algalita is definitely concerned that the knowledge they are sharing is sound and their science credible, members tend to be especially pragmatic in their evaluation. If Moore spoke of the "great utility" of the garbage patch concept for raising awareness, trash island is far more frustrating because of the way it impedes practical solutions. For Algalita's community relations coordinator:

> people [who] will call with ideas or plans, with methods to quote, clean up the ocean of plastic unquote. And frankly they don't have a clue. A lot of that comes from the fact that they think there are big islands of trash out there, and oh yeah, we can go out there and we can put a boat out there and we can actually hitch a boat to one of these plastic islands and start working on that…it gives people such a false impression that they start building on this false impression and wasting time and energy on something where they can be devoting it to something else. (Gallagher, personal interview, 2012)

Trash island creates extra work for those sharing knowledge about the ocean, as they must re-explain and push against solid ideas people bring with them.[50] Trash island also creates extra work as these same people are "wasting time and energy," on impractical solutions. They are, as she says, "building on false impressions."

Though Goldstein and Algalita's staff see themselves as part of very different organizational structures, they have more in common that they think: both strive to correct the form of the problem through facts with hopes of redirecting the path to solutions. As with dismissive encounters, university researchers maintain a rigid model of the relationship between scientific knowledge and forms of care, where legitimate concern cannot be grounded in anything other than the 'truth.' Both White and Goldstein

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[50] "And you have to just go back and explain to people when they call and when they write, that it isn't like that out there. If media had it right in the first place they would be very, very helpful to the public and not give us such a tough time of re-explaining things" (Gallagher, personal interview, 2012)

are quick to point out Algalita researchers' lack of rigorous academic training in the ocean sciences. A Scripps Institute of Oceanography press release from the expedition led by Goldstein, becomes an argument for who can do science. Algalita, in the meantime, had been on numerous expeditions and published several peer review articles by 2007. The organization has definitely circulated some questionable claims over the years.[51] Algalita, however, prides themselves not only on raising awareness, but on the quality of their facts. As explained by their director: "Algalita really tries to keep the facts accurate. People come to us for accurate information. They will tell us that. They say if you want to know something you go to Algalita, you guys are authentic." Where Goldstein's science must be solid enough to pass the scrutiny of peer review, Algalita's must stand against the plastic industry in court when others call on it to do so. Both Goldstein and White mention that Algalita has done much to improve over time.

Corrective encounters coalesce around the task of rendering the island absent while maintaining the presence of plastic problems: shifting how the public understands the shape of the problem from trash island to plastic soup, while maintaining interest and support. The belief in the existence of a trash island can be remedied with good science and faithful communication of its products. Though nonprofits demonstrate a kind of flexibility between accuracy and awareness that does not sit well with science, it is the refusal to participate in corrective encounters that appears as the worst offence. Goldstein's frustration with Greenpeace is grounded in the organization's insistence that people caring is all that matters, not how or on what grounds. But as dismissive encounters demonstrate, commitments to science and accuracy can easily become

[51] Most notably the 6:1 plastic to plankton ratio.

antithetical to specific kinds of concern and change. There is a tendency for plastic problems to disappear along with the trash island. But far more often, people engaged in corrective encounters lament the tenacity of trash islands. You can get out the sample jars, show all kinds of images of microplastics, talk about toxins in seawater, about plastic fragments stuck in bodies, but the island will not go away.

Constructive Encounters: Building on Trash Island

Constructive encounters describe experiences with dense accumulations of plastic waste that lead people to build trash islands in the sea. Trash island is both the problem and the solution: it is missing but it can be built. A trash island in the North Pacific is not a misconception, but rather something to be conceived. As such, people who engage in corrective encounters tend to embody a certain entrepreneurial spirit, approaching ocean plastic as a lost resource and the ocean as the domain of potential profit. Waste can be brought back into material economies of value through recycling. While based on interactions with plastic on beaches, in rivers, in images and stories, constructive encounters (so far) tend to be future oriented, comprised of plans for islands-to-be rather than completed projects. With corrective encounters trash island becomes most obviously performative as architects, artists and others shape plastic pieces in its image. Those involved challenge forms of care based in scientific fact alone, but often draw on research to show that their schemes are feasible. If those engaged in corrective encounters hope to keep trash islands from coming to be, participants in constructive encounters work to render absent island present. But building floating trash islands, like disappearing them,

proves more difficult than expected as plans formulated on land encounter the challenges of the open seas.

Figure 2.3: WHIM Architecture's rendering of Recycle Island in the middle of the North Pacific Subtropical Gyre.

Constructive encounters are exemplified by the image of a plastic island circulated in the name of the garbage patch, where the presence of dense accumulations provides inspiration for grand recycling and development plans. Figure 2.3 is an architect's rendering of Recycled Island, a floating metropolis made form waste collected at sea. The artist has carefully arranged tangles of plastic, blue canals slicing apart colorful wedges of greens, red, yellow, orange and purple sorted into habitable land. In the upper right corner, a Laysan albatross, the poster-victim of ocean plastic pollution, soars across the sky, banking slightly toward the island, landing place in sight. This hint of movement is echoed in gentle waves breaking into an occasional whitecap in the water below. The blue expanse characteristic of dismissive encounters is reduced to a frame supporting an island that appears to be very much present.

In this section I explore constructive encounters through Recycled Island, an ongoing project led by Ramon Knoester, founder of the Rotterdam-based WHIM Architecture. WHIM creates architecture situated within broader contexts through a recursive approach combining research and design: "Where society changes, architecture should adapt," and then provide "feedback into the society that created it" in return (WHIM 2014). For Recycled Island, the context is plastic in the North Pacific Gyre, and the project is transforming waste materials into habitable land for humans. As outlined on the WHIM website:

> The proposal has three main aims; Cleaning our oceans from a gigantic amount of plastic waste; Creating new land; And constructing a sustainable habitat. Recycled island seeks the possibilities to recycle the plastic waste on the spot and to recycle it into a floating entity. The constructive and marine technical aspects take part in the project of creating a sea worthy island (WHIM 2014)

The project description is steeped with the rhetoric of creative potential: seeking, creating, constructing paths to new possibilities, and, ultimately to new land. Not content to simply clean up the gyre, or even "all" the plastic in the ocean, the project combines concern with ocean plastic with concern for climate refugees. As Knoester explained to me by email:

> In the Netherlands, where I live, we grow up with what floods can do and the beauty of a long coastline. I'm an architect and floating houses are still growing in popularity. In a situation where sea levels are rising and building materials become a scarcity it is a necessity to make connections. The image of a floating plastic Island in the ocean is horrifying and attractive at the same time. Turning the marine litter into a building material for a flood proof island is the best solution I can think of. (Knoester, personal correspondence, 2014)

What otherwise might be a strange combination starts to appear far more reasonable when you take a second think about why a Dutch firm might be preoccupied with the consequences of rising sea levels.

A floating sustainable society built out of the salvaged discards of a watery climate-changed world, Recycled Island is a constructive encounter on the grandest scale. The plans describe 10,000 square kilometers landmass, a figure and form inspired by the Island of Hawaii, and capable of supporting 500,000 people. In a second image, the albatross becomes tour guide, flying a canal lined with skyscrapers. The smooth, rounded edges and symmetry bespeak a Jetson's meets Monsanto mid-century retro-future. The postwar promise of freedom and prosperity through consumption (Cohen 2004) is delivered at last through recycling and sustainable technology. The island will be self-sufficient, powered through solar and wave energy, with seaweed harvesting a source of compost and biofuel. The people though, dining canal-size or strolling the palm-lined walkways, look a lot more like tourists than like the seaweed farming citizens in the project description.

People engaged in constructive encounters need not be trained as scientist or have direct experience with plastic at sea. Indeed, they are facilitated by the lack of direct experience, as much as by the desire to do something about it. People planning a "floating entity" do, however, need experience with dense accumulations of plastic, if only using images of them as motivation. Knoester has not himself been to the any of the ocean gyres, but he has seen pollution along coastlines. The promotional materials for Recycled Island are thick with photographs of plastic piled deep on beaches and the project Facebook page is a juxtaposition of images of heavily polluted coastlines,

including a huge deposit of bottles massive, contrasted with bright computer generated images of Recycled Island surrounded by clean shores and even cleaner water. It is much easier to imagine building something from piles of plastic washed up on beaches or floating down urban rivers, than from samples of plastic soup.

Above all, people who participate in constructive encounters embody an entrepreneurial spirit, where problems are always opportunities. Ocean plastic becomes a lost recourse, the gyre a potential site of profit. WHIM makes this quite clear among the multiple benefits of making Recycled Island: "This will clean our Oceans intensely and it will change the character of the plastic waste from garbage to building material. The gathering of the plastic waste will become a lot more attractive." Recycle Island both cleans up the ocean, and brings waste back into the realm of useful, valuable material, the embodiment of the firm's recursive approach to architecture. By becoming profitable it provides incentive for others to do the same. At least in theory. In fall 2012 I pledged modest support to the project's Kickstarter campaign in return for the privilege of receiving project updates by email. The campaign aim was raising sufficient funds to build a Recycled Island prototype in the form of a floating, self-sustaining single family home. The campaign was unsuccessful, raising only $1,811 of the $70,000 required for the funding to go through. The project team explained via email correspondence that they have received "a positive reaction, but very little financial support." My $10 did not add up.

WHIM is not the only source of such schemes. The organizations and researchers I work with regularly receive emails concerning what they, with scare quotes, call "solutions." There are proposals for using robot jellyfish, whose undulating tentacles can

gently separate plastic from marine life. Others describe massive plastic extracting conveyor belts positioned just below the sea's surface, tilted of course, so fish cannot lie on them. Electrolux even has plans for getting plastic out of the sea and into appliances, both the tool for removing plastic and the final products are vacuums (Schwartz 2010). In my personal favorite, a woman neatly combines concern about the garbage patch with concern for endangered species, proposing the capture and recycling of ocean plastic into replacement habitats for polar bears. People could sponsor the artificial ice flows to offset costs, she continues, giant brand names visible in satellite images. Through cleanup and recycling, ocean plastic and climate change once again resolve into profits.

While constructive encounters begin on land, whether with piles of plastic or through images of more distant problems, the "floating entity" is to be fully realized at sea. Recycled island is designed in Rotterdam with the intention of building a floating island in the North Pacific Gyre, the location chosen for its proximity to the source: "By recycling and constructing directly on the spot with the biggest concentration of plastic waste, long transports are avoided" (WHIM 2014). There is some confusion about whether this involves constructing an island or simply developing the one that is already there. The media coverage describes the difficulty of plastic collection, given the size of the Pacific, and that "it will take years to gather enough plastic before there's enough to melt together to form the gargantuan island" (Nelson 2011). But those commenting on these articles have their own ideas about what Recycled Island entails, "I think to build on top of it would be a bad idea. Its just human to cover it up and forget about it but its still there," writes one, while others jump to weigh in on whether or not there is already a

floating garbage island (Schwartz 2010). Does trash island exist? Or will it come to exist as Recycled Island? Is the plan possible at all? Knoester is well aware of the challenges:

> Ah Yes, it is not easy because it has never been done before. The plastics are difficult to collect. The plastics are altered by the sun and ocean water. The Island should be very strong to withstand high waves. And this is all true. If it was easy, then we would already have several Islands floating there. We have to make a big effort to make Recycled Island happen. Sometimes complexity is mistaken for something else (Knoester, personal correspondence, 2014)

In WHIM's more recent projects, the original ambitious plans seem to give way to far more modest proposals for floating recycled parks and villas. In the movement from original concept to prototype, constructive encounters drift closer to land, to river mouths and harbors where plastic is more plentiful:

> Plastic waste is a structural problem in open waters. Via rivers a subsequent part of plastic litter enters our seas and oceans, where it becomes part of the plastic soup. The Nieuwe Maas is an important European river that takes the pollution from the inland to the sea. (WHIM 2014)

Accompanying images of "Recycled Park" show bright green grass and tree covered floating platforms anchored against backdrops of office tours, residential towers and even the port of Rotterdam. A visual conception of merged before and after images positions a bright floating park surrounded by clean water, birds and jumping fish in contrast with a river inhabited only by a stream of trash floating toward the sea. With the park recycling once again, gives "new value," this time to a river. But again, these projects are prototypes, puzzle piece building blocks for Recycled Island, whose original plan "looked big and still does" (Knoester 2014).

With constructive encounters, questions of credibility and accuracy through good science, so central to dismissive and corrective encounters, are usurped by questions of

feasibility and conviction. WHIM integrates knowledge about ocean plastic on pragmatic terms, rather than for focusing on credibility in scientific ones, academic or otherwise. Research means learning how to overcome challenges and make the project possible, for example investigating the best recycling techniques:

> Design always starts with an idea. If that idea is not common, then we have the find possibilities to still realize our imaginative proposals. This is one important aspect of research for our office. Now for Recycled Park we are researching how we can take the most plastics from the river and what the best recycling technique is for our proposal. (Knoester, personal correspondence, 2014)

The Recycled Island online presentation and Kickstarter promotional videos give considerable space to demonstrating techniques for island building where those engaged in dismissive and corrective encounters focused on educating the public about gyre pollution. At times, the Recycled Island project does get framed as a means of raising awareness about the plight of the seas, but it is not conceived as an act of science communication. Where the Recycled Island website makes general claims about the extent of plastic pollution in the ocean, the claims are attributed to vague "experts" or more often, simply go unreferenced. With constructive encounters, credibility lies in carrying out proposed projects. One ABC News headline makes Recycled Island sound like a fait accompli, "Pacific Ocean to Receive Plastic Island" (Barnes 2010), as if it is only a question of when, but most commentators are more cautious, labeling the project "ambitious," "bold" and perhaps even "impossible" (Messenger 2010; Nelson 2011). That there is a plastic problem in the ocean, however, is not a question: "One thing is certain: the debris field stirring in the North Pacific Gyre only stands to grow in size if nothing else is done about it" (Nelson 2011).

In constructive encounters plastic pollution is very much present, but so too is trash island. Whether it is already existing or not as a physical entity is only a matter of process and time: a missing island can be built from plastic in the gyre. Poking fun of constructive encounters is an easy way to elicit laughter from audiences and smiles from readers, especially when images of futuristic floating cityscapes are readily available. But to dismiss island building and other grand cleanup schemes with humor is to ignore what makes them powerful. In constructive encounters, the concept of floating trash islands survives despite attempts to dismiss it as impossible or to dilute it into plastic soup too costly to strain. Though those with scientific training tend to focus on why such projects are impossible in technical terms, the dissection of engineering minutiae takes attention away from why constructive encounters are so compelling despite this.

Constructive encounters exemplify "romantic" solutions, to quote several of my informants, but I am most interested in how they position cleanup as *the* necessary (read only) kind of care, and in the case of Recycled Island, floating landmasses as their logical form.[52] It is only a matter of technique and costs.[53] Trash islands, already existing or to be built, preclude discussions of other (less romantic) kinds of responsibility, of producing and using less plastic in the first place, or legislating reusable containers in place of disposable ones. In practice, the Recycled Island has shifted sites and scales while maintaining cleanup and recycling as reasonable and potentially profitable solutions.

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[52] Islands, as Grove (1995) suggests, are colonial concepts, a decidedly Western way of finding sense and value by drawing boundaries around 'new' lands.

[53] One presenter of such a cleanup scheme at the 2013 conference in Hawaii continued to insist that they had enough money to clean up the ocean, despite the pleas of various members of nonprofits in the audience who pointed out how much more they could do with those funds on land.

Though morphing from giant open ocean metropolis to parks a bare fraction in size while retaining floating plastic island form, achieving even smaller parks and villas is a way of demonstrating the real possibility of the giant floating metropolis. Constructive encounters work from an island absence to make its presence seem inevitable, if not as something already existing, then as something that could/should/will come to be.

Myth/Mis-/Missing: The Generative Potential of Material Absences

While mainstream media coverage has undoubtedly contributed to widespread awareness of the Great Pacific Garbage Patch, it is not in the (mis)representations of media coverage alone that trash island assumes the potential to come into being or not. The language and images and objects of these reports continue to nurture trash island forms and myths, but it is in encounters where specific people – oceanographers, activists, journalists – interact with plastic at sea and on shorelines and with each other that trash islands are made and unmade. Encounters are not true or false, accurate or not; they are doings, meetings, makings. Though I have outlined three kinds of encounters as performed by people I have met, encounters by definition they are not reducible to specific individuals or groups.[54] Algalita's work on the garbage patch prompted researchers like Goldstein and White to address the topic, while their critiques pushed

[54] Even those I have chosen as exemplary of a specific kind of encounter could be featured across multiple sections. White, for example, bent on making the island disappear, does so in the name of correcting public understanding. At the same she engages directly with trash island: as White calculates that the garbage patch would be less than one percent the size of Texas (Oregon State University 2011), she squishes dispersed fragments together with the power of math. Individual participation also changes over time. Goldstein's project was intended as a dismissive encounter (to the extent you can prove something is not there), but becomes corrective after she is surprised by how easy it is to find plastic in the gyre. Unlike many environmental issues, where the struggle is in getting the public to care about risks identified by academic research, ocean plastic moved from a public issue to an academic one.

Algalita to modify their methods and their claims. It is through these interrelationships between entanglements of knowledge, matter and care that trash island absences and presences emerge.

Kinds of encounters are especially helpful for showing the relationships between forms of matter (as nothing, as soup, as island) and forms of care (for something else, with good science, by cleaning up). The existence of plastic pollution as a 'real' problem rests not only with the amount of plastic or toxins or potential harm, but also with how solid it appears on the sea surface. The physical form ocean plastic does or is imagined to take – its very materiality – cannot be separated from forms of care. Moreover, caring, as Puig de la Bellacasa describes, "involves a notion of doing and intervening" (2011: 89) that is replete with ethico-political imperative: to defend science, to save the seas, to respond to coupled socio-ecological crises. The very difficultly of undoing, replacing or otherwise overcoming gyre plastic's associations with trash island becomes evidence that knowledge and care and material form inextricably emerge together. Despite the lack of scientific evidence that a trash island does or ever did exist in the North Pacific Gyre, even its absence demands care.

As an absence, trash island is a missing thing, a landmass that cannot be located, but it is also a process: it is made and unmade in the encounters that aim to disappear it, change it, create it. Each set of encounters documents an attempt to render trash island an absolute presence or absence, but trash island continues to escape these attempts at stabilization. For those engaged in dismissive encounters trash island is, or at least should be, an absolute absence. As trash island disappears, it can take the ocean plastic with it, and dismissive encounters end in the nonproduction of knowledge and inaction (Frickel

2014). Corrective encounters too are attempts to show the absolute absence of a trash island, but here people are caught in the tricky position of making the island absent without losing the plastic with the landmass. This begins with a problem of "undone" science, that once done has the potential to transform trash island into soup. Finally, constructive encounters with trash island suggest that no absence is completely absolute. Trash island arguably qualifies among Frickel's elusive "things that are not there or anywhere and probably never where" (2014: 88), yet a trash island that may not exist now or in the past, but could become in the future. Caring for missing things has the potential to bring them in to being.

Missing or present, trash island is inextricable from the becomings of gyre pollution as matter of concern and care: even its absence is part of the entanglement. In its endurance as something that is both present and absent, trash island is an "unformed object," a confluence of "potentiality and loss" (Murphy 2013; Stuart 2013). As I join a team intent on setting the record straight by agreeing on the shape and form of the problem, the trash island lives on. As a shadow that cannot be erased by better facts, and as a plan for building it that is at once more and less solid than myth. Heading to sea, we will bring trash island with us. As something we know does not exist, as something that continues to frame discussions of gyre plastic, and, as something we quietly hope we just might see.

Chapter 3
Witnesses in the Garbage Patch:
Intersections of Humans and Plastic at Sea

Where Chapter 1 focuses on water and plastic coming to circulate together, and Chapter 2 outlines how multiple forms of the problem inform and emerge with media coverage about trash islands, this chapter describes the movement and transformation of people as they learn about gyre plastic by travelling to and through the Great Pacific Garbage Patch on a boat. I chronicle my experience as a participant on the Algalita Marine Research Institute's July 2011 North Pacific Expedition, which I joined in order to understand how the garbage patch is shaped by practices of seeing and sampling plastic at sea. As we search for circulating plastic, the path of the boat cuts a thin line across gyre currents, a trajectory marked by the intermittent encounters of humans and scattered objects and fragments. Participants expected the destination to be somehow obvious; if not an island, at least a place where we would know we had arrived. But the garbage patch, amorphous and fluid, was not self-evident. Without stable coordinates or recognizable boundaries, our knowledge and experience of absent island and present garbage patch needed to be built through collective experiences, assembled piece by piece from encounters with gyre plastic.

As formalized in the official press release, Algalita's July 2011 North Pacific Expedition is charted to collect a fresh round of plastic samples from previous study sites and to gather fish, water and plastic for affiliated university-based research projects. The

voyage is Algalita's eighth foray into open ocean sample collection.[55] The need to look more closely at changes in the North Pacific over time comes in the wake of a study by the Sea Education Association that found ocean plastic accumulations to be unchanged in twenty years in the North Atlantic (Law et al. 2010). To those familiar with the Pacific, like Algalita's July 2011 expedition research coordinator Marcus Eriksen, these numbers not only seemed counterintuitive in light of the increasing plastic production and patterns of Pacific Rim development over the same period, but went against experience at sea: "We suspect there's greater accumulation, which means more harm to sea life and potentially to humans," he explains (Algalita 2011). A new round of surface samples and the resulting measurements could help make the case that plastic pollution is a growing problem.

But if the goal is procuring scientific evidence of changing amounts of plastic in the gyre, there is a seemingly strange mismatch between the task and the human skills at hand. Reading the bios of the thirteen crewmembers, I learn that only one has PhD training as any kind of scientist. Nor is it for our qualifications as sailors that we have been chosen. I am not alone in my complete lack of knowledge about sailing. That I have company in my inexperience provides only the slightest comfort before congealing into calculated fear: we are about to embark on a nearly three thousand mile ocean crossing and the chance the person sitting next to me knows something about sailing hovers around one in four. What, I wonder, is someone as under-qualified as I doing, about to sail the remote reaches of the North Pacific in the name of science?

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[55] The organization has since completed two more research expeditions. A multi-part exploration in 2012 of the Western Garbage Patch and the debris field that resulted from the 2011 Japan tsunami; and a one-month stay in the gyre hosted by Captain Moore in 2014.

There are some clues in the handouts provided to participants and the media, where the trip is billed as an "eco adventure," and a chance to participate in science on the high seas (Algalita 2011). Fees paid by the guest crew, officially ten thousand dollars per person, are a major source of funding for the voyage. But we are not being asked to sponsor science from afar with our checkbooks; rather, it seems imperative that we take part in science and sailing at sea. The chance to "participate in such research and learn how it is conducted" even appears first among a list detailing the purpose and scientific objectives for the voyage, a combination of research and education characteristic of Algalita's self-professed "research activism." When I later ask Algalita's founder, Captain Moore about the benefits of bringing people 'like me' on expeditions he explains:

> You don't have the right to discount what people tell you as being unreal. All science is based on observation, so peoples' experiences of the garbage patches, these plastic accumulation zones, that experience is a data point in this whole scientific endeavor of understanding what's happening in our ocean. And those data points are valid. They need to be communicated, they need to bear witness to this fact. The more people that get out there and are able to bear witness the better. (Moore, personal interview, 2012)

It is precisely *because* we the guest crew do not yet have such experience that it is so valuable to have us along. As interested non-sailors, non-scientists we have the most to learn from the voyage. We are here to witness.

In science and technology studies, the witness is a familiar figure in the production of matters of fact. For Shapin and Schaffer (1985), witnesses are critical to the very emergence of experimental science, where direct or "actual" witnesses in attendance at experiments provide testimony of their observations and lend the gentlemanly moral

credibility of their social standing to the production of legitimate knowledge. The privilege Moore awards to experiences in the garbage patch is similarly grounded in practices of direct witnessing, where being "out there" is part of the production of "valid" knowledge about plastic pollution. Moore (who is not himself formally trained as a scientist) makes a case for the epistemic value of *all* observation, articulating a symmetry between acts of witnessing for science and for activism, where witnessing implies direct and affective experience as a form of communication. However, as we witnessed, and as I show in this chapter, experiencing the garbage patch is by no means self-evident.[56] Just as with modern experimental counterparts, the possibility of witnessing a garbage patch and producing credible knowledge of it emerges from an assemblage of social relations, protocols and practices for encountering plastic. For our lay experiences to count as "data points," we must become witnesses in, of, and with the garbage patch.

In this chapter I describe the structure of witnessing that allows expedition participants to 'see' a plastic pollution problem in the absence of a trash island. I begin in Honolulu, the "crossroads of the Pacific," where the crew assembles and departs at the intersections of travel and trade, land and sea. Before we can look for plastic, or even head toward the accumulation zone, we must adjust to life at sea, socialized into the teams and routines that keep boat and humans moving together in the right direction. Though plastic is a seemingly common material, even as we reach the accumulation zone, encounters with it are not obvious; they involve collective negotiations of what we are seeing and whether it is significant. I then detail how those leading the expedition

[56] Writing abut the "immodest witnessing" of late 20th century feminist alternative health practices, Michelle Murphy (2012) also positions experience not as self-evident, but as something to be interrogated along with its epistemic privilege.

shape these event-like meetings of people and plastic (a netball, contents of sampling devices, a fishing float) into corrective encounters that produce experiences as "fact" about "what's happening in our ocean." We arrive in the garbage patch not by reaching and crossing a set boundary, but by witnessing it piece by piece, experiencing gyre plastic as a problem only in concert with the lived experience of the vastness of the sea.[57]

Pacific Crossings

Figure 3.1 Replica "Crossroads of the Pacific" sign at the Pearl Harbor Visitor Center. Photo by the author.

[57] The process of building a case – piece by piece – for the garbage patch as matter of concern has similarities to witnessing in the courtroom. The capacity to see 'truth' rests on choreographed practices of directing vision (Goodwin 1994) and the visual authority being created and defended (Jasanoff 1998). The garbage patch emerges as events are shaped into an object of knowledge and experience.

Honolulu has a long history as the "Crossroads of the Pacific."[58] The city is an intersection of trade and tourism, conflict and hybridity, land and sea, a fitting gathering place for a diverse crew arriving from Seoul, Sydney, San Francisco and beyond. This is my first visit to Hawaii, and in the days before our departure I do typical tourist activities – swimming, snorkeling, shopping –that are increasingly punctured by reminders that I will not be leaving in typical fashion. At the Pearl Harbor visitor center I pause at a "Crossroads of the Pacific" sign marking the distance to various corners of the globe (Figure 3.1). Silhouettes of the Hawaiian islands are centered in the sea, in the middle of a bright yellow "X" formed by the intersection of faraway points of departure. It is a replica (with added military landmarks) of a sign that stood at the Kau Kau Corner Restaurant in the 1940s. "North America, 2150 miles," it reads, a humbling reminder that I am about to sail that distance and more without a speck of dry land in between.

The same winds and currents that helped skilled navigators reach these shores many centuries ago (Davidann et al. 2008) now bring synthetic waste from around the Pacific Rim. On the Fourth of July, I walk the shores of Waimanalo beach, a long stretch of bright sand not far from Honolulu, picking up plastic trash as I go. The pieces I gather are weatherworn and faded, suggesting distant origins. Like most places on the island of Oahu's windward side, Waimanalo beach boasts both rugged beauty and a steady accumulation of gyre plastic from around the Pacific Rim that crosses back and forth from sea to sand, washing in and out with each turn of the tide. Dragging an increasingly weighty garbage bag on a hot morning across only a small section of one beach, unable to

[58] First published in September 1914, the Honolulu Chamber of Commerce official periodical is titled "Honolulu at the Crossroads of the Pacific."

collect all the little pieces mixed in with the sand, I began to get a very practical sense the impossibility of cleanup. Multiplying the number of plastic bits I am attempting to collect by Oahu's 112 miles of coastline alone, I can barely begin to imagine the immensity of the problem, or what I will encounter at sea. As holiday beachgoers speak of flights home, I stare out at the horizon with growing sense of uncertainty.

The day before our departure, I carry my small duffel bag of carefully chosen possessions to the harbor, heading for a blue-hulled single mast boat. Hesitating, I contemplate the gap between sailboat and the dock before stepping tentatively onto the seventy-two-foot *Sea Dragon* that is to be my home for the next three weeks. I move cautiously because I will share this space with twelve strangers, because this will be my first fieldwork experience, because I have a tendency to get nauseous on swings at the park. I have never once before set foot on a sailboat, and to cross this small slice of aquamarine harbor separating stable ground from rocking boat is to admit that I am about to cross the exponentially greater 2706 miles that separates Honolulu from Vancouver, all while supposedly conducting ethnographic research and helping to steer a boat.

Though science and sailing are to be a team effort, there are still people in charge. Clive Crosby, the skipper, is responsible for getting crew and boat to Vancouver intact and preferably on time. A father with two young daughters at home in the UK, he appears capable and thoughtful, if slightly uncomfortable with his authority. "Please do not call me Captain," he urges as we meet. Next in command is First Mate Dale Selvam, originally from New Zealand, but with a current address in the Canary Islands. Dale's relaxed approach and lively stories provide counterpoint to Clive's straight talk and measured caution. Alternating duties for the duration of the voyage, their shift changes

are often marked with instructions to change the configuration of the sails and ropes that you had just 'correctly' secured following directions from the other. Heading up sample collection and guest crew projects is research director Marcus Eriksen, long-time plastic pollution activist and co-founder of the 5 Gyres organization. Incredibly media savvy, with the experience of seven previous expeditions through gyres around the world and a PhD in science education, Marcus is the center of well-deserved attention. Though he sometimes seems to be performing for the cameras, his passion – whether for plastic pollution, dinosaur bones, telling a good story or ensuring the crew has a good experience – seems genuine.[59] I meet the rest of the crew one-by-one, trying to match faces to photos from our bios. We are from Australia, Canada, Korea, Taiwan, and around the United States. We are teachers, researchers, artists, activists, and filmmakers, cautiously gauging experience, forging new friendships and masking our fears. The interests we bring are diverse, but we share the desire to see plastic pollution in the gyre, and travelling there requires a boat.

[59] Marcus proves to be an incredibly eclectic character. During the voyage he tells stories about motorcycle crashes in Turkey, leading his own dinosaur dig in Wyoming, and that one time he sailed from California to Hawaii on a raft made of plastic bottles (and ran out of food). A fellow crewmember dubbed him "the most interesting man alive."

Becoming Witnesses "On a boat, looking for plastic"

Figure 3.2: Stepping aboard the Sea Dragon in Honolulu. Photo by Laura De Wolff.

For the first four days running, Marcus wears a white t-shirt from a previous expedition. It has big lettering on the back that is amusing for its accuracy and oversimplification: "I'm on a boat, looking for plastic," reads the shirt. This section describes how neither being on a boat nor looking for plastic are as straightforward as they sound; they involve the collective negotiation of new routines, protocols and equipment as participants are socialized into routines of running the ship. Marcus has not only plotted projected sample sites, he has a quasi-serious map of the expected trajectory of social relations on board that turns out to be rather accurate. His social relations prediction goes: Week 1) Sick and cautiously getting to know each other; Week 2) Wow! So many cool people; and Week 3) Grumpy with a chance of snapping as we look toward land. But the first task is simply staying on the boat. At times this requires tether lines,

harnesses, and very conscious efforts to hold on physically and mentally. Next, comes working in teams to run the boat: steering, cleaning, cooking, eating, and sleeping. It is only after bodies begin to adjust and we are competent in the basics of life at sea that we can start looking for the plastic we have come to see and sample.

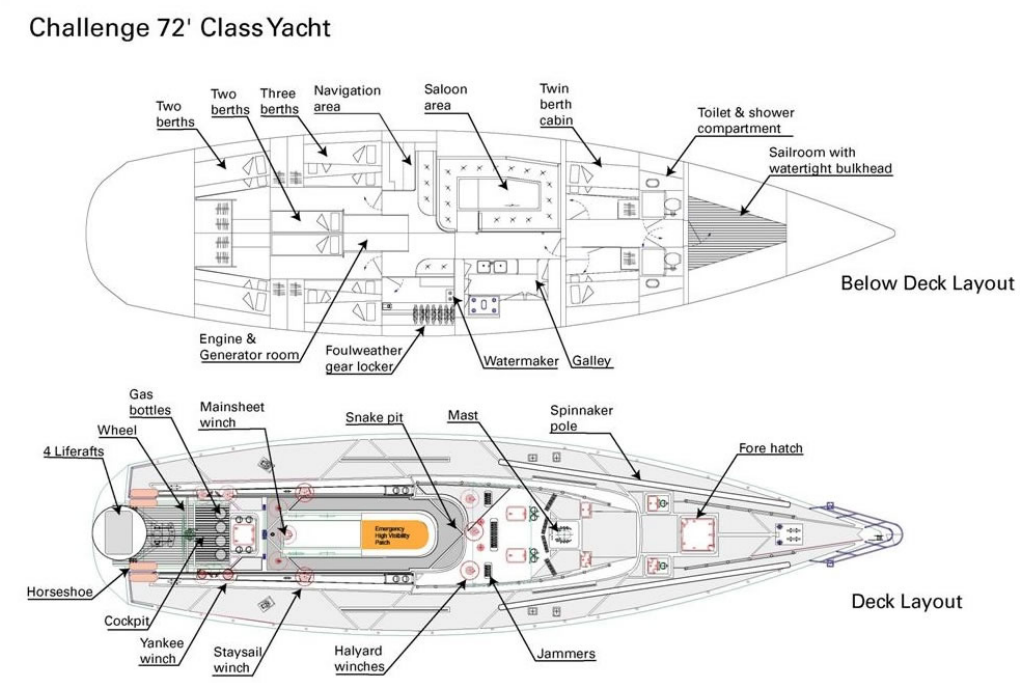

Figure 3.3: Labeled diagram of the 72 foot racing boat and gyre traveller, the Sea Dragon. From the Pangaea Explorations website.

The *Sea Dragon* was built for the Global Challenge Race in 2000, designed to travel around the world against the prevailing winds, or, the "wrong way" (Pangaea Exploration 2014). It is an incredibly seaworthy vessel – or so the charter organization Pangaea Exploration's website says – though it was made for safety and speed rather than research. In the months leading up to the voyage I poured over photographs, videos and diagrams of the galley, bunks, and saloon, trying to imagine life at sea. With blue-painted hull and single mast standing almost one hundred feet tall, the boat in the harbor looks

familiar, but my body does not yet know how to move through this space. I immediately stub my toes on one of the many deck rails, long metal bars raised a few inches off the deck that are perfectly positioned for tripping. Heading below deck, I feel awkward on the ladder-step stairs, and wonder if the faint rumbling in my stomach is a sign of impending sickness, nerves, or both.

There is very little personal space on board; the expedition will be an inherently collective experience. First Mate Dale assigns bunks in the U-shaped communal sleeping area in the stern. Returning participants have already staked claims to the slightly wider, slightly more private bunks at the very back. I am assigned the top tier of a triple. I survey the narrow stretch of blue canvas slung between two metal poles, the bib-like sides and dangling black webbing straps hinting that the vessel was not designed for gentle harbors. Along with the bunk, I have a single yellow plastic crate for my belongings; anything that does not fit in the crate gets stored in your bed for the duration. Even the narrow passageway in the bunk area is overflowing with provisions: the floor is strewn with boxes of fresh fruits and veggies. Sending an email requires navigating a supply of potatoes and papayas to use the one satellite-connected computer that hosts a single email address we share thirteen ways.

In addition to assorted belongings that may or may not fit in the space provided, we all bring our respective projects to the expedition: Tim Silverwood, Australian activist and photographer, plans to make a documentary; Karen Ristuben, an environmental artist from Boston, is fulfilling the social practice requirement for her MFA project; Ming Hui-Liao is a marine biology MA and activist who must give a public presentation upon her return to Taiwan; Hank Carson, marine ecologist and University of Hawaii Postdoc, is

collecting samples of invertebrates that live on plastic. We all have projects on our minds, but it soon becomes clear that our first responsibility is staying on the boat. The morning of our departure brings a crash courses on sailing. “Safety first,” reminds Clive, before quizzing the new crew. “What is the first rule of man overboard?” he asks. “Yell man overboard?” suggests navy engineer Rob Johnson. “Throw them a line,” offers Judy Volquardsen, a retired schoolteacher from Kona. Suspecting a trick question, I guess correctly: “Don’t fall overboard.” As corollary, we are warned against surreptitiously relieving ourselves off the side of the boat: drowned bodies tend to show up FOA. “Fly Open on Arrival,” Judy translates, betraying substantial sailing experience unique among the guest crew. Returning participant Caroline Box, an activist from San Francisco who works in coastal management, then helps distribute gear: self-inflating life vests that double as harnesses, and ‘foulies,’ a set of navy bib pants and matching jacket for wet conditions. I fumble with the unfamiliar gear and contemplate, now standing in the tangled straps of my incompetence, whether the neon yellow hood on my jacket will save me in case of failure to obey the first rule of man overboard. Our real project, in all seriousness, is simply staying attached to the *Sea Dragon*. To see plastic and return from the experience, we must first learn to move with the boat.

The *Sea Dragon* is not a fancy research vessel with support staff. It is an adventure sailboat chartered by a non-profit. It runs on teamwork and wind (also copious amounts of Tang, Korean hot sauce, and diesel fuel). Regardless of experience, everyone is expected to contribute to the running of the boat around the clock. Each day is marked by five watch shifts, lasting six hours when it is light out, and four hours through the night. In addition to making hourly log entries and taking care of sample collection, each

shift comes with a specific set of responsibilities. The morning team cleans the boat and cooks lunch; the afternoon shift does lunch dishes and cooks dinner; the evening watch then does the dinner dishes. At night, we do hourly log entries, sip tea, tell stories, and make sure we stay awake and at the ready in case sails need adjusting. At all times, someone has to take the wheel to keep the *Sea Dragon* pointed in the right direction; the autopilot we are told, is out of order.[60] Failing to realize the implications of the math, I do not yet realize that the resulting rhythm of three teams against five shifts will deprive us of two out of three solid nights of sleep for the duration of the voyage. The pattern does produce some consolation in the form of a fortunate side effect that we come to call "Sunday": having both six-hour daytime slots off during the day, working the short 6-10pm evening watch and then, blissfully, sleeping through the night until it is time for the next early morning watch.

Marcus, who was quietly sizing up the guest crew over drinks the night before our departure, is in charge of sorting people and their respective research, sailing and documentary skills into what will hopefully be three functional teams. Since almost all of our waking hours will be spent together, who is and is not on your team is rather important. I land on Marcus' team along with a pair from the Seoul Broadcasting Corporation: Jin, a high status director of photography, and Brandon, his assistant and translator. They are here on assignment filming for a Korean documentary about threats to the ocean called *The Last Pacific*, but may not have been fully informed of the

[60] The autopilot, it turns out, simply needed to be calibrated, a process completed in ten minutes by turning the boat in a full circle just before our arrival in Vancouver. Dale admitted at this time that not using the autopilot had the benefit of keeping the crew occupied, especially though the long night watches.

conditions of participation. They are surprised to learn that they too will be responsible for cleaning toilets and waking up in the middle of the night to steer the boat. A surprise no doubt exacerbated by reports that their colleagues are filming on a fully staffed luxury cruise ship near Tahiti. I, for one, am pleased with my assignment, optimistic that the combination of Marcus, who is a major figure in the plastic pollution world, and the professional film crew puts me in a privileged position for research and other important activities. For now, it means our team has the first morning watch shift. Within minutes, I, the lone women on my watch team, am on hands and knees scrubbing several days of harbor grime from the bathrooms (or 'heads' in boat-speak), hoping this is not a sign of a gendered division of labor to come.

Our noon departure from Honolulu is a highly choreographed media event complete with helicopter film crew whose short fuel range means we leave right on schedule. Plastic grocery bags accidentally brought on board with last minute supplies are frantically spirited out of sight of the cameras as we pose in life vests and fragrant purple leis, smiles brimming with nervous energy. We cast off to the sound of the approaching helicopter. The expedition's very first heading caters to the aerial film crew, directly out to sea away from the accumulation zone for documentary adventure shots that will stand in for the open ocean. We motor out of the harbor, passing surfers at the break, waving to tourists on day cruises, and watching the high-rises of downtown Honolulu shrink behind us. Then it is time to raise the main sail on the hundred foot mast, and things are a bit hectic as many of us do not know the ropes - the difference between a halyard and a sheet and what they control. There are more hands than tasks and I end up standing around awkwardly alternately trying to help and to stay out of the way. Then, as the wind catches

the sail, the boat adjusts to a startlingly steep angle that is soon to become the new normal. Clinging to the deck, I suddenly understand the need for the toe-stubbing rails and tether lines that run the length of the boat.

Media satisfied, we change course, proceeding leisurely along Oahu's protected leeward shores. I admire the hilly coastline with new seriousness: this will be the last land we see for weeks. For the moment, we are all just excited to be on our way and eager to get to know each other, swapping backgrounds and coming up with team names. Caroline, who sailed across the South Atlantic on the *Sea Dragon* earlier in the year, names her watch team the C-Boxers. Hank and I work on nicknames for the our groups: the Ming Dynasty "who reign for short periods," for his; and "manwatch," for mine ("It's like a cross between a man sandwich and Baywatch," jokes Hank, but the rest of my team is less amused, and we become the "Wolff Pack" in my honor). We eat bowls of penne with pesto for lunch, nap in the sun and take photos, posing against the outline of Oahu, as dolphins flip and dive at arm's reach, riding the wake of the bow. A rainbow appears in the mist of a distant squall. And then we round the point.

As land quickly disappears into the distance, the horizon twists into staggered peaks and valleys fractured by white spray. The leisurely afternoon cruise dissolves into choppy ten-foot swells and thirty-knot winds of the open ocean so wrongly named Pacific. Without a stable point of reference, our bodies stay on the boat, but struggle against and succumb to its unfamiliar rhythms. I'm still mostly holding on when I volunteer to go below deck so Marcus can show me how to make an entry in the ship's log. The fine detailed work of reading coordinates and time is my undoing. Though I somehow fail to vomit even once during the voyage, I repeatedly go through the motions.

It is rough enough that we are not allowed to vomit over the edge of the boat directly. Instead we line up, crouching four in a row, heaving and depositing lunches on the outer deck where Clive the skipper stands unperturbed with the hose at the ready and the practiced reminder that if all we do between here and Vancouver is lie in our bunks and drink water, we will survive.

Lying in our bunks in private misery, we are headed to the accumulation zone, but are for the moment completely incapable of witnessing anything beyond the plastic baggies we clutch in our hands in case of sickness. Imagine you are on a spinning fairground ride and have taken a few rotations too many. You close your eyes and use all your strength to endure the remaining thirty seconds. Except there are twenty more days to go. There is a three-day gap in my field notes. What I remember of that time, like life on the boat, does not conform to terrestrial practices of night and day: a mess of dark and light dream-states punctuated by moments of relative clarity. Fighting wave after wave of nausea; fumbling for gear in dark closets; begging for a water bottle refill; dreading trips to the head located in the treacherously bouncing bow. Though I try to pry my sea-tossed body from the safety of my bunk at the appointed time for watch that first night, my legs give way to vertigo. With shame and relief I crawl back into my bunk where I remain for a full 24 hours. The first guest crew email to leave the boat – since it is a shared email, I see my fellow crew members' email subject lines every time I go to send a message – bears the telling subject heading: "Holy Shit Fuck Mountain."

Slowly our bodies adjust and we learn to cope, acquiring the new skills needed for life at sea. Caroline perfects the move from horizontal-in-bunk to vertical-on-deck (the only two somewhat bearable positions), declaring she is going to "yak" while calmly

getting dressed, and making it outside just in time to follow through. I learn to steer before I manage to eat or brush my teeth. At 2:00am on the second night, I am still feverish, dizzy and disoriented, but with help from the team going off duty, I manage to get gear on my body and my body on deck. Ascending from the stuffy hold, the cool air is an instant relief, the Milky Way spills across the dark sky. Marcus and Brandon are already on deck, Jin in his berth suffering from seasickness. Dale decides it is a perfect time – the middle of the night, seas and stomach still churning – to teach a complete novice to steer. At least there is nothing to crash into out here except fishing boats, which, he assures me, are "lit up like Christmas trees." Dale gives me the current declination for the compass, then directs me to simply pick a star straight ahead and aim for that. With a few tips for not overcorrecting against the waves, and warnings about something called 'luffing,' which I deduce has something to do with the sail making flappy sounds, the introductory lesson is over. I am left to direct our progress towards the garbage patch, which Dale will monitor on the computer screen below deck. Tethered to the boat by the five-foot length of red webbing attached to my life-vest harness, I am jostled by swells I cannot judge in the dark, which periodically send splashes of seawater over the bow and directly into my face. The wheel comes up almost to my chin, and feedback from the boat is occasionally strong enough for my feet to achieve liftoff. "Stay on the boat. Keep wind in the sails. Aim for the star," I repeat to myself. Flying along at 10 knots, with shooting stars above and bioluminescence below, I finally feel I am contributing something. The rest of my watch team nods off as I hold the wheel through dawn.

Figure 3.4: Holding the wheel in calm seas, the world off-kilter as the boat slants with the wind.

The process of learning to run the boat and move with it leaves marks on bodies and challenges senses. Each evening at 6 pm, everyone on board makes a mandatory appearance for dinner (though not all eat), and Clive gives an update on our course and forecasted conditions. Clive later tells me that he uses this time to silently count bodies, making certain he has not lost anyone in the meantime. We compare bruises, field test every ginger product available, and learn to distinguish by sound whether or not a wave hitting the bow is strong enough to soak your face when holding the wheel at the stern. And finally, on the fourth day, with eyes no longer fixed strictly on the horizon in seasick desperation, we look for plastic.

Corrective Encounters in and with a Garbage Patch

As life on the boat settles into an increasingly familiar pattern, the days melt together into rotation of watch duties, meal times, night and light. Yet the routine of sailing through the accumulation zone does not in itself conjure a garbage patch from the

sea. Instead, intermittent encounters with plastic interrupt the steady rhythms of sailing. In this section, I show how these events become corrective encounters, interactions between people, boats, plastic and water, structured to reveal the 'true form' of the problem. As outlined in chapter 2, corrective encounters are interactions with gyre plastic that focus on channeling existing care toward practical solutions, but come with the risk of disappearing the whole problem with the island. On the expedition, corrective encounters unfolded in a multi-part process involving the presentation of plastic bits we encounter as the ('real') garbage patch; admitting we are not seeing what we expected; and finally, the ongoing and messy reconciliation of the lack of a solid garbage patch with the continued existence of a plastic pollution problem. The point of intercepting flows of plastic at sea is not to clean them up directly (though some pieces do get brought on board), but to align people and plastic in new relationships that demonstrate "realistic" responses:

> To see it for yourself, you get a realistic idea of where your efforts should be. Efforts should not be on cleanup and that becomes clear being out here. The post consumer cleanup is not going to happen at sea with nets scooping up the ocean (Eriksen, personal interview, 2011)

Participants will be able to channel their experience witnessing into appropriate solutions back on land.

The first encounter with plastic that interrupted human routines happened on the afternoon of our fourth day at sea. Still too rough to collect scientific samples, a 'trawl' net designed for higher-speeds is skipping along in the water collecting samples for education purposes (see chapter 4 for a detailed description of the sample collection process). Unfavorable conditions are beginning to alter expectations, reducing possible

sample sites from thirty, down to twenty-five. Battered by the rough seas, concerned about various projects, everyone is anxious to get to the area of calmer seas that are mysteriously "just two more days away" for the third day running. Everyone swears they know there is no trash island to be found, but I suspect we all got on the boat with lingering hopes of finding it, or at the very least, something spectacular. At this point, however, we are quietly wondering if we will see anything at all. A mid-morning commotion on deck rouses the sleeping night crew, including myself, from our bunks. The 'trawl' net towed alongside the boat to collect plastic particles has itself been caught by floating waste. It is the humans that have been caught by plastic, rather than vice versa. The perpetrator is quickly identified as a 'netball,' a knot of escaped fishing nets and lines. Approximately six feet in diameter, the plastic mass threatens to permanently liberate a crucial sampling instrument on its first day in the water. Unlike the plastic it is meant to catch, the high-speed trawl does not float. That we have only one on board is adding to the sense of urgency. At the same time, a fishing line that has been trailing behind the boat all day without response, emits a demanding ratchet sound as it unwinds with the weight of a fish that was likely taking shelter under or looking to eat fish taking shelter under the netball.

An intersection of boat, people, plastic and water, and even a fish, this encounter breaks the flow of life on the boat, and of the boat through the water. The netball is a call to action: to save the trawl, to slow the boat, to reel in the fish. Everyone is on deck regardless of watch shift or sleep schedule. In a rush of activity accompanied by cranking winches and flapping sails, the crew move to slow the boat, save the trawl and catch the fish, ideally without losing track of the netball. The resulting loss of forward motion

allows the waves to toss the boat from side to side with renewed vigor. The netball event is a revealing moment, as teams fragment into individual decisions between being immediately helpful – running to crank winches, fetch a knife, reel in the fish – or personal project oriented – running to grab cameras in the pursuit of photo evidence. But even the rush for cameras contributes, articulating the shared understanding that what is happening is indeed significant, that we are (finally) seeing evidence of a garbage patch problem.

The gyre plastic we have come to witness is divided by size into two main types, macro and micro, each with distinct sets of social practices and protocol for observation.[61] Macrodebris, like the netball, but also bottles, fishing floats, and chunks of foam, is generally the object of an activity called 'debris sighting' where those on watch during the day are tasked with scanning the ocean for any visible plastic and then recording observations in the 'debris log,' a stack of spreadsheets on a dedicated clipboard. It is not enough to simply 'see' plastic, sitting on the boat deck as a passive audience to whatever happens to float by. Witnessing macrodebris is a collective practice that involves making plastic – a single piece at a time - visible to others by agreeing upon its form, and recording its location as part of a garbage patch. It was common, especially at first, for those on deck to confer over the size, shape, type and even color of plastic objects passing by before writing an entry.

[61] For the purposes of the expedition the micro/macro division was defined in pragmatic terms of objects we could see with our eyes from the boat deck, and plastic caught in the sample nets. In the scientific literature, micro debris is most commonly defined as equal to or less than 5mm, and macrodebris as greater than 2 or 2.5 centimeters (Goldstein 2012; Lippiatt et al. 2013).

Figure 3.5: Typical macrodebris: a black fishing float with an attached community of gooseneck barnacles.

From his station at the wheel, Tim calls out "netball," thinking he sees a tangle of abandoned fishing nets off the port side of the boat. As becomes common practice, at least for these first days, collaborative discussion ensues about what is actually being seen. The netball becomes a tube with a piece of net attached, recorded as four feet long, six inches in diameter. Others suggested three feet, but defer to Hank whose marine ecology degree commands a certain amount of authority on deck, particularly when Marcus and his nine plastic-seeking expeditions of experience is not around. We learn through negotiation and from each other, what materials count as gyre plastic, and how to describe them. The description of the netball-become-tube is stabilized and marked in the log with the time and coordinates of the sighting, but the questioning continues: Had the tube, now officially 'light' in color, previously been a more brilliant blue? Was a similar length of tubing seen earlier a part of a hagfish trap? Is that a yellow bottle up ahead? The possibility of more objects interrupts my attempts to record the conversation about the

tube. Temporalities collide, as we discuss the matter at hand, present objects' past lives, and what we might still come to see.

These first few plastic pieces incite qualified excitement. Tim, still at the helm, enthusiastically declares that the plastic "looks promising." I am uneasy about the statement, not sure whether or not to agree as I weigh the stakes. Seeing lots of plastic is potentially good for the 'cause,' as documenting its problematic presence may instigate change back on land. At the same time, finding a lot of pollution seems like bad news for the ocean, and is the ocean not ultimately the 'cause'? Or, is this simply relief because documenting anything justifies the considerable expenditures of time and money that have brought us out here to witness *something*? Other questions remain. Collectively, there is agreement that we are seeing (some) plastic, but how are we to know that it is in and of the garbage patch? Though our route was mapped in advance getting to where we can witness the garbage patch requires more than sailing to a set of coordinates. The garbage patch is a mobile, amorphous space without clear boundaries. Or so we are learning. At dinner, Clive explains that the relatively stable high-pressure system that flattens seas to define the accumulation area in the middle of the North Pacific Gyre is smaller and further north than is normal for July. The same wave action that is making people sick, churns floating plastic below the surface and out of sight. Our arrival in the Great Pacific Garbage Patch is marked as much by an ocean calm enough for seeing and sampling debris, as it is by established coordinates. There are other hints that we have 'arrived.' The fish caught along with the netball must first be dissected and declared free of plastic before it becomes dinner; in the garbage patch, worries about toxins trump the temptation of fresh food. But still the crew is plagued by conditions of doubt. "Are we

there?" I joke daily with shipmate Ming, who shrugs and laughs in response. Searching for signposts, I photograph the navigation desk computer display of a red boat icon nearing dots of calm blue at the center of concentric weather zones. But for the most part, we gaze intently at the deep blue sea, waiting.

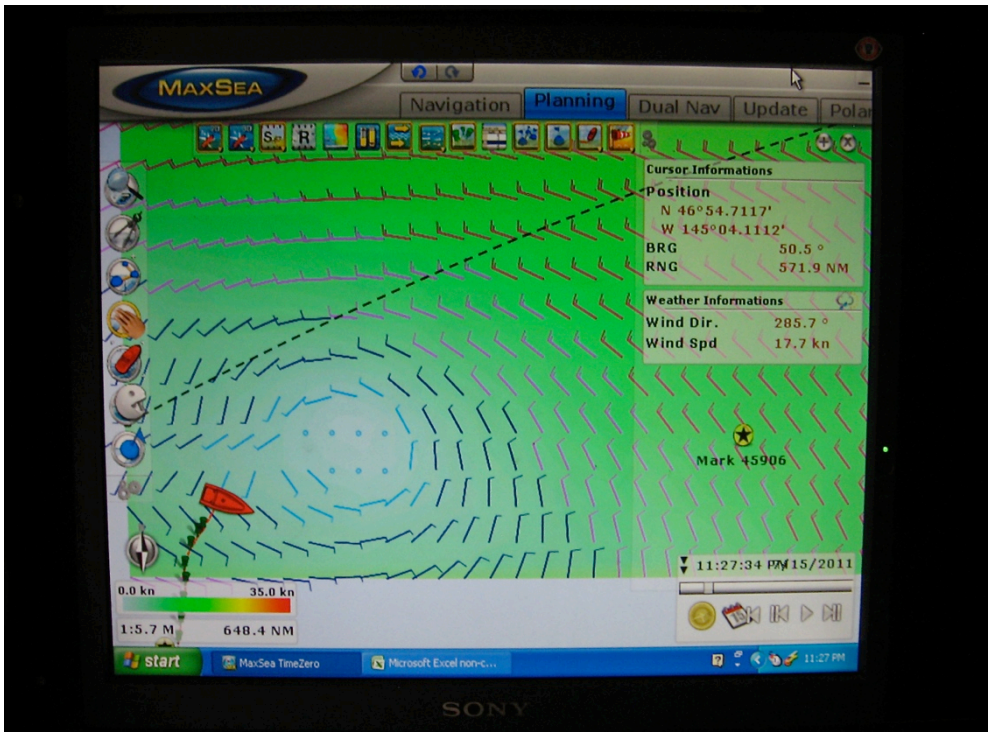

Figure 3.6: The Sea Dragon approaches the heart of the high pressure zone. Photo by the author.

The netball turns out to be the largest chunk of plastic we encounter during the entire voyage. If we are to witness the garbage patch, it must be built from scattered bits and pieces. The task of convincing us that what we are seeing *is* the garbage patch, that fragments and single objects were also 'encounters' (calls to action) in and with the garbage patch falls most of all on Marcus. As research coordinator and Algalita representative, he is entrusted with making sure we have a good experience and get what we need for our projects. As with first learning to see plastic, those with the most

experience guide participants in understanding that these bits and pieces are something to be seen and something to show others whether a single fishing float or a scientific surface sample.

Practices of debris sighting bring waste into new relationships that gave objects an agreed-upon form and physical location as gyre plastic. The power of macrodebris sightings depends on making waste self-evident through the *social* practices of demonstration.[62] On occasions where macrodebris needs to be caught as specimens, one or more 'spotters' point at the object, trying to keep it in view as a third person runs for the net, and yet another person maneuvers the boat into position (Usually Clive or Dale who had the sailing skill needed for more precise movement). On more than one occasion, the seventy-two foot boat makes multiple circles in pursuit of a single twelve-inch diameter fishing float. We hold our breath as people and boat slowly come into alignment with the object of our pursuit, cheering when successful. Marine ecologist Hank Carson then inspects samples for promising research specimens. The rest of the crew take photos, posing with gooseneck barnacle covered bottles and chunks of buckets held toward the camera, blue horizon in the background, as if to say, see, we are here and there is plastic here too. The 'caught' objects slowly pile up, stripped of barnacles to minimize smells, tied together in the back corner of the boat. These exercises sometimes end in defeat, as the right combination of people, net, boat, and plastic fail to converge,

[62] Where representation implies standing for something else, demonstration is grounded in conditions of s*elf*-evidence. As Claude Rosental (2008; 2013) points out, however, these conditions are not already given. Evidence, in his account even mathematical proof, emerges with practices of 'showing' that structure group activity. Demonstration, then, involves collective practices of making apparent, making visible, giving tangible form and putting on display.

and fishing buoys or bottles float out of reach. But even in 'failure,' practices of debris sighting help materialize the garbage patch by designating objects as worthy of the chase.

Though less charismatic, microplastic samples destined for laboratory analysis also end up on display. Bringing in the sample net involves at least three people working in cooperation to steer the boat, record data and secure the sample. Someone rinses the bits and pieces of synthetics and marine life from the net through a sieve, which, more often than not, gets passed around for all to see. Marcus takes care to point out specific objects – a pen lid, a bottle cap, pre-production plastic pellets – on one occasion apologizing to a pelagic crab about to be preserved. He also assures us that these were indeed samples with 'lots' or 'typical' amounts of plastic, even deeming one the 'densest' sample he has seen in all his voyages. Here too, crewmembers pose with plastic, smiling while holding samples for the cameras. Trawl-by-trawl, piece-by-piece, we amass evidence of a garbage patch. Referring to his week-by-week projection of the mood on board, Marcus also suggests that social relations too are unfolding in typical fashion, if not better than expected. We have fewer personality conflicts this time, he notes, citing the willingness of vegetarians to cook meat for others without complaint. He hints that this has not always been the case with boatloads of activists in the past.

Some samples or the conditions of their collection, however, are not ideal for sharing these garbage patch encounters with others not present. There are several cases where encounters are staged or re-staged more explicitly for the cameras. Since the unforgiving weather makes filming, especially from off the boat, difficult at best, the day of our 'arrival' in the high-pressure zone is one of the few chances to get in the water. At lunch the saloon buzzes with animated discussions about our various goals and how to

best organize them. Jin and Brandon have a heated conversation in Korean. They were hoping, Brandon, translates, to dive around accumulations of plastic debris in the finally calm water, but they are not sure what to do since there is not exactly a floating island out there. Someone suggests throwing some of the objects we have collected back in to the water, tied together so nothing gets lost. I have already stood at the bow pointing in reenactment for Jin and Brandon's camera, and watched Hank throw a float back in the ocean, recapturing it for Tim's film project.

Figure 3.7: Staging science at sea. Marcus poses for Jin with the manta trawl in the background.

There is precedent. But as someone else points out we have already stripped this mornings' catch of barnacles, so it wouldn't be "real." Reproduction of encounters is not itself seen as troubling, but staging encounters that are not faithful to 'reality' is out of bounds.[63]

[63] There was, however, a tendency for the staging of encounters to write out the many people and heterogeneous work involved. Many times this was subtle, simply being asked to move my feet out of camera view. On one occasion, however, I watched as a filmmaker asked Hank, the marine ecologist, to singlehandedly recreate the sample collection process for a documentary, privileging the individualized experience of a lone heroic 'scientist' as the producer of knowledge (Oreskes

Plastic Witnesses and Forms of Doubt

With land almost in sight, it begins to sink in: these floating bits and pieces are all we will see of the garbage patch, at least from our current vantage point on the *Sea Dragon*. The lab storage crates are filled with sample bottles, the preserved slurry of plastic and plankton, but the ocean is as blue as ever. To what extent does the promise of witnessing hold? Citing his many expeditions worth of experience, Marcus remains ever optimistic: "of course seeing it for yourself just makes all the misconceptions melt away." Yet even after three weeks at sea, reconciling unidentifiable plastic bits with images of a dense accumulation of recognizable consumer goods remains a struggle. Guest crew begin to speak more candidly about the hopes that brought them aboard, admitting that the gyre plastic we experienced was not what they execrated. But expectation and experience are not so easily resolved through corrective encounters where "misconceptions melt away." The relationships formed through the expedition give shape to a problem that stands in tension with representations of a 'trash island.' At times the garbage patch of our imaginations threatens to dissolve into a sea of doubt, challenging convictions that plastic in the open ocean is indeed a serious problem. At other times the island lingers in missed opportunities and bad luck, or, as a mass that could be assembled from the fragments.

Though no one every admitted to expecting a floating metropolis, there is growing consensus that the plastic we encounter is not in the amount or form we were expecting. "I knew that it wasn't going to be this island of plastic that you could pick up, but I did expect to see more marine debris concentrated than we saw," explained Karen.

1996). Some kinds of witnessing were more equal than others (Haraway 1997).

The kinds of objects encountered is also unexpected, as she continues:

> Just being out here and being in the experience of it, and seeing what we actually pull up, makes me rethink some of the presumptions I had going into it. Like we picked up mostly fishing debris on this trip. We don't know where the microplastics came from, if they came from land-based source, but that's one of the preconceptions I had, that most of it was going to be things that we recognized as domestic products or household products and we didn't see much of that at all. (Ristuben, personal interview, 2011)

Even returning participant Caroline's experience is at odds with her expectations. She too embarked on her first expedition with visions of something solid: "I actually expected to see a lot more plastic. I think like a lot of people on this voyage expected. The media has told us, at least when I imagine it, I imagine it as like a dump in the ocean." But even with previous gyre experience, she was still under the impression that there would be more to see in the North Pacific: the best known and densest of the accumulation zones. This was, after all, *The* Garbage Patch. "I actually expected to see more here," she continued, "because if you think about the countries around the ocean, this ocean has a lot more big countries, America, Japan, China so it makes sense."

For others, uncertainty surfaces in worries about whether and how to share their experience at sea with others. Ming worries about how to describe the problem to people in Taiwan, especially her sponsors. People believe what they see, she explains, but plastic is much more visible on beaches in Taiwan than out in the gyre, so how to convey a problem when it does not look so obvious? Or when we have seen a lot of fishing gear that most people will not relate too. Jin and Judy had similar concerns, noting that they had seen more plastic on beaches in Korea and Hawaii respectively. Jin is especially surprised by what he sees as the meager contents of our trawls; they seem so clean in

comparison to beaches. The lack of something more photogenic, concentrated and easily visible, threatens the existence of a problem at sea relative to problems of plastic on land.

To some extent, however, Marcus has reason to remain optimistic. The voyage does challenge preconceptions about the form of the garbage patch: consumer things fall apart and that accumulations can appear dispersed, at least on the surface. Karen does "rethink some of the presumptions," in the way Algalita founder Moore had hoped: "I think it's dampened my, not my passion for the issue, but it's brought a really healthy dose of reality to my idea of what this problem is." For Karen, the voyage shifts visions of bottles, bags and packages to a "reality" of dispersed fragments, without jeopardizing her general sense of concern for gyre plastic. Jin too leaves the boat with an acquired respect for the prevalence of microplastics and the toxins they can harbor. The missing island gives way to new forms of concern, rather than standing as evidence of an absence problem.

But the garbage patch as island does not disappear completely. It fills spaces formed by lingering worries about what we did not see. "Did we somehow miss it?" Judy wonders aloud. The lack of greater concentrations is attributed to the weather, "because of the sea conditions and the wind and all of that, it wasn't that conducive to it," in Karen's words. Even our luck, for Tim:

> I still believe we were just unfortunate with this voyage not to see the true heart of the accumulation zone. I'm not skeptical to its existence because you can't deny it. When you go on those beaches and you see the amount of stuff that's being washed up, and there's cleanups happening monthly if not weekly, so you know it's coming through in a constant barrage. It's out there. But it really puts into perspective when you're on a vessel, just tracing a very thin line through it, that you're probably not going to see stuff that's going to shock you as much as you think you might. (Silverwood, personal interview, 2011)

Despite the weeks at sea, pulling up sample after sample of microplastics, in the vastness of the ocean the possibility remains that there is still something more "out there," the "true heart" of the garbage patch. Even for Marcus himself, the island is not witnessed into irrelevance of misconception:

> Everyone expects to see plastic. And they do see a little bit here and there, but I think what people need to understand, is that collectively it does become a mountain of trash. The earth is 70% ocean. You get these massive subtropical gyres, and the area of the gyres combined is a quarter of the planet's surface, and that is this thin dispersed plastic soup. If you consolidate that then you get your Texas-sized mountain of trash. (Eriksen, personal interview, 2011)

If you add all the pieces together, he reasons, there would be enough for an island.

The Vast Continuity of the Sea

Figure 3.8: View of the horizon from the boat in the garbage patch. Photo by the author.

If a garbage patch begins to emerge in the patterns of routine, and in the events of sailing and sampling over the course of the voyage, it only becomes a global problem in concert with crew members' changing relationships with the sea. Among the most striking things

learned on the voyage by almost everyone is the size of the ocean. Yes, we knew the Pacific was the largest of the oceans; yes it looked like a big place on paper; but to gaze out at the 360 degrees of horizon twelve miles away in all directions for weeks on end is something else entirely. As we travel, the boat leaves an ephemeral trail of bubbles in our wake. At night they glow green-blue with phosphorescent plankton. The horizon shifts from wonder to monotony, an ever distant border impossible to reach; a constant reminder that the "very thin line" the boat cuts through the "massive" gyre is narrow, and the swatch of surface skimmed by sample nets, narrower still. And in the vastness of the sea, within the tension between ocean as sublime and ocean as knowable, resides both the possibility of a garbage island that could be, and the possibility of seeing all the tiny pieces as a problem.

For Caroline, the expedition is an incomparable lesson in "how big the ocean is, because you can't really realize how big it is until you are in the middle of it. You look at a map and you're like it's huge, but it's *huge*." Karen too speaks, of the immensity of the sea, "There's so much ocean out here," but also of having "a different relationship with the horizon now, and certainly the wind and the weather and sails flapping and all of that." Even Tim, an avid surfer, reluctantly admits to having a new sense of the sea:

> I think it's so silly, because I've spent a lifetime in the ocean, but it just seems so much bigger than it ever has before. It seems ridiculous, but getting on a boat that moves at a relatively slow pace and trying to cover a few thousand miles, you just look around you and you're like holy crap the ocean is so huge. I think that actually strengthens the debate really when you think about what comes up in the trawls. You think, wow, really. You put that manta trawl out and you're looking at a 60 cm by 15 cm aperture crawling through the surface of the ocean for two miles over the space of an hour and you're getting plastic. And you start looking around you and you're like holy crap, there's a lot 2 miles by 60cm

> transects out there. So that puts it into perspective for me. (Silverwood, personal interview, 2011)

It is in relationship to this vastness that the tiny bits of plastic assume the significance of a global material problem; that we see them in every sample for the almost three thousand mile duration. This new sense of scale is exactly what Algalita Captain Moore hoped for in bringing members of the public to sea:

> The time that it takes you to get there, first of all, impresses upon you the size of the ocean. And then the extent to which it has become polluted has that much greater of an impact. So I think the main reason for taking people there to see this phenomenon is so they get a sense of the scale of the problem. This is the main problem with questions from the audiences in my speeches, is that lack of scale. Invariably someone will come up afterwards and want to just vacuum all this stuff up or catch it with a net. (Moore, personal interview, 2012)

We are not simply witnessing plastic, but witnessing it as a relationship between humans and the ocean.

Conclusion

At the end of the voyage Marcus prepares an expedition report summarizing our accomplishments. It includes a map (Figure 3.9) where he has carefully added colored dots marking each of our sample sites to those of previous Algalita voyages. I cannot help but notice how featureless and devoid of life the ocean appears, purple background behind trails of colored data points marking a zone of plastic concentration. I volunteer to compile the results of the debris log for the report. In its totality the list looks impressive, naming the kinds of things that could be expected to make up a garbage patch – buoys, bottles, bucket lids, a bowl, a cup.

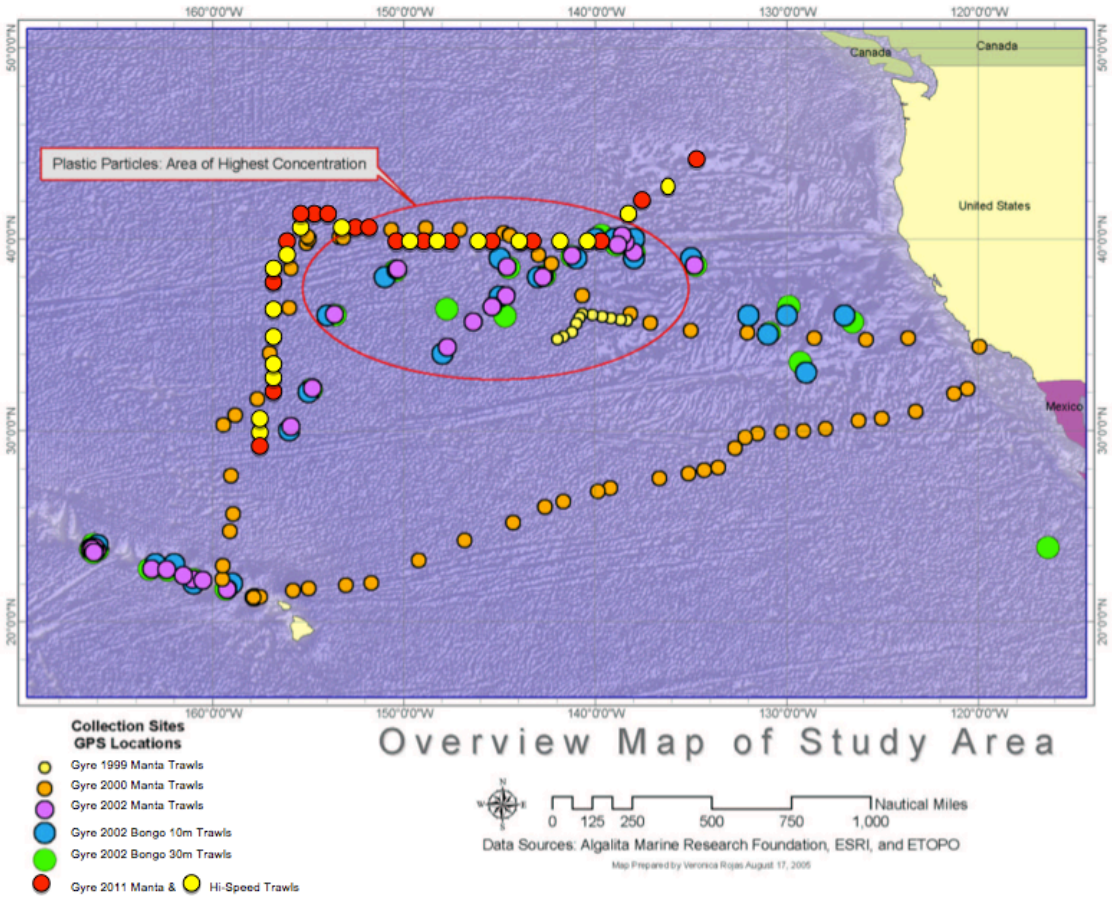

Figure 3.9: Map of Algalita sample sites between 1999 and 2011. July 2011 scientific sample locations are red dots, and education sample locations are large yellow dots.

In making the table I relieve objects of not only their coordinates, but the many components of their encounters, erasing the negations and uncertainty, changing descriptions of "bluey" to "blue," dropping "-ish" and pencil sketches, choosing a single number when a rage of sizes is offered. I think of all the relationships excluded by these tiny dots and neat spreadsheets: the human camaraderie and negotiation; the nausea, excitement, apprehension and boredom; the forgiving *Sea Dragon* and her patched sails; the tenacity of fish and barnacles and other forms of marine life living on and with plastic. In the chapters that follow I take up two of these components: Chapter 4 follows the ubiquitous microplastic fragments in our samples as they travel divergent paths

becoming either scientific facts or educational tools; Chapter 5 then considers the entanglements of marine life that lives on and with plastic.

I am still often asked what it was like at sea, and if I saw a plastic island there. My answer remains much the same as the day I arrived in Vancouver: the ocean is indeed big, and there is a troubling amount of plastic to be found there once you learn how to see it, if not in the form you might expect.

Chapter 4
Diverging Models of Science and Activism: Plastic Knowledge in Motion

Processes of producing and sharing scientific knowledge about ocean plastic pollution necessarily extend beyond direct witnessing in the gyre. After three weeks at sea, the paths of the many actors assembled as Algalita's 2011 North Pacific Expedition diverge. The humans return to their respective homes around the world; the boat continues on to Mexico for repairs; and plastic samples set off in new directions depending on the conditions of their collection at sea. This chapter continues to follow physical pieces of gyre plastic as they move along three trajectories: as scientific samples moving through laboratories to become facts about the density and distribution of plastic marine debris; as education samples engaged in public demonstrations of knowledge about the garbage patch; and as escaped plastic that evades both collection and measurement. For each, I outline the connections between collection processes, the path samples then take, and the knowledge produced. I show how knowledge about the Great Pacific Garbage Patch is constituted in different forms, as gyre plastic circulates or (or not) in sometimes-competing projects of making knowledge and making knowledge legible to a broad public.

As evidenced by the organization's recent rebranding as "Algalita Marine Research and Education,"[64] the non-profit marine research group is committed to both producing and sharing knowledge about ocean plastic pollution. For Algalita members,

[64] The name change, from "Algalita Marine Research Institute," was meant to better reflect the organization's strengths after an extensive pro bono "capacity building" evaluation carried out in 2012 and 2013.

research is the foundation of outreach and education. In the worlds of Bill Francis, President of Algalita's Board of Directors:

> We want to utilize the information by applying proper science, measurement of the materials that are in the ocean, and then using those hard facts as tools to help educate and make people aware of what the issues are. So the two go hand in hand. You can't educate properly, I don't think, about science without having some basic information…. Why do science if you're not going to educate somebody about what you've found? So they go hand in hand. (Bill Francis, personal interview, 2012)

Science and education go "hand in hand," as science is meant to be shared with and made useful to others. Algalita's work, to repeat the words of founder Charles Moore, involves "trying to know things that matter." This sentiment about the interconnection of (useful) science and education is echoed by laboratory manager, Gwen Lattin:

> It's all one. It's really just different focuses on the same topic or aspect. You shouldn't do research just to get the information and hide it away in the drawer. It should come out, what you are doing should be able to be shared with other people. And it's the sharing with other people that is the education. (Lattin, personal interview, 2012)

Though Director Marieta Francis is more familiar with education and outreach, she too recognizes the importance of conducting research to provide a sense of "validity" to the project of "raising public awareness." Youth are an especially important demographic for outreach activities with hopes of educating the next generation of decision-makers. It is important to note, however, that Algalita does not advocate for specific policies or otherwise make a point of lobbying, instead approaching activism through research: "Let's do the science, let's figure out what the science tells us, and then let's logically extend that to help people do the right things," Bill Francis explained.

Though committed to a joint project of plastic pollution science and education, there is a sometimes-uneasy relationship between the two components in practice. This

friction is most explicit in a set of concerns surrounding the physical separation of Algalita's office and laboratory. Algalita's Long Beach office is the main workspace for Algalita's director, education coordinator and office assistant. The office is the base for administrative and education activities, including fundraising, event and expedition planning, and general meetings. Algalita's laboratory is thirty Los Angeles traffic-complicated miles away in Redondo Beach. The lab is home to most post-expedition research activities and the two part-time researchers who process and archive ocean surface samples with the help of volunteers. Having these two spaces does come with advantages, particularly, long-standing deals on leases, though their separation is more than a matter of (in)convenience (my commute took two hours by public transportation, and 45 minutes by car, traffic permitting). Algalita members most often spoke of this spatial division as an organizational communication challenge: "there's not as much support in getting them what they need to do their job better, or in finding ways to help them be more efficient and effective in what they're doing," Bill Francis pointed out. Office staff do not regularly visit the lab space and vice versa. "I've seen various stages of the analysis, but I've never gone to the lab and worked for a week sorting a sample," admits director Marieta Francis. These concerns, however, went beyond supervision and infrastructure, with the laboratory positioned as a distinct culture. "It's different there," I was told before my first visit, "you'll see." By dividing my time between the two spaces, I inadvertently filled an organizational gap, and became a welcome link between office and laboratory.[65]

[65] It was in this capacity, that I felt most uncomfortable as a participant observer during my time at Algalita and was most aware of my capacity to alter what I was trying to study. Commuting

At first, I saw this separation as the physical manifestation of a separation of matter and meaning, with plastic materials relegated to the place where the science happens, and information flowing through education and media practices in another. Knowledge made in one place, and shared through another. Though the separation of office and lab is indicative of the sometimes tense relationships between practices and activities of doing science and raising awareness, the goal is held in common: "We may be thinking the same thing… the people in the lab are looking at it this way, and I'm looking at it this way, but it's the same concern" (Marieta Francis, personal interview, 2012). Despite apparent distances and differences, Algalita members at both sites emphasize the importance of material samples in doing their work. This chapter describes how gyre plastic moves through the spaces of science and education. Specific combinations of instruments, researchers, protocol, data allow plastic samples to perform different kinds of knowledge as they travel beyond the expedition: scientific samples become measured data, and educations samples, evidence of the 'reality' of gyre plastic.

The heart of this chapter "follows" in the tradition of laboratory studies, approaching knowledge as process rather than product by attending to the minutiae of everyday practices that constitute particular facts (Latour & Woolgar 1979; Lynch 1985; Traweek 1992). Here the "fact" is the distribution and quality of plastic in the North Pacific. I describe in detail the transformation of bottled gyre samples into measured data.

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between Long Beach and Redondo Beach, I had to navigate between my desire to help the organization by facilitating communication between office and laboratory and fears I was acting like a spy for one or the other. Overall, I beleive I helped the office staff understand the intricacies of laboratory work, as Marieta commented, "until you got here and were telling me about how you analyzed the samples and all that, I really had not seen, I've not seen that in progress." Though at times, I worried that I was spreading gossip instead of something more helpful, and would run over conversations in my head, hoping I had done or said the right thing.

Traditional laboratory studies, however, have a tendency to remain within the bounds of the laboratory. Their strength and their weakness, as others have pointed out, is emphasizing the local rather than how knowledge then endures or travels (Amsterdamska 2008). For Algalita and the garbage patch, however, the research processes is not bounded by the laboratory or scientific publication; the point is to make results available and legible to broad publics. I follow how samples circulate to and through but also beyond lab studies, as samples of global problem are brought to the laboratory, but must then be made a global matter of concern.[66] Finally, I consider the gyre plastic left unaccounted for in the scientific process, as it challenges both current models of knowledge production, and the possibility for management.

Collecting Gyre Samples for Science and Education

34°57'N, 156°57'W: In the fading evening light of our sixth day at sea, research director Marcus Eriksen and watch teammate Bradon haul in a sampling net, interrupting its course skimming a narrow slice of ocean surface. From amongst the expected plastic confetti-sized fragments and translucent jellyfish captured by a net opening only fourteen centimeters wide, Eriksen pulls a bite-marked toothbrush and a small, grey plastic gorilla. In this section I describe the protocol and process for collecting ocean surface samples, detailing the coordination of people and devices that lead to the capture of, among other things, one grey plastic gorilla. I see collection practices as sites of intervention that "interrupt and refigure" flows of floating debris, as encounters that create possibilities for

[66] This is similar to what Edwards (2010) calls making global data and making data global, but I place more emphasis on how knowledge becomes public (or not).

future trajectories (Hayden 2003: 179). The specifics of practices at sea allow some gyre plastic samples to travel as measurable representatives of ocean accumulations, where others cannot. Intersections at sea become moments of divergence, setting education and scientific samples along separate paths.

Plastic specimens are not simply awaiting measurement, as stable objects in a codified space.[67] Sampling gyre plastic is a form of "travelling knowledge production" (Hayden 2003). The moving ocean must first be transformed into sample sites bounded by fixed coordinates provided by the assemblage of computers, satellites, national interests, and the reading of a small display screen on the *Sea Dragon*. The number of collection sites and the distance between them are calculated to map onto Algalita's previous activity in the area, and to ensure enough data for later analysis. Collection sites, however, are also delineated by geopolitical boundaries. Because they do not have necessary permits, Algalita cannot collect specimens within national "exclusive economic zones" (EEZ), causing data points, and with them, possible scientific knowledge of the Garbage Patch to break off 200 nautical miles from shorelines. The intricacies of American maritime law further shape the course of the expedition. The British-owned *Sea Dragon* cannot legally carry its thirteen passengers between two US ports, and is diverted inconveniently North of the accumulation zone toward Vancouver, Canada.

Sea state permitting (and many days it was not), daily expedition activities revolve around the collection of scientific samples for a variety of projects. As described in Chapter 3, the crew helps snare macrodebris for the examination of their marine

[67] Here I draw on Bruno Latour's analysis of soil science and forest fieldwork. Describing the process of making the field site legible, he states "For the world to become knowable it must become a laboratory" (1999: 43).

inhabitants (see Figure 3.4). We also gather water samples in a humble galvanized metal bucket on a rope for nanoscale scrutiny back on land. Even fish caught for human consumption are first subject to careful dissection, stomach contents checked for potentially toxic plastics, and organs preserved for later analysis. The majority of research time and energy, however, is dedicated to the collection of surface samples that could become representative of the density and distribution of plastic in the accumulation zone.

Figure 4.1: The 'suitcase' manta trawl. Photo courtesy Rob Johnson.

These samples were collected with a "manta trawl" (Figure 4.1), a device similar to those long-used by marine biologists collecting surface plankton samples. Named for the large winged ray it loosely resembles, the manta trawl funnels the top 25 centimeters of the ocean through its long tapered net, trapping plastic and anything else that floats and is larger than 333 microns (0.0333 centimeters) in the fine mesh of its removable 'cod end' (quickly rechristened the 'codpiece'). The smaller version on board, a 'suitcase' manta with a 60 centimeter wide mouth, is modified for ease of air transport and to

facilitate use on the *Sea Dragon*, which built as a racing sailboat, does not have the winch to assist in launching and retrieval that would be standard equipment on a dedicated research vessel (See Figure 2.1).[68]

When deployed according to strict protocol, the manta trawl allows particles from the Pacific to travel as scientific samples; the collection process makes them available for later measurement and calculation. Deploying the manta trawl generally takes the work of the entire team on watch at any given time. First, the skipper or first mate supervises slowing down the boat to two knots, which often requires bringing in sails. A member of the watch team acting as the data recorder locates the dedicated clipboard and stopwatch, while someone else ensures that the cod end is screwed on tightly with two hose clamps (we lose one cod end during the trip, inadvertently adding to flows of waste). A third person then reads off the long string of digits on the "flow meter," a device that measures the water passing through the net opening. The flow meter will later help control for variable collection conditions by measuring how much ocean passes through the trawl during each sample period. Working together, the team records the flow meter start point on the data sheet along with the sea state (following the Beaufort scale) and salinity (measured with yet another device). With boat, net and data sheet prepared, two people lower the trawl over the edge of the boat. Coordinated with a loud countdown, they drop

[68] Research activities were made possible with some minor alterations to the boat, but mostly with a lot of making due. The laboratory space was a requisitioned single-berth cabin with the mattress removed. The remaining wood bunk became a lab bench, where marine ecologist Hank Carsen set up his digital microscope to take images of invertebrates living on plastic. But with space at a premium, the lab was also home to a small freezer, the bread-maker, and a slowly dwindling supply of vegetables. There was barely enough room for one person to stand. It was not long before he realized that using his digital microscope alongside the hardworking bread maker would trip the breaker on the limited electrical system. Bread versus science quickly became a daily decision: make fresh baked goods for lunch or let Hank use his microscope.

the trawl into the water as the data recorder starts the timer and records latitude and longitude with to-the-second precision from the digital reading at the navigation desk below deck. Exactly an hour later (to the second) the actions are performed in reverse, the contents inspected, rinsed and bottled. Extreme care is taken to number and label the bottles, ensuring that contents stay connected to both a specific slice of the ocean surface and the conditions of its collection.

Figure 4.2 Sample Collection: deploying the manta trawl; looking into the cod end of the high-speed trawl; bottled 'gorilla' sample. Photos by the author.

Instruments and boats, however, often require different types of routines. The slow speed specified for sample collection conflicts with boat schedules, which rarely permit crossing entire oceans sails reefed (brought in to reduce the sail surface and boat speed), at two or less knots an hour. Marcus and a colleague on a previous expedition improvised and created the high-speed trawl from duct tape and spare parts when a

captain refused to slow down in the name of science.[69] With a much smaller opening and streamlined design, its current iteration can withstand a much faster clip, but boat speed and waves cause it to skip across the surface. A few of the plastic pieces and the occasional small fish are extracted for later analysis of toxins, and the high-speed samples are also labeled with coordinates, but without a steady, measured flow of water through the trawl, the sample cannot later be used to calculate the density and distribution of plastic in the gyre. Most of the non-standardized samples it collects are generally destined for education and outreach projects, not Algalita's laboratory.

Figure 4.3: The mixed plastic and marine life contents of the "gorilla trawl" education sample. Photo by the author.

Left to skip along the surface for the much longer period of eight hours, the high speed trawl results in our visibly densest and most photographed sample, complete with

[69] These tensions occasionally surface on the *Sea Dragon* too, as the skipper made a point of repeatedly distinguishing between total miles travelled including those "for science," and those travelled in the "right direction," meaning Vancouver.

the toothbrush and grey plastic gorilla (Figure 4.3). Aside from the toothbrush and gorilla, the sample contents are similar in quality to others from the expedition. There are a few smaller recognizable items – two black pen lids, a white nozzle from a spray bottle – but most plastic appears as a motley handful of unrecognizable fragments. The small round white pieces are not polystyrene crumbles, but pre-production plastic pellets or "nurdles." Washed out to sea before becoming recognizable objects, they are industrial, not consumer waste. These synthetic materials are mixed together with plankton, *velella velella*, salps and other creatures collectively referred to as 'jellies' by the crew, and a lone pelagic (open sea) crab. This combination of synthetic materials and forms of life appear in almost every Algalita sample.

The method of sample collection shapes immediate interactions as well as future trajectories. While manta samples are quickly and carefully bottled, preserved and stored, high-speed trawl samples can be touched and passed around. The pieces in Figure 4.3 were rearranged for the camera, pen lids placed in visible contrast on top of a blue plastic chunk, the crab and gorilla turned to face the audience.[70] Images of this sample were the most widely circulated from the expedition, not only because of the amount of plastic, but because of the sense of familiarity and scale provided by the toothbrush and gorilla. Even weathered and worn, the gorilla, so recognizable and so out of place, is a charismatic figure among the anonymous bits. Although it was collected from the same part of the ocean, on the same expedition, by the same crew, the sample process means that the gorilla is not destined for laboratory life. It is not the character of plastic alone, but the

[70] At one point this extended to an entire photo shoot with the gorilla posing with crewmembers and shown helping with basic tasks on board the sea dragon: writing an entry in the log book, helping to steer the boat, and even stirring the couscous for dinner.

way circulations of boat, water, device and people intersect that now shapes its path.

Trajectory 1: Making Knowledge in the Laboratory

Back on land, my path and that of the North Pacific samples diverge. All of the manta trawl samples (carefully wrapped in baby diapers, ziplock bags and packed in a suitcase) accompany marine ecologist, Hank Carsen, across the Pacific once more, this time by airplane to the University of Hawaii, Hilo. While our paths again converge six months later when I visit Hawaii on a research trip, I first return to California where I spend three months learning analysis procedures at Algalita's laboratory, helping to 'work up' manta samples from the previous year's South Atlantic voyage. To produce measured scientific knowledge about gyre plastic, the samples must travel both to and around the laboratory with the contents, coordinates and conditions of their collection intact. But samples and the data produced with them are not the only circulating entities that go into the creation of laboratory science. I approach the laboratory not as a center that standardizes samples into neatly bounded 'facts' for dissemination, but as itself constituted by multiple circulations. In this section I focus on the material flows of plastic, instruments and people and the work of coordinating encounters between them, showing how scientific samples become a measured fact about the distribution and density of plastic in the North Pacific Subtropical Gyre.

Algalita's Redondo Beach laboratory is behind the SEA Lab, a hands-on ocean science center managed by the LA Conservation Corps. Twice a week, I walk past brightly painted ocean murals and groups of school children peering into blue tanks of halibut and lobster, to a squat beige building at the back. Its modest rooms house

Algalita's archive of plastic samples from oceans around the world, and two dedicated staff members equipped with humble instruments and extraordinary patience. They are surrounded by microscopes, balances, documents and all manner of plastic waste: samples-in-process are gathered near the sink, bagged vials of finished samples are perched on top of a metal rack, and white bags of beach trash mysteriously occupy much of the available floor space. An informal display of specimens congregate near the window: jars of mixed plastic and plankton from different gyres, bags of plastic-laced 'sand' from Hawaii, and locally sourced samples of industrial plastic pellets, shavings and dust for comparison with those retrieved from the sea.

Like the path of the expedition across the gyre, the circulation of samples through the space of the lab is mapped in advance. On my first day I am handed a copy of the ten-page research protocol outlining the method for everything from sample preparation to data entry and quality control in a series of nearly fifty discrete steps. This document prescribes the specific movements of plastic and plankton through various instruments, standardized trajectories for producing codified knowledge with scientific standing. Even though I am not a credentialed scientist, following this protocol (under supervision) qualifies my work as 'scientific'. The document itself represents the circulation of scientific skills, a modified protocol for plankton research, honed by over a decade of Algalita projects, and most recently, shared and demonstrated to the University of Hawaii researchers in preparation for the processing of the new samples form the North Pacific.

After I have read the protocol, lab manager Gwen Lattin brings out the remaining samples from the previous year's South Atlantic voyage stowed under the counter in an ordinary cardboard box, awaiting analysis. Limited funding slows processing to what the

semi-regular stream of trained volunteers can conduct, but limitations of instruments and skills further limits the kinds of research the small nonprofit lab can carry out. While the toxins that stick to and leach from marine plastics are a growing concern for marine life and human health, the lab does not have the costly equipment for the kind of analytical chemistry and toxicology projects performed by some of Algalita's university affiliates. As a result of the limitations, Algalita focuses on the less technical (if by no means less involved) project of plastic quantification: calculating the distribution and density of plastic per volume of seawater, weighed against plankton.

The first main step for analysis involves painstakingly separating plastic from plankton under the microscope. Though I have read the protocol closely, the instruction to 'remove all recognizable pieces of plastic' does not prepare me for the actual task. Though Gwen has carefully selected a beginner's sample that is relatively less dense with tricky plankton, and I am looking for a common substance that ostensibly floats, picking out plastic is not so simple. My first look under the microscope reveals a surprising world of strange sea monsters. The beige and clear bits of gloop which I assumed were pulverized jellies, transform into a crowd of creatures. I see symmetrical pieces with bulging eyes, segmented bodies and hairy appendages (not plastic!). To my relief, I also see a few brightly colored fragments recognizable as plastic, which I gracelessly chase around the dish in an attempt to remove them with forceps.

But plastic does not always come in bright whites, blues and greens, or float nicely in plain view. With Gwen carefully supervising and sharing the kind of advice that comes with years of experience, I learn to look where plastic hides in the shadows of the meniscus at dish edges, how to stir the sample to unstick pieces from the bottom and each

other.[71] With more practice and supervision, I learn to distinguish tatters of clear plastic film from the fingerprint-like markings of fish scales, and fraying synthetic line from tapered zooplankton appendages. Sorting through a microscopic ocean a teaspoon at a time, the sample seems irreconcilable with the experience of sailing for weeks across the vastness of open seas. In the lab, gyre plastic becomes more stuff that gets counted.

Figure 4.4: Pieces of a single North Pacific Gyre sample, fully sorted, weighed and labeled. Photo by the author.

Once untangled from the plankton, the plastic pieces are rinsed through a series of repurposed geology sieves of increasingly smaller mesh size. This results (after more hunting for hard to see pieces, and unsticking of stubborn ones) in a set of plastic pieces divided into six size classes, which is then dried at controlled temperatures. Sufficiently desiccated, plastic pieces get further sorted not once, but twice. First by 'type' – determined largely by shape where fragments are sorted into pellets, line, thin film, and

[71] Classification, as Roth (2005) describes, is a situated practice whose performance goes far beyond written, codified protocols.

foam (distinguished by the crunchy sound it makes when pinched by forceps) – and then again by 'color' groups. Each set is counted and weighed, deposited in a labeled vial, and the data recorded (Figure 4.4).

Forgetting all I have read of the messy practical work of classification (Roth 2005; Waterton 2002), and with it the importance of tacit knowledge and the agency of things, I expect counting and colors to be straightforward: how many plastic pieces in the dish? What color are the pieces? But sun-brittle pieces shatter under pressure of forceps, changing size and multiplying in number mid-process. Wisps of clear film that threaten to take flight with the slightest breeze do not register as matter even on the finely tuned scales. Fishing line tangles into pieces that are somehow one and not one at the same time. I work out the difference between 'white' and 'transparent,' then return in the changed light of a cloudy day to find the distinction unreplicable. The seemingly innocuous sprinklings of colored dots that occupying very little physical space become hour long projects of sorting and counting hundreds, and in extreme cases, thousands of fragments that must add up across data sheets. As with sample collection, these plastic pieces do not always circulate neatly according to research protocol from bottle, through dish and sieve, from balance to vials. In frustratingly practical terms, I confront the fluidity of a material that refuses to conform to solid expectations and standard demands.

Laboratory work is a kind of choreography that requires separating some things while keeping others together as they move. This involves coordinating flows of plastic pieces, but also flows of volunteers and data. A group of trained volunteers help with sample processing, usually arriving individually in the early afternoon, some on regular weekly schedules, others not. Many people work on the same sample, often not at the

same time. Each sample-in-progress is laid out on a paper towel, white square corralling jars, vials and bags of plastic in plankton, with a sticky-note listing the tasks remaining. For the meticulous work of quantification to constitute the garbage patch as plastic pollution measured and mapped, plastic pieces must circulate in discrete sample groups with data intact. The close quarters of capped glass vials, and tightly-lidded jars help ensure sample pieces continue to travel together, while careful labeling systems keeping otherwise anonymous pieces attached to collection data. Often only a piece of tape and permanent marker keep it scientific.

For gyre samples to travel as scientific knowledge they must circulate beyond the laboratory as data that can be interpreted and shared. Once sample sets have been processed and spot-checked, and data entered into spreadsheets, calculations are run by lab staff and affiliated researchers. Collecting and processing representative samples of ocean surfaces allows marine scientists to estimate the density of plastic in the ocean and calculate how accumulations have changed over time. Some results end up in peer-reviewed journal articles (though the North Pacific samples were still being processed in Hilo almost two year after the expedition). Almost all are eventually destined to become data points on an interactive GIS map of the Pacific that Algalita is producing to facilitate data sharing. But even as plastic samples are translated into these written ‘inscriptions’ transformed as entries in spreadsheets – the data is underwritten by the material presence of carefully archived samples – paper data sheets, glass vials of sorted plastics, and sleeves of dried plankton gathered together in a labeled plastic bag.

Trajectory 2: Making Knowledge Public through Demonstration

Upon arrival in Vancouver at the end of the expedition, the scientific samples we collected on the North Pacific Expedition remained carefully packed away, ready to travel to the lab. The gorilla sample, in contrast, was in Marcus' hands as we met the local press, ready to show those on land what we had seen.[72] For Algalita, scientific knowledge is valuable in pragmatic terms: it must not only be produced, but shared widely in the hopes of having what Moore describes as "plastic conversations," about the consequences of synthetics and their place in our lives (Moore, personal interview, 2012). Though Algalita members often speak in terms of getting the word out and sharing good, hard facts, the basis for these "plastic conversations" is in many ways material, as plastic pieces themselves are enlisted to demonstrate problems of pollution in the ocean to broad audiences. In this section, I trace the path of education samples (like the one I was given at the end of the expedition) and show how making knowledge public involves sharing more than ephemeral 'messages' or accurate 'information.' Each sample becomes a demonstrated fact about the 'reality' of plastic pollution in the garbage patch.

The same week I start participant observation at the laboratory, I begin spending three days a week at Algalita's office in order to understand how gyre plastic circulates through education and outreach. Tucked among shops in Long Beach marina, Algalita's office is a small single room with just enough space for three desks and a conference table. The walls are lined with shelves holding an assortment of books and articles about

[72] An image of Marcus holding out the sample appeared on the front page the next day, along with a headline declaring "frightening" amount of plastic in the ocean (*The Province* 2011*)*. The source of the word "frightening" was none other than myself. Taken out of context by a reported that assured me she knew there was no island. Yet, in speaking, I inadvertently became caught up in a 'constructive encounter' (Chapter 2).

ocean plastic pollution, and a supply of signed copies of Moore's newly published *Plastic Ocean*. The office is also home to a collection of materials – including sample jars of plastic from all five oceans that sit within easy reach on a shelf – that can be assembled into the "display," which is used for education and outreach. On a normal weekday at the office there is usually the director, one or two other staff, and a semi-regular flow of various Algalita affiliates and the occasional visitor off the street. When explaining ocean plastic pollution to first time visitors, the office staff are quick to reach for sample jars to help explain the organization's work and the problem at sea. Most public interactions, however, happen elsewhere: at formal public talks, in classroom visits to local schools, and through tabling at a host of regional events.

On a brilliantly hot Saturday morning in September 2012, a hundred or so people carrying green plastic buckets scour the wide stretch of sand near the Long Beach pier. A group of wet-suit clad divers gripping bright orange mesh bags wade into the sea, and a small crowd gathers around a cluster of tents. The annual International Coastal Cleanup day is an event that will gather over half a million volunteers to thousands of such official sites in almost one hundred different countries (Ocean Conservancy 2014a). I find Algalita's education coordinator Katie Allen in the shade of a tent that she is sharing with members of the local Surfrider chapter, a wetlands restoration group, and the Port of Long Beach "Green Team" (who somewhat disconcertingly assure me they are cracking down on the storage of oil barrels over storm drains). Across the parking lot, registered volunteers check in to the event, picking up buckets, bags and gloves, and, I cannot help but notice, bottled water.

Figure 4.5: Algalita's education coordinator walks visitors through plastic pollution issues with samples close at hand.

At the Algalita table, Katie has carefully arranged a collection of photographs and samples of plastic in various states. I take the empty seat in front of a wood and glass case that holds the mostly plastic stomach contents of a single baby albatross. With an accompanying a photo of the plastic-filled ribcage of a dead bird, this is evidence of plastic harm, but more importantly, positioned to draw people to the table. The resulting choruses of "eeew gross" and "what *is* that?" begin conversations as I funnel the crowd toward Katie, who asks kids to stop by with full buckets from the beach to show her what they have found. The adults listen attentively as Katie helps identify objects from the beach. She then coaxes her audience to make connections between these larger local objects and other objects displayed on the table, including much smaller fragments from a beach in Hawaii, and the small bits mixed with marine life from the garbage patch. Deftly reaching for maps of ocean currents, and photos of research boats and sampling devices, Katie moves between images, physical samples, local watersheds, and the garbage patch, weaving a story of materials in motion.

Returned from afar, weathered but far from disappeared, plastic pieces help elucidate the fluid connections between nature and culture, human products and the ocean, a problem of relationships and flows. Where the movements of gyre samples around the laboratory are choreographed to ensure plastic pieces remain attached to the ocean, the display table is arranged to form new relationships, helping to connect everyday human life to distant consequences. Katie has thoughtfully chosen and arranged materials on the table in order to start "plastic conversations." The image of the plastic-filled bird carcass is not meant as a scare tactic, but chosen for its ability to draw people in (on other occasions, she uses an image of a turtle with an hourglass figure shaped by a plastic ring for similar effect). The arrangement of the 'stuff' – the samples jars, the case containing contents of the albatross stomach, the images – is itself a narrative, and Katie wonders how to ensure other Algalita members set up the table to tell a story the same way in her absence.

Among the materials on the table, the gyre samples have special status for their ability to communicate the 'reality' of distant problems. As I suggested in Chapter 2's description of corrective encounters, sample jars help give the presenter authority, even if she has not travelled trough the gyre herself. But the jars of mixed up bits of plastic and marine life themselves are imbued with the power of demonstration. Experienced Algalita members agree that there is something about shaking and swirling watery samples that changes audiences in ways that words or images alone cannot:

> actually showing somebody plastic that was recovered from the… farthest reaches of the ocean, sampled off the surface, is very impactful. People really look at that and go, oh wow, I had no idea that was out there. So that's the biggest part: show and tell for the education…. It just helps people visualize what the problem really is. And I do the same type of

> thing when I'm doing presentations. I try to bring a sample and help people understand that this is real. It's not a figment of somebody's imagination; it's real. And here's what we've got – just take a look at it. (Bill Francis, personal interview, 2012)

That sample contents *are* the real Great Pacific Garbage Patch as toxic soup is assumed to follow directly from the form of the material fragments themselves. The sample jars, furthermore, are seen as more trustworthy that images – they cannot be photoshopped. Where the power of debris sighting on the expedition depends on making waste self-evident through the *social* practices of 'showing,' (Chapter 3) the circulation and display of plastic bits helps emphasize the active role plastic materials themselves play in creating conditions of self-evidence. The self-evidence of plastic waste also resides in the very 'thingness' of what is being shown.[73]

This kind of material power underpins assumptions that effective understanding and solutions will follow from material demonstrations, not from arguments or debates waged in words alone. Expedition organizers hope that participants will become ambassadors for plastic pollution, displaying samples and sharing stories, as Katie does at the Algalita table. Following recommendations, I rinsed the sample I received to help share my experience of the North Pacific Expedition sample of formalin and transferred it into much friendlier alcohol for permanent storage and clearer viewing. Comparing my sample to Algalita's collection, I notice a strange effect: plastic that floats in seawater does not float in alcohol. Looking at gyre plastic congregate at the bottom of containers, I wonder why sinking plastic is the recommended form for demonstrating a floating garbage patch. What exactly makes an education sample good for sharing science? Does

[73] Following Chandra Mukerji's (1997) work on territorial power demonstrated in the gardens of Versailles.

authenticity rest in looking like a miniature ocean of plastic? In the scientific protocol that shaped its collection?

This is further clarified in part when I learn that some education samples are constructed specifically for kits available for purchase from the organization.[74] These samples are assembled piece-by-piece from reconstituted lab specimens or selected from larger high-speed trawls. In explaining this process, Katie describes education samples as well-made not according to scientific protocol (such as random sampling), but for including an 'ideal' mixture of recognizable pieces and smaller fragments from the actual Garbage Patch. Above all, they are good samples for sharing scientific knowledge by virtue of their contents having made the long journey to and from ocean gyres. The samples are an embodiment of circulation in a way that litter from a local beach is not, their meaning tied to their physical movements both as plastic around the Pacific and around display tables.

As education samples put in the view and the hands of the public, gyre plastic becomes waste brought back from where it does not belong. Making knowledge public is not simply sharing data or 'results' from the laboratory; it involves bringing plastic itself for people to see. The 'fact' produced in sharing knowledge about gyre plastic is different, too: where the circulation of scientific samples through the laboratory produces measured data about the density and distribution of plastic participles in the North Pacific Subtropical Gyre (see Figure 4.6), the circulation of education samples demonstrates the 'real' form of a garbage patch problem as plastic soup (see Figure 2.2).

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[74] Thus marking another set of circulating 'biographies' of plastic from consumer goods to waste, and back to commodities once again (Kopytoff 1986).

Trajectory 3: Escaped Plastic and Missing Knowledge

Despite efforts to collect and quantify gyre plastic, and to make knowledge of a plastic problem public with hopes of fostering change, plastic continues to circulate around the North Pacific. Achieving widespread awareness or compiling a global database do no in themselves bring plastic back under human control. The day the gorilla arrived in our nets, Marcus Eriksen was inspired to contemplate the uncanny fates of plastic toys:

> I once found a plastic lion washed ashore on Easter Island, toy soldiers in Bermuda, wheels from toy cars almost everywhere I've been, and even a spider-man leg in the stomach of an albatross on Midway Atoll. How much plastic is in the air right now as you read this, hovering in the stomachs of seabirds around the world? (Eriksen in Algalita blog post from July 2011).

His description of an uncountable plastic migration stands in marked contrast to the carefully labeled scientific samples and the measured knowledge the samples are intended to produce. In this section, I describe encounters that do not happen, sketching possible fates of the gyre plastic not intercepted by Algalita's North Pacific Expedition or others like it. Here plastic not collected or otherwise intercepted becomes a problem for the ocean and for science, escaping not only from sample nets but also from attempts to model it. This section considers how gyre plastic continues to escape attempts to know and manage it, briefly sketching these possible trajectories (revisiting questions of absence introduced in Chapter 2).

As was the goal in organizing expeditions, data from gyre samples collected and processed by Algalita get taken up to show that accumulations in the North Pacific Subtropical Gyre are growing over time. Miriam Goldstein, at Scripps, includes

Algalita's public data along with all the other sources she could find, in a time-series study, in calculating that "Microplastic debris in the North Pacific increased by two orders of magnitude between 1972–1987 and 1999–2010 in both numerical (NC) and mass concentrations (MC)" (Goldstein et al. 2012).[75]

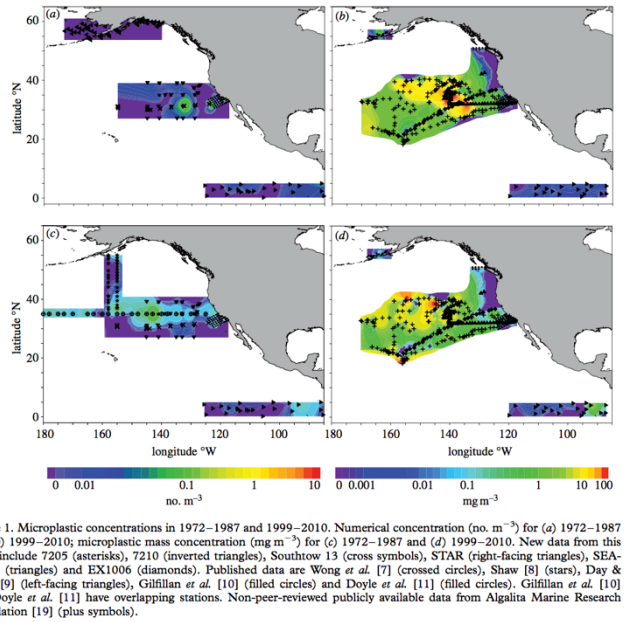

Figure 1. Microplastic concentrations in 1972–1987 and 1999–2010. Numerical concentration (no. m^{-3}) for (*a*) 1972–1987 and (*b*) 1999–2010; microplastic mass concentration (mg m^{-3}) for (*c*) 1972–1987 and (*d*) 1999–2010. New data from this study include 7205 (asterisks), 7210 (inverted triangles), Southtow 13 (cross symbols), STAR (right-facing triangles), SEAPLEX (triangles) and EX1006 (diamonds). Published data are Wong *et al.* [7] (crossed circles), Shaw [8] (stars), Day & Shaw [9] (left-facing triangles), Gilfillan *et al.* [10] (filled circles) and Doyle *et al.* [11] (filled circles). Gilfillan *et al.* [10] and Doyle *et al.* [11] have overlapping stations. Non-peer-reviewed publicly available data from Algalita Marine Research Foundation [19] (plus symbols).

Figure 4.6: Goldstein's (2012) representation of increasing microplastic concentrations in the North Pacific Subtropical Gyre.

In other words, the amount of plastic in the Pacific is 100 times larger than it was four decades ago. The results are not especially surprising given an exponential increase in global plastic production over the same period (Plastics Europe 2013). Since plastic is incredibly slow to degrade, especially in seawater, the majority of plastic that has entered the ocean should still be floating out there, somewhere.

[75] Despite differences between people at Scripps and Algalita (see Chapter 1), Goldstein deems Algalita's data was worth including, if with the qualification that it is "non peer-reviewed." In a personal interview, Goldstein (2012) explained that where Algalita offered a range of data, she chose the lower estimate.

According to a recent study published by National Academy of Sciences however, the numbers do not add up. A team led by Carlos Duarte, oceanographer at the University of Western Australia, surveyed global oceans in 2010 and 2011, collecting trawl samples much as we did on the North Pacific Expedition, and combining results with existing estimates including Goldstein's. Their conclusion is striking: the models fail to account for the vast majority of plastic expected to be floating in the ocean (Cozar et al. 2014). Where models based on surface samples estimate the amount of plastic floating in global oceans in the tens of thousands of tons; those based on global plastic production and the probability of plastic ending up in the ocean estimate the amount to be in the millions of tons. "We can't account for 99% of the plastic that we have in the ocean," Cózar explained to the press (Chen 2014).

So how, then, to understand of the fate of gyre plastic? Duarte's team suggests a few possibilities that I describe here in a bit more detail. First, seabird and other forms of marine life can ingest plastic, mistaking it for food. The best-known example is the Laysan Albatross, whose stomachs often contain plastic. With a dense population in the Northern Hawaii Islands, Laysan Albatross are known to forage for ocean plastic, bringing it back as food for their chicks (Auman et al. 1998; Gray et a. 2012). As included in the Algalita table display, the plastic contents of albatross chick bellies are often arranged and photographed as evidence of harm caused by plastic (though the scientific literature is more cautious in listing the cause of death). Not all plastic "eaten" is as recognizable as the spider-man leg that Marcus found. One study determined that microplastic particles could make their way into the very blood of mussels (Browne et al.

2008). Other very small plastic pieces may simply be slipping through the grid of the sampling net.

Another possible trajectory for missing plastic involves sinking. From the start, not all plastic floats in seawater. Take the lid off your single-serving water bottle (made of polyethylene terephthalate) and it will fill with water and head for the bottom, while the cap (made of less dense polypropylene) will float.[76] But even plastic that begins on the surface may sink with the added weight of organic matter. The added weight of algae or a covering of fish feces (from ingestion) can send plastic below the surface. This vertical migration, however, may only be temporary: if the algae dies, for example, the plastic piece may return to the surface. Other plastic still, washes up on shores around the Pacific with storms and tides. Once up on shore it may be picked up by a beach cleanup or not. The Ocean Conservancy boasts collecting 12.3 million tons of trash off of beaches and out of watersheds in 2013 alone, though not all of it is plastic (2014a). Other pieces may be washed back out to sea to resume making laps around the gyre.

Gyre plastic, then, doubly escapes from attempts to manage it: first from disposal practices meant to keep it out of ocean, and then again from attempts to measure and track it. Gyre plastic makes laps of the North Pacific in ways that are sometimes expected, at least according to the latest current models, but in other ways that are not, travelling at times to places that humans cannot follow. Duarte's team calls for further research to "resolve the fate of the missing plastic debris" (Cózar 2014). Others point to problems in the calculation, noting that estimates of how much plastic should be in the

[76] Though far more difficult and expensive to access, a number of studies have begun to quantify plastic on the sea floor (Pham et al. 2014).

ocean are based on estimates from the 1970s (Chen 2014). Their calls are echoed in news coverage about the results that point to knowledge gaps and the need for more data and better models. In both cases, the missing plastic is evidence of absent knowledge and undone science (Frickel 2010).

Conclusion

Plastic knowledge is made in, about, and is itself in motion. Following samples as they travel beyond the expedition, this chapter detailed some of the ways gyre plastic moves through the production and sharing of knowledge about its accumulation in the ocean. There is a general tendency for the paths of scientific and educational samples to diverge as they are processed, stored, arranged and shared in different ways. What might otherwise be seen as plastic waste (or not be seen at all) becomes something to be counted, something to be shown, or something that remains unknown. For oceanographers, there is the problem of measuring and modeling things that are unevenly distributed and in constant motion in and around the ocean (see Chapter 1). Knowledge about these movements is made through further circulations of plastic through sample nets and laboratories. And still more circulations are involved in processes of sharing knowledge with the public. Moreover, as gyre plastic continues to circulate as data or through demonstration there is a tendency for the "fact" shifts from what is the distribution and quality of plastic in the North Pacific accumulation zone to a more general sense of what it is like 'out there.' Though Algalita is dedicated to both research and education, the results of science do not seem to speak directly to public questions.

There is recognition, in the emphasis on showing education samples, that accuracy in strict scientific terms might not accurately convey a sense of concern for gyre plastic.

Though shaped by conditions of collection at sea, these trajectories are not absolute. Scientific samples preserved in the laboratory may be reconstituted for education purposes, and pieces sneezed out of Petri dishes may once again be lost. Not all the plastic gathered on the North Pacific Expedition gets caught up in either project. The macrodebris we gathered in the North Pacific, is unceremoniously deposited in a nearby dumpster, its future trajectory unknown; the plastic gorilla remains packed away in a box in a Los Angeles area garage. In following plastic knowledge beyond the laboratory, I also account for how plastic continues to evade attempts to know it on a larger scale, as models fail to account for materials lost at sea. In doing so I map the travels of plastic to places humans cannot always follow, plastic that continues to matter in ways that cannot be counted.

When global models come up short, the scientific community is quick to see missing plastic as undone science, pointing to the need for more research and better models. I see, in contrast, a challenge to the very idea that measurement in the conventional sense can form the basis for management. As Samantha McBride argues, plastic is decidedly modern waste: "synthetic, unpredictable, and above all heterogeneous" (MacBride 2012: 174), though she too calls for better 'information.' What if the missing plastic is approached not as a problem of measurement, but as a problem of plastic being plastic. What if all the messiness of re-counts, missing pieces, and plastic that will not sit still is taken as evidence that new approaches are needed for dealing with "solid" waste in all its circulations? In the next chapter, I draw parallels

between cultures of classification in science and of conservation, moving from circulation as divergence to circulation as entanglement, of science and care, plastic and marine life.

Sections of Chapter 4 appear in an article accepted with revisions at *Space and Culture* and may appear in 2015.

Chapter 5
Plastic Species:
Tangled Naturecultures in the Plastisphere

When I set out to chase plastic on the *Sea Dragon* I was not at all expecting to learn that diverse communities of marine life live on and even flourish with gyre plastic. Yet marine ecologist Hank Carson was on board to study just that. Below deck midway through the voyage, Carson gave me a tour of his tiny improvised laboratory space, little more than a bunk with the mattress removed to form a workbench. Standing next to the bread maker, and with his laptop perched on the freezer (that filled with scientific tissue samples as it was emptied of meat for human consumption), Carson took digital microscope images of invertebrates plucked from the macrodebris the crew had snagged from the gyre earlier in the day. It was here, as I looked at pictures of snails and sea slugs, that I first heard the term "plastisphere." As Carson explained, the plastisphere is a term some scientists use when referring to communities of organisms that live attached to or associated with plastics. "It's like the anthropocene for marine biology," he continued, drawing comparison with the geological age defined by extreme human impact on the environment. Delving further into the scientific literature after the expedition, I learned that the plastisphere is made of the "associations" and "novel interactions" of life forms defined by their relationship to a human product in the ocean: eggs laid on a plastic bag, gooseneck barnacles burrowed into foam, or bacteria nestled on synthetic fragments (Goldstein et al. 2012; Amaral-Zettler et al. 2011; 2013). The term emerged from studies of 'rafting,' an area of marine biology concerned with how organisms not only flourish

but also travel and potentially become invasive species by hitching rides on floating materials.

As I became more familiar with these communities proliferating at sea, I began to notice plastic and life hybrids proliferating in public education campaigns as well: birds with cigarette beaks, taxonomies of bottle fish, plastic bags described as agents with power to impact wildlife. Presented as "dangerous" and "non-native species," these images of plastic-creatures were meant to encourage the cleanup of plastic from the sea, the very possibility of their category-crossing existence an argument for untangling human materials from natural ones. In these comingled zones of science and culture, oceans and images, a lively politics of belonging is emerging with plastic entanglements that simultaneously threaten and reconstitute the boundaries between natural and artificial matter. This chapter explores the tensions between the material associations of gyre plastic and life in the ocean and the imperative to separate them in the pursuit of knowledge and solutions. Examining the circulations of plastic in and with life, I show how materials come to belong or not as they travel together in the Pacific.

Gyre plastic is not simply human-made 'matter out of place' (Douglas 1966); it is also a matter of life (and death) as bodies come to live, travel and die with plastic, and with plastic inside them. I position plastic-creatures among the emergent relations of beings and things, habitats (not just habit) as an example of what Grosz (2013) calls the "inter-implications of forms of life with inorganic forms" (235). Developing conceptions of material (dis)entanglement through multispecies ethnography and studies of the classification of the *bio*, I consider the indeterminacy of 'species' coming-in-to-being (Dahlberg et al. 2013) as practices of producing and sharing knowledge about plastic in

the ocean. These practices create and maintain a physical separation between the materials of nature and culture, just as they are concerned with nature/culture associations. I argue that the 'danger' of plastic-life relationships lurks not in associations but in the very categories used to understand and live with forms of plastic and forms of life, in the kinds of belonging that emerge with kinds of materials, and, in the failure to recognize the impossibility of their separation.

Where chapter 3 describes the human communities 'gathered' by gyre plastic, in this chapter I describe the intricate 'becomings with' – the ordinary interactions of being alive (Haraway 2008) – of plastic and marine life in the ocean that offer new possibilities as both habitat and as threat by supporting but also transporting potentially invasive creatures. I begin with an overview of 'entanglement' as a concept in both marine ecology and science and technology studies, and then detail how scientific knowledge of material *association* between plastic and life depends on their *separation* into kinds of matter that is sorted, counted and weighed against one another. Following these closely coupled tanglings and untanglings through nonprofit and government public education campaigns (Heal the Bay and the California Coastal Commission for the Pacific; the Catalan Water Agency for the Mediterranean) the tensions between kinds of plastic and kinds of life become explicit arguments that position separation – cleaning up human materials from beaches and the sea – as the dominant course of action for addressing plastic pollution. Together, these cases show the physical and conceptual indeterminacy of species as bounded bodies, logical types and playful kinds. Finally, I consider alternative possibilities for belonging and responsibility that do not fall back on the

categories of nature/culture, human/non, positioning the relationships of the plastisphere as evidence of the impossibility rather than necessity of separation.

Entanglements in and with Science

For scientists and activists working with plastic pollution in the ocean, entanglement is the technical term for marine life ensnared by plastic debris: fishing line slowly strangling seals, plastic bottle rings giving hour glass figures to turtles. These are physical relationships – contact between animal bodies and plastic materials – that in the words of marine biologist David Laist, "put animals at a survival disadvantage" (1987). Entanglement causes "serious injury or death" (EPA 2013), as "many animals, if not most so caught, find it difficult to escape entanglement and are doomed to drown or die from injury, starvation and general debilitation" (Gregory 2009). In marine debris science, entanglement is negative by definition. From a science and technology studies perspective, however, the plastisphere, with relationships that are *supportive* of life, not just in contact with it, complicates this formulation. Its associations inhabit the cracks between the very categories of plastic and animal, synthetic and natural, waste and life. I begin by extending this ambiguity to plastic-life relationships at sea more generally, rather than with assumptions of 'bad' plastic threatening a 'pristine' ocean 'environment.'[77] Approaching the plastisphere (broadly conceived) with a science and technologies studies understanding of entanglement helps show how these categories, and

[77] In doing so, I am working across the divisions of scale that exists in the current published scientific literature, where studies of entanglement focus on larger mammals and birds, and studies of the plastisphere on much smaller invertebrates and bacteria.

with them, assumptions about whether plastic can or should be removed from the sea, emerge with processes of knowing life and plastic in the ocean.

For STS, science is part of material entanglement. As Karen Barad (2007) demonstrates by bringing entanglement experiments in quantum physics into STS theory, there is a performative tendency for the apparatus to produce the very phenomena it is designed to investigate. Scientific practices do not simply represent preexisting conditions and characteristics, but are implicated in their ongoing formation. Barad emphasizes such 'intra-actions,' the constitutive relationships between matter and meaning, refusing to begin with boundaries already drawn. Focusing more specifically on the divisions between human and nonhuman species, Donna Haraway (2008) makes a similar ontological intervention, arguing for interspecies dependencies where "the partners do not precede the meeting; species of all kinds, living and not, are consequent on a subject- and object- shaping dance of encounters" (2008: 4). Here species, alive and dead, organic and not, are 'becomings with' of beings and categories, entities and systems for sorting. In the plastisphere, humans, disciplines and ocean creatures 'become with' plastic. Kinds of materials and species come to belong or not as they live or not with the movements of synthetics at sea and with the practices of science and environmentalism. And plastics are named as species in return.

More recently, diverse actors from STS have been infiltrating cultural anthropology. Taken up by the emerging subfield of multispecies ethnography, a multitude of creatures from meerkats to microbes (Candea 2010; Helmreich 2009) are key figures in a 'species turn' that problematizes the categories of nature and culture. The concept of species is itself understood to be multiple and even potentially dangerous if it

reinscribes biological similarity and difference at the expense of diverse encounters (Kirksey and Helmreich 2010). Similar boundary challenges are also appearing in studies of the classification of the bio as researchers are questioning how and when twitching strands of Petri-dish meat and other synthetic fleshy matter encountered in the laboratory qualify as life (Zurr 2013). Practices and categories of sorting along species and lifelines are not only political, they arguably have a performative tendency to make the world in their own image.[78] Claire Waterton (2002) cautions however, that this is not a simple, traceable process whereby social and political factors embedded into classifications are reflected directly back on the world: "classifications seem to take off in unanticipated directions, refusing to adhere to the stable groupings we think they are. This results in an evolving assemblage of meanings attaching themselves to classes…and transform both the discourses and the material objects being discussed" (196). As with Barad's physicists, the practices of scientific sorting are entangled with their objects and objectives.

The categories of nature and culture, however, persist in ways of knowing plastic-life entanglements and the ways of dealing with them that follow. They mark an affinity between scientific interest in marine plastics and a popular ethos of care for the ocean that emerges with assumptions about what kinds of matter and what kinds of life belong in the ocean. They continue to form foundations for whole systems of knowledge, action

[78] Geoff Bowker (2005) explains, using endangered species as example, that only entities that can be named and studied will be saved. Over time, categories project the conditions of their making, shaping the world in their own image as those species considered endangered are more likely to survive.

and arguably the very conditions for the proliferation of category-crossing relationships at sea.[79]

Tangles of Waste and Life at Sea

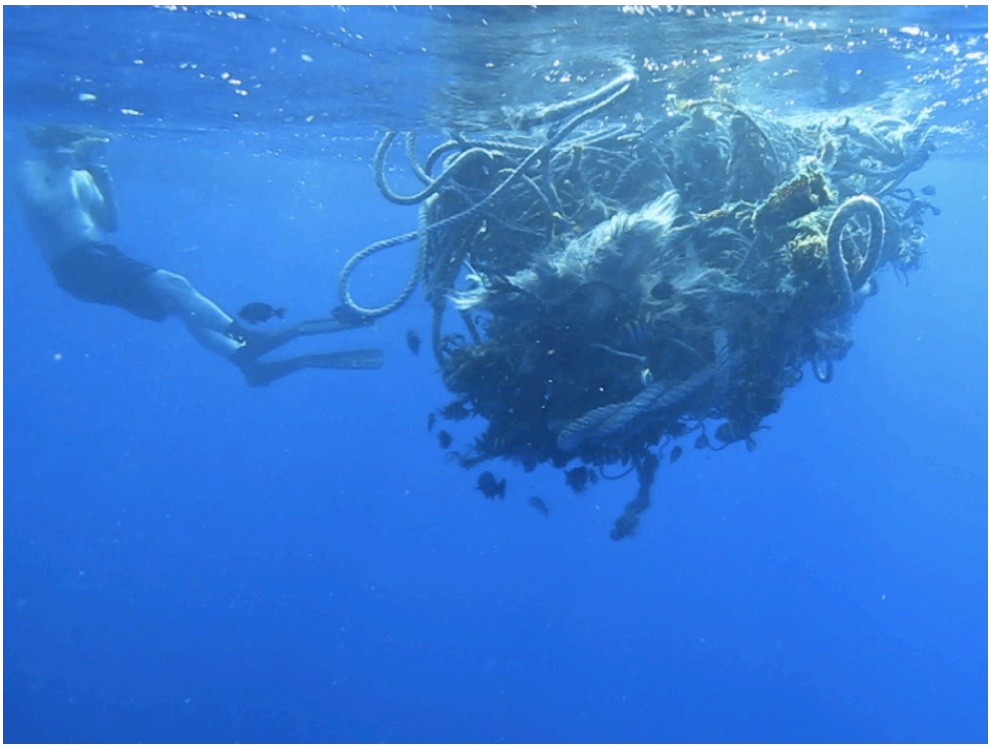

Figure 5.1: Ghost net with reef fish and human, as encountered on the North Pacific Expedition in July 2011. Photo courtesy of the Algalita Marine Research Institute.

The day the North Pacific Expedition was caught by the netball was particularly eventful. The netball depicted in Figure 5.1 was a kind of ocean tumbleweed about six feet in diameter made of knots of escaped fishing nets and lines, known as 'ghost nets' for their tendency to keep fishing in the absence of humans. Not only did the netball threaten to sink the high-speed sampling device (as recounted in Chapter 3), it provided

[79] Latour (1993) has long argued that practices of purification are implicated in the very proliferation of hybrids. With plastic pollution, purification spills out of the lab, onto beaches and city streets and into the sea, supporting a whole culture of 'cleaning up' plastic from the environment.

one of the few opportunities for expedition participants to get in the water.[80] Hank, Brandon and Jin (the marine ecologist and the Seoul Broadcasting Corporation team) dove into the still-churning seas to investigate, returning with photographs and samples of a strangely beautiful tangle, shelter to a host of coastal species: coral reef fish, sea slugs, and even a lone oyster. Though these creatures are understood to belong in the ocean (unlike the plastic), they would not otherwise be found so far out to sea. Their existence here is precarious, entangled with the netball, as both shelter and snare; the mobile habitat is capable of killing their tenants in rough weather.

Entanglements with gyre plastic can also be embodied in the most literal sense, as plastic materials become part of all kinds of bodies, including those of jellyfish.[81] *Velella velella*, for example, are palm-sized jellyfish commonly found on the open seas of the North Pacific. They have a clear oval or round body, marked by visible concentric growth lines, like tree rings. This base supports a circle of short, blue-purple tentacles below, and a half circle 'sail' above, the distinguishing characteristic of its popular names: 'by-the-wind-sailor' or 'sea raft.' Counting passing debris from the boat deck, I often confused velella with crumpled bits of plastic film. Over the course of the voyage, I honed my plastic vision, learning with the other crewmembers, to visually distinguish jellies from plastic with a quick glance.

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[80] The netball becoming entangled with the Sea Dragon is not an isolated incident. Derelict fishing gear (and also lost shipping containers) floating just below the surface is a significant navigational hazard, and the object of dedicated marine debris prevention and removal programs (NOAA 2014c).

[81] Not to mention the associated synthetic toxins found in living things everywhere. See Celia Roberts' (2007) work on endocrine disruptors.

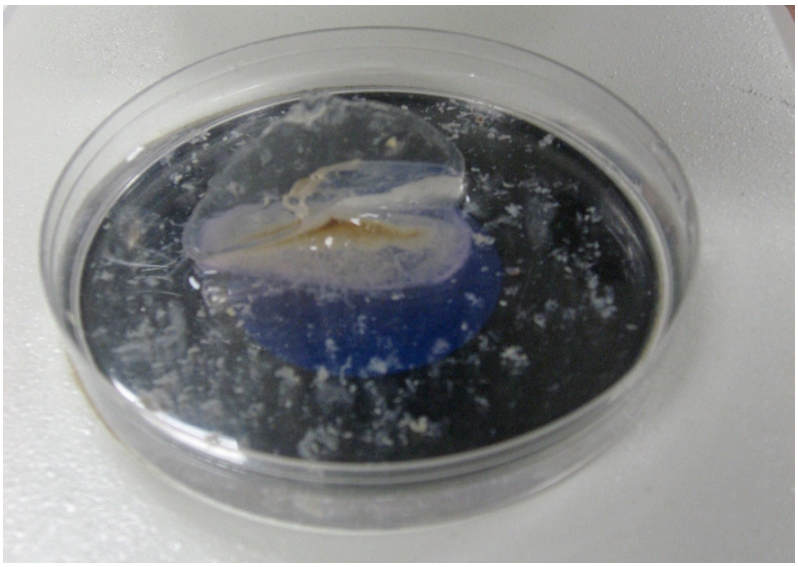

Figure 5.2: Velella velella from ocean surface sample. Photo by the author.

But upon closer inspection this division does not always hold. Some velella have incorporated synthetic materials right into their bodies. These plastic fragments are not only superficially attached to their outsides or temporarily ingested through their insides. Stuck to soft bodies, like a grain of sand in a pearl oyster, plastic bits appear to be completely enveloped into gelatinous flesh. They are both plastic and jellyfish.

Plastic and life not only exist together, they move together. In studies of 'rafting,' where the term plastisphere originates, marine biologists and ecologists seek to understand how specific species and their distribution are potentially altered with the plastic in their lives. Until recently, hard substrates – sturdy floating materials – available for travel were restricted to logs or mats of greenery that could only travel so far without human intervention (i.e. stuck to or in ships) before degrading or becoming waterlogged. Synthetic plastics provide new possibilities for long distance travel, and with them, new concerns about invasive species as organisms move to new places. Marine creatures

come to *not* belong in their relationships with plastic. But plastic also travels with life, as jellyfish and other bodies become the 'raft' for plastic.

The entanglements that constitute the plastisphere cannot simply be undone. With the netball, removing waste from the water is not inherently good for those it shelters; with the jellyfish, it would involve precise, body-cutting surgery. But despite the proliferation of plastic-life alliances at sea, both scientific and popular practices surrounding plastic pollution in the ocean are caught up with the familiar separation of nature and culture (Latour 1993). The next two sections consider how these divisions are constituted physically and conceptually in the work of producing and sharing knowledge about plastic pollution in the ocean. I will then suggest that science and technology studies offers a constructive path past the scientific and popular imperative to purify nature and culture, a way of responding to plastic pollution that opens up space for these shelters and bodies.

"Plastic versus everything else": Separation as scientific knowledge

At Algalita's Redondo Beach laboratory, technicians and volunteers painstakingly process surface samples of mixed up plastic and organisms sifted from the open seas. With the aim of quantifying and monitoring the distribution of plastic in the ocean rather than studying the intricacies of life on plastic, Algalita researchers do not describe their work using the term 'plastisphere.' They do, however, establish the quantity of plastic in relationship to the quantity life by establishing a plastic to plankton ratio.[82] In practice

[82] The plastic to plankton ratio is behind the widely circulated claim that plastic outnumbers plankton 6:1 in the North Pacific. This figure however, is widely critiqued by oceanographers and

this involves quite literally weighing one against the other. But first they must be separated.

Figure 5.3: Ocean surface sample sorted into plastic and plankton at the University of Hawaii Hilo. Photo by the author.

Working with forceps under dissecting microscopes, staff sort samples into two glass jars, most commonly labeled plastic and plankton (a process described in detail in chapter 4). The two jars are variously described as plastic/manmade for the one, and plankton/animal/organic/natural/real for the other, these categories for sorting culture matter from nature matter contain assumptions about what belongs in the ocean or not. When I asked for clarification about the categories, the lab manager explained that the plastic to plankton ratio was a comparison between nutritive and nonnutritive materials

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marine ecologists who point out that plankton populations are incredibly variable, and that Algalita's method of weighing dehydrated plankton does not account for the large proportion of water in fully constituted plankton bodies.

floating in the open ocean, or the likeliness a body looking for a meal would get something it could (or should) digest. “Basically, it’s plastic versus everything else,” she clarified. These jars are not metaphorical boxes, but rather form the basis for a physical separation that ends with a material archive of dried plastic bits and dried plankton bits in separate plastic bags.

The process sounds relatively simple, but at both Algalita’s California lab and an affiliated lab in Hawaii, I observe staff and volunteers struggling to untangle plastic and life into separate containers (as detailed in Chapter 4). On a sunny winter afternoon, I listen as a volunteer describes the contents of her Petri dish as “a plant with legs on it;” moments later, another volunteer hesitates and confers with her colleague before depositing a fragment (or is it a fish tooth?) in a jar labeled plastic. As a veteran lab technician described in an interview, these kinds of incidents are a constant challenge, especially for those starting out, “like everybody says in the beginning, is this plastic or is this real, is this plastic or is this real? And in the beginning you’re going, you’re looking at this huge amount of stuff and you don’t know what’s what.” Even those with years of experience and marine biology training are quick to provide examples of specimens causing trouble: pieces of plastic film camouflaged by algae that cannot be scraped off; or salps, a jelly-like filter feeder, with plastic on their insides. Should the plastic be removed? Was it already part of them, or were plastic and bodies merged by the force of water through the net used for sample collection? In which jar do they belong? The boundaries between what counts as life and what does not are constantly breaking down and being remade as the ambiguity encountered at sea meets the rigid containers of the laboratory.

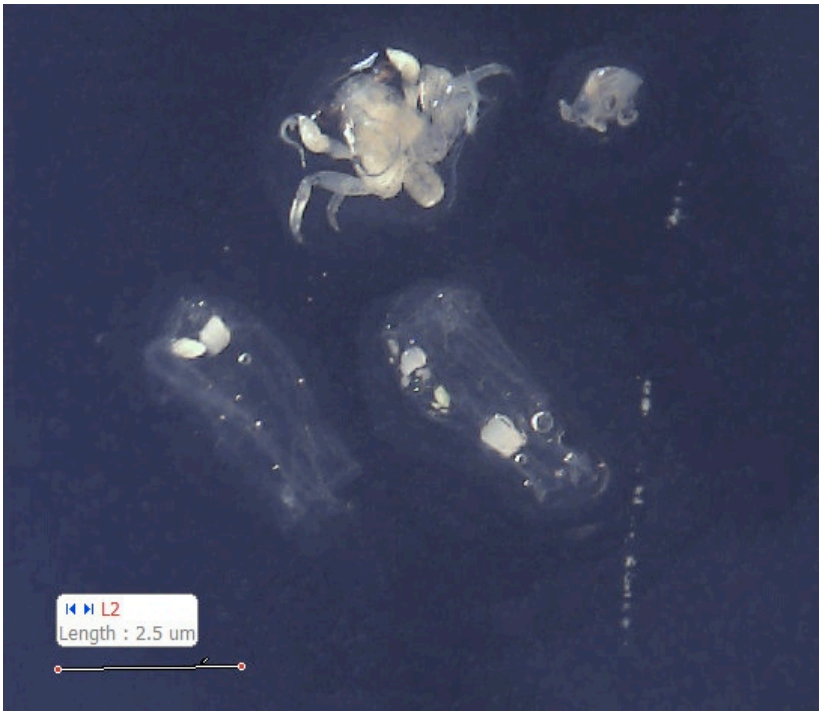

Figure 5.4: Two salps with plastic fragments (and a tiny crab). Courtesy of the Algalita Marine Research Institute.

There is also the sense, however, that this is simply science as usual. When asked in interviews, the lab manager (a marine biologist) was not at all troubled by what I see as the almost ironic practice of *separating* of plastic and life in order to understand how they are *connected*; breaking down problems into smaller pieces is simply a necessary step in the production of scientific knowledge. These practices of ordering, however, are constitutive of more than knowledge; they produce plastic and marine life as ontologically distinct forms of matter.

At the Scripps Institution of Oceanography in San Diego, Miriam Goldstein also sorts samples of plastic and marine life. She is explicitly engaging with the plastisphere, looking for a possible relationship between halobates – marine water-skeeter and only true ocean insect – and the amount of plastic in the ocean. Though halobates skate across the water's surface, its eggs need to be anchored to a floating platform. This means that

the halobates population is limited by the availability of sturdy materials or 'hard substrates' on the ocean surface. This also means that it's possible that the proliferation of plastic is getting caught up with life at the level of populations. Though the calculations are more involved, here too separation is necessary for establishing relationships. Researchers painstakingly pluck plastic pieces and halobates eggs, one by one, from samples under dissecting microscopes. With access to expensive equipment at a major research institute, plastic pieces can be quantified by ZooSCAN, an optical analysis system designed to count and classify plankton (no hand weighing of plastic bits here), but the halobates eggs still get counted and classified by hand and eye. To Goldstein's surprise, she found a very strong statistical correlation between the amount of plastic and the amount of eggs: halobates appears to be thriving. While plastic appears to be good for the marine insect, the implications for other marine ecology and for humans are far more ambiguous.

In all her research, however, Goldstein only found one case where plastic was embedded in fleshy matter: a piece of plastic in a jellyfish tentacle. She insisted that the plastic-creature was a statistically insignificant one-in-thousands anomaly. While the situation was unlucky for the specific jelly involved, it was certainly not grounds for challenging established ways of understanding the ocean and its species.[83] She argued that in all the other cases, plastic was forced into bodies during the collection process, pointing out that feeling tube of a salp was far too small to accommodate fragments visible to humans. Because she understood the symbolic power of such images, in her

[83] As Roth (2005) observes, scientists have a tendency to dismiss and discard 'monster' or 'mongrel' specimens that do not fit within established categories.

words, as "metaphors," she was wary of sharing her photograph of the plastic-tentacle for fear of it being used to misrepresent the fate of life in the Pacific. With scientific practice itself implicated in its making, this plastic-life entanglement was dismissed of material significance for science. What remained was the problem of (social) meaning, and the attempt to control it by controlling the circulation of images.

I did first encounter the salp and velella images in a public presentation given by Captain Charles Moore, the Algalita founder credited with discovering what has become known as the Great Pacific Garbage Patch. Part of Algalita's efforts to raise awareness about plastic pollution in the ocean, Moore positions plastic-studded jellies as a transgression of natural boundaries, and evidence of human reach gone to far. "We are turning the creatures of the ocean into plastic," he cautions. After continuing to explain how plastic and its associated toxins alter bodily systems, he concludes, by claiming that "Plastic is not an inert substance. It is bio-active." Here the relationships between kinds of matter, the very entanglements that at times defy and at other times are simply denied by the categories of sorting in the laboratory, are resolved by attributing plastic the lively capacities of movement and transformation. But this resolution is replete with assumptions of legitimacy and belonging based on the very same categories of natural and synthetic material: ocean creatures should not become (with) plastic.

"Dangerous Species": Separation as public knowledge

Practices separating nature from culture are by no means restricted to the production of scientific knowledge about plastic in the ocean. If not falling under the rubric of 'plastisphere' as a realm of scientific study, similarly 'novel associations'

between plastic and marine life at large can be found in the poster and video campaigns of organizations, both government and nonprofit, aiming to educate the public about the problems of synthetic pollution. I consider in turn the California Coastal Commission poster series "Non-native species of the California Coast," the widely circulated "Dangerous Species" poster produced by the Catalan Water Agency, and San Francisco-based organization Heal the Bay's short mockumentary *The Majestic Plastic Bag*. Casting plastic-creatures as lead characters, these productions at once award new kinds of agency to plastic objects while simultaneously discouraging relationships with biological life, a feat made possible by the indeterminacy of the 'species' concept itself.

The walls of the Algalita lab are covered with an array of written and visual materials: plastic identification flow charts, reminders not to wash people dishes with the science sponge, and advertisements for pollution-related events. One slightly faded poster in particular catches my attention each visit: labeled the 'Cig Egret' it features a mean-looking heron on the beach, head seamlessly transitioning to tubular white and orange tobacco-product prosthetic beak.[84] Produced by the California Coastal Commission it is an advertisement for the annual coastal clean-up day, part of a state-led public education program mandated to "engage the public in protection and restoration activities" (CCC 2012).[85] Framed by the worn edges of a well-thumbed trading card, the Cig Egret is presented as a distinct species, part of a series that includes the company of Spork Crab and Cola Bass. Titled "Non-native species of the California Coast," the posters attempt to

[84] Despite appearing as paper, cigarette filter contain thousands of synthetic fibers that do not biodegrade. By number of individual pieces, they are one of the most common items found during beach cleanups (Ocean Conservancy 2014b).

[85] With direct ties to the international coastal cleanup organized by the Ocean Conservancy, the California cleanup is part of one of the worlds largest volunteers events.

link the desire to collect with the imperative to cleanup.[86] Their power depends on public recognition that such plastic-crossed creatures are unnatural, an argument positioning bodily entanglements of plastic and animal life as a problem for which cleanup is the appropriate solution. To collect waste is to keep such illegitimate species from becoming reality.

Figure 5.5: The California Coastal Commission "Cig Egret" poster promotion coastal cleanup day in 2005.

In contrast to the shock tactic photographs of *dead* albatross chicks circulated elsewhere (images of decomposing bodies revealing piles of ingested plastic), the Cig Egret poster, described on the Coastal Commission website as 'surreal,' plays with the

[86] Not to mention the politics of being declared "non-native" by the Government of California.

possibility of equally disturbing ways to be *alive*. The concept of species is imbued with the irony of inanimate plastic waste coming to life, but at the same time implicated in the life and death politics of the work of conservation. Cig Egret acts as an anomalous animal 'other' defining what counts as acceptable through deviance from species as logical types and scientific categories.[87] The posters perform cultural work maintaining divides between nature and culture, making unacceptable possibilities public where scientific work tends maintain divides by dividing or hiding exceptional cases.

First appearing in 2005, the non-native species posters are part of a decade long series of campaigns that themselves mark a transition from animal to plastic kinds. The 2003-4 cleanup day campaign features stylized local (read native) animal species worthy of care, and free of trash: a cautious raccoon, skinny-legged avocet, bright red newt, and a snappy crab. In 2005 the crab has morphed into Spork Crab, and the avocet into the Cig Egret.[88] Modified in subsequent years, these suspect creatures lose their trading card frames. The images become sharper in resolution, more photographic in presentation, and decidedly less imaginary in effect. New to the parade of plastic species, are a bottle-headed 'poptopus' and the 'monarch wrapperfly', whose delicate wings are laced with ingredient lists and barcodes revealed only upon close inspection. The updated posters prominently display the numbers of the items in question collected at clean-ups to date: 5,066,669 cigarette butts, 1,102,042 bottle caps. By 2010 when another new poster series

[87] Harriet Ritvo (1997) chronicles how the treatment of 'monsters' and other deviant cases in classification becomes part of contests over what counts as 'normal,' or indeed, what gets counted at all. See also Star (1991).

[88] While all these objects contain synthetics of some sort (even the cola-bass aluminum can is lined with synthetic resin), waste in watersheds and on beaches is not yet visually synonymous with plastic in this set of posters.

makes its debut, coastal creatures are completely replaced by colorful photographs of artfully arranged plastic trash collected on Kehoe beach in Northern California. “Help Reduce Trash,” reads the text above a gathering of bottle cap and other materials separated by type, collections of actual plastic materials from a named shoreline. In the course of six years, the posters mark a transition from coastal animal species worthy of protection, through trash-animal entanglements, to sorted plastic ‘types’ that are themselves problematic. United by the messy logic of species and the necessity of cleanup that provides continuity with each new series, kinds of coastal wildlife become kinds of trash. Always a social product (if always also material), the very concept of species itself becomes ‘plastic’, ethical and emergent, rather than fixed and immutable (Rees 2010).

Plastic-species are not endemic to the posters of the Government of California. Moving from coastal encounters to the sea, a poster produced by the Catalan Water Agency in 2005, and widely circulated on the Internet more recently, also crosses kinds of life and kinds of waste. Stamped across the top of the page in bold black font, the title reads “The Most Dangerous Species of the Mediterranean.” The contrasting stark white background is host to a diverse array of colorful ocean creatures that upon closer inspection reveal themselves as a diverse array of trash posing in animal form. Plastic bottle-fish and cigarette sea stars take the place of the expected sharks and spiny fish. Each species is accompanied with brief fact-sheet of defining characteristics. “The plastic bottle,” reads one caption, “Origins: beaches, city streets and boats. Behavior: causes serious damage to marine flora and fauna. Average lifespan: 300-500 years.”

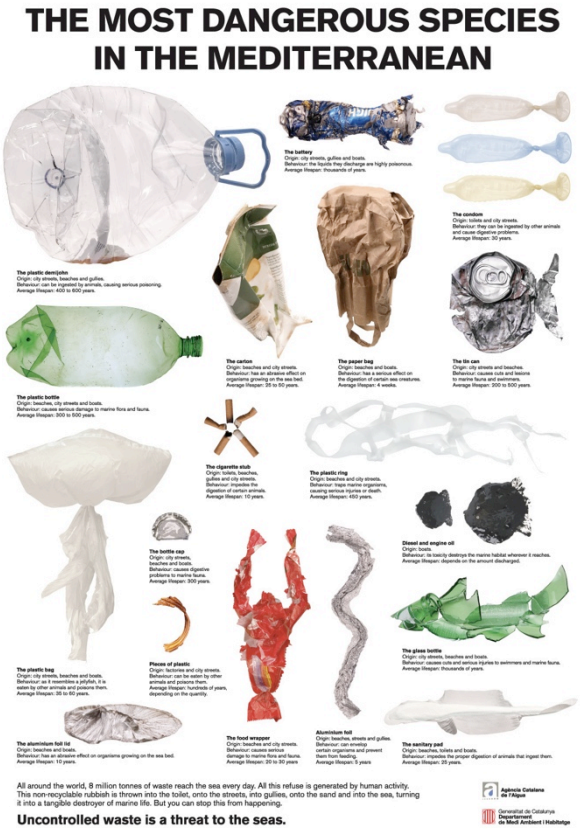

Figure 5.6: "The Most Dangerous Species in the Mediterranean" poster by the Catalan Water Agency.

Human origins and synthetic properties are slotted into animal categories. Spelling out the connections between bottles and condoms, lobsters and fish, the tagline reads "Uncontrolled waste is a threat to the seas." Roaming free, plastic is a danger to the wellbeing of the ocean. The poster suggests the possibility of not only undesirable plastic-life mixtures, but possibilities for new kinds of undesirable agencies.

Well-versed in STS traditions of distributing agency to any entity capable of making a difference, at first I happily read the poster as awarding agency to nonhuman things. It does, after all, draw a parallel between animal and plastic capacities for performing dangerous acts. Imagining plastic-monster fish that swim around when we are

not looking seemed like a productive way to remember the unintended consequences of synthetics, that they too have 'lives,' and are active participants in the shaping of seascapes. Upon further consideration, however, I realized that poster's powers are also grounded in the impossibility of just that: waste is not and should not be equated with wild creatures. Plastic trash might be bad for the environment, but it cannot sting like a jellyfish, or bite like a shark. These are species that (we) should not meet. The poster relies on and produces audiences that know that types of waste do not count as species; an audience that invested in demonstrating this understanding by adding scare quotes around "species" in the title of reposts.

The animal agency of plastic is explored more elaborately in *The Majestic Plastic Bag,* a 2010 'mockumentary' produced by Los Angeles-based Heal the Bay, a non-profit advocacy group dedicated to the protection of marine ecosystems. In this case, the organization specifically supported bill AB 298 prohibiting the distribution of single use bags statewide (which failed to pass in 2012). A clever parody of wildlife documentaries, the film traces the migration of a humble disposable white t-shirt bag also known as the common grocery bag. Starting its life in a grocery store parking lot (store name obscured but still obvious behind a carefully placed tree), the bag is born on the ground but soon takes flight, learning to ride the wind. Narrowly escaping death in an urban park to join the inevitable path of water toward the sea, the bag displays the (un)expected characteristics of natural species as it flies, floats and swims toward its destiny: the garbage patch in the middle of the Pacific Ocean. Delivered with the deadpan third person narration of Jeremy Irons (the bag moves, but does not speak), and reinforced with

a dramatic score, the film displays an impressive command of wildlife program tropes with Nature Channel accuracy.[89]

If presenting the bag in this way awards it a kind of life, it is intentionally undermined by parody that relies on the very impossibility of just that. This is evident in the contradictions of a "plastic cycle of life," in the jarring dissonance of "billions of other plastic species," as the video plays with the gap between natural and artificial, animate and inanimate kinds. The "helpless plastic" persists despite the dangers of park services that clean up, branches that snag and sea life that consumes plastic. But inverted by mockumentary form (the inclusion of fearsome teacup yorkie as predator serving as reminder of the obvious), plastic species become the true danger. With the cultural impossibility of plastic bags being natural species, it is humans, and not plastic, that have the power to control the bag's destiny (in this case by voting). Heal the Bay reminds the public that "the plastic bag is not indigenous to the Pacific," again calling up the power of the invasive. In the end, the bag is as artificial as the landscapes it traverses: the asphalt jungle, manicured parks, and cement rivers of Los Angeles. The "thriving community" in the middle of the ocean is one that should not thrive. In each of these three cases the boundaries distinguishing life and not life are again broken down only to be reconstituted in ways meant to motivate particular forms of responsibility. As with the scientific studies, the public images at once connect and separate kinds of waste and kind of life.

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[89] For a detailed account of the rise of the wildlife documentary genre see Cynthia Chris's *Watching Wildlife* (2006).

The Matter of Belonging

The assumptions about belonging that are at times only implicit in scientific practices – the ties between plastic and invasive species; the dismissal of plastic-jellyfish; the references to organic matter as 'real' – become explicit with the posters: danger lurks where plastic invades the spaces and species of natural life, spawning creatures that do not fit with existing categories and kinds. These cautionary creatures, hovering at the edges of emergence, are what Michelle Murphy calls "anticipatory objects," as they are shaped by the "not-yet of the future" (Dalhberg et al. 2013). This particular articulation of 'danger' marks a significant shift in the cultural history of plastic. According to Jeffrey Meikle, as plastic proliferated mid 20th century, so did worries of plastic invading *social* life. Touted as overcoming the limitations of traditional materials, synthetic plastic was understood as a complete break between the social and natural worlds. The danger lay not in entanglement with nature-creatures, but in threatening to "liberate the human race from the millennia of its biological past" (Meikle 1997: 245).

Now scientists and activists struggle to liberate the biological from the human, the animal from the plastic. If plastic is given a life or the lively characteristics of animal-creatures, it is to make the point that plastic is not natural. Plastic that acts independently of humans, especially that which gets mixed up with life, is plastic not only out of place, but out of control. Restoring order requires diligent efforts to keep kinds of life matter and plastic matter in their respective places. Where scientific work poked and pried mixed samples into separate containers, the posters and mockumentary poke and pry apart entanglements with irony, humor and common understandings of lively material boundaries. Exercises in purification are not, of course, simply for the sake of

maintaining categories (although after prolonged periods of meticulous sorting in the lab it certainly begins to feel this way). For scientists and policy makers, ordering and counting plastic is a way of monitoring threats to ocean resources – to marine life, fisheries, and navigation – where measuring and establishing change over time becomes a kind of management in itself. Maintaining rigorous categories is especially critical for Algalita, as a non-profit particularly invested in establishing their research as sound and legitimate science.[90] For the plastics industry and entrepreneurs, gathering plastics is a way to profit from untapped resources, recycling ocean plastics into new (and often rather greenwashed) products. For others still, separating out plastics is a way of resolving the aesthetic dissonance of synthetics scattered across natural spaces, of caring for environments and the health of humans and other creatures.

The separations performed by the images are no less material than the manipulation of scientific samples. Very practical concerns about nature/culture divides surface when the imperative to purify, sort or cut, is materialized in (proposed) solutions: clean up – attempting to remove pieces of plastic from the sea – is the responsible action promoted by the posters, and the dominant response to plastic pollution in the ocean from the public more generally. At the April 2013 Earth Day beach cleanup on Oahu, for example, volunteers sorted waste that had been collected from the Pacific. Selected pieces deemed relatively free of 'biofouling,' free of "life" pollution, are destined for the method soap company, where they will be magically transformed into brand new 'ocean plastic' bottles (the fine print clarifies that only 10% is post-consumer waste; even less is

[90] In interviews, university-based marine debris researchers variously described Algalita's work as "citizen science" or even as "not science," though most continue to make use of Algalita data and cite Algalita publications.

from the ocean). Here entangled traces of plastic life are reduced to rows of molded bumps suggesting sea urchin spines.

Figure 5.7: Method 'Ocean Plastic' soap bottle (fine print clarifies only 10% ocean and post-consumer recycled materials). Photo by the author.

For those doing research at sea, there is an unwritten rule that if you touch plastic waste then you are then responsible for removing it from the ocean. Leaving or returning plastic is tantamount to polluting. Swimming in the Pacific mid voyage in July 2011, a crewmember came across a blue plastic crate. Though the crate may once of held bottles of some sort, it is now coated in a fine layer algae and home to school of fish; an exciting find after days of netting scatterings of unrecognizable confetti-sized plastic bits. But as I watch my colleagues remove the crate from the water I cannot help but think of how to also care for the aptly named convict surgeonfish, newly liberated from plastic. Floundering about the boat deck, they are soon to be returned to the sea where they 'belong' but do not belong. Without their plastic shelter, the coastal reef fish now exposed in the open ocean will soon fall prey to other creatures.

Figure 5.8 Dale Selvam with the crate of coastal reef fish in North Pacific Ocean. Photo courtesy of the Algalita Marine Research Institute.

This one small act of cleaning up is rife with assumptions of belonging, of bad plastic, of responsibility for human products, assumptions that ignore the communities that live on and with gyre plastic. In materializing nature/culture categories through practices of separation, they also constitute kinds of ontologically distinct matter that are already tied to assumptions about what belongs in the sea. Plastic in the ocean becomes pollution; organisms that travel on plastic potentially become invasive; and plastic-creatures become transgressions of the very categories of material existence that do not belong anywhere. Distinguishing between these kinds of materials becomes the basis for awarding the status of belonging and even of living. Despite attempts to bring all kinds of actors into the account, though the very existence of these fish mid-ocean only makes sense in relationship to plastic migrations, the crate must either be left in or removed from the sea.

Plastic species exceed classification. When scientist, educators and activists use the categories of nature and culture as grounds for knowledge and action, they underestimate the liveliness of matter: the capacity of plastic to circulate in ways unintended by humans and to form associations with all kinds of life. At the same time, humans are doing much more than making plastic and disposing of it carelessly. The relationships between plastic and life are transformed by the very practices of knowing them, merged in the sample nets, in the images, in the new plastic bottles of processes that are supposed to maintain separation. To use nature/culture divisions for the production and sharing of knowledge about plastic pollution, is to base forms of belonging on the same divisions that preclude – while at the same time facilitating – the very becomings that constitute the plastisphere in the first place.

A version of Chapter 5 is under review as part of a special issue on "Indeterminate Bodies" at *Body and Society,* and may appear in late 2015.

Conclusion

In this dissertation I aimed to describe how a garbage patch of floating plastic becomes a matter of concern, both a measurable object of science and a problem emblematic of global challenges for humans and oceans alike. I have argued that the garbage patch emerges with forms of care, with materials and meanings already entangled in the practices and processes of making and sharing knowledge. By following gyre plastic in its many circulations – with ocean currents around the North Pacific, as the stuff of headlines, through laboratories and models; in its capacity to gather diverse actors to the middle of the ocean, to demonstrate the 'reality' of a global problem and to foster lively aquatic communities – I showed how the garbage patch comes to matter in its many associations, and with assumptions about what to do already attached.

A major challenge, in approaching a material problem as a communication and science studies scholar, was accounting for the multiple forms of the garbage patch without losing track of actual plastic in the ocean. Throughout my fieldwork, and in writing each chapter, I endeavored to hold plastic close, resisting slippage from a material problem of plastic in the ocean to a problem of ideas in the realm of representation alone. I showed how even the most mythical representations of trash islands are connected to interactions with synthetic materials, and how knowledge is made and shared in circulations of physical samples. Examining encounters at the intersections of material circulations rather than as contests of fact or interests alone helped keep focus on the enduring material problem as it traveled from oceans to publics and back again.

I began by diverting attention from the 'discovery' of an already existing object by considering the many contingent, and above all – material – encounters that lead to

marine debris science and the understanding the plastic can travel ocean currents without humans transforming and transformed in the process. In Chapter 2, I further elaborate a framework of encounters – dismissive, corrective, and constructive – as they help elucidate the interconnections of gyre plastic, material forms and solutions in the presence/absence of a trash island. Even 'mythical' media representations of a trash island are grounded in physical plastic pieces. Chapters 3 and 4 begin to put this framework into practice in making sense of participant observation, while shifting emphasis toward movement and entanglement. The expedition team heads across the sea to witness the correct form of the problem, chasing meteorological, material and metaphorical moving targets. Trajectories set in motion at sea continue toward data and demonstration, but without resolving into a single version of the problem.

Together, these diverse interactions with plastic at sea, in labs and on beaches, with the myth of the trash island, with the ocean more generally, are all part of what I call "constitutive encounters," moments of intersection and divergence in the making and unmaking of the garbage patch as global environmental problem in its multiple forms. Circulation becomes both method and site for studying dynamic problems that challenge both geopolitical boundaries and traditional top down and bottom up approaches in the social sciences. Though I did much of my fieldwork with a nonprofit, I intentionally avoided taking social movements (the dominant approach to environment in STS) as my starting point. I wanted to understand the many kinds of movements that connect global environmental problems to cultures of consumption and waste.

In following plastic materials, my account of knowledge production also emphasizes material power and resistance. This project began with a proposal concerned

with material agency, with plastic that escaped from attempts to control and manage it, traveling without humans to distant ocean environments. The dissertation ends, however, in tangled relationships of responsibility and belonging. I do tell a story about unruly materials: plastic pieces caused all kinds of trouble, hiding, breaking, floating, and blowing away from the people and instruments designed to coax them into nets, bottles, data and models. Though I tried to hold plastic close, it kept coming up missing: in tallies on my data sheets that did not match the pieces in vials; in the persistence of an island no one can find; in global calculations that do not match what is samples at sea. As theories awarding agency to nonhumans have become increasingly mainstream over the course of the project, it is imperative to think in practical terms about where they can lead. What, as I am often asked, is to be gained from all this writing about the lives and liveliness of plastic things? As partial response, in Chapter 5, I push questions of material agency and relational ontology out of the laboratory and toward questions of responsibility for plastic-species. In the next section I briefly reconsider relationships between garbage patch science and activism. I then outline two directions for further research and, as means of conclusion, return to the associations of the plastisphere, suggesting how we might live responsibly with plastic.

Science, Activism, and Matters of Care

This past summer, Captain Charles Moore marked the 15-year anniversary of his first research trip through the garbage patch, leading a team on the *Alguita* on a six-week visit to the gyre. After returning from what was his tenth voyage through the accumulation zone, Moore is still speaking of a garbage patch, of the ratio of plastic to

life, and even, of solid islands. Moore described his latest plastic encounters in an opinion piece published in the *New York Times*:

> Plastics of every description, from toothbrushes to tires to unidentifiable fragments too numerous to count floated past our marine research vessel Alguita for hundreds of miles without end. We even came upon a floating island bolstered by dozens of plastic buoys used in oyster aquaculture that had solid areas you could walk on. (Moore 2014)

I can imagine marine scientists reacting to his words, eyes rolling, sighing to themselves, "Oh, not again. Why won't the solid island go away?" I can hear them telling me, "See, I *told* you Algalita was the source of all those misconceptions." After several years making my own laps of the North Pacific, here is what I have to say in return.

It is tempting to pit scientists against activists, and at times I use these same division as a rhetorical device marking the extremes of variations in modes of knowing, sharing and caring for gyre plastic. On a continuum from strictest scientific accuracy to fundamental desire for change at any cost, however, I would locate Algalita the organization on the science-leaning side of center.[91] Instead of calling out Moore, who has undoubtedly been instrumental in bringing attention to ocean plastic pollution (and who very likely did encounter some kind of floating configuration it was possible to stand on), I would like to again draw attention to the similarities between Algalita and the academic-based scientific community. First, every single person I worked with or interviewed recognized the implications of the 'garbage patch' term and 'trash island'

[91] I would also like to clarify, that Moore alone is not Algalita. There has been increasing distance between the founder and the organization in recent years. Others at Algalita continue to describe ocean plastic pollution in rather different terms. On numerous occasions, I overheard the education coordinator explain of the garbage patch: "Its not a real place, it's an accumulation area," or watched as the office or laboratory team themselves cringed at news reports.

forms. The solutions that seemed to follow were also understood as problematic, recycling technologies and cleanup strategies that were limited at best. Algalita too sees value in 'good science,' takes pride in the legitimacy of their facts, strives toward accuracy in scientific terms, though the capacity to follow through can be limited by facilities and training. Second, *both* science and activism have forms of care already built in to their practices. Scientific models of plastic circulation and distribution come from a history of 'managing' oceans through measurement, of prioritizing environmental problems and research in the very same economic terms that cause problems in the first place.[92] Calls for further research, and the vulnerability of the scientific method in court can be equally troubling.[93] Meanings and solutions are not only in the 'interpretation' that follows as results are discussed and disseminated, but built into ways of knowing and the very things that become 'known.'

More specifically, to all those who see themselves as scientists, I wish to impart the sense that communicating the 'truth' may not look like a strict vision of accuracy, especially if the 'truth' is that people *should* care about gyre plastic or about the ocean. And to those engaged in activism, the reminder that the form of the problem does matter, at the very least, in the forms of care that come with it. If you speak of islands people can stand on, do not act surprised when architects draw up plans for their development. At the same time, I encourage everyone to embrace 'things-in-relationships,' not facts about

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[92] At the same time that Moore speaks of islands he insists on the impossibility of cleaning up the garbage patch, pointing instead to problems of capitalism: "in the end, the real challenge is to combat an economic model that thrives on wasteful products and packaging." Moore's critiques of capitalism, at odds with others' pragmatic optimism, were often a source of unease (especially when he was speaking at youth events).

[93] See Oreskes and Conway 2011.

objects. Algalita education samples may not be scooped directly from the sea, but then neither are scientific 'facts.' Both need to be explained in and as process. Algalita and Scripps offer programs that head in this direction (school visits, hands-on laboratory experience, blogs about research in action). These are possible starting point, but need to be followed through from data to policies, from laboratories to broader publics, not only as matters of fact, but as matters of concern and care.

For Further Research

As I continue with this project, there are two sets of circulations I will pursue further: first, the flows of debris associated with the March 2011 Japan tsunami. Though I conducted research in Japan, Hawaii and Oregon directly specifically at understanding how tsunami debris refigured questions about plastic pollution in the Pacific, I do not thoroughly integrate it in this dissertation. The data I collected far exceeded the space I had for it here, and I very much desire to address the tsunami with due respect. As I continue to work through my data, I will pay particular attention to how questions of origins and responsibility are refigured by the tsunami. Where the vast majority of garbage patch plastics are anonymous pieces in international waters, tsunami debris has a known place and date of origin, and represents new opportunities for marine debris science. It also presented new challenges; commonly described as 'displaced items' rather than 'waste', tsunami debris is arguably more strongly connected to lost lives, than careless disposal.

The Western Garbage Patch and Tsunami Debris Expeditions that Algalita planned and led during my fieldwork in Long Beach, were, like other expeditions meant

help corroborate these models with observations at sea and careful measurement of representative samples of the ocean surface, using the same methods they have developed for the study of plastic pollution. At the same time, Algalita had to carefully negotiate scientific opportunity and media attention while dodging possible accusations of disaster tourism, as seats on the expedition were offered to those who could pay. I also began to notice more general concerns about the conflation of the Great Pacific Garbage Patch with tsunami debris and vice versa. As I continued my fieldwork in Hawaii, Oregon and Japan, I spoke with beach cleanup coordinators who reported that volunteers where now assuming that anything that looked "Asian," was Japanese.[94] The arrival of material objects on the west coast – a buoy, a boat, a motorcycle – were fraught with fears of waste arriving en masse prefigured by historical tensions across the Pacific. NOAA, however, responded with incredible caution, reluctant to declaring any specific object tsunami debris: only thirty-four 'official' objects as of spring 2013. I would like to more systematically consider how the tsunami has changed research and education about plastic pollution, and how Algalita's research is based on and comes to shape assumptions about relationships between waste, ocean currents and people on both sides of the Pacific.

A second path for further investigation revolves around changing relationships with plastic on land, both before and after my fieldwork. How does the garbage patch continue or break from longer histories of environmental and plastic concerns? During the course of my fieldwork, plastic bag, bottle and most recently, micro-bead bans (the

[94] Including things like bottle caps with Korean characters, but in an especially memorable example, a piece of root that looked like 'ginger' (which, being commonly served with sushi means it must be Japanese).

tiny plastic 'scrubber' bits in body wash that wash down drains) have proliferated. Though I follow gyre plastic from sea through laboratory toward published 'facts' and reasonable solutions, this does not tell us whether and how marine debris science or garbage patch awareness are part of specific policy decisions and other changes. Though powerful corporations make appearances here and there, they are most often relegated to footnotes.[95] In doing so, I would attend more explicitly to the processes and contradictions of consumer culture and capitalism, the relationships between material politics and moral economies of waste.

How to Live Responsibly With Plastic

Ocean plastic pollution is far more than unsightly litter, a sign of careless consumer excess. Those who care for it do more than produce and share knowledge about its effects, or put matter back in its place. I would like to end by contending that our many associations with synthetics constitute a plastic culture. We are *all* living in the plastisphere. These entanglements, familiar and strange, are not ones that we can simply undo with our science or with our cleanups, with tiny forceps or litter lifter tongs. The persistence of plastic shows the need for acting as if humans are and will always be connected to the ocean, whether through the materials we produce or the actions we take in seeking to know and control them. I am not suggesting that plastic in the ocean is

[95] Two more incidents from my fieldwork are worth mentioning here: First, a Coca-Cola representative was present at the Vancouver press release at the end of the expedition, keeping tabs on where the plastic activist community might be headed. And second, a case where the maker of Chico reusable bags (who dresses as a 'bag monster' to fight plastic pollution) was taken to court by the disposable plastic bag industry for allegedly tarnishing their product's good name.

good. I am calling for the rethinking of how plastic pollution comes to be understood as bad, and offer some possibilities for reconsidering both the role of plastic and the role of humans in these ocean entanglements.

Plastic is not solid waste

Plastic waste matters when and because it moves. The garbage patch is made of materials in motion, circulating as waste, samples, knowledge, all made problematic because plastic does not sit still. Just as waste is corralled into data points, plotted on maps, displayed for the public, it keeps changing form in the lab and as it continues to flows in, out and around the ocean. Plastic materials are themselves flows, enduring as constantly changing conglomerations of chemicals (and of humans, animals, others) that stand in contrast to bounded, solid objects. A common trope in public presentations about plastic pollution is to emphasize how plastic's prodigious and gratuitous endurance: it is "made to last forever, designed to throw away" (5 Gyres 2014). This results in tension between establishing a garbage patch as a measured place where plastic pollution accumulates unchanged (facts about density and distribution) and communicating processes of waste flows and knowledge production (messy circulations). Instead of continuing to frame plastic in terms of objects that need to be placed in the right bin, I suggest instead embracing plastic in its multiple flows. This may include, as a group recently called for in *Science,* officially declaring plastics hazardous substances (Rochman et al. 2013).

Plastic evades control

Yet the namesake malleability of plastic is commonly understood according to human terms at the moment of production. Garbage patch materials simply need to be brought back under human control and regimes of value, through cleanup, recycling, development, new technologies. These strategies are all after-the-entanglement attempts to put matter back in its assumed place. As I argued in Chapter 5, practices based on separation and belonging in nature/culture terms, cannot accommodate the complexity of plastic-species – including plastic-human – relationships. Plastic exceeds classification, models, measurement, organic decomposition. It will always do things that humans cannot control: getting into oceans, bodies, escaping from our best plans to recycle or bury it. The movements of plastic are not only unintentional, they stray from human paths just as they connect humans to oceans. I propose instead beginning with the assumption that plastic is lively and already entangled, that it will circulate and get caught up with life; plastic vital to everyday human life also becomes vital to and with other forms of life regardless of human desires. To justify production or use based on assumptions of best-case scenarios is to underestimate plastic's own powers.

Plastic deserves more power, not less

Plastic is political because it has agential power, transforming its surroundings as the material moves and changes. As is becomes a concern, there are increasingly calls to address it as a single material in terms of absolutes. New products that are "BPA-free,"

calls to "ban the bag," policies for "zero waste," and even attempts to live "plastic free."[96] Responsibility cannot come from unbendable rules or a single vision of the problem, but from constantly engaging with – and *responding* to – messy worlds (Haraway 2008). We need to think more of rather than less of plastic; deal with not demonize; approach as powerful, not just bad. To proceed responsibly through complicated worlds where facts and materials are constantly in motion and solutions cannot always be mapped in advance. It is by embracing rather than warning against or trying to undo knots already tangled, that synthetic materials can be understood to have lives in relationships we cannot sever because were are part of them. But entanglements are only the beginning. Relationships are places to start asking new questions, not explanations or answers in and of themselves. Just as we need to make more of plastic – as fluid, lively, powerful – we also, quite simply, need to make less of it.

[96] On September 30, 2014, California signed the first state-wide ban on disposable plastic bags (Steinmetz 2014).

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