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REDEFINING POLLUTION:  
PLASTICS IN THE WILD

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## PREFACE

Before “Redefining Pollution: The Case of Plastics” there was “Genealogies of Garbage: Historical Paradigms of Garbage and their Impact on Trash.” My original proposed dissertation was about how activists and technocrats accomplished the “impossible” task of cleaning up a stinky, swampy, trashy nineteenth century New York City by inventing city-wide curbside trash pick up and snow removal. Popular wisdom held that New York was inherently filthy and therefore unable to have clear, clean streets, yet it was the first American city to boast universal municipal solid waste removal. My aim was to compare this feat to current “insurmountable” waste problems facing the twenty-first century such as nuclear waste and plastics recycling. While I was considering different present-day case studies, someone asked if I would write about the Great Pacific Garbage Patch. I said no. It was too hard. It really *was* impossible; nothing could be done about the soup of plastics that were part of ocean ecosystems, since they were both permanent and dispersed in such a way they could not be cleaned up. I soon realized this impossibility is exactly why I should focus on ocean plastics. Plastic pollution is now the sole case study in my dissertation because it is an impossible problem. That is, it cannot be solved through the methods we have used to tackle pollution before, and it cannot be solved if we continue business-as-usual.

This dissertation was written through a dedication to environmental activism. It is thus normative in nature, though not always explicitly so. The overall project has been to create a theory of action based on data and research so that the problems of plastic

pollution can be described as thoroughly as possible in all their controversy and complexity, and so solutions to mitigate its effects can be as well matched to the problems as possible. While a dissertation is written for a small academic audience, I have drawn on this work to conduct workshops, create and teach a course in environmental communication, and to start conversations in the activist and environmental worlds outside of academia. This work is a start towards a manuscript that I hope will be useful to activists, scientists, and concerned citizens dedicated to solving impossible problems.

## I. INTRODUCTION

In 2001, plastic outweighed plankton in the Pacific Ocean by six to one.<sup>1</sup> Some Greenland Natives have so many industrial chemicals in their bodies, including those used in plastics, they can be classified as toxic waste when they die.<sup>2</sup> They must decide if they will breast feed and transfer their toxic burdens to their babies. Today, plastics are in every body of water and in every human body, with complex and largely uncharted effects. Ocean plastics and body burdens are the twin manifestations of plastic pollution. They are unique not only because of their ubiquity and persistence, but also because most efforts to solve or mitigate their effects are failing. Typical proposed solutions include beach clean ups, plastic bag bans or switching to BPA-free bottles. Yet if every beach were cleaned, all plastics recycled, and all demonstrably harmful chemicals banned, ocean and bodily plastic pollution would not disappear. If plastics are diluted, metabolized, or contained, the hallmarks of pollution control, they still pollute. Efforts to control plastic pollution are failing because plastic pollution exceeds regulatory definitions of pollution.

Moreover, we have little idea of how plastics and their chemicals, called plasticizers, behave outside of laboratories and consumer goods, in the wild. Biologists and chemists in subfields as diverse as toxicology, epidemiology, endocrinology, and oceanography,

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<sup>1</sup> Moore, C., S. L. Moore, et al. (2001). "A Comparison of Plastic and Plankton in the North Pacific Central Gyre." *Marine Pollution Bulletin* 42(12): 1297-1300.

<sup>2</sup> Cone, M. (2005). *Silent Snow: The Slow Poisoning of the Arctic*. New York, Grove Press: 32.

face a similar methodological problem. Characteristics of traditional scientific knowledge production about modes of action and harm such as causality (this *caused* that), certainty (this *clearly* caused that), and specificity (*this* definitely caused *that*) are challenged by plastic pollution. For example, in toxicology, basic tenets used for thousands of years, such as the linear relationship between dose and response (“the danger is in the dose!”), do not hold for plastics and plasticizers. Usual measurements of toxicity, the ability to track contaminants, and predictive models for long-term effects are also failing. It is not only pollution control that is failing in the face of plastics in the wild, but also methods for tracking, analyzing, and understanding plastics.

With the failure of traditional forms of pollution control and knowledge, different stakeholders, from industry lobbyists to breast cancer activists, argue for different definitions of and precautions against plastic pollution. Some consumer movements ask for the complete eradication of plasticizers from their bodies, an impossible request to accommodate; even DDT, banned in most developed countries in the 1970s, is still found in breast milk today.<sup>3</sup> Government policies and regulations are failing to protect consumers, but without a new framework with which to evaluate this new aberrant pollutant, state agencies continue to allow plastics and plasticizers to enter our bodies. Thus, plastic pollution is not merely a technical problem of wayward pollutants, but is also an epistemological problem for the science upon which policy and advocacy depend. I hypothesize that describing the points that make plastic pollution such an

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<sup>3</sup> NRDC. (2005). "Chemicals: DDT." Healthy Milk, Healthy Baby, Chemical Pollution and Mother's Milk. Retrieved 9/7/12, from <http://www.nrdc.org/breastmilk/ddt.asp>.

“impossible” problem will simultaneously describe what new definitions of pollution have to take into account, and where “business as usual” has to change to make plastic pollution mitigation viable.

### Environmental Problems Are Wicked Problems

In 1973, Horst Rittel and Melvin Webber, two urban planners, wrote about a shift in urban planning from an ethos of efficiency to one that recognizes the complexity of problems that arise from open systems, particularly when these systems are both material and social in nature:

By now we are all beginning to realize that one of the most intractable problems is that of defining problems (of knowing what distinguishes an observed condition from a desired condition) and of locating problems (finding where in the complex causal networks the trouble really lies). In turn, and equally intractable, is the problem of identifying the actions that might effectively narrow the gap between what-is and what-ought-to-be.<sup>4</sup>

Because open systems are made of and are part of other open systems, defining, locating, and intervening in a problem is not only difficult, but also impossible to do with complete acuity. Examples include inner city poverty, the obesity crisis, and plastic pollution. Each problem is symptomatic of and constitutes other problems. Thus, efforts to solve them are likely to lead to other problems, or at least affect other parts of related systems in unanticipated ways.

Rittel and Webber call these wicked problems: “ We use the term ‘wicked’ in a meaning

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<sup>4</sup> Rittel, H. W. J. and M. M. Webber (1973). "Dilemmas in a General Theory of Planning." *Policy Sciences* 4: 159.

akin to that of 'malignant' (in contrast to "benign") or 'vicious' (like a circle) or 'tricky' (like a leprechaun) or 'aggressive' (like a lion, in contrast to the docility of a lamb)."<sup>5</sup>

There is no way to draw a boundary around the edges of a wicked problem where the effects and causes of the problem, and the influence of proposed solutions, stops.

Contradictory, shifting, complex, and ever-expanding circumstances in wicked problems often exceed both current knowledge and consensus, particularly because a "plurality of objectives [are] held by pluralities of politics" by different stakeholders, each with a different set of knowledges, standards, needs, and desires.<sup>6</sup> The information needed to describe and solve a wicked problem is not available in advance because each wicked problem is essentially unique in its complexity and so has never been solved before.

Rittel and Webber maintain that urban planning and social problems are inherently wicked, while scientific and technological problems are "tame." Yet case studies in science and technology studies show that scientific problems, far from being tame, have a brand of wickedness that adds questions of evidence, expertise, and knowledge production to issues of materiality, infrastructure, culture, and societal norms.

Environmental problems are inherently wicked because of the collision and collusion of science, policy, public and industry stakeholders, and the fact that many twenty first century environmental issues are both relatively novel and occurring on unprecedented global scales. Additionally, ecosystems are already systems within systems with complex and irreducible sets of internal influences. Defining an environmental problem becomes

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<sup>5</sup> Rittel 1973: 160.

<sup>6</sup> Rittel 1973: 160.



a substantial hurdle to intervening to solve or mitigate it, and this difficulty is characteristic of environmentalism.

Strictly speaking, “plastic pollution” is not a problem. It is a phenomenon, but it is not a problem, as it does not “distinguish an observed condition from a desired condition.”<sup>7</sup> In some cases, plastic pollution advocates call for a “desired condition” of plastic-free landscapes or bodies. This is materially impossible. Plastics are everywhere and they are permanent—this does not mean that a plastic-free body is not a legitimate desired condition, but that it is not materially feasible. Defining a feasible versus a desired condition constitutes its own set of problems. Yet, even when a feasible condition is proposed—for example, a less uneven distribution of harm for women, children, fetuses, and northern populations—it is hard to know where to intervene. If plastic pollution is ubiquitous and its chemicals are able to travel long distances, how do we reduce harms to certain populations? Defining plastic pollution in terms of social justice based on an unequal distribution of harm is just one way to look at the effects of plastics on human and ecological health. There are countless other ways of defining the problem and desired conditions. This is true of most, if not all, environmental issues in the twenty-first century.

Finally, Rittel and Weber make a normative claim about wicked problems that also holds for environmental problems: “you may agree that it becomes morally objectionable for the planner to treat a wicked problem as though it were a tame one, or to tame a

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<sup>7</sup> Rittel 1973: 159.

wicked problem prematurely, or to refuse to recognize the inherent wickedness of social problems.”<sup>8</sup> Here, they imply an ethics of defining wicked problems. Such problems, characterized by complexity and open systems made up of material and social elements, must be recognized as such, and this recognition must be carried into efforts to define them. Thus, defining a problem and deciding where to draw boundaries concerning what is and is not part of the problem have effects in the world outside of the planning room, regardless of proposed solutions. Because of these effects, being in a position to define problems one way and not another is a form of power. Thus, contests of definition are always already also contests of power and politics. For example, at the Fifth International Marine Debris Conference in Honolulu, Hawai’i, conference organizers constantly referred to ocean plastics as “marine debris,” including plastics in the category historically reserved for driftwood, sea beans, and other naturally occurring floaters. Yet many conference attendees railed against the term “marine debris,” insisting that “[i]f 60-90% of the marine debris that we are finding in the Ocean is Plastic [sic], then let's call it what it is: Plastic Pollution.”<sup>9</sup>

### The Work of Definition

Definition plays a major role in environmental change. How a problem is defined simultaneously defines solutions to that problem, and controversies over ecological

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<sup>8</sup> Rittel 1973: 161.

<sup>9</sup> Russo, D. (2011). "Plastic Pollution, not Marine Debris!" Retrieved 9/25/12, from <http://plasticpollutioncoalition.org/2011/03/plastic-pollution-not-marine-debris/>. Cohen, D. (2011). "Marine Debris is a misnomer. It is Plastic Pollution." TED Conversations. Retrieved 9/25/12, from [http://www.ted.com/conversations/1807/marine\\_debris\\_is\\_a\\_misnomer\\_i.html](http://www.ted.com/conversations/1807/marine_debris_is_a_misnomer_i.html).

problems pivot on contests of definition by different stakeholders, which flesh out a problem in all its wickedness and complexity. Because plastic pollution is a relatively new, emerging phenomenon, its definition is hardly settled. Using Rittel and Webber's statement that wicked problems cannot be absolutely defined (in their words, "definitively described"), what results when scoping environmental problems is a competition to determine a dominant definition, which invariably will not capture all aspects of the problem. That is, no definition of an environmental problem will ever capture all aspects of the problem. What gets prioritized and what gets left out are the stakes of these competitions.

Though definitions of wicked phenomena are always already partial, they play a foundational role in the types of solutions that are deemed possible or impossible, feasible or infeasible, just or unjust. Definition is defined by the Oxford English

Dictionary as:

The setting of bounds or limits; limitation, restriction.

The action of defining, or stating exactly what a thing is, or what a word means.

A precise statement of the essential nature of a thing; a statement or form of words by which anything is defined.

The action of making definite; the condition of being made, or of being definite, in visual form or outline; distinctness; spec. the defining power of a lens or optical instrument, i.e. its capacity to render an object or image distinct to the eye.<sup>10</sup>

Definitions are not nouns. Definition is an action, a technique by which an object or class of objects comes into being. Definition work designates an "essence" by dividing one

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<sup>10</sup> (2012). "Definition". *Oxford Dictionaries*, Oxford University Press. Retrieved 9/7/12, from [www.oed.com](http://www.oed.com).

element from others and making that element a feature of priority. For plastic pollution, different stakeholders are working to prioritize characteristics that match their view of the world, their needs and desires. They are trying to essentialize plastics. Definition work, then, refers to any actions that attempt to distill something amorphous into something essential. It includes the act of setting boundaries, of categorizing, of making statements about the nature or essence of a thing, of distilling many attributes of a thing into its “essential” characteristics, and the action of bringing something to view, making it distinct from the background. Techniques of definition work can be rhetorical (making “a precise statement,” as in the example above of “marine debris” versus “plastic pollution”), they can include mediation through scientific or other tools (“the defining power of a lens”), and they can be organizational in nature (“setting of bounds”). Like wicked problems, definition work involves material, social, and political systems.

Definition work does not always come first, followed by a solution. Rather, diagnostic work itself is definitional, as it “discover[s a problem’s] hidden character, and then, having exposed its true nature, skillfully excise[s] its root causes.”<sup>11</sup> Both definitions and solutions are based on a sort of core essence of a phenomenon. But what if this essence is contested, or the phenomenon is new, or the methodologies for “uncovering” the “true nature” of something are not benign, but deeply politically and economically motivated? Each of these questions is pertinent to plastic pollution, which makes it an

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<sup>11</sup> Rittel 1973: 159.

ideal battleground on which to study techniques of definition and how they affect action.

In *Meeting the Universe Halfway*, physicist and STS scholar Karen Barad quotes Niels Bohr about the materiality of definition work in the laboratory: “given a particular measuring apparatus, certain properties [of the measured object] become determinate, while others are specifically excluded. Which properties become determinate is not governed by the desires or will of the experimenter but rather by the specificity of the experimental apparatus.”<sup>12</sup> Measurement is just one technique of definition, but the idea holds true for all methods that “uncover” phenomena. A central argument in Barad’s work is that any phenomenon includes the apparatuses used to investigate it. Her most striking example comes from quantum physics, where light behaves like a wave in one experimental set up, and like a particle in another. Neither is considered an error, and light is said to have “a wave-particle duality” based on these experimental designs. Different apparatuses result in different findings, and phenomena are always bound in an inalienable marriage with their techniques of definition, even if these techniques fall into the background of knowledge and are forgotten. In fact, the term phenomenon comes from the Greek word *phainomnenon*, the “thing appearing to view,” based on *phainen*, “to show.”<sup>13</sup> Phenomena are the direct result of definition work. Whenever I use the term “phenomenon,” I am using it in the same way Barad and

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<sup>12</sup> Barad, K. M. (2007). *Meeting the Universe Halfway: Quantum physics and the entanglement of matter and meaning*. Durham, Duke University Press: 19.

<sup>13</sup> (2011). "Phenomenon". *Oxford Dictionaries*, Oxford University Press. Retrieved 9/7/2011, from [www.oed.com](http://www.oed.com).

others in STS do, to signify both the observed event as well as the techniques of definition that brought the event into view to begin with.

The contingent nature of objects, phenomena, and knowledge about them is foundational to science and technology studies:<sup>14</sup>

STS takes a variety of antiessentialist positions with respect to science and technology. Neither science nor technology is a natural kind, having simple properties that define it once and for all. The sources of knowledge and artifacts are complex and various: there is no privileged scientific method that can translate nature into knowledge, and no technological method that can translate knowledge into artifacts.<sup>15</sup>

Science and technology studies hinges on questions that investigate the premises and underlying suppositions and processes that go into making something “natural” or “matter of fact.” Facts, theories, and findings do not become established because they are part of nature and are uncovered during the course of scientific and other investigative processes. Rather, in different contexts, with different apparatuses, social norms, and methodologies, different sorts of facts, theories, and findings result. This is not to say that each apparatus produces such different phenomena that one instance of “ocean plastics” in a beach survey is incompatible with another instance from a sea trawl. Annemarie Mol’s ethnography of atherosclerosis, a disease characterized by the hardening of the arteries, shows that “from one moment, place, apparatus, specialty, or treatment [in the hospital], to the next, a slightly different ‘atherosclerosis’ is being

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<sup>14</sup> The main finding in one of the most influential texts in STS: Latour, B. and S. Woolgar (1979). *Laboratory Life: The Social Construction of Scientific Facts*. Beverly Hills, Sage Publications.

<sup>15</sup> Sismondo, S. (2010). *An Introduction to Science and Technology Studies*. Chichester, West Sussex, U.K.; Malden, MA, Wiley-Blackwell: 11.

discussed, measured, observed, or stripped away.”<sup>16</sup> In the doctor’s room, atherosclerosis is pain experienced after walking twenty feet. In the pharmaceutical laboratory, it is the brittle substance seen on the edges of veins in a cadaver leg. In the operating room, it is the dark area on the x-ray. She calls this atherosclerosis’ “multiplicity” to describe a shimmering, shifting ontology that is recognized as something called atherosclerosis despite a range of techniques of definition. Atherosclerosis coheres despite its multiplicity, despite different and sometimes competing definitions, “as a more or less stable network of associations.”<sup>17</sup> The same is true of plastic pollution. Even in the example above, where conference organizers insisted on calling something “marine debris” while environmental and health advocates called the same thing “plastic pollution,” both groups were talking about plastics floating in the ocean.

Many STS scholars have worked to theorize and name multiplicities, the bundles of material-social entities that populate our world. As already mentioned, Karen Barad reappropriates the term “phenomena” to signify an experimental apparatus, including its observer, and what it shows. She also uses the term “entanglement,” sometimes as a verb to describe the materialization of facts, and sometimes as a noun to indicate “the primary ontological units” in the world—the world is populated with “entanglements”

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<sup>16</sup> Mol, A. (2002). *The Body Multiple: Ontology in Medical Practice*. Durham, Duke University Press: back cover.

<sup>17</sup> Law, J. and V. Singleton (2003) "Object Lessons." Centre for Science Studies, Lancaster University, Lancaster, UK: 3.

rather than “things.”<sup>18</sup> Likewise, Actor Network Theory (ANT) is premised not only on nodes that may be objects, people, or institutions, but also the relationships between them, making all phenomena and action inherently relational. John Law and Vicky Singleton call objects that are “energetic, transformative, and depend on difference” “fire objects.”<sup>19</sup> Donna Haraway uses “cyborgs” to challenge “natural” binaries like human-machine, female-male, and other opposition definitions.<sup>20</sup> The list of terms and metaphors is long. Unessentializing objects, categories, and definitions and, in the words of Rittel and Webber, opening them back up to the wickedness from which they came, is a central methodology in STS studies.

Some STS scholars also investigate the politics of definition work, where politics refers “in the broad sense [to] relations, assumptions, and contests pertaining to power.”<sup>21</sup> One of Geoffrey Bowker and Susan Leigh Star’s goals in *Sorting Things Out: Classification and its Consequences* is to uncover “the practical politics of classifying and standardizing.... There are two processes associated with these politics: arriving at categories and standards, and, along the way, deciding what will be visible or invisible within the system.... Whatever appears as universal or indeed standard, is the result of

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<sup>18</sup> Barad 2007: 141.

<sup>19</sup> Law 2003: 9.

<sup>20</sup> Haraway, D. J. (1994). “A manifesto for cyborgs: Science, technology, and socialist feminism in the 1980s.” *The Postmodern Turn: New Perspectives on Social Theory*. S. Seidman. Cambridge; New York, Cambridge University Press: 82-118.

<sup>21</sup> Appadurai, A. (1986). *The Social Life of Things: Commodities in Cultural Perspective*. Cambridge, Cambridge University Press: 57.



negotiations, organizational processes, and conflict.”<sup>22</sup> They pay particular attention to what is made invisible within systems, and the politics of those choices. Likewise, Donna Haraway uses the term “nature-culture” to call attention to, and then collapse, the assumed binary between nature and culture in the figure of the cyborg. In some of the earliest work in STS on the power relations inherent in creating and maintaining definitions, she argues that “the natural” has never existed as such, and is interested in “what’s at stake in maintaining the boundaries between what gets called nature and what gets called culture in our society.”<sup>23</sup>

In *Politics of Nature*, Bruno Latour differentiates between “matters of fact,” “the indisputable ingredients” of a well-defined phenomenon, and “matters of concern,” “an expression invented...to recall that ecological crises have no bearing on a type of being (for example, nature of ecosystems), but on the way all beings are manufactured: the unexpected consequences as well as the mode of production and the manufacturers remain tied to” the phenomenon under study.<sup>24</sup> Latour’s matters of concern are another name for socio-technical hybrids that STS holds is true of all scientific and “natural” objects. But more importantly, matters of concern also posit that processes of definition—“the way all beings are manufactured”—are foundational to environmental crises. That is, environmental crises are not given in advance, but made through

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<sup>22</sup> Bowker, G. C. and S. L. Star (1999). *Sorting Things Out: Classification and its Consequences*. Cambridge, Mass., MIT Press: 44.

<sup>23</sup> Haraway, D. J. and T. N. Goodeve (2000). *How Like a Leaf: An Interview with Thyrza Nichols Goodeve*. New York, Routledge: 50.

<sup>24</sup> Latour, B. (2004). *Politics of Nature: How to Bring the Sciences into Democracy*. Cambridge, Mass., Harvard University Press: 224.

definition. This is certainly the case with plastic pollution, where some stakeholders define plastics as benign materials that are only dangerous if misused by silly consumers, in which case there is no crisis, while other stakeholders argue that plastic chemicals are toxic, and since plasticizers are in every body, we are in the midst of a full-blown catastrophe.

### Controversy

When advocating for hybrid, entangled, fiery, multiple matters of fact, STS scholars create new labels based on new definitions of how things relate in the world. They define them as wicked problems, or wicked objects. Definitions are not inherently bad. We would not be able to think, communicate, or act without concepts with relatively stable boundaries. STS scholars, including myself, are not arguing for an abolition of all definition, but are drawing attention to the social process and power inherent in definitions, particularly if they have become dominant, naturalized, and unquestioned.

Controversy is often the result of a contest of definitions, where various parties have stakes in different essences, boundaries, categories, and their ramifications.

Controversy is one way to turn matters of fact into matters of concern, or, make the always already social and cultural nature of science and technology apparent. While they do not write explicitly about the role of definition in their work on controversy, Michel Callon, Pierre Lascoumes, and Yannick Barthe state that,

One of the central things at issue in these [environmental] controversies is precisely establishing a clear and widely accepted border between what is considered to be unquestionably technical and what is

recognized as unquestionably social. The line describing this border fluctuates throughout the controversy. To declare that an issue is technical is effectively to remove it from the influence of public debate; on the other hand, to recognize its social dimension restores its chance of being discussed in political arenas.<sup>25</sup>

Defining phenomena along social or technical lines is a pivotal part of controversy. Is plastic pollution a problem of overconsumption, and therefore social, placing solutions in the hands of consumers? This definition shifts the solution to behaviour change. Or is it a problem of synthetic polymers and plasticizers, making prevention and mitigation a technical, scientific question? This definition shifts the solution to a technological fix. Or do such questions neglect the wicked nature of disposable plastics? Are there other parties, systems and sources of harm that are not accounted for in these two definitions? Will either of the two proposed solutions cause harm or other unanticipated effects themselves? The ongoing investigations that controversies engender aim “less at establishing the truth of the facts than at making the situation intelligible.”<sup>26</sup> That is, controversies, via a contest of definitions, make the object or phenomena well rounded, less a matter of fact and more of a matter of concern by bringing its producers, funders, detractors, apparatuses, and potential consequences into the light, making the entire situation apparent in all its complexity.

Controversies have the tendency to reveal which parties are using which techniques of definition, and what interests they may have in those methods and definitions.

Definition work involves “the action of making definite” by naming the “essential nature

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<sup>25</sup> Callon, M., P. Lascoumes, et al. (2009). *Acting in an Uncertain World: An Essay on Technical Democracy*. Cambridge, Mass., MIT Press: 25.

<sup>26</sup> Callon 2009: 28.

of a thing.” According to Bruno Latour, “there are indeed essences, but these are obtained by institution[s] at the end of an explicit process that gives them durability and indisputability by attaching attributes to their substance.”<sup>27</sup> Essences are brought about by institutional processes, much like Barad’s phenomena are brought into view through apparatuses. Phenomena are indivisible from their apparatuses; essences are indivisible from their institutions. Most importantly, “essences” likely reproduce the values and interests of the institution that shape them. Thus, institutions and their power become one of the “open systems” that characterize wicked environmental problems.

As a process that brings potentially hidden players into the fray, Callon, Lascomes, and Barthe, as well as activist organizations from Occupy Wall Street to the Natural Resources Defense Council, believe that controversy is essential to democracy. In fact, the subtitle to Callon, Lascomes, and Barthe’s *Acting in an Uncertain World* is “an essay on technical democracy,” and the subtitle to Latour’s *Politics of Nature* is “how to bring the sciences into democracy.” While I will not get into different definitions of democracy (and whose interests each serves), for the purposes of ecological-technical-social problems such as plastic pollution, controversy does two things that leads environmental problems and their proposed solutions towards democratic ideas.

First, it brings issues into public, exponentially increasing the number of stakeholders who can potentially engage in the problem. As already noted, one of the stakes of defining something as technical versus social is that technical problems are solved off-

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<sup>27</sup> Latour 2004: 241.

stage in laboratories, while social problems are more appropriate to debate in the public sphere. By defining all technical and scientific objects as always already also social, STS allows all objects onto the public stage.<sup>28</sup> Bringing new voices into public discourse is also the goal of many types of environmental communication and advocacy.<sup>29</sup> In fact, the Principals of Environmental Justice drafted at the First National People of Color Environmental Leadership Summit in 1991 states that environmental justice is not only about “the right to be free from ecological destruction,” but also “demands the right to participate as equal partners at every level of decision-making, including needs assessment, planning, implementation, enforcement and evaluation.”<sup>30</sup> We could add definition to this list of decision-making moments. A tenet of environmental justice is communication between stakeholders and the controversy it often engenders.

The power of controversy is not only to bring more people into a public forum so we somehow reach a quorum of stakeholders. Rather, the power of controversy over ecological-technical-social objects is that it *creates* publics. John Dewey argued that, “the public consists of all those who are affected by the indirect consequences of

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<sup>28</sup> As a stronger version of this, the premise of Latour’s *Politics of Nature* is that there has never been a defacto separation of politics and objects, but a forced separation that gave certain parties powers over others in determining who could speak for objects and in what forums. Latour 2004.

<sup>29</sup> Cox, R. (2012). *Environmental Communication and the Public Sphere*. Thousand Oaks, Sage Publications: 24-25, 32.

<sup>30</sup> (1991). *Proceedings: The First People of Color National Environmental Leadership Summit*. First People of Color National Environmental Leadership Summit, Washington, DC, United Church of Christ Commission for Racial Justice. Delegates to the First National People of Color Environmental Leadership Summit. (1991). “Principles of Environmental Justice.” Retrieved 9/25/12, from <http://www.ejnet.org/ej/principles.html>.

transactions, to such an extent that it is deemed necessary to have those consequences systematically cared for."<sup>31</sup> That is, publics and their political demands are generated when "transactions" outside of their control affect them, including the exchange and circulation of plastics in environments and plasticizers in bodies. Drawing on Dewey's work, some scholars have called such groups "material publics" to signify publics consisting of "materially and physically entangled actors" rather than publics made up via discursive exchanges.<sup>32</sup> One of the challenges of environmental material publics is that their common bond is exposure to environmental harms and thus may not know each other, speak the same language, or even consider the effects environmental harms have on them in the same way. Controversy in public forums can help them find one another.

The second way that controversy forwards democratic ideals is that controversies invariably involve multiple "plausible but fictional scenarios that provide acceptable interpretations of the observed facts."<sup>33</sup> That is, controversies imagine possible futures and debate which are acceptable, desirable, and just, and which are not. What kind of relationships between stakeholders as diverse as industry lobbyists and breast cancer activists, objects, and the environment are tolerable, and which are not? According to

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<sup>31</sup> Dewey, J., L. A. Hickman, et al. (1998). *The Essential Dewey: Pragmatism, Education, Democracy*. Bloomington, Indiana University Press: 285.

<sup>32</sup> Marres, N. (2005). "Issues Spark a Public Into Being: A Key but Often Forgotten Point of the Lippmann-Dewey Debate." *Making Things Public*. B. Latour and P. Weibel. Cambridge MIT Press.

Braun, B. and S. Whatmore (2010). *Political Matter: Technoscience, Democracy, and Public Life*. Minneapolis, University of Minnesota Press.

<sup>33</sup> Callon 2009: 22.

anthropologist Mary Douglas, such questions are the ones that define pollution itself: “pollution ideas are the product of an ongoing political debate about the ideal society... [P]ollution beliefs uphold conceptual categories dividing the moral from the immoral and so sustain the vision of the good society.”<sup>34</sup> Is it wrong for industry to use nature as a place to store hazardous waste, or is it “nature’s gift” to capital? Is the presence of plastic chemicals in every human body acceptable, regardless of whether there is proof of harm, or is it only unacceptable after indisputable proof of harm has emerged? The premise of my research is that plastics constitute a new form of pollution, and thus provides an opportunity to redefine pollution, to contest the dominant “vision of a good society,” and to seriously consider alternatives.

### Plastics Literature

Plastic pollution is already embroiled in controversy, and a number of secondary texts have been pivotal in rounding out plastics as a matter of concern, and bringing out new stakeholders and publics. The majority of these books are journalistic, a fitting genre for making the issues accessible to a wide, popular audience. Countless news articles alert the public to the fate of seabirds that consume plastics, the rising counts of plastic chemicals in American house pets, and micro-controversies over plasticizers in soup cans, but there are surprisingly few long-form journalistic works. Some of the more in-depth investigative journalism texts include *Silent Snow: The Slow Poisoning of the Arctic* by Maria Cone, an expose of the accumulation of toxins in the far north and how it is

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<sup>34</sup> Douglas, M. and A. B. Wildavsky (1982). *Risk and Culture: An Essay on the Selection of Technical and Environmental Dangers*. Berkeley, University of California Press: 36-7.

affecting indigenous populations, and *Chasing Molecules: Poisonous products, human health, and the promise of green chemistry* by Elisabeth Grossman, an overview of endocrine disruptors and their relationship to environmental health.<sup>35</sup> Scientist-activists, including Curtis Ebbesmeyer, Charles Moore, and Richard Thompson, have also written about how they have come to discover, analyze, and then advocate against ocean plastics.<sup>36</sup> Susan Freinkel's *Plastic: A Toxic Love Story* exemplifies a third type of journalistic work, where the author relates her efforts to navigate a confusing barrage of competing claims about plastics in her own life.<sup>37</sup> These journalistic works are mainly descriptive and lay out scientific and industry facts about plastic pollution, and the way these facts have turned the authors into stakeholders. These texts, as well as the majority of activist works such as those by artist Chris Jordan showing photojournalistic images of plastics in the bellies of albatross carcasses, rely on the power of facts to persuade—and sometimes shock—their audience into action.

The lion's share of texts on plastic pollution are scientific literature written by and for scientists, including articles about the ecological, biological, and chemical effects of plastics and their chemicals, the earliest of which dates to 1960 and records the

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<sup>35</sup> Cone 2005.

Grossman, E. (2009). *Chasing Molecules: Poisonous products, human health, and the promise of green chemistry*. Washington, DC, Island Press/Shearwater Books.

<sup>36</sup> Ebbesmeyer, C. C. and E. Scigliano (2009). *Flotsametrics and the Floating World: How one man's obsession with runaway sneakers and rubber ducks revolutionized ocean science*. New York, NY, Smithsonian Books: Collins.

Moore, C. and C. Phillips (2011). *Plastic ocean: how a sea captain's chance discovery launched a quest to save the oceans*. New York, Avery.

Thompson, R. C., Y. Olsen, et al. (2004). "Lost at Sea: Where Is All the Plastic?" *Science* 304(5672): 838.

<sup>37</sup> Freinkel, S. (2011). *Plastic: A Toxic Love Story*. Boston, Houghton Mifflin Harcourt.



“confounding” discovery of a rubber band in a puffin’s stomach in the UK.<sup>38</sup> Since then, scientists in fields as diverse as marine biology and toxicogenomics have produced thousands of articles on the effects of plastics and plasticizers, with the majority published in the past five years. These serve as my primary sources. In contraposition to these articles, many forms of industry literature refute evidence of harms related to plastic pollution. Industry literature often takes the form of scientific and journalistic articles, as well as websites, public campaigns, conference proceedings, and advertisements. These are the textual arenas where many plastic pollution controversies play out.

A smaller number of secondary academic texts in the humanities and social sciences have been written about plastic since Roland Barthes’ 1957 essay entitled “Plastics.” Barthes does not write about pollution per se, but foregrounds plastics’ characteristic tendency to resist, “a state which merely means an absence of yielding.”<sup>39</sup> This state is also characteristic of plastic pollution. Jeffrey Meikle’s excellent *American Plastic: A Cultural History* shows how the rise of plastics as a ubiquitous material for consumer goods was not inevitable, but the result of specific relationships between technology, culture, the military, and national economic goals during the nineteenth and twentieth centuries.<sup>40</sup> In June 2011, an auditorium full of academics in the social sciences and humanities, with a sprinkling of scientists, gathered for “Accumulation: The material

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<sup>38</sup> Bennett, G. R. (1960). "Rubber bands in Puffin's stomach." *British Birds* 53: 222.

<sup>39</sup> Barthes, R. (1972). *Mythologies*. New York, Hill and Wang: 98.

<sup>40</sup> Meikle, J. L. (1995). *American Plastic: A Cultural History*. New Brunswick, N.J., Rutgers University Press.

ecologies and economies of plastic,” a one day symposium at Goldsmiths’ College in London. Despite consensus over the well-established and growing evidence of plastic’s negative ecological and political effects, I was struck by the diversity of definitions of plastics used by presenters. One presenter discussed how no one knows how long it truly takes for plastic to degrade, followed by another, equally accurate presentation about how plastic ages, scratches, discolours, and degrades, leading to the dispossession of durable plastic goods. Few presenters worked exclusively on plastics, and plastic was used to think through a myriad of problems from a catalogue of disciplines. “Accumulation,” the proceedings of which will soon be an edited volume, highlighted the plasticity of plastics as an ecological-technical-social material.

Other academic work, including my own, focuses on plastic pollution specifically. These include Gaye Hawkins’ various pieces on plastic bags, Jody Roberts’ work on plastophobia, and Nancy Langston’s comparative work that juxtaposes DES and BPA.<sup>41</sup> All of these works, either explicitly or implicitly, work to make plastics a matter of concern. Most are explicit about moving towards action and activism, or offer frameworks to best address plastic pollution mitigation. They advocate for or against specific definitions of plastics as matters of concern. Despite differences in the ways plastics are understood in these works, to my knowledge, there are no secondary

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<sup>41</sup> Hawkins, G. (2001). "Plastic Bags." *International Journal of Cultural Studies* 4(1): 5-23.  
Hawkins, G. (2006). "Plastic Bags." *The Ethics of Waste: How we Relate to Rubbish*. Lanham, Md., Rowman & Littlefield Publishers: 21-44.  
Roberts, J. A. (2010). "Reflections of an Unrepentant Plastiphobe: Plasticity and the STS Life." *Science as Culture* 19(1): 101-120.  
Langston, N. (2010). *Toxic Bodies: Hormone Disruptors and the Legacy of DES*. New Haven, Yale University Press.

academic texts that support the industry view of plastics.

*Redefining Pollution: Plastics in the Wild* is the first book-length work that looks at both ocean plastics and body burdens together rather than separately, based on the insistence that they pollute in ways that systemically challenge notions of pollution. This work is not just an expose or catalogue of the dangers of plastic “in the wild” or a warning about pollution, but synthesizes information from a wide range of disciplines and sources—science, policy, activists, industry, and artists—not only to describe the state of controversies over plastic pollution, but how the contest is waged. It will be of interest to those interested in the politics of measurement and observation, of social-scientific methods in general, and the use of science in social change more specifically. It constantly link the specific materialities of plastic polymers and plasticizers—how and where they circulate, their toxic effects, who produces them and who suffers from their production—to systemic issues of how we understand circulation, measurement, toxicity, cause and effect, risk, harm, pollution, and industry-government-citizen relationships. Plastic pollution denaturalizes these relations because dominant models of pollution cannot describe, predict, or contain plastics, making them suddenly apparent. Just as invisible and taken-for-granted infrastructure becomes visible upon breakdown, naturalized ideas of what pollution is, how it is defined, how it works, and how we know about it are being disrupted by plastic pollution and are thus more available to study. Though plastic pollution is an acute threat to human and ecological health, it is used here as a case study rather than where the research begins and ends. It is a case study for looking at how definition works, and how it has the power to shape

worlds. In this case, this world-shaping power is literal, as the final stage of my research links definition work to environmental action.

### On Action

What is to be done in the face of competing definitions? How can we act when our problem phenomenon is a wicked matter of concern? In this dissertation, I advocate for a mode of action from the premises outlined here—that ecological phenomena are never “natural,” but part of a nested set of social, material, and political systems. The materiality of plastics is foundational to action because materiality is fundamentally relational. It makes a difference that plastics are synthetic polymers rather than natural polymers or monomers because the former will circulate in environments for centuries, while the latter may not circulate at all. It matters whether we are talking about PET or silicone because each has different plasticizers, and will have different effects on bodies. It matters how long beached plastics have been in the sun because this determines how much they will fragment, and thus what kind of animals find them edible. Plastics are persistent (literally) and insistent in ways that affect how they move through ecosystems, bodies, laboratories, and the public sphere.

My insistence on materiality stems from on my work in environmental activism, where many, if not most, popular environmental actions have a tenuous relationship to the materiality of the problem they are trying to address. Recycling, for example, one of the most popular and widespread daily environmental behaviours in North America, is rarely understood as an industrial process that uses energy, virgin materials, and

pollutes. As my conclusion will outline, recycling plastics is one of the few actions that does not positively impact plastic pollution because of the material dimensions of both plastics and recycling processes. In environmental activism, materials matter, and need to be in the forefront of defining problems and proposed solutions.

A view of materialism-in-action can be counted under “new materialisms,” a relatively new subfield that cuts across disciplines in the humanities and social sciences.<sup>42</sup> The central idea in new materialism is that matter acts. Matter has agency, and this agency is expressed in the dynamism of humans and materials working in concert.<sup>43</sup> As such, new materialism is anti-essentialist and essentially relational. New materialism offers a way to think of several problems presented by plastic pollution: the effects of plastics in the wild and in bodies are largely unpredictable; plastics are both inert in that they are waterproof, corrosion resistant and long-lived, but they are also constantly leaching and off-gassing chemicals and infiltrating both remote (oceanic, northern) and intimate (bodily) ecosystems; and finally, plasticizers do not act through predictable causal

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<sup>42</sup> N.A. (2010). “New Materialisms and Digital Culture.” Conference at Anglia Ruskin University

Barrett, E. and B. Bolt (2012). *Carnal Knowledge: New Materialism through the Arts*, I B TAURIS.

Ahmed, S. (2008). "Open Forum Imaginary Prohibitions: Some Preliminary Remarks on the Founding Gestures of the 'New Materialism'." *European Journal of Women's Studies* 15(1): 23-39.

Coole, D. H. and S. Frost (2010). *New Materialisms: Ontology, Agency, and Politics*. Durham; London, Duke University Press.

Bennett, J. (2010). *Vibrant Matter: A Political Ecology of Things*. Durham, Duke University Press.

<sup>43</sup> There are many other works in STS that focus on the “dynamism of humans and materials working in concert,” such as Pickering, A. (1995). *The Mangle of Practice: Time, Agency, and Science*. Chicago, University of Chicago Press.

forces, which makes models of causality more complex than many modes of action, including government regulation, are adapted for.

This materialism is different than Marx's historical materialism, whereby changes in human society over time are based on the mode of production. That being said, economic activity is central to a wicked materialism because economics, including the drive for profit, is one of the systems that make ecological problems like plastic pollution wicked to begin with, and one of the forces that defines plastics and pollution in certain ways. One of the arguments that emerges from my research is that capitalist industries are not only stakeholders in controversies surrounding plastic pollution, but many of the current techniques of definition that dominate such controversies are inherently capitalist.

This is more than just a theory of science-based action that takes materials seriously, however. When materialism is relational and wicked, tied up in apparatuses, techniques, interests, and institutions, then this thing called "plastic pollution" is more than an object or material phenomenon; it becomes a node in which many systems come together, and from which these systems can be recognized and addressed. It opens the possibility for systemic change, changes in definition as well as changes in techniques of definition, and changes in the systems that have prioritized and naturalized previous definitions. I have argued that definition is a verb, an action word. Definition is an action, and we need actionable definitions for environmental change. Even as I argue against traditional, regulatory definitions of pollution and the techniques

that enable them, I am also proposing new definitions and ways of defining environmental problems, and thus advocating for certain types of solutions.

This dissertation, through its definition work, is a form of environmental activism. By my definition, activism is any activity that bridges the gap between what is and what ought to be. It is a fundamentally normative activity, and certainly does not have to be radical. It can be deeply conservative. Regardless, it requires definition work to articulate the current state of affairs, and what those affairs ought to be. Poor definition work in activism results in poorly identified points of intervention, a consistent problem in American mainstream environmentalism as the example of recycling above illustrates. I will take this up again in the conclusion.

Pollution is an especially good case through which to study and perform definition work and activism because, following Mary Douglas, pollution itself is a way to articulate the gap between the “is” and the “ought.” In her 1966 *Purity and Danger: An Analysis of Concepts of Pollution and Taboo*, Douglas argues that definitions of pollution are always already social, a “reaction which condemns any object or idea likely to confuse or contradict cherished classifications,” a way of establishing when matter is “out of place.”<sup>44</sup> Pollution beliefs and taboos attempt “to force one another into good citizenship. Thus we find that certain moral values are upheld and certain social rules defined by beliefs in dangerous contagion, as when the glance or touch of an adulterer

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<sup>44</sup> Douglas, M. ([1966]1984). *Purity and Danger: An Analysis of Concepts of Pollution and Taboo*. London, Ark Paperbacks: 35.

is held to bring illness to his neighbours or his children.”<sup>45</sup> Through her anthropological work, Douglas argues that these foundations of pollution are universal, and “the difference between pollution behaviour in one part of the world and another is only a matter of detail.”<sup>46</sup> Even in cosmopolitan societies with strong scientific frameworks for understanding the world, pollution reflects symbolic systems and visions of “the good society.” We merely use science to draw the line between pollution and non-pollution. In any society, pollution ought not exist, and contests over definitions of pollution simultaneously describe a good or just society, particularly in terms of proper or ideal relationships between industry, government, and citizens. This dissertation follows many of these contests to analyze the “ought” implicit in appeals to specific definitions of pollution. I also propose some of my own.

### Chapter outline

Each chapter investigates different, and often conflicting, sets of materials and systems that work to define plastic pollution. The first chapter, “Defining Pollution,” outlines a brief history of how material pollution was defined during the early nineteenth to mid twentieth centuries, and particularly the development of the notion of assimilative capacity, or allowable limits of pollution. Though contests over definitions of pollution were fierce within government and scientific agencies, the dominant meaning that emerged specifically benefited government practices of dumping sewage and drawing drinking water from the same sources. Pollution became a quantity at which a toxin

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<sup>45</sup> Douglas 1984: 3.

<sup>46</sup> Douglas 1988: 35.



could no longer be absorbed by an ecosystem or body, and thus caused irreparable harm to living organisms. Over time, the state-based definition of pollution was solidified via scientific methods within environmental policy, and remains the basis of much environmental regulation today.

In the second chapter, “Redefining Pollution: Things Fall Apart,” I show how plastics thoroughly defy the definitions of pollution so carefully developed over the previous century. Both ocean plastics and endocrine disruptors exceed the concrete, understood, and well-measured model of pollution to challenge not only practices of pollution control that have worked (at least in theory) for a century, but also theories of what pollution is and how it works. This is where the unpredictable nature of plastic pollution becomes the most apparent, as plastics and their chemicals are inextricably folded into living systems, correlated with—but never found to be fully causal of—a host of illness and genetic shifts, and cease to follow the age-old doctrine of toxicology: the danger is in the dose. Plastics also undo ideas of assimilation, contamination versus pollution, sinks and spills, and the containment of pollutants as a main strategy of pollution control.

Thirdly, “Plastics in Publics: Regimes of Perception and the Politics of Definition” is a chapter on some of the controversy that has resulted from plastics’ defiance of dominant definitions—and safety precautions—of pollution. It traces the effects of a controversy over definitions of plastic pollution within two public forums. The first part of the chapter covers a technocratic sphere populated by NGOs, plastics industry

lobbyists, scientists, and the Food and Drug Administration (FDA). As these stakeholders enter a semi-public debate over bisphenol A (BPA), a chemical used in many plastics, power relations that dictate what counts as evidence and viable information emerge. The second part of the chapter looks at a public sphere made mainly of civilians, consumers, and other “material public” stakeholders. One of the activist campaigns against plastic pollution within this sphere called Not In My Body (NIMB) proposes a new definition of pollution that does not rest on allowable limits of pollutants, but total presence and absence. Each sphere’s contest over techniques of definition are simultaneously contests over what counts as representable and under what conditions, because accepted representations work towards sanctioning the evidence, techniques, and values that created them.

Given that chapter three multiplies the definitions of plastic pollution by different stakeholders, many in direct opposition to one another, the fourth chapter, “Scales of Plastic Pollution,” asks what has to be taken into account in any definition of plastic pollution, particularly if the problem is meant to engender viable solutions. I describe the effort, and eventual failure, of oceanographers to use the methods of climate change modeling to describe global plastic pollution in the oceans. Following this failure, though largely undeterred by it, scientists continue to believe plastics are in every ocean, every landscape, and every body on earth, and that they last in geological time that outlasts the human species. I develop a theory of scale as a way to evaluate how relationships matter at different scales so interventions can target processes that make a difference.

In the concluding chapter, “What is to be done,” I use this theory of scale and the behaviours of plastic and its chemicals covered in the second chapter to evaluate how proposed solutions address the key characteristics of plastic pollution. Proposed solutions include ocean and beach clean ups, recycling, bioplastics and biodegradation, consumer refusal, extended producer responsibility, plastic bag and BPA bans, the European Union Commissions’ Registration, Evaluation, Authorisation, and Restriction of Chemicals (REACH) program, green chemistry, the adoption of the precautionary principle, and alternative economic systems that are not driven by profit and growth. These examples bring the research full circle to exemplify why action based on wicked materiality is a more ethical and effective mode of intervention than current regimes of pollution control.

## II. DEFINING POLLUTION: NATURAL THRESHOLDS AND ALLOWABLE LIMITS

### The Technocratic Context of Pollution Definition

Imagine a city with thousands of flush toilets, but no public sewers. Think about where you will put your wastewater. Think of the smell and the muck. How will you keep that muck and stink from sliding into your drinking water? Despite the exponential increase of indoor plumbing during the nineteenth century, not a single American city simultaneously built a public sewer system to take care of its liquid waste.<sup>47</sup> It was common to store sewage for indeterminate amounts of time in backyard cesspools, which often overflowed, seeped, and spilled into streets and basements. In New York City, 120,000 city horses compounded the issue by each producing over twenty pounds of manure and several gallons of urine daily, much of which was left in the streets to mix with human and kitchen waste.<sup>48</sup> There was no universal curbside municipal solid waste infrastructure at the time, but an informal, decentralized scavenging system for sorting through the solid waste dumped on the streets, which could not keep up with a steadily increasing urban population. Urbanites “literally got en-tangled in pig's tails and jaw bones” or would “[meet] with the putrefying carcass of a dead dog” as they walked

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<sup>47</sup> In 1863, Boston's population of 178,000 had 14,000 water closets, 87,000 water fixtures, and only rudimentary private sewers.

Tarr, J. A., J. McCurley, et al. (1980). “The Development and Impact of Urban Wastewater Technology: Changing Concepts of Water Quality Control, 1850-1930.” *Pollution and Reform in American Cities, 1870-1930*. M. V. Melosi. Austin, University of Texas Press: 62.

<sup>48</sup> Melosi, M. V. (1981). *Garbage in the Cities: Refuse, Reform, and the Environment: 1880-1980*. College Station, TX, Texas A&M University Press: 24.

through city streets.<sup>49</sup> The effluents of inner-city tanneries, slaughterhouses, reduction plants, breweries, paper milling and textile manufacturing compounded the “filth problem” by dumping their waste into the public water sources from which drinking water came. These were also the waterways where citizens often (illegally) dumped their sewage. The lower, immigrant classes were plagued by disease and foul conditions, but increasingly, so too were the homes, noses, and health of the upper classes.<sup>50</sup> Something had to be done.

One of the radical goals of the progressive era sanitation movement (1890s-1920s) was universal sanitation, including citywide solid waste management, potable water supplies, and sewer works. Only municipal governments could afford such capital-intensive projects, and sanitarians argued that it was the government’s duty to provide urban living conditions conducive to the success and health of all its citizens, poor and wealthy alike. Municipal governments eventually consented. In 1880, Chicago had three hundred and thirty-seven miles of private sewers. By 1905, it had 1,633 miles of sewers, almost all of them public. Philadelphia’s two hundred miles of sewers in 1880 had increased to 1,041 by 1905.<sup>51</sup> However, few of these systems purified sewage before ejecting it into waterways.

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<sup>49</sup> Larsen, L. H. (1969). "Nineteenth-Century Street Sanitation: A Study of Filth and Frustration." *The Wisconsin Magazine of History* 52(3): 240.

<sup>50</sup> For more on how class played into the sanitation reform movement, particularly in terms of how ideas of pollution and disease threatened the identity of the well-to-do urban classes and how this motivated various sanitation efforts, see Burnstein, D. E. (2006). *Next to Godliness: Confronting Dirt and Despair in Progressive Era New York City*. Urbana, Ill., University of Illinois Press.

<sup>51</sup> Tarr 1980.

At the turn of the century, municipal governments had a sticky triad of responsibilities: disposing of wastes into waterways, procuring clean drinking water for citizens from those waterways, and legislating water quality. In 1919, an employee of the Hygienic Laboratory in Washington DC named Earle B. Phelps, a graduate of the new biochemical engineering program at MIT, wrote a great understatement: "[w]ith the growth of industry, ... and the increasing joint use of streams for the purposes of water supply and waste disposal, conflicts of interest arise."<sup>52</sup> He surmised, "[o]f immediate and pressing interest is the fixing of standards of permissible pollution, which will comply with the common law conception of reasonable use and develop the maximum advantageous use of the streams."<sup>53</sup> Phelps and many of his contemporaries wanted to solve the tension between urban waste disposal practices and drinking water quality without ceasing to use waterways as municipal and industrial sewers. Allowable limits of pollution was the solution.

Phelps, and others like him in the relatively new fields of civic and sanitary engineering, were increasingly employed by the government to untie the Gordian knot of government-sponsored pollution, need for clean water, and pollution regulation. Environmental pollution as we know it today was developed within this technocratic context. "Technocracy" is a term first used in 1919 by William H. Smyth, a Californian

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<sup>52</sup> Phelps, E. B. (1919). "Stream Pollution and Its Relation to the Chemical Industries." *The Journal of Industrial and Engineering Chemistry* 11(10): 928-929.

<sup>53</sup> Phelps 1919: 928. "Reasonable use" was tied to efficiency and industrial needs rather than public or ecological health per se.

engineer, to describe "government by science or by scientists."<sup>54</sup> While there was a specific technocracy movement in the 1920s and 30s that was quite radical in its position using science against capitalism and for wide social change, here it refers to the more general ethos where the scientific method is used to solve social problems within the domain of government agencies. Technocracy is a combination of technological and scientific problem solving in institutions of bureaucracy whose job it is to referee between different interested groups, where cost efficiency and governance is often prioritized over other interests. Technocracy provided not only the context, but also the principles upon which a dominant model of pollution would develop.

This is a story of how pollution came to be defined as a specific type of phenomenon in the early twentieth century within the technocracy of the United States by tracing one of pollution's foundational aspects: assimilative capacity, the limit of pollution an environment can naturally endure and assimilate. Assimilative capacity has become a naturalized part of our ideas of environmental harm and our methods of pollution control today. The overall argument underlying this research is that plastic challenges the tenets of assimilative capacity, but first, to tell the story of its undoing, I will illustrate some of the conditions that made it foundational to begin with.

This chapter has four sections, the first of which looks at how scientists and governments came to work together to combat water pollution, and the resultant crisis

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<sup>54</sup> Raymond, A. (1933). *What is technocracy?* New York,, Whittlesey House, McGraw-Hill: 3, 16.

of definition. There were hundreds of different definitions of water pollution in circulation, all of which would lead to different, and often opposing, measures of pollution control. The second section looks at the early history of one of the main methods for defining pollution, assimilative capacity, that came to be used during the twentieth century and is still in use today. The third section discusses how assimilative capacity, or the amount of pollution nature can endure without causing harm, was part of a larger theory about the robustness of nature being developed in a variety of scientific and managerial disciplines. In each of these technocratic research contexts, nature was shown to be robust within limits, and scientific efforts were focused on identifying and managing those limits. Pollution was one small part of this larger project. Finally, the last section of the chapter outlines why theories of allowable limits of pollution such as assimilative capacity work so well in policy discussions. Technocratic techniques of defining and solving problems create certain types of entities that tend to be bounded, quantified, and simplified. Overall, this chapter outlines how environmental pollution came to be defined in the twentieth century to ground an understanding of what plastic challenges, disrupts, and otherwise exceeds it in the twenty-first.

#### A Technocracy for Sewage

Phelps was just one of many scientific experts called on by politicians to work on the water problem. Government officials did not possess the expertise to determine if water was polluted or not, particularly since the germ theory had wrested the ability to identify harmful water away from the layperson sense of smell, taste and experience,



and placed it squarely in the laboratory. Governments needed scientists. This marriage of governance and technical science is the foundation of technocracy. With the Massachusetts Board of Health leading the way in 1869, by 1909 it became the norm to create a board of experts representing the fields of medicine, chemistry, bacteriology and sanitary engineering to determine the safety and quality of water and to advise the government of how to best proceed with regulation and infrastructure.<sup>55</sup> The loyalties of these scientists were split. They were accountable to the state as their employers, industry as major stakeholders in water debates, and to citizens as stakeholders often in need of protection, yet were also expected to be “objective” spokespersons for nature beholden to no interest group.

Under the pressure of meeting the divergent needs of stakeholders, definitions of clean water and pollution proliferated:

“[Polluted water is] Any liquid containing, *in solution*, more than two parts by weight of organic carbon, or 3 part by weight of organic nitrogen in 100,000 parts by weight.”<sup>56</sup>

“The chief characteristics of unpolluted water: It is tasteless and inodorous, possesses a neutral or faintly alkaline reaction, rarely contains in 100,000 pounds more than one-half pound of carbon and one-tenth pound of nitrogen in the form of organic matter, and is incapable of putrefaction, even when kept for some time in close vessels at a summer temperature.”<sup>57</sup>

“[B. coli’s] presence in water is to some extent indicative of pollution, although its abundance rather than its mere presence must be

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<sup>55</sup> Tarr 1980.

<sup>56</sup> Denton, J. B. (1881). *Sewage disposal, ten years' experience in works of intermittent downward filtration*. London, E. & F. N. Spon: 9.

<sup>57</sup> N.A. (1876). *Seventh Annual Report of the State Board of Health of Massachusetts*. Massachusetts. Boston, Wright & Potter, State Printers: 26.

considered as the criterion. The test for *B. coli*, in order to be of definite value, therefore, must be not only qualitative but quantitative.”<sup>58</sup>

“There is no such thing as pure water, even at the sources, nor anywhere except in a laboratory.”<sup>59</sup>

In response to this cacophony, in 1904, *The Builder*, “an illustrated weekly magazine for the architect, engineer, archaeologist, constructor, sanitary reformer and art lover,” lamented that,

The public demanded to be supplied with what was defined in various Acts of Parliament as “pure or wholesome water”-- that is, water free from pollution-- and water engineers were anxious to meet their requirements. The misfortune was that there were such diversities of opinion as to what constituted a pure and wholesome water, that neither engineer nor the public knew what to believe.<sup>60</sup>

Many of these “diversities of opinion” were generated as part of a major conflict within water policy circles between 1900 and 1917. Some policy experts, usually medical professionals, argued that municipal and industrial effluents should be purified before dumping them into waterways because even one wayward microbe could cause illness, and the science of detection was still in its infancy. Others, often sanitary engineers and chemists such as Phelps, thought waterways were best used as extensions of sewers, and potable water could be either sourced from other locations or filtered from polluted

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<sup>58</sup> Committee on Standard Methods of Water Analysis (1905). *Report of Committee on Standard Methods of Water Analysis to the Laboratory Section of the American Public Health Association*. A. P. H. Association: 84.

<sup>59</sup> N.A. 1876: 26.

<sup>60</sup> N.A. (1904). “Pure and wholesome water and pollution.” *The Builder* 86(3202): 658.

water. Both sides of the argument, often represented in the same government report, generated different ideas of how pollution should be officially defined.<sup>61</sup>

Earl B. Phelps argued for a contextual definition of pollution, where, “[p]ure water has been defined as a water that contains no harmful or deleterious substances with respect to the purpose for which it is to be used. In accordance with this very practical definition typhoid germs constitute an impurity and calcium salts do not in the case of a drinking water supply, while the reverse is true in the case of boiler water.”<sup>62</sup> In agreement, a colleague wrote that, “[i]t has generally been held, and in most instances rightly held, that the degree of dilution necessary [of sewage for swimming water] is merely that which will prevent a nuisance, having reference primarily to unsightly floating matter and bad odors. For most rivers and many of the smaller streams of the country, this requirement as to the cleanness of the waters is all that is necessary.”<sup>63</sup> By their definition, whether a waterway was polluted depended on what the waterway was being used for. However, even amongst supporters of this approach, there were still problems of definition; it was agreed that drinking water was to be free of harmful

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<sup>61</sup> Environmental historian Joel Tarr characterizes the two sides of this debate as water filtration vs. sewage treatment proponents, while Walter Westman, a government employed ecologist, calls one side ecologists (Tarr’s sewage treatment champions) and the other technologists (those supporting water filtration). Tarr 1980: 72-77.

Westman, W. E. (1972). "Some Basic Issues in Water Pollution Control Legislation: Contrasts between technological and ecological perspectives on the regulation of effluents underlie current debates in water pollution legislation." *American Scientist* 60(6): 767-773.

<sup>62</sup> Phelps 1919: 928.

<sup>63</sup> Hansen, P. (1913). "The Control of Stream Pollution." *Transactions of the Illinois Academy of Science* 6: 55.

microbes, but “[t]here is room for some difference of opinion as to the amount of *B. coli* which should be necessary to condemn a water supply.”<sup>64</sup> Thus, even after advances in the detection of microbes and other pollutants, governments and their experts were still struggling with the question of “an arbitrary line” of where polluted water was divided from acceptably clean water.

According to *The Rivers Pollution Prevention Act* drafted in 1876, which created the governmental impetus for many of these arguments,

There is no such thing as absolutely pure water in nature, and the waters met with in our springs, lakes, rivers, and sewers, form a series gradually increasing in dirtiness; there is actually no definite line of demarcation separating the purest spring water from the filthiest sewage.... It is, therefore, obvious that, for the purposes of efficient legislation, an arbitrary line must be drawn between waters which are to be deemed polluting and [those deemed non-polluting].<sup>65</sup>

By 1917, the argument in sanitation policy as to whether all effluents should be purified before being dumped or whether just drinking water needed to be filtered was resolved in favour of the more economic practice, where “economic practices” includes both cost-saving practices that processed as little pollutant as possible, as well as the favoritism of industry allies and their profits.<sup>66</sup> Thus, within policy circles, the task of defining pollution became narrowly focused on determining acceptable limits of

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<sup>64</sup> Bartow, E. (1909). “Chemical and Biological Survey of the Waters of Illinois.” *University of Illinois Bulletin* 7(2): 41.

<sup>65</sup> N.A. (1876). “Appendix B: Fourth Report of the Commissioners Appointed in 1868 to Inquire into the best Means of Preventing the Pollution of Rivers.” *The Rivers Pollution Prevention Act, 1876, 39 & 40 Vict. c. 75; with Introduction, Notes and Index*. A. Glen. London, Knight & Co: 75-76.

<sup>66</sup> Though many municipalities still chose to purify sewage. See Schneider, D. (2011). *Hybrid Nature: Sewage Treatment and the Contradictions of the Industrial Ecosystem*. Cambridge, Mass., MIT Press.

pollution, since government and industrial infrastructure caused some pollution.

Governments knew the type of “arbitrary line” they wanted to draw, but still struggled with how and where to draw it.

#### A Line Less Arbitrary: Streeter, Phelps, And Assimilative Capacity

In 1925, the line between pollution and non-pollution became less arbitrary when Earl B. Phelps was paired with H.W. Streeter, another sanitation engineer, under the direction of the United States Public Health Service to investigate the condition of the Ohio River. While other scientists were asked to conduct biological examinations and chemical analysis of the river, the two public health engineers studied oxygen demand. Wastewater from sewage and some industrial processes contain organic materials that are decomposed (eaten) by microorganisms, which use oxygen in the process. The amount of oxygen consumed by these organisms to break down waste is called biochemical oxygen demand (BOD). Calculating biochemical oxygen demand indirectly measures the amount of organic waste in a waterway.

Yet Streeter and Phelps were not interested in measuring how much organic matter was in the Ohio River so much as learning about the river's ability to purify itself via its waste-eating microorganisms. This purification was sustained through the river's own reintroduction of depleted oxygen that the microbes required, called the rate of reaeration (the mesh tip of your kitchen facet, which adds air to your water, is called an aerator). Streeter and Phelps believed "[t]he condition of a polluted stream at any time is the result of a balance between these [oxygen] resources and the demand made upon

them by the organic polluting matter carried by the stream."<sup>67</sup> Their aim was to locate and quantify the point where balance became imbalance, and to express it in a quantifiable equation of inputs and outputs. The imbalance, when the river could no longer replace the oxygen needed by the microbes to process organic wastes, marked the moment of pollution.

Well before the 1800s and the urban sanitation movement, people had noticed that moving water removed chemicals and effluents the faster and further the stream moved from the source of contamination. Flow rate and distance were two of the variables Streeter and Phelps included in their equation to predict the oxygen balance. Today, self-purification is understood in terms of metabolism and assimilative capacity. Assimilative capacity is "the amount of waste material that may be discharged into a receiving water without causing deleterious ecological effects,"<sup>68</sup> or, more simply, the "ability of a body of water to purify itself of organic pollution."<sup>69</sup> It is, in other words, the rate of metabolism is compared to the rate of pollution, and assimilative capacity marks the place where the two are equal. With assimilative capacity, it is not that contaminants disappear so much as they are metabolized or occur in such low doses that they do not cause harm, and therefore do not constitute pollution. The moment a

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<sup>67</sup> Streeter 1925: 4.

<sup>68</sup> Novotny, V., and Krenkel, P. A. (1975). "A waste assimilative capacity model for a shallow turbulent stream." *Water Res. (G. B.)*, 9: 233 in Campbell, I. C. (1981). "A Critique of Assimilative Capacity." *Water Pollution Control Federation* 53(5): 604-607.

<sup>69</sup> Peirce, J. J., R. F. Weiner, et al. (1998). *Environmental pollution and control*. Boston, Butterworth-Heinemann: 373.

concentration of a pollutant causes harm, it has overwhelmed the waterway's assimilative capacity.

After determining the conditions under which the river stopped replenishing the biological demand for oxygen in the Ohio River, Streeter and Phelps created the graph below.

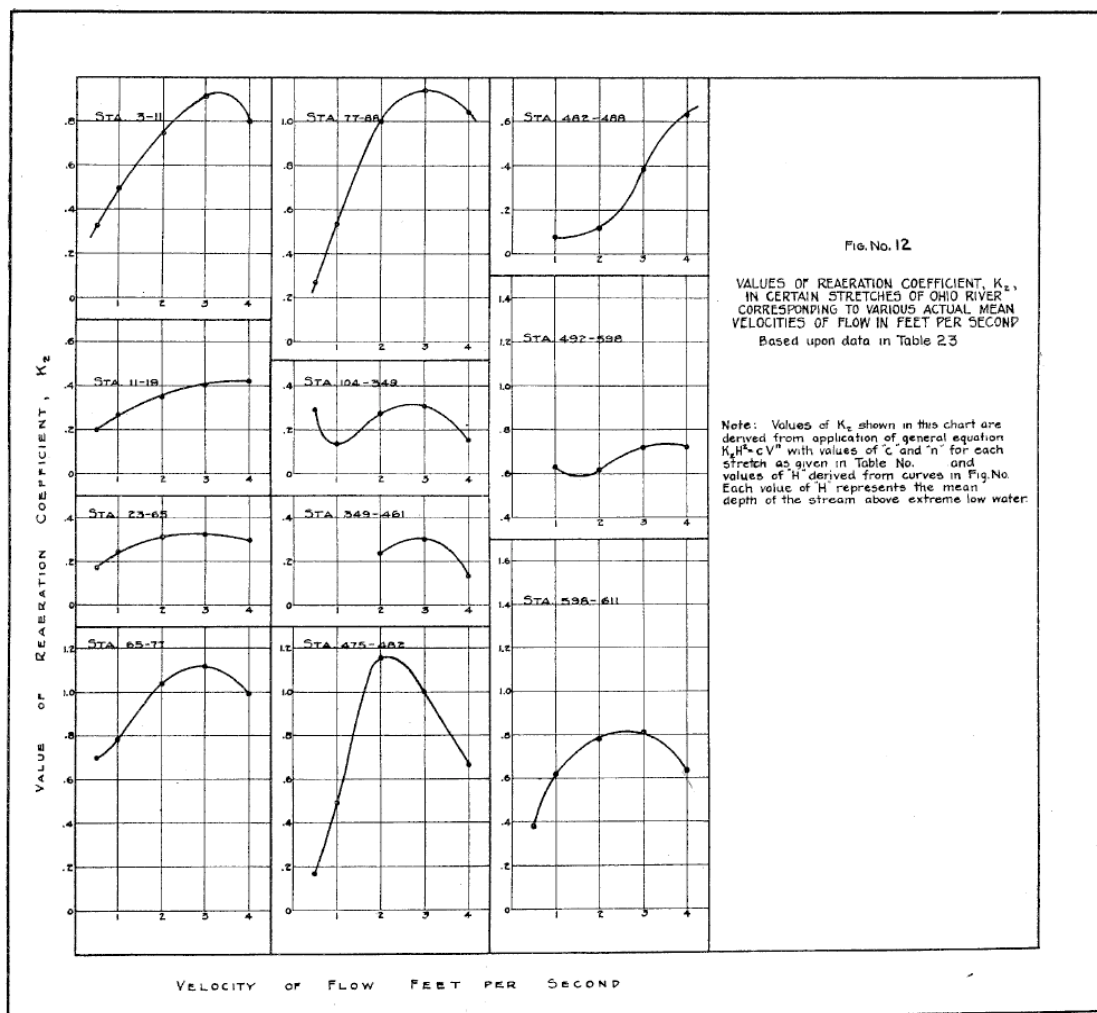


Figure 1.1: The rate of reeration (the process of reoxygenization) on the left, versus the speed of the river on the bottom of the graph results in curves that show the points at which the river can no longer purify itself (the droop in the graph). This is one of several graphs in the report, all with similar curves but different variables.

There it is! You can see it: the assimilative capacity of the river is represented in the droop of the curve, over and over again. The point at which each line droops (the top of the sigmoid curve) is the moment that increasing velocity does not contribute to an increase in reaeration. In different places, with different variables, and different amounts of organic pollutant, the individual numbers might change, but the curve looks the same each time.

Pollution had been generally understood, but not clearly defined with boundaries and borders. Here, the kernel of organic pollution is apparent, as the inverse of a purification curve, in black and white, over and over. This is how definition works. Techniques of definition are the formal and practical practices of setting boundaries or limits, and making statements about the essential nature of something through those limits. In Streeter and Phelps' curves, the essence of pollution is a moment of imbalance in a natural-industrial system, expressed as assimilative capacity. Not only is assimilative capacity a way to set limits, but those limits appear as properties of nature. Essences are thought to be universal. The law-like phenomenon of assimilative capacity, already apparent through the repeated sigmoid curve, allows the standardization and quantification of variables such as depth, flow, and reaeration rate, and the eventual creation of a formula that works in any river, anytime.<sup>70</sup> For the first time, pollution is

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$$^{70} \frac{\partial D}{\partial t} = k_1 L_t - k_2 D$$

Where,

- $D$  is the saturation deficit, which can be derived from the dissolved oxygen concentration at saturation minus the actual dissolved oxygen concentration ( $D = DO_{sat} - DO$ ).  $D$  has the dimensions  $\text{g/m}^3$ .



law-like: "It has been shown in the foregoing text that the oxygen self-purification of the Ohio River is a measurable phenomenon, governed by definite laws and proceeding according to certain fundamental physical and biochemical reactions. Because of the fundamental character of these reactions and laws, it is fairly evident that the principles underlying the phenomenon as a whole are applicable to virtually all polluted streams."<sup>71</sup> The Streeter-Phelps equation showed that the rate of biochemical processes were specific to nature and a chemical, but general to bodies of water. The curves represent larger, invisible forces of nature at work that are always at work. Streeter and Phelps had spoken objectively for nature, and their findings happened to coincide with the desires of government and agency, though not always citizens. This allowed pollution to be defined through assimilative capacity, where "harm" is understood as the moment at which a river can no longer purify itself, ascertained through calculus. Within twenty-five years, the Ohio River study was hailed as a classic.<sup>72</sup> More complex versions of oxygen demand, based on the Streeter-Phelps model, were introduced during the 1960s. The Streeter-Phelps equation is still used today.

Defining allowable limits of pollution, and thereby environmental pollution itself, is not just about intervening into matter and categorizing it. The Streeter-Phelps equation and

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- $K_1$  is the deoxygenation rate.
  - $K_2$  is the reaeration rate.
  - $L_t$  is the oxygen demand remaining at time,  $t$ .
  - $t$  is the elapsed time.

I include the entire formula here so you can see which variables were isolated and deemed essential for establishing self-purification, and thereby organic pollution.

<sup>71</sup> Streeter 1925: 59.

<sup>72</sup> For example, see Bloodgood, D. E. (1954). "Water Dilution Factors for Industrial Wastes." *Sewage and Industrial Wastes* 26(5): 643-646.

their partnership with government, which allowed their definition of pollution to become standard in technocratic pollution control, shifted what counted as pollution away from statements like those made by English water and food examiner John Clough Thresh in 1904:

Standards may be useful to the beginner and the inexperienced, but are carefully to be avoided by the expert and experienced. They are chiefly advocated by those who have some 'process' or 'method' which they have devised and wish to commend, and so far all such processes have failed to stand the test of time. What is wanted is the application of common-sense to the subject of water examination. How can any analysis, however complete, tell us anything of the liability to pollution?<sup>73</sup>

After Streeter and Phelps, Thresh's conviction is no longer valid in technocratic circles. On the contrary, the Streeter-Phelps equation and its definition of organic pollution were successful in technocratic circles precisely because it had some "process or method" that could be reproduced in any waterway. Expertise was now measured in terms of certain quantifiable, generalizable methods. Gone, too, were statements accessible to "common sense" such as "good water... is understood by the engineer to mean a palatable, wholesome water."<sup>74</sup> Instead, organic river pollution was established as a quantifiable moment of imbalance in an industrial ecosystem.<sup>75</sup> Definition creates things, ontologically. Categorization, as one technique of definition, makes things mutually exclusive, such as pollution and non-pollution, along lines of what the

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<sup>73</sup> Thresh, J. C. (1904). *The Examination of Waters and Water Supplies*. Philadelphia, P. Blakistons's Son & Co: vi.

<sup>74</sup> N.A. 1876: 26.

<sup>75</sup> The concept of an industrial ecosystem is fleshed out and nuanced in Daniel Schneider's work in *Hybrid Nature: Sewage Treatment and the Contradictions of the Industrious Ecosystem*, but for our purposes, it refers to the foundational role of metabolic processes of an ecosystem to meet the needs of industry. Schneider 2011.

organizational logic considers essential properties.

If the presence of a pollutant does not signal a pollution event unless it reaches a certain concentration, then pollutants do not always pollute—they only contaminate—and a second-order classification system for dangerous and harmless pollutants emerges. That is, the presence of a pollutant does not immediately denote pollution. A present-day undergraduate textbook on marine pollution teaches young scientists this classification system, a legacy of a technocratic prerogative of allowable levels earlier in the century:

Contamination is the presence of elevated concentrations of substances in the water, sediments or organisms, i.e. concentrations that are above the natural background level for the area and for the organism.

Pollution is the introduction by man, directly or indirectly, of substances or energy to the marine environment resulting in such deleterious effects as harm to living resources; hazards to human health; hindrance of marine activities including fishing; impairment of the quality for use of seawater; and reduction of amenities.

In other words, contamination may provide a warning signal, but it does not constitute pollution...<sup>76</sup>

Textbooks are repositories for knowledges that have become legitimate and normative within a discipline. The definition of contaminants versus pollutants within a textbook signals that allowable limits of pollution, through equations and other quantifications of imbalance or harm, have become standardized. So, too, has an anthropocentric approach to pollution, where only human uses and needs are considered legitimate sites for harm, and marine life is only mentioned insofar as it is used for fishing. This anthropocentrism is reflected in the calculus and categorizations of pollution.

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<sup>76</sup> Clark, R. B. (1986). *Assessing Pollution Damage: Marine Pollution*. Oxford, Clarendon Press: 7.

In *Sorting things Out: Classification and its Consequences*, Geoffrey Bowker and Susan Leigh Star state that a “‘standard’ is any set of agreed-upon rules for the production of (textual or material) objects.”<sup>77</sup> In this case, these rules, or technocratic procedures, produce contaminants, pollutants, biochemical oxygen demand, and assimilative capacity, but they also produce a certain kind of nature. It is no coincidence that the Streeter-Phelps equation was so readily accepted, as their framework of allowable limits and reproduction of sigmoid curves resonated in other areas of technocratic and scientific knowledge production being developed at the time. One of the characteristics of categorical orders is that “[t]he system is complete. With respect to the items, actions, or areas under its consideration, the ideal classification system provides total coverage of the world it describes.”<sup>78</sup> This total coverage included not only environmental pollution, but also the environment.

#### Nature’s Sigmoid Nature

The nature of nature has long been contested. Whether nature is inherently mechanistic, “red in tooth and claw,” harmonious, or a victim of human kind has been debated by science and technology scholars, politicians, scientists, engaged citizens and others for centuries. The physical environment as it relates to pollution is no different. The theory of allowable limits required a certain idea of nature, an idea that resonated with many other disciplines, from nutrition to population ecology to toxicology. This section will look at some of the conditions that led assimilative capacity, as one tenet of

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<sup>77</sup> Bowker, G. C. and S. L. Star (1999). *Sorting Things Out: Classification and its Consequences*. Cambridge, Mass., MIT Press: 14.

<sup>78</sup> Bowker 1999: 11.

pollution theory, as well as other theories of allowable limits, to become naturalized—that is, how it became a background premise of how the world worked, upon which new theories and practices could be built.

Since the fifteenth century, port managers had calculated the amount a ship could carry, and thus how much it owed in port duties, by tonnage.<sup>79</sup> In the mid-nineteenth century, port managers faced a problem. With steam powered engines replacing sails in seafaring vessels, part of a ship's area and weight was dedicated to weighty fuel and machinery. British statisticians set to work to find a formula for "carrying capacity" rather than tonnage to measure (and profit from) that which "[exceeded] what a person could directly observe."<sup>80</sup> Since that time, the concept of carrying capacity has been used in many contexts. Indeed, the term is often used interchangeably with assimilative capacity in pollution texts, for they are both about calculating and controlling "natural" thresholds.

In his history of carrying capacity, Nathan Sayre defines carrying capacity broadly as "the amount of X that Y was *designed* to carry."<sup>81</sup> Thus,

When carrying capacity was first applied to living organisms and natural systems, in the 1870s, it retained its literal sense of conveying or transporting some X, and was expanded to include animals and humans; subsequently, it was applied to such things as rivers and the wind.<sup>82</sup>

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<sup>79</sup> Sayre, N. F. (2008). "The Genesis, History, and Limits of Carrying Capacity." *Annals of the Association of American Geographers* 98(1): 122.

<sup>80</sup> Sayre 2008: 123.

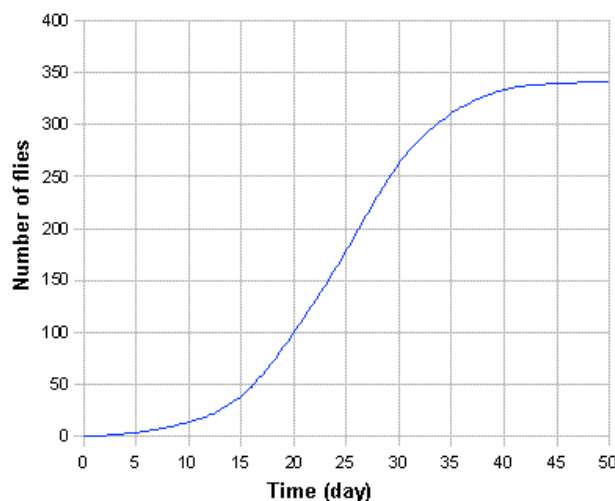
<sup>81</sup> Sayre 2008: 123. Emphasis in original.

<sup>82</sup> Sayre 2008: 123.

For grazing and land management, Y was a landscape, or even the entire earth, and X included animals—though mainly animals used for hunting, fishing, birding, and other human uses—and humans. Aldo Leopold, the celebrated American environmentalist and founder of the land ethic, used the concept of carrying capacity to manage wildlife areas:

When the maximum wild density of grown individuals attained by a species, even in the most favorable local environments, ... that maximum may be called the saturation point of that species.... It should be observed that while saturation point appears to be a property of a species, carrying capacity is a property of a unit of range.<sup>83</sup>

Leopold then managed a range based on its carrying capacity to develop "the art of making land produce sustained annual crops of wild game for recreational use." That is, he designed landscapes to carry a maximum load of animals. Like Streeter and Phelps, Leopold made the limits of nature apparent through the calculation of thresholds. Today, undergraduate biology students learn about the concept of carrying capacity with fruit flies in the laboratory.



In this graph, *drosophila* (flies) increase in population until they reach their carrying capacity, the point at which food and space become limited and the birth and

Figure 1.2: *drosophila* carrying capacity.

<sup>83</sup> Leopold, A. (1933). *Game management*. New York, London, C. Scribner's Sons: 50-51.

death rate even out. Here, Sayre's X, the thing carried or added to a system, in this case flies, is on the y-axis, and Sayre's Y, the ship, landscape, or in this case, glass jar, is implicit in the x-axis, the number of days flies spend in the jar. The flat line at the top of the graph marks the carrying capacity of the laboratory jar. The S-shape of this graph is called a sigmoid curve, which, as a genre of logarithmic curves, exhibits a progression that accelerates and approaches a climax or saturation point over time.<sup>84</sup>

A sigmoid curve is also foundational to toxicology, a field used to define the toxic thresholds of chemical pollutants. The classic dose response curve, pictured below,

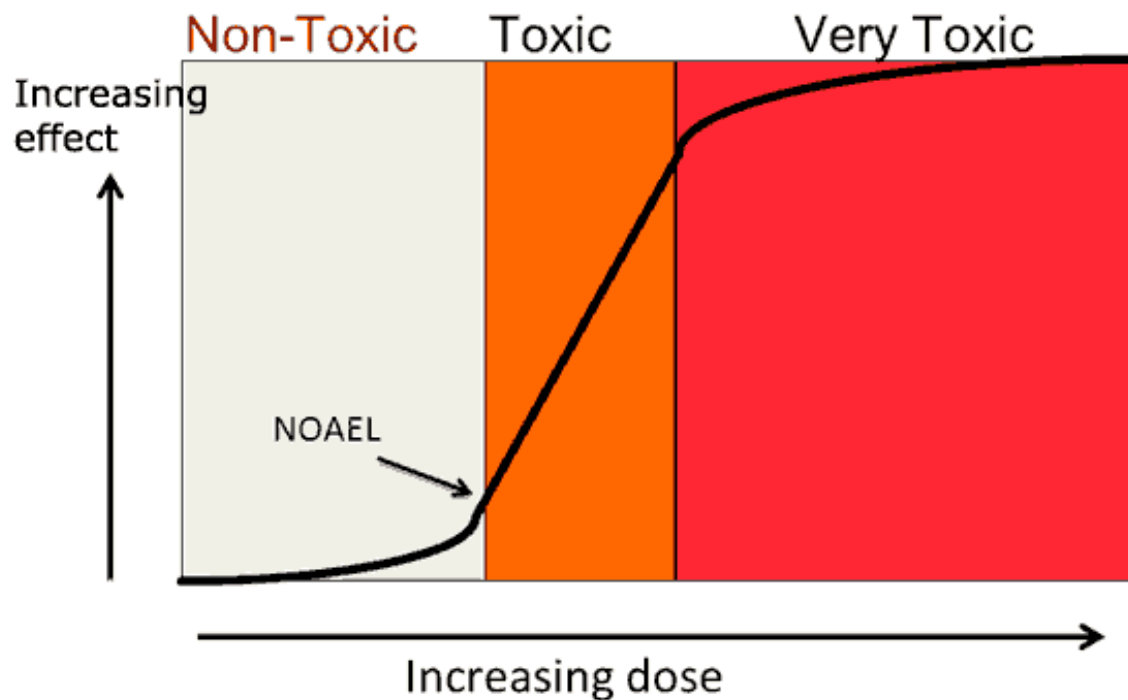


Figure 1.3: No Observable Adverse Effect Level (NOAEL) in toxicology.

<sup>84</sup> You might recognize these curves from Malthusian studies of human world populations, such as Ehrlich and Ehrlich's *The Population Explosion* (1990). The argument is that humans, X, also have a limit to growth based on the earth's (Y), carrying capacity. Ehrlich, P. R. and A. H. Ehrlich (1990). *The Population Explosion*. New York, Simon and Schuster.

shows how a dose of toxin results in increasing amounts of harm until the harm reaches a saturation point or the organism dies. There are two thresholds in this dose-response graph. The top of the S-shape is the threshold of maximum harm, but the lower part of the S-shape indicates the amount of toxin a body can handle before harm manifests.

The moment before harm becomes apparent is called the no observable adverse effect level (NOEL). Different toxins have their own distinct curves and NOELs, like toxic fingerprints, but all traditional dose-response curves have the same sigmoid shape. Since the time of Hippocrates (circa 400 B.C.E.), a maxim of toxicology is that the danger is in the dose, or that toxins are only harmful after a certain threshold (NOEL) has been surpassed.<sup>85</sup> In broad terms, it could be said that Streeter and Phelps calculated the NOEL of the Ohio River and used it as the line between pollution and non-pollution.

The sigmoid nature of toxicity is sufficiently law-like that the Environmental Protection Agency (EPA), responsible for writing and enforcing federal pollution regulations, based the allowable level of bisphenol A (BPA), a chemical commonly found in plastics, on the authority of the curve rather than on empirical data. In 1982, scientists within the U.S. Department of Health and Human Services' National Toxicology Program carried out "a series of experiments designed to determine whether selected chemicals produce

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<sup>85</sup> Gallo, M. A. (2008). "History and Scope of Toxicology." *Casarett and Doull's toxicology: the basic science of poisons*. L. J. Casarett, J. Doull and C. D. Klaassen. New York, McGraw-Hill: 1-4.



cancer in animals,"<sup>86</sup> including the chemical BPA. Rats were fed BPA at levels between 1,000 and 10,000 ppm. Scientists measured the rat's body weights, their mortality rate, and looked for cancerous cells. They found "no convincing evidence that bisphenol A was carcinogenic for F344 rats or B6C3F1 mice of either sex," but all treated rats exhibited reduced body weight compared to controls.<sup>87</sup>

The "[r]educd body weights in rats... was considered a direct adverse effect [a form of harm] of exposure to bisphenol A," by the Environmental Protection Agency (EPA), and so they used the study to determine a legislated "oral reference dose" (RfD) for the chemical.<sup>88</sup> That is, they determined a NOAEL for BPA. Oral reference doses (RfD), are structurally similar to assimilative and carrying capacities in that "thresholds exist for certain toxic effects" below which harm does not occur. Bodies can assimilate some chemicals, and this threshold, re-calculated to include differences between rats and humans, and expanded to anticipate uncertainty and sensitive populations such as children and the elderly, becomes the oral reference does (RfD), or lowest acceptable amount of the chemical that can be ingested safely.

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<sup>86</sup> National Toxicology Program. (1982). *NTP Technical Report on the Carcinogenesis Bioassay of Bisphenol A (CAS NO. 80-05-7) in F344 Rats and B6C3FX Mice (Feed Study)*. U.S. Department of Health and Human Services. Bethesda, Maryland, National Institutes of Health. NIH Publication No. 82-1771: ii.

<sup>87</sup> National Toxicology Program 1982: vii.

<sup>88</sup> Environmental Protection Agency. (1988). "Bisphenol A. (CASRN 80-05-7)." *Integrated Risk Information System*. Retrieved 4/16/12, from <http://www.epa.gov/iris/subst/0356.htm>.

The EPA based their threshold on the lowest dose used in the study (50 mg/kg/day), because though the study "failed to identify a chronic NOAEL for reduced body weight," the EPA was confident "that the NOAEL for reduced body weight in rats is probably not far below the [Lowest Observed Adverse Effect Level] LOAEL of 1000 ppm of the diet."<sup>89</sup> In short, they extrapolated a NOEAL from the lowest dose used in the study because they reasoned that the NOEAL was completely predictable based on a classic sigmoid curve. The EPA expressed "high confidence" in their practice of back-creating observations that have never taken place even though they express only "medium" confidence in the study itself "because this study, although well controlled and performed, failed to identify a chronic NOAEL for reduced body weight."<sup>90</sup> The maximum oral Reference Dose (RfD) for humans, still in use today, was set at 50 µg per kilogram of body weight per day. Let me reiterate: though there was no empirical evidence that showed when a dose of BPA began to harm rats, the EPA was highly confident in the sigmoid nature of toxicology curves to assume and then legislate the amount anyhow. Their confidence in the curve is the basis of the regulation designed to keep us safe today.

The structuring logic of the EPA's decision to estimate a No Observable Adverse Effect Limit (NOEAL) for BPA based on the study's lowest dose is the same logic of assimilative capacity and carrying capacity. Arguably, one of the reasons the Streeter-Phelps equation was canonized so readily was that the sigmoid nature of nature was already

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<sup>89</sup> Environmental Protection Agency 1988.

<sup>90</sup> Environmental Protection Agency 1988.

widely accepted at the time because of its use in other fields such as wildlife management, rangeland, and even nutrition.<sup>91</sup> In short, there was an epistemological premise to the way pollution was defined in the early twentieth century, and the Streeter-Phelps equation merely provided a finer resolution and a more exact calculus to define something that already presumably existed. What the studies across different disciplines made apparent is that nature is robust within limits, and these limits can be calculated, predicted, visualized on a graph, and thus managed.

In *Risk and Blame*, Mary Douglas describes “four kinds of myths about nature’s predictability” that emerge from empirical observations of human-environment interactions: nature is capricious, nature is fragile, nature is robust, and nature is only robust within limits.<sup>92</sup> For Streeter and Phelps, port managers, toxicologists, rangeland managers, the EPA, and undergraduates studying fruit flies in glass jars, empirical evidence points to nature being robust within limits. The “essential” “nature” of environments emerges through its perceived reactions to human intervention. That is,

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<sup>91</sup> Assimilative capacity was a term used in nutrition at the same time the conflict over water quality standards and definitions was occurring in the early twentieth century, where it referred to “the ability of the organism to convert the digested nutrients of the feed into body tissue.” I will not pursue this history here because while some studies quantified “the precise amount of carbohydrate which the patient can tolerate,” for example, no graphs or visualizations about the trend seem to have been created. The only collections of data about this kind of assimilative capacity in a visual form are charts of positive-negative cases where individuals with certain diseases had abnormal assimilative capacities rather than a quantification of those capacities. In this section I will focus on cases where both the concept of assimilative capacity and the quantification of assimilative capacity were central to the construction of natural thresholds.

<sup>92</sup> Douglas, M. (1992). *Risk and Blame: Essays in Cultural Theory*. London; New York, Routledge: 262.

nature's characteristics are apparent through pollution. An abundance of sewage, range animals, or a toxin shows an S-shaped nature, a nature of limits. Nature's thresholds and ability to absorb a degree of harm is demonstrated repeatedly and, is seemingly, universal. While carrying capacity, assimilative capacity, and No Observable Adverse Effect Levels might be measuring different things in different contexts, each appears to reaffirm that nature can tolerate abuse within limits, that these limits can be expressed in sigmoid curves, and so can be quantified, predicted, and thus managed.

#### The Technocratic Nature of Pollution

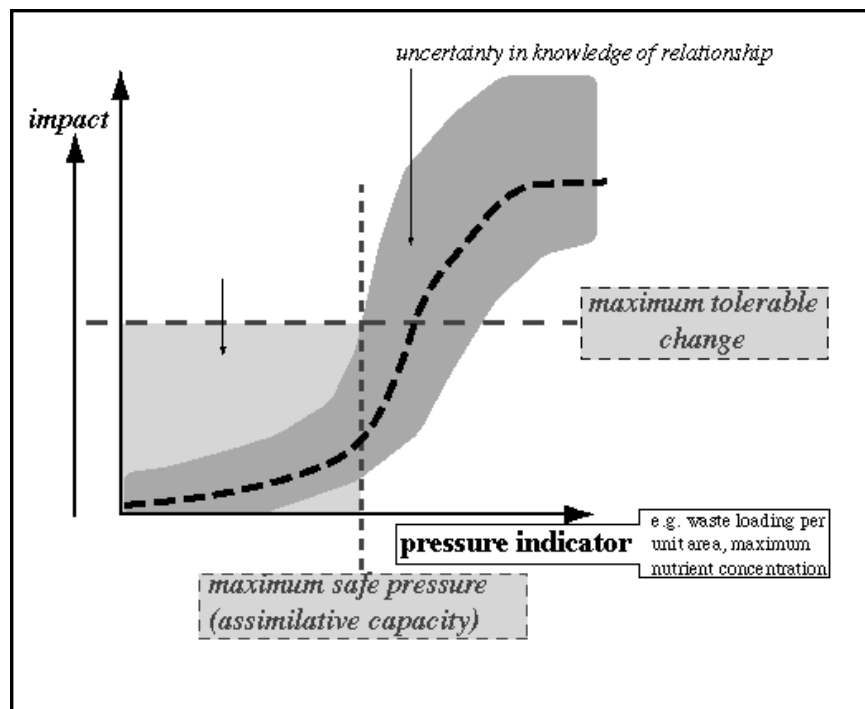


Figure 1.4: Assimilative capacity expressed as a sigmoid curve. The areas of interest for policy makers are, first, the maximum safe pressure (assimilative capacity), and secondly the light grey area beneath the point of maximum tolerable change, which is interpreted as a natural resource (the allowable amount of effluent that can be discharged). Image modified from Scasa Toolbox: <http://www.ecasatoolbox.org.uk>

When Swedish scientists and policy makers were struggling to create regulations for transnational acid rain in the 1990s, they expressed "a kind of relief ... when the concept [of critical load] was introduced into the CLRTAP [Convention of Long Range Transport of Air Pollutants]." One scientist recalls, "[w]hen the concept was introduced into the CLRTAP work, there was light."<sup>93</sup> The success of the concept of critical load, a Swedish synonym for assimilative capacity, was that "it is like a piece of wood where a nail can be fastened."<sup>94</sup> The final CLRTAP document begins with the statement that, "[n]ature can tolerate pollution up to a certain limit. A critical point is reached beyond which nature's own purifying capacity is trespassed."<sup>95</sup> The report's single goal is to identify that critical point so legislation, international cooperation, and regulation systems can be built around it.

One of the reasons assimilative capacity, carrying capacity, No Observable Adverse Effect Limits, and critical loads are "like [pieces] of wood where a nail can be fastened" within technocratic policy forums is because they appear as a law of nature or matter of fact, rather than a stakeholder opinion. They reflect facts rather than desires or human needs. This familiarity and universality reduces the need for discussions and consequently facilitates the policy-making process.<sup>96</sup> Policy conversations start after

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<sup>93</sup> Olsson, J. A. (2002). *Setting Limits in Nature and the Metabolism of Knowledge: The Case of the Critical Load Concept*. Tryckeri, LTAB Linkopings: 86. In Sweden, the quantity by which assimilative capacity is exceeded is called the Critical Load.

<sup>94</sup> Olsson 2002: 86.

<sup>95</sup> Olsson 2002: 77.

<sup>96</sup> Olsson 2002: 90.

Also see Hajer, M. A. (1995). *The Politics of Environmental Discourse: Ecological*

assimilative capacity or some other expression of natural allowable limits of pollution has already been established as true, and the proliferation of theories of pollution that characterized the late nineteenth and early twentieth centuries can be avoided.<sup>97</sup> Allowable limits of pollution became a given, and conversations focused on where those limits occurred and how they were to be used. That is, there was still controversy in technocratic circles about what pollution was, but this conversation was restricted to definitions that included assimilative capacity, natural thresholds, and allowable limits.

At the 1960 National Conference on Water Pollution, the first convention in the United States that brought scientists, engineers, politicians and industry representatives together—a truly technocratic gathering— delegates tried to agree on the familiar problem of how to recognize and regulate pollution. While the proceedings of the National Water Conference on Water Pollution are full of disagreements about the best way to define water pollution and arguments concerning methods for managing

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*Modernization and the Policy Process*. Oxford, New York, Clarendon Press; Oxford University Press.

<sup>97</sup> Because of this use of nature in politics, Bruno Latour emphatically states that “[t]here has never been any other politics than the politics *of* nature, and there has never been any other nature than the nature *of* politics.” He means that nature and politics have often been articulated at separate bodies, but nature has often been used to abort political discussions by positing objective facts beyond dispute and beyond ideology, which politics ought to emulate, follow, or at least accept and move on. By claiming to be outside of culture, politics, and stakeholder opinions, statements about nature guide culture, politics, and decisions that affect stakeholders. This is the crux of Latour’s argument in *The Politics of Nature*, as well as in much science and technology studies generally, particularly when science and nature become synonymous. The use of the authority of nature (and science) to assert indisputable facts will be challenged in “Plastics in Publics,” chapter three.

Latour, B. (2004). *Politics of Nature: How to bring the sciences into democracy*. Cambridge, Mass., Harvard University Press: 28. Emphasis in original.

pollution, the diverse cascade of principles and definitions of pollution put forward in similar forums at the turn of the nineteenth century are entirely absent, and assimilative capacity plays a central role. Overall, delegates agreed that:

Standards of cleanness should be established with due regard to:

- (a) Assimilation capacities of waters receiving pollution.
- (b) Realistic appraisals of waterway uses and applicable standards of cleanness.
- (c) Realization that dollars are important and that expenditures must be warranted by needs and benefits.<sup>98</sup>

Discussions then focused on what “due regard” might look like for various interested parties, from environmentalists to industry representatives. Assimilative capacity, “best use” and cost efficiency (and profits) are already foundational to the model of pollution control people were there to discuss. This stabilization of the range of disagreements, from what pollution meant in the early twentieth century, to “a classification system designed to serve the purposes of evaluation,... [to] evaluate benefits and costs [of pollution control] in a systematic manner”<sup>99</sup> in 1960 is the result of fifty years of pollution definition by American technocracies. While there was still debate, it occurred within a narrow range of meanings.

Twentieth century definitions of pollution, and particularly assimilative capacity and other expressions of allowable limits, are essentially technocratic. The techniques used to define pollution within such a technocracy privileged ways of “seeing like a state,” a phrase developed by James Scott in his book by the same title. According to Scott, the bounding, essentializing, and quantifying simplifications characteristic of technocratic

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<sup>98</sup> U.S. Department of Health, and Welfare. (1960). *Proceedings The National Conference on Water Pollution*. U.S. Department of Health, and Welfare. Washington, D.C.: 585.

<sup>99</sup> U.S. Department of Health, and Welfare 1960: 115.

definitions are “the basic givens of modern statecraft,” a way to slice up nature’s complexity in a manner that creates things that meet the needs and logics of the state, but exclude other aspects. According to Scott, technocratic logic is based on what he calls “a high-modernist ideology,” which:

is best conceived as a strong, one might even say muscle-bound, version of the self-confidence about scientific and technical progress, the expansion of production, the growing satisfaction of human needs, the mastery of nature (including human nature), and, above all, the rational design of social order commensurate with the scientific understanding of natural laws.<sup>100</sup>

This is how science, technology, governance, and industrial capitalism are bound together. Though Scott does not use pollution control as a case study in his book, it is a prime example of a phenomenon born of a high-modernist ideology. State governance of pollution, at least in aspects based on allowable limits and natural thresholds covered here, is a “rational design of social order commensurate with the scientific understanding of natural laws,” specifically natural laws that demonstrate robustness within limits. Pollution control is social (and always has been) because it is a normative practice. It defines what pollution is and how it works, but at its core it is an activity that states what ought and ought not be done, where, and by how much. While human history is full of examples of “pollution control” practices, setting quantitative guidelines for allowable limits of pollution is a unique modern approach.<sup>101</sup> The state that Scott considers is a technocratic state, one that must referee between competing interests

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<sup>100</sup> Scott, J. C. (1998). *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed*. New Haven, Yale University Press: 4.

<sup>101</sup> Douglas, M. (1984). *Purity and Danger: An Analysis of Concepts of Pollution and Taboo*. London, Ark Paperbacks.



and therefore make problems legible to different groups, but which always already prioritizes cost efficiency and profit.

The goals of early governmental definitions of pollution, remember, were staked in finding an allowable limit of pollution given state practices of dumping sewage and regulating pollution while trying to appease both citizens and industry. Properties that met these needs, including the quantification of self-purification, were sought out and circulated via techniques of definition that worked well within the technocracy. The result of this particular technocratic ordering of nature is that nature is made apparent as something robust within limits, where "too big a push risks sending it [the biosphere] over the edge of the containing frame. This is the myth to encourage risk-averse planning controls, government intervention, [and] restriction on the market."<sup>102</sup> A sigmoid-shaped nature produced within a technocracy is the type of nature that needs legislation in the first place.

#### The Economic Nature of Pollution

Another hallmark of technocratic techniques of definition is creating units that are easily legible and circulate well in an economic system. That is, pollution is an economic object. When assimilative capacity is expressed as a quantity, and, as the Wisconsin Department of Natural Resources employee states, that quantity is "allocated among

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<sup>102</sup> Douglas 1992: 263.

dischargers,"<sup>103</sup> then polluters can calculate the dollar amount such a resource is worth to them. How much money does a factory save by putting a certain amount of pollution in the river as opposed to having to clean the effluent before dumping it? The boon of assimilative capacity can be calculated as a dollar amount, as a cost efficiency, as a contributor to profit. This isn't to say that pollution is merely legible in economic systems, but that pollution is inherently economic, as it has been part of an industrial ecosystem with profit as its goal since allowable levels were settled on as the dominant meaning of pollution at the turn of the century. Thus, discussions about pollution are always already rooted in economic values and calculus.

The concept of an industrial ecosystem is foundational in Daniel Schneider's work in *Hybrid Nature: Sewage Treatment and the Contradictions of the Industrial Ecosystem*, where "the metabolic processes of an ecosystem are exploited to extract resources such as food, fabrics, pharmaceuticals, or fuel,"<sup>104</sup> or, in the words of geographer Morgan Robertson, it is "the apprehension of ecosystem processes as metabolisms through a new calculus of value."<sup>105</sup> Nature provides a sort of ecosystem service that industry depends upon. Industrial ecosystems are not theoretical—they are part of an ongoing practice of pollution control: "the purification capacity of a stream might best be defined as the working capacity for removal of dissolved and suspended solids (both

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<sup>103</sup> Christianson, R. (1979). "Wisconsin's Approach to Developing Waste Load Allocations." *Water Pollution Control Federation* 51(3): 630.

<sup>104</sup> Schneider 2011: xvi.

<sup>105</sup> Robertson, M. (2011). "Measurement and alienation: making a world of ecosystem services." *Transactions of the Institute of British Geographers*: 3.

organic and inorganic)... quantified where possible."<sup>106</sup> Nature becomes an industrial worker. According to one bacteriologist working in the mid twentieth century, bacteria "worked for free, took no breaks, and never struck."<sup>107</sup> Metabolism becomes a type of value-producing labour, legible to the economic value systems industry and governments depend upon. In *The Proceedings of the 1960 National Conference on Water Pollution*, Leonard Pasek of the Kimberly-Clark Corporation states that, "[t]o a very substantial extent, American industry—and thereby our economy—has been built upon the base of that valuable economic asset, the ability of our great waterways to dilute, assimilate, and carry away industrial wastes."<sup>108</sup> This logic of natural-economic asset was in place before Streeter and Phelps were sent to the Ohio River. It set their research agenda and their decision to focus on measuring the self-purification rate of the river rather than the amount of organic waste per se. It was part of their apparatus, and so part of the phenomenon of biological oxygen demand. It remains part of pollution legislation and discourse today.

### Dissent, or Not

Within technocratic circles, there is dissent about the use of nature made by industry. Yet, even those who disagree with polluting practices based on assimilative capacity have found solutions within a technocratic logic that maintain the primacy of allowable limits. Some policymakers and politicians, along with environmentalists, have fought

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<sup>106</sup> Lueck, B. F., A. J. Wiley, et al. (1957). "Determination of Stream Purification Capacity." *Sewage and Industrial Wastes* 29(9): 1055.

<sup>107</sup> Schneider 2011: 26.

<sup>108</sup> U.S. Department of Health, and Welfare 1960: 549.

against using the full assimilative capacity of a waterway, even though within the definition of assimilative capacity this would not cause harm. A committee at the National Conference on Water Pollution “express[ed] its conviction that the goal of pollution abatement is to protect and enhance the capacity of the water resource ... and that this goal can be approached only by accepting the positive policy of keeping waters as clean as possible, as opposed to the negative policy of attempting to use the full capacity of water for waste assimilation.”<sup>109</sup>

This is a different definition of pollution whereby any addition of industrial or urban human-made effluents is unacceptable. As a consequence to this view, non-degradation policy arose to preserve water that had not yet reached its maximum allowable limit of contamination. Non-degradation policy “is a type of broad-gauge ambient standard under which the minimum [amount of allowed pollutant] is based ... on a historic baseline of actual resource quality.”<sup>110</sup> In other words, non-degradation policy aims to keep water as close to its pre-industry state of purity as possible in explicit opposition to using its assimilative capacity to dispose of waste even though staying within a river’s assimilative capacity is not supposed to result in pollution. While non-degradation policy uses a different “arbitrary line” of what counts as harm—the current or historical levels of pollution rather than an assimilative capacity threshold—it does not question assimilative capacity or the status of “the area under the graph” (see Figure 1.4, above) as a natural resource. In fact, non-degradation policy reifies the area under the graph as

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<sup>109</sup> U.S. Department of Health, and Welfare 1960: 564.

<sup>110</sup> Himes, N. W. (1976). "A Decade of Nondegradation Policy in Congress and the Courts: The Erratic Pursuit of Clear Air and Clean Water." *Iowa Law Review* 62: 645.

an ontological thing to be preserved. An article in the *Iowa Law Review* written in 1977 explains that nondegradation policy “serves as the pollution control analogue to wilderness preservation in public lands management.”<sup>111</sup> Non-degradation policy, while attempting to protect waterways from any sort of pollution, solidifies the bounded, reductive, quantified logic of technocratic pollution. That is, it reestablishes the “arbitrary line” by arguing that it should be used in a different way.

Defining a problem a certain way leads to some solutions being feasible, or even thinkable, and others not. In the technocratic approach to pollution control, alternative definitions of pollution, types of pollution control, and even natures have been left aside. The impetus for Scott’s work on *Seeing Like a State* is that despite best intentions and rigorous definitional campaigns, many state projects to control and improve natural and social environments have led to unqualified disasters through the mis-definition or over-simplification of problems and environments. Today there is a growing unease about the effectiveness of current pollution control measures, despite the technocratic problem-solving ethos guiding new initiatives. In the case of plastic pollution, the ineffectiveness is stark. Every American state-sponsored effort to solve plastic pollution has failed to mitigate or even address the issue. Recycling drives, prohibiting ocean dumping, beach clean ups, “safe” BPA-free plastics, and asking consumers to “vote with their dollars” for plastic alternatives have not stemmed the flow of plastic or the harms it causes. Plastic pollution exceeds technocratic logics of allowable limits, thresholds, assimilative capacity and industrial ecosystems, and so defies usual practices of

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<sup>111</sup> Himes 1976: 645.

pollution control. Plastics constitute a different type of pollution, and therefore require a different ethos of pollution control, and even point to a different type of nature, one that is not robust within limits. This is the plastics problem.

### III. THINGS FALL APART: REDEFINING POLLUTION THROUGH PLASTICS

For the Snark's a peculiar creature, that won't  
Be caught in a commonplace way.  
Do all that you know, and try all that you don't:  
Not a chance must be wasted to-day!

- *The Hunting of the Snark (An Agony in 8 Fits)*  
by Lewis Carroll, 1874

Turning and turning in the widening gyre  
The falcon cannot hear the falconer;  
Things fall apart; the centre cannot hold;

- *The Second Coming*  
by William Butler Yeats, 1919

In light of plastics, definitions of pollution developed since the early twentieth century fall apart. Their center, their “essences... obtained by [technocratic] institution[s] at the end of an explicit process that gives them durability and indisputability by attaching attributes to their substance”<sup>112</sup> can no longer hold. This relatively short chapter will look at the material characteristics of plastic pollution that make it such an “impossible” problem, and specifically at how plastics defy dilution, metabolization, quantitative thresholds, and linear cause and effect relationships foundational to technocratic definitions of pollution. Plastics move knowledge away from concrete, understood, and well-measured matters of fact towards less known, less bounded, elusive systems of influence that challenge not only practices of pollution control that have worked (at least in theory) for a century, but also broader theories of what pollution is and how it works.

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<sup>112</sup> Latour, B. (2004). *Politics of Nature: How to bring the sciences into democracy*. Cambridge, Mass., Harvard University Press: 241.

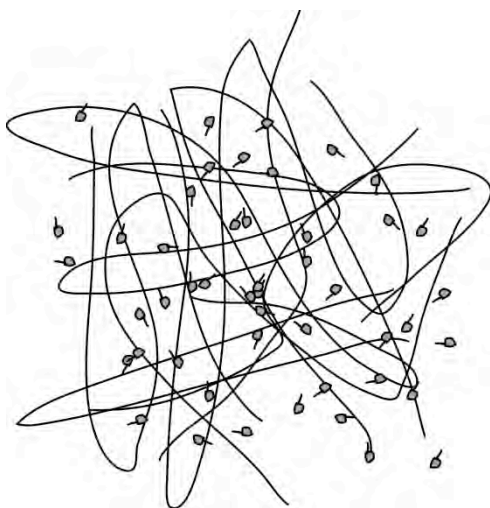


Figure 2.1: Long polymer strands with plasticizers nestled among them. Diagram by the author.

### Introducing: Plastics

Plastics pollute in a unique way because of their materiality. Plastics are made of long, strong polymer chains. Polymers are chains of hydrogen, carbon, and often one other molecule (hydrocarbon chains) with

incredibly strong bonds between them. All plastics are polymers, but not all polymers

are plastics. Natural polymers include horn, hair, wool, DNA, and proteins, all of which are biodegradable. The first synthetic polymer was Bakelite, developed in 1907.<sup>113</sup> Like other plastic polymers, Bakelite is made from petrochemicals—in this case, coal—and its polymer bonds do not biodegrade. These staunch polymer bonds are the reason plastics do not corrode or biodegrade, and why plastic products can be thin and light, yet strong. Their molecular strength make plastics long-lived and able to travel long distances. Sunlight is one of the few ways the bonds can weaken over time, though this may take hundreds of years. In landfills or ocean bottoms without light, plastics can last in geological timeframes. That is, plastic polymers are forever.<sup>114</sup>

However, hydrocarbon polymers by themselves often do not meet all the needs of plastic goods. Pure polyvinyl chloride (PVC), the plastic used in most shower curtains, for

<sup>113</sup> Celluloid was developed before Bakelite, but as it is a biodegradable polymer like hair or horn, it is not considered synthetic.

<sup>114</sup> Weisman, A. (2007). "Polymers are Forever." *Orion* (May/June). Retrieved 9/25/12, from <http://www.orionmagazine.org/index.php/articles/article/270/>.



example, is a white, brittle solid that does not possess the flexible, soft, mould-resistant, flower-patterned qualities of a shower curtain. To make many plastics more supple, fire retardant, purple, and countless other qualities, chemicals called plasticizers are added, such as bis(2-ethylhexyl) phthalate (DEHP), bisphenol A (BPA), or polychlorinated biphenyls (PCB), three of thousands of examples. These plasticizers cannot bond to the polymers on the molecular level— this would change and weaken the strong bonds that characterize polymers and would cease plastics from being plastic. Instead, plasticizers nestle among the polymers strands. This loose affiliation means that plasticizers leave their plastic hosts fairly easily. They off gas and leach, and eventually end up in water tables, soil, air, and bodies. There are plasticizers in every body in the world, and plastics in every ocean in the planet. The longevity of plastic polymers and the promiscuity of plasticizers allow them to enter bodies and ecosystems, where their materiality causes unusual things to happen.

Drawing on scientific articles in marine science, oceanography, toxicology, endocrinology, and environmental health as primary source material, this chapter describes these “unusual things” and what they mean for definitions of pollution. First, I will look at how plastics in the ocean not only defy, but also complicate the processes of metabolization and dilution upon which assimilative capacity depends. Plastics become more dangerous, rather than less, when taken up in bodies and ecosystems or diluted in waterways, making traditional pollution control measures potential sources of pollution. Moreover, because diluted and assimilated plastics cause harm, the threshold model of pollution developed in the twentieth century and its differentiation between

contamination and pollution no longer holds. The threshold model is further troubled by the second part of the chapter, which concentrates on plasticizers that enter endocrine, or hormone systems. Plasticizers actively engage with—and disrupt—hormone systems in many animals, including humans. Endocrine disruptors do not have the same kinds of thresholds of harm such as No Observable Adverse Effect Levels (NOEALS) established to differentiate between pollution and non-pollution, and in fact have the greatest effects at the lowest doses. The chapter concludes with how a ubiquitous, threshold-less form of pollution exceeds a nature that is robust within limits. Instead, I offer other ways to think about how plastics interact with bodies and ecosystems “in the wild.”

## Ocean Plastics

### Assimilation Undone

The inshore marine environment ... has the capacity to receive a certain amount of waste discharge without damage to its other uses and in fact a valuable and legitimate use of the near shore marine environment is as a diluting and assimilating environment for waste materials, provided these are introduced within the capacity of the environment. By capacity is meant a rate of introduction which will not result in degradation from the standpoint of other uses, such as fishing and recreation.<sup>115</sup>

- United Nations Secretary-General, 1968

Like Streeter and Phelps, and other technocrats covered in the last chapter, the United Nations Secretary-General champions assimilative capacity, the quantity of pollutant an ecosystem can handle, and therefore the amount humans and industry can pollute before causing harm. The ocean—or “inshore marine environment”— is a great gift to

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<sup>115</sup> N.A. (1968). “Marine Science and Technology: Survey and Proposals, Report of the Secretary-General.” In Gorman, M. (1993). *Environmental Hazards: Marine Pollution*. Santa Barbara, Calif., ABC-CLIO: 129.

pollution control because of its vast assimilative capacity. As the UN Secretary-General mentions, the mechanics of assimilative capacity are two fold. First, there is assimilation, which is another word for metabolization. The microbes, plankton, plants, and fish “eat” pollution and turn the chemicals into less harmful metabolites. Secondly, there is dilution. Since the danger of toxins reside in their dose, massive bodies of water disperse the pollutant so even unmetabolized chemicals are not harmful. Neither of these concepts, foundational to assimilative capacity and pollution control, apply to ocean plastics.

There is a common misconception that ocean plastics have formed a roaming, plastic island. But there is no island. When scientists from the Algalita Marine Research Foundation returned from the North Pacific Ocean in 2000 after measuring plastics for the first time, they used the metaphor of an island to evoke the scale and density of plastics they found. The media took the metaphor literally and ocean plastic activists have been fighting the “plastic island” ever since. There have been countless suggestions for third parties to tow, mine, and clean up the plastic island, but none of these actions are appropriate for how ocean plastics pollute. Rather than an island, scientists found that most ocean plastics are less than five millimeters in size. These are called microplastics. They are created when sunlight causes plasticizers to off gas or leach, and, as a result, the plastic returns to a more brittle, pre-plasticized state. Thus, microplastics are plastic polymers with fewer plasticizers. These microplastics, along with macroplastics such as abandoned fishing gear, lost buoys, and motorcycles floating in the wake of the Japanese tsunami, are unevenly dispersed throughout the water

column, floating and suspended amongst the plankton. Ocean plastics are more of a soup than an island.

Ocean plastics are unevenly distributed both locally and globally. About half of all plastics are denser than water, and sink, while half float. We know little about plastics on the ocean floor because submersible technology and methodologies are disproportionately expensive, time-consuming, and cover smaller areas compared to what is available to investigate floating plastics. We know that plastics are on many, perhaps even most or all seafloors, and that they are more concentrated in harbours and near shores.<sup>116</sup> Floating plastics are a somewhat different story. In the center of each of the world's five oceans, water cooled by air streams sinks and draws surface water downward, fueling a massive, slow-moving circular current. These currents are called gyres. As water cools and drops at the center of these gyres, anything floating in the water is left on the surface. This process results in the accumulation of floating debris, like plastic, in the center of each ocean. The North Pacific Gyre, the first area of extensive plastic pollution research, has been nicknamed "the garbage patch" because of its concentration of floating plastics.

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<sup>116</sup> Claessens, M., S. D. Meester, et al. (2011). "Occurrence and distribution of microplastics in marine sediments along the Belgian coast." *Marine Pollution Bulletin* 62(10): 2199-2204.

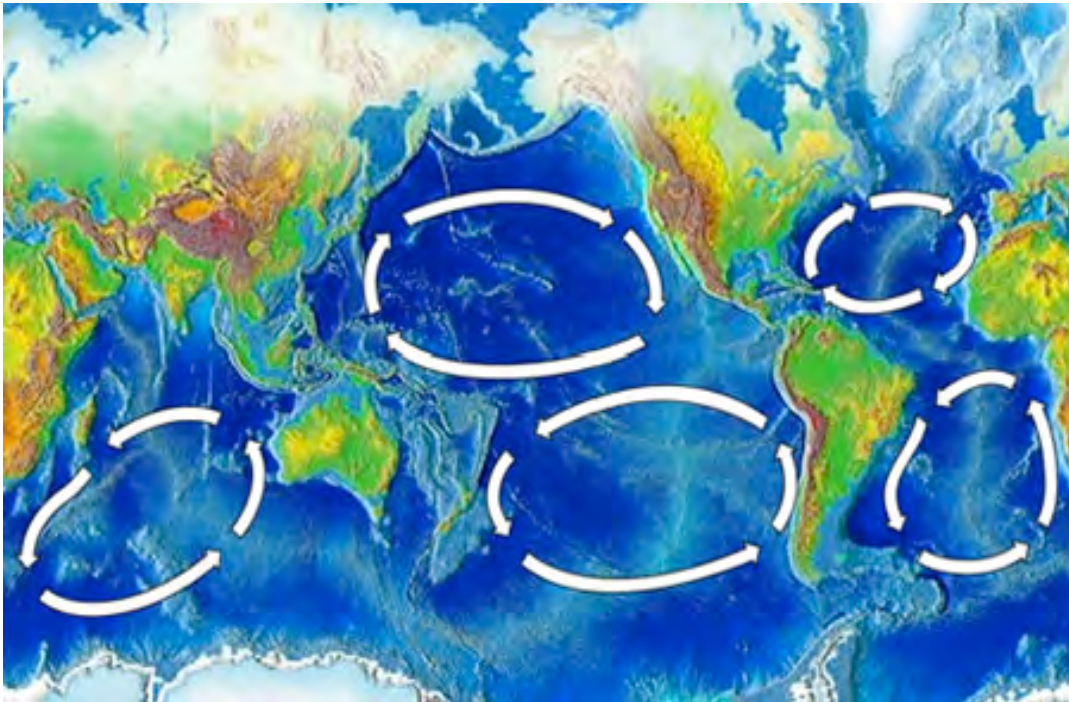


Figure 2.2: Location of the world's oceanic gyres. Image from 5gyres.org.

While sedimentary and floating plastics are dispersed unevenly over the planet, they are also inextricable from their local environments. Microplastics are mixed with sand. Floating plastics do not float on the top of the water so much as they bob below the surface at different heights amongst the plankton and the fish. Within the UN Secretary-General's frame of the ocean as a diluting and metabolizing resource, this does not seem to be a problem. In fact, the assimilation of plastics into the environment is the basis of industrial ecosystems. But there is a problem. Plastics assimilate too much and not at all.

### Assimilation Gone Awry

Far off the coast of British Columbia, an employee of the North Pacific Flying Squid Fishery is confused. He is hauling in the deep-sea nets used to catch flying squid. Among the squid, a single, bright yellow, bottle-nosed fish punctuates the catch.<sup>117</sup> Such fish live in reefs. But this is the deep, open ocean. How did it get there?

Thousands of miles away, near a completely different ocean in Cornwall, UK, scientists are watching to see if mussels will eat the particles of polystyrene in the laboratory aquarium. Not only are they ingested, the "particles of polystyrene translocated from the gut cavity to the circulatory system in as little as 3 days and persisted in the circulatory system for over 48 days."<sup>118</sup>

Not far from the Cornwall lab, a beachcomber kicks through the sand, noting that some of the grains are light blue. She bends down to pick some up. Why is the sand blue, she wonders?

The juxtaposition of the UN Secretary-General's statement about the "valuable and legitimate use of the near shore marine environment is as a diluting and assimilating environment for waste materials" and the above vignette of near and far shore ocean experiences (and experiments) hints that something is amiss with assimilative capacity. Something is not lining up. The basis of assimilative capacity is metabolism and dilution. Nature's metabolism is integral to the industrial ecosystem, where nature can handle industrial effluents through assimilation. This metabolism is what Streeter and Phelps' Biological Oxygen Demand (BOD) measured in the last chapter. Dilution is also necessary, for too much effluent in too high a concentration can overwhelm an ecosystem and cease the metabolic process. The ratio of effluent to substrate is what

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<sup>117</sup> Moore, C. (2011). "Lecture and Book Release: Plastic Oceans with Captain Charles Moore." New York University, presentation, 11/3/12. The reef fish in the Flying Squid nets is a story Moore told during his presentation on ocean plastics.

<sup>118</sup> Browne, M. A., A. Dissanayake, et al. (2008). "Ingested Microscopic Plastic Translocates to the Circulatory System of the Mussel, *Mytilus edulis* (L.)." *Environmental Science & Technology* 42(13): 5028.

makes something a harmless contaminant or a harmful pollutant. As the adage goes, "the solution to pollution is dilution." Yet, in the stories above, dilution, metabolism, and assimilation have been disrupted. Blue plastic sand seems to meet some of the criteria of dilution, and perhaps assimilation, but probably not metabolism. What is plastic doing to these foundational tenets of pollution control?

First, let's consider assimilation. The Oxford English Dictionary contains two definitions for assimilation: "[t]he action of making or becoming like; the state of being like; similarity, resemblance, likeness," and "[c]onversion into a similar substance; esp. the process whereby an animal or plant converts extraneous material into fluids and tissues identical with its own."<sup>119</sup> In the scenarios above, plastics have "become like" natural objects. Floating plastics "become like" reef habitats, and a reef fish, usually confined to near shore environments, is able to live within the Flying Squid Fishery's territory in the middle of the North Pacific.<sup>120</sup> Smaller fragments of plastics under five millimeters in size called microplastics "become like" food for fish and mussels, and then "become like" blood, and they circulate for forty-eight days. Microplastics "become like" sand, and mesh with sediments on beaches and the ocean floor. Ocean plastics have become like habitat, like food, like blood, like sand. They seem to have assimilated, according to the OED's first definition.

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<sup>119</sup> (2012). "Assimilation." *Oxford Dictionaries*, Oxford University Press. Retrieved 9/7/12, from [www.oed.com](http://www.oed.com).

<sup>120</sup> Gregory, M. R. (2009). "Environmental implications of plastic debris in marine settings: entanglement, ingestion, smothering, hangers-on, hitch-hiking and alien invasions." *Philosophical Transactions of the Royal Society B: Biological Sciences* 364(1526): 2013-2025.

But of course they have not assimilated according to the second definition. They have not been "[converted] into a similar substance." The strength of synthetic polymer bonds means that rather than breaking down into their constituent molecules or metabolites, plastics fragment into smaller and smaller microplastics, which still exhibit all the molecular structures and characteristics of plastics.<sup>121</sup> The blue grains of sand and the tiny bits of polystyrene ingested by mussels are plastic, through and through. They are not metabolized.

This is the problem with ocean plastics: they have assimilated too much, yet not at all. As the UN Secretary-General suggests, the marine environment dilutes wastes that originate on land through waterways, sewer drains, and breezes.<sup>122</sup> The ocean is downhill from everything, and light, waterproof plastics can travel long distances. The oceans become the world's largest sink. Yet, the result is a worldwide synthetic soup, not the full assimilation of plastic contaminants as the UN Secretary-General anticipates. Dilution without metabolism is merely accumulation. Rather than assay harm, the dilution plastics instigate harm.

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<sup>121</sup> Andrady, A. L. (2011). "Microplastics in the marine environment." *Marine Pollution Bulletin* 62: 1596-1605.

<sup>122</sup> More than eighty percent of ocean plastics come from land. Moore, C., G. L. Lattin, et al. (2011). "Quantity and type of plastic debris flowing from two urban rivers to coastal waters and beaches of Southern California." *Journal of Integrated Coastal Zone Management* 11(1): 65-73.



The types of harm ocean plastics engender depends on their size. Larger pieces of plastic, or macroplastics, including lost or abandoned fishing gear called “ghost nets” entangle and choke marine life, drowning them, even as they also provide floating habitats for other biota. Many of these “hitchhiking” animals and plants find their way to isolated island ecosystems, often becoming invasive species.<sup>123</sup> Microplastics have their own perils. They increase chemical toxicity and decrease oxygen transfer in the sediment, poisoning and choking organisms that live there.<sup>124</sup> Microplastics and plastic bags “become like” food and are eaten by half of the world’s marine species, from whales to plankton, but they are not enough like plastic that they can be digested. Some microplastics are small enough to pass through the digestive system and back into the ocean, but often they stay in the digestive tract and accumulate, causing discomfort, disability, and even death for the animal. In some places in the ocean, including the Flying Squid Fishery’s territory, plastics outweigh food stocks by six to one, meaning there is six times more food-like plastic than food.<sup>125</sup>

Though plastics are diluted in the ocean, they also work against dilution. Water-borne plastics can absorb up to one million times more toxins than the surrounding water because oily (hydrophobic) chemicals are repelled by water and are attracted to

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<sup>123</sup> Gregory 2009.

<sup>124</sup> Gregory 2009.

<sup>125</sup> Moore, C., S. L. Moore, et al. (2001). "A Comparison of Plastic and Plankton in the North Pacific Central Gyre." *Marine Pollution Bulletin* 42(12): 1297-1300.

plastics.<sup>126</sup> Microplastics are usually coated in toxins, leading oceanographers to nickname ocean microplastics “poison pills.” When plastics are ingested by marine life, harm comes from mechanical effects of plastic such as feeling full and not eating, choking, gastrointestinal blockage and puncture, but there is also chemical harm. The individual animal is dosed with toxins. Some chemicals become concentrated at the top of food chains through a series of prey-predatory relationships, where predators ingest both their prey and the toxins the prey carries. As predators eat large numbers of toxic prey, the toxins move from the food to its own tissues. If the predator is also the prey for another animal, the toxins become more concentrated still. This process is called biomagnification. Natives with traditional diets that include marine mammals such as seals and whales are at the top of long marine food chains. Polar bears and Greenland Natives are the most contaminated beings in the world, though there are no major sources of pollution in the far north.<sup>127</sup> Ocean plastics enable this accumulation.

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<sup>126</sup> Mato, Y., T. Isobe, et al. (2001). "Plastic Resin Pellets as a Transport Medium for Toxic Chemicals in the Marine Environment." *Environmental Science & Technology* 35(2): 318-324.

<sup>127</sup> Cone, M. (2005). *Silent Snow: The Slow Poisoning of the Arctic*. New York, Grove Press.

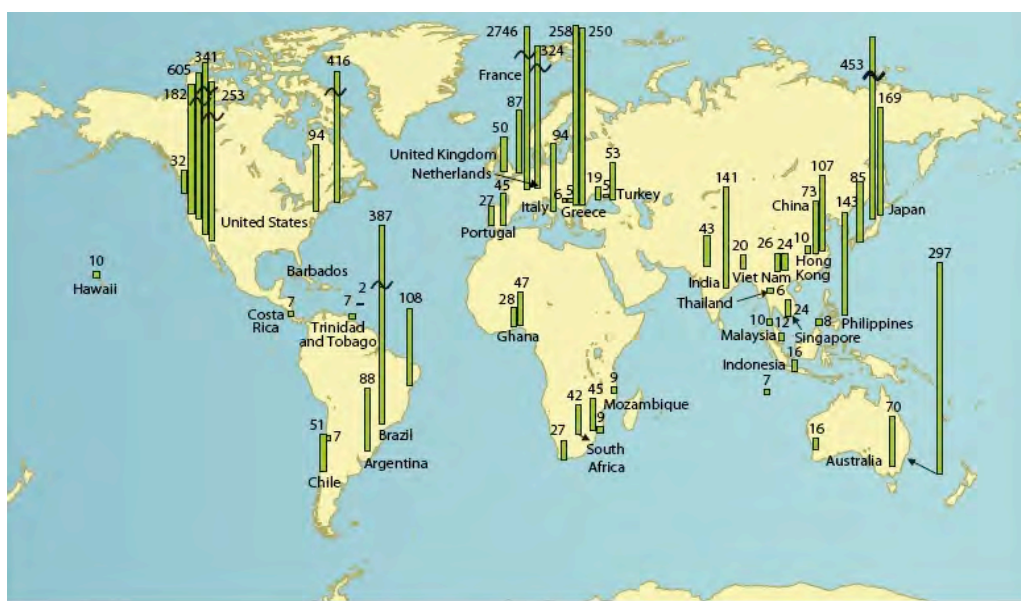


Figure 2.3: Concentration of PCBs, a hydrophobic chemical, on beached plastic pellets (nanograms/gram of pellet). Source: Ogata et al. (2009) with addition information by International Pellet Watch (2010).

### Plastic Travels

Biomagnification is only one path that plasticizers and other pollutants take to the far north. Plastics off-gas in homes, offices, manufacturing sites, and outdoors. Every winter, a high-pressure air system sweeps from the east coast of North America across the Atlantic Ocean and into Greenland. At the same time, air originating in mainland Europe is pushed into its high Arctic: "In a matter of days or weeks, chemicals that originated in the cities of North America and Europe are contaminating the Arctic's air. When they reach the cold air, they condense and drop into the ocean or onto the frozen ground, where they are absorbed by plants, then animals [then people]. The colder the ocean and the air, the slower the natural process of decomposition, so most of the

chemicals in the Arctic remain there."<sup>128</sup> Some plasticizers, such as those used in polyvinyl chloride (PVC), are persistent organic pollutants (POPs). POPs are classified by their lack of discernable half-life, the ability to bio-accumulate, high toxicity, and the tendency to travel long distances. Like buried plastic, POPs exist in geological time. Over the next few thousand years, POPs will concentrate in the north, just as plastics will accumulate in the oceans. This longevity, toxicity, and propensity to travel and accumulate in remote, "pure" landscapes are what POP plasticizers and ocean plastics have in common as pollutants.

We have followed plastics and plasticizers around ocean gyres, into the blood of mussels and up to the Arctic, but how do plastics reach the ocean in the first place? Contrary to early activism and legislation in the 1980s that focused on ocean dumping and beach litter, an intuitive connection premised on the proximity of pollution source and pollution, scientists have found that more than eighty-five percent of ocean plastics originate inland.<sup>129</sup> The miracle of plastic is its combination of light weight, strength, durability, and cheapness. The low cost of producing plastics means that many plastic products, notably single-use packaging, enter the waste stream immediately after use. The majority of plastic pollution is disposable packaging. These disposables wash out of or blow away from waste bins, streets, transfer stations, trucks, landfills, and other solid waste infrastructure. The ocean is downhill from everything. While around ten percent

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<sup>128</sup> Cone 2005: 165.

<sup>129</sup> Moore, C., G. L. Lattin, et al 2001.

of municipal solid waste is plastic, over eighty percent of beach waste is plastic.<sup>130</sup> Ocean plastics are not a litter problem. That is, they do not result from bad consumer behaviour, but from an entire industrial and commercial infrastructure. In fact, ten percent of all ocean plastics are raw plastic production pellets called "nurdles" that come from the manufacturing process.<sup>131</sup> Even if all litter stopped tomorrow, all plastics were placed in recycling bins, and everyone brought reusable bags to the grocery store, ocean plastics would not be reduced due to the longevity, ubiquity, continued creation of plastics, and their ability to escape the waste stream. I will take this into account when I discuss proposed solutions to plastic pollution in the final chapter.

### Troubling Definitions

The ability for certain pollutants to both belong and not belong in environments, to simultaneously assimilate too much and not at all, problematizes some of the categories that have long defined pollution control, such as sinks and spills. Sinks are repositories for waste, "those environmental zones that receive, absorb, and contain wastes," such as landfills or the UN Secretary-General's ideal near shore marine environment. Spills, on the other hand "are a way to describe the movement and exchange of wastes that do not conform to a clear trajectory or network, but, rather, express more formless... geographies." Spills are the unplanned, uncontained, uncontrolled movement of wastes

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<sup>130</sup> Barnes, David, et al. 2009. "Accumulation and fragmentation of plastic debris in global environments." *Philosophical Transactions of the Royal Society B: Biological Sciences* 364(1526): 1986.

<sup>131</sup> Thompson, R. C., C. J. Moore, et al. (2009). "Plastics, the environment and human health: current consensus and future trends." *Philosophical Transactions of the Royal Society B: Biological Sciences* 364(1526): 2153-2166.

through ecosystems.<sup>132</sup> Sinks are thought to either contain or metabolize their wastes over time, while spills are unable to contain or metabolize an excess of waste. Oceans are sinks for plastics even as plastics are spills within them. Once plastics enter the oceans, they do not leave them easily. Without sunlight or oxygen, plastics on the ocean floor (roughly half of all ocean plastics) do not break down molecularly and are likely to stay on ocean bottoms for thousands of years.<sup>133</sup> Floating or beached plastics exposed to the sun fragment into tinier pieces, working their way into smaller and smaller scaled ecosystems. They can be as small as viruses, yet still retain all the properties of plastics.<sup>134</sup> Thus, ocean plastics are sinks for plastics, yet plastics continue to spill into ecosystems even after they are “contained” in sinks. They do not conform to a trajectory of progressive metabolism or a known life cycle, and they accumulate and cause harm through their containment.

Likewise, ocean plastics complicate the distinction between contaminants and pollutants. Their categorization, introduced in the last chapter, is based on dilution: “Contamination is the presence of elevated concentrations of substances” while “Pollution is the introduction by man, directly or indirectly, of substances or energy to the marine environment resulting in such deleterious effects as harm to living resources.”<sup>135</sup> Traditionally, “deleterious effects” are defined quantitatively by the

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<sup>132</sup> Gabrys, J. (2009). "Sink: the dirt of systems." *Environment and Planning D: Society and Space* 27: 666-7.

<sup>133</sup> Andrady 2011: 1601.

<sup>134</sup> Andrady 2011: 1602.

<sup>135</sup> Clark, R. B. (1986). *Assessing Pollution Damage: Marine Pollution*. Oxford, Clarendon Press: 7.

amount of a substance that an organism or ecosystem can no longer assimilate. Yet, dilution does not work with plastics in oceans the way it does with sewage in streams because harm is not easily based on concentration. Is a single microplastic a contaminant or pollutant? Does it depend on the microplastic in question, on the quantity and kind of extraneous toxins it has accumulated in the water, or the organism about to eat it?

Charles Moore, founder of the Algalita Marine Research Institute, says it takes only one plastic bag to choke a turtle.<sup>136</sup> Yet a 1988 study that consisted of feeding chickens polyethylene pellets found that plastic-fed birds ate less and developed slower than control birds, “thus reduc[ing] fitness,” but it did not kill them.<sup>137</sup> Both statements—that even one piece of plastic can kill, and that multiple ingested plastics does not kill but may reduce fitness, broadly defined—are part of a scientific and public discussion that is rethinking the link between presence and harm in theories of pollution, a topic that will be taken up in detail in the next chapter. In the previous chapter, I outlined how the quantification of harm allows technocrats to draw the line between harm and no harm, pollution and non-pollution. This line is not clear with ocean plastics, where mortality, the hallmark of harm, is either impossible to quantify, as most marine animals die away from human observation, but more so because it is difficult to tell what counts as harm.

Ocean plastics are like Lewis Carroll’s snark:

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<sup>136</sup> Moore 2011.

<sup>137</sup> Ryan, P. G. (1988). "Effects of ingested plastic on seabird feeding: Evidence from chickens." *Marine Pollution Bulletin* 19(3): 125-128.

For the Snark's a peculiar creature, that won't  
Be caught in a commonplace way.  
Do all that you know, and try all that you don't:  
Not a chance must be wasted to-day!

Ocean plastics “won’t be caught in a commonplace way.” They cannot be scooped up, towed away, or mined for raw materials because their soupy dispersal makes them inextricable from their environment. Attempts to separate them can harm the environment they’ve “become like.” However, they have not been metabolized in these environments, so their resilient synthetic polymers travel long distances, circulating plastics globally. Ocean plastics entangle animals, absorb water-born chemicals that are ingested by marine animals, and finally bioaccumulate up the food chain. These are just the harmful effects we know about, and many of them cannot be “caught” or measured because they happen at sea, and because much of this “harm” does not result in obvious signs of illness or death.

I have covered plastic polymers in the ocean. What about plasticizers? Fish and other animals (like humans) can metabolize them. As a result, they have a different accumulative topography. As we shall see, metabolism is still not the answer to pollution control.

#### Plasticizers and Endocrine Disruptors

In a laboratory in 1998 Cleveland, scientists led by Patricia Hunt were studying genetic reproductive processes in rats. One day, all of their rats—those in the test and in the control groups— displayed the same chromosomal abnormality. The scientists turned



their attention to tracking down the source of these unexpected anomalies: “[w]e identified damaged caging material as the source of [a chemical] exposure, as we were able to recapitulate the meiotic abnormalities by intentionally damaging cages and water bottles” by soaking them in a new cleaning product recently used in the laboratory.<sup>138</sup> The cleaner had caused unusual amounts of bisphenol A (BPA), a plasticizer, to leach from the polycarbonate cages and water bottles.<sup>139</sup>

#### Levels and Thresholds Undone

We know about bisphenol A (BPA) from the discussion in the last chapter about toxicological dose-response curves. Recall that, in the 1980s, the EPA set a maximum oral reference dose (RfD) of BPA based on the lowest dose tested by the National Toxicology Program's (NTP) carcinogen study because, though the rats did not appear to have increased rates of cancer, they all had decreased body weights. There are several differences between Hunt's accidental (and then reproduced) experiment and the National Toxicology Program's carcinogen study. First, they had different endpoints.<sup>140</sup> The NTP was looking for signs of cancer (and also noted mortality rate and body weight) while Hunt's group was looking at cell division and chromosomes. More strikingly, however, is the difference between the amounts of BPA used in each study. Both groups used a dose of 1000 ppm of BPA, but Hunt's team also tested much smaller

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<sup>138</sup> Hunt, P., K. Koehler, et al. (2003). "Bisphenol A exposure causes meiotic aneuploidy in the female mouse." *Current Biology* 13: 546.

<sup>139</sup> Also see Howdeshell, K. L., P. H. Peterman, et al. (2003). "Bisphenol A Is Released from Used Polycarbonate Animal Cages into Water at Room Temperature." *Environ Health Perspect* 111(9): 1180–1187.

<sup>140</sup> An endpoint is the part of the body that scientists test for changes following chemical exposures, such as the liver, or even individual cells in the liver.

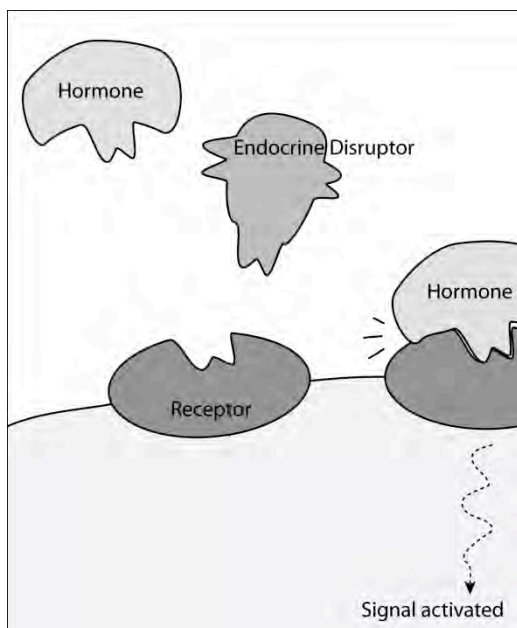


Figure 2.4: Hormones and endocrine disruptors can both activate receptors because of their similar shapes. Image by the author.

concentrations meant to mimic the amount of BPA that leached from water bottles. In Hunt's study, even at trace amounts of BPA that are known to metabolize in the body, "a significant increase in congression failure...and a dose-related increase in the level of abnormalities, was observed."<sup>141</sup> It seems that the NTP and the EPA need to include different endpoints to identify adverse effects, like Hunt's scientists did, and lower the maximum oral reference dose.

BPA is water-soluble and metabolizes in the body. The metabolites that BPA breaks into leave the body through urine approximately six hours after ingestion.<sup>142</sup> Yet BPA does not cease to cause harm, regardless of the dose or the metabolism rate of the body. Like

<sup>141</sup> Hunt 2003: 549.

There is little debate that BPA metabolizes in bodies (though there is disagreement about how and where and how completely it metabolizes in different bodies). There is also disagreement on whether BPA metabolizes in water. A study by Dow Chemical Company, one of the world's major producers of BPA, concluded that BPA was readily biodegradable in water. Other studies have concluded the opposite. Thus, the charge that BPA is an example of a pollutant that metabolizes without thresholds only holds for bodies.

See: Staples, C. A., P. B. Dome, et al. (1998). "A review of the environmental fate, effects, and exposures of bisphenol A." *Chemosphere* 36(10): 2154.

<sup>142</sup> Bushnik, T., D. Haines, et al. (2010). *Lead and bisphenol A concentrations in the Canadian population*. Statistics Canada. 21: 2

ocean plastics, BPA does not fit the logic of assimilation, allowable limits or natural thresholds. BPA "becomes like" its surroundings; it circulates in the body and behaves like a hormone. BPA and other plasticizers are classified as endocrine disruptors. Endocrine disruptors "disrupt" the hormone system because, rather than acting like poisons and foreign trespassers, they participate in the body's normal systems in abnormal ways. Hormones travel through the bloodstream until they encounter a receptor with a shape that compliments their own. They fit together, like a lock and key (see figure 4, above). When the two bind, the receptor activates and signals the DNA in the cell to get to work. Some of this work includes expressing genes, developing tissue, or making proteins.<sup>143</sup> Plasticizers such as BPA act as rogue keys, signaling cells to work out of turn or blocking receptors so other hormones cannot bind to them. Rather than breaking things, processes work differently and unplanned proteins and gene expressions occur. This may result in nothing notable—a gene that expresses itself out of turn may just create extra or malformed, harmless proteins. On the other hand, various plasticizers have been correlated with infertility, recurrent miscarriages, feminization of male fetuses, early-onset puberty, obesity, diabetes, reduced brain development, cancer, and neurological disorders such as early-onset senility in adults and reduced brain development in children.<sup>144</sup> BPA is one of only thousands of plasticizers, all of which act as endocrine disruptors. I focus on BPA because it is one of

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<sup>143</sup> Langston, N. (2010). *Toxic bodies: hormone disruptors and the legacy of DES*. New Haven, Yale University Press: 7.

<sup>144</sup> Halden, R. U. (2010). "Plastics and Health Risks." *Annual Review of Public Health* 31: 179-194.

Grun, F. and B. Blumberg (2007). "Perturbed nuclear receptor signaling by environmental obesogens as emerging factors in the obesity crisis." *Rev Endocr Metab Disord* 8: 161–171.

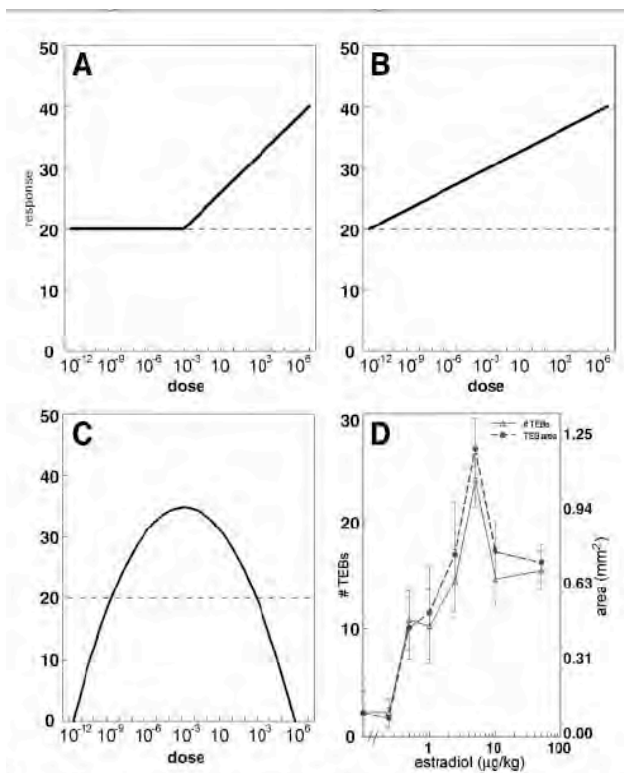


Figure 2.2: From Vandenberg, et al. (2009). "Bisphenol-A and the Great Divide: A Review of Controversies in the Field of Endocrine Disruption." *Endocrine Reviews* 30(1): 78.

the most studied plasticizers. Of the 85,000 synthetic chemicals registered in the United States in 2010, with around 2,000 added each year. Forty percent of these have no data at all, while "more than ninety percent have never been tested for their effect on human health." Most plasticizers used in consumer products have never been tested.<sup>145</sup>

Why did Patricia Hunt's study find effects of toxicity at low doses, while

the National Toxicology Program found fewer effects at high doses? Was it merely a case of endpoints? Or is there something unusual about the relationship between endocrine disruptors and doses? Endocrine systems have a feedback loop whereby high amounts of a hormone—any hormone—signal the body to shut down or reduce the synthesis and acceptance of that hormone. When there is too much of a hormone in the body, the body stops accepting it. This feedback system enables small amounts of a

<sup>145</sup> Gray, J. M., J. L. Nudelman, et al. (2010). *State of the Evidence: The Connection Between Breast Cancer and the Environment*. San Francisco, Breast Cancer Fund: 14. Bennett, L. M. and B. J. Davis (2002). "Identification of mammary carcinogens in rodent bioassays." *Environmental and Molecular Mutagenesis* 39(2-3): 151.

hormone or endocrine disruptor to create larger effects at smaller doses, and lesser or no effects at high doses.

This graph shows three hypothetical curves and one empirically determined curve to explain different kinds of dose-response relationships. Curve A is a chunky version of the sigmoid curve where a toxin has no observable adverse effect until a threshold dose of  $10^{-3}$  units is achieved. It is the type of curve that was used to calculate an allowable oral dose of BPA in the 1980s. Curve B illustrates a linear non-threshold, where there is no amount of poison a body can accommodate, but where increasing amounts of the poison results in an equal increasing amount of harm: double the dose, double the harm. Effects at high doses can be used to predict effects at lower doses. This curve is characteristic of dose-response relationships for many heavy metals, carcinogens and some forms of radiation. Curve C is called a nonmonotonic curve. There is a response at low doses, but no response to higher doses of a toxin. This curve is characteristic of endocrine disruptors as they interact with the wider endocrine system and its feedback loops.

Effects at high doses cannot be used to predict effects at low doses and visa versa.

Curve D visualizes data from rats exposed to the endocrine disruptor estradiol. These particular nonmonotonic curves (C and D) are inverted U's, but endocrine disruptors can also make U-shaped nonmonotonic curves where there is a high response at both low

and high doses for various end points, but nothing occurs at doses in between.<sup>146</sup> In contrast to the dogma in toxicology that the danger is in the dose, which has held for thousands of years, many studies have seen a lack of both thresholds and linear progressions of relationships between doses and responses.<sup>147</sup> The structural logic of thresholds does not apply to plasticizers. Like ocean plastics, plasticizers are not benign when they become part of living systems. On the contrary, this is what makes them dangerous.

#### A New Toxicology

These findings are changing the science of toxicology. In 1996, *Our Stolen Future*, a *Silent Spring* for endocrine disruptors, proposed the low-dose theory and recommended special regulation.<sup>148</sup> *Our Stolen Future* and other scientific reports gradually lead to “a fundamentally different approach to toxicity testing,” particularly in how experiments are designed.<sup>149</sup> Toxicologists are increasingly testing potential endocrine disruptors at much lower doses, often called “environmentally relevant doses,” which are based on

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<sup>146</sup> Vandenberg, L. N., M. V. Maffini, et al. (2009). "Bisphenol-A and the Great Divide: A Review of Controversies in the Field of Endocrine Disruption." *Endocrine Reviews* 30(1): 79.

<sup>147</sup> Vandenberg 2009. But also Crain for water, and more radically, O'Connor, who argues that no chemical measurement reliably predicts sediment toxicity. Crain, D. A., M. Eriksen, et al. (2007). "An ecological assessment of bisphenol-A: Evidence from comparative biology." *Reproductive Toxicology* 24(2): 225-239. O'Connor, T. P. and J. F. Paul (2000). "Misfit Between Sediment Toxicity and Chemistry." *Marine Pollution Bulletin* 40(1): 59-64.

<sup>148</sup> Colborn, T., D. Dumanoski, et al. (1996). *Our Stolen Future: Are We Threatening our Fertility, Intelligence, and Survival?: A Scientific Detective Story*. New York, Dutton.

<sup>149</sup> Marty, M. S., E. W. Carney, et al. (2011). "Endocrine Disruption: Historical Perspectives and Its Impact on the Future of Toxicology Testing." *Toxicological Sciences* 120(suppl 1): S93-S108.

levels of exposure already encountered by humans and other animals. The recommendation to test for effects of low doses are outlined in *Toxicity Testing in the 21st Century: A Vision and a Strategy* a sort methods handbook published by the National Research Council in 2007. Before this, “[a] meta-analysis of 20,285 toxicology studies conducted between 1962 and 1998 found that only 1% of the published studies met the criteria set a priori to determine whether a study was designed properly to detect a NMDR curve,” that is, a curve characteristic of endocrine disruptors rather than the traditional sigmoid curve.<sup>150</sup> The goal of publications such as *Toxicity Testing in the 21<sup>st</sup> Century* is to change this trend towards studies that can detect low dose effects characteristic of endocrine disruption.

More strikingly, however, is the move towards toxicogenomics, a relatively new science that aims to understand how a whole genome responds to toxicity. Toxicogenomics allows a researcher to look for changes at the genetic level “though gene expression profiling: Microarrays containing thousands, or even tens of thousands, of genes referencing important biochemical pathways, DNA repair mechanisms, toxin metabolizing processes, and other vital functions are used increasingly in experiments that attempt a ‘systems biology’ approach to toxicology, illuminating how multiple genes respond in complex ways to toxic exposure.”<sup>151</sup> That is, rather than identifying an

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<sup>150</sup> Vandenberg 2009: 79.

National Research Council and Committee on Toxicity Testing and Assessment of Environmental Agents. (2007). *Toxicity Testing in the 21st Century: A Vision and a Strategy*, The National Academies Press.

<sup>151</sup> Fortun, K. and M. Fortun (2005). "Scientific Imaginaries and Ethical Plateaus in Contemporary U.S. Toxicology." *American Anthropologist* 107(1): 45.

environmental problem based on harms, toxicologists study the mechanisms, influences and behaviours of genes in the presence of toxins, including endocrine disruptors. They will eventually attempt to deduce harm from those experimental observations.<sup>152</sup> Harm is not defined in advance, but deduced from reactions that may or may not look like traditional ideas of ill effect.

This more holistic view and experimental process is a major departure from a toxicology that mainly relied on testing and measurement. Traditionally, when asking the question “is this substance toxic?” the answer would be yes or no, and by how much.

Toxicogenomics, while ultimately remaining a way to investigate the toxicity of substances, is “an approach that focuses on the connections themselves, reaching systemic understanding through recognition of patterns, rather than through complete measurement and comprehensive mapping.”<sup>153</sup> This shift in focus and methodology, along with the deluge of information that comes from looking at multiple genes for reactions to various toxins at different doses, results in doing more work in conditions of not-knowing. Robert Toule, a senior professor of toxicology that works with STS scholars Kim and Mike Fortun, “insists that toxicologists must make more creative use of the limited information at hand for environmental health research and that understanding is not dependent on comprehensiveness.”<sup>154</sup> With toxicogenomics, a science developed to interrogate the toxicity of endocrine disruptors in acknowledgement of all their complexity, there is a shift to open, contingent, and working forms of knowledge that

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<sup>152</sup> Marty et al. 2011.

<sup>153</sup> Fortun 2005: 49, paraphrasing Robert Toule, a senior profession of toxicology.

<sup>154</sup> Fortun 2005: 49.



are nonetheless useable in policy and other contexts of environmental health. But why this wholesale shift to precarious epistemologies? Is it just because of low dose effects and a new genetic endpoint?

### Complicating Causality

The low dose-high effect behaviour of endocrine disruptors and their effects on genes are only part of what makes their form of pollution novel and complex. I will borrow from Horst Rittel and Melvin Webber's "Dilemmas in a General Theory of Planning," where they call problems that cannot be "definitively described" "wicked problems," and from political theorists Diana Coole and Samantha Frost's notion of "new materialism" where "materiality...materializes, evincing immanent modes of self-transformation that compel us to think of causation in far more complex terms."<sup>155</sup> Rittel, Webber, Coole and Frost agree that, "phenomena are caught in a multitude of interlocking systems and forces," often becoming "links tying open systems into large and interconnected networks of systems."<sup>156</sup> That is, pollutants are not discrete, completely material foreign actors that infiltrate a separate system. They are part of those systems. Their wicked materiality does not stop at the edges. In the case of endocrine disruptors, this structure of systems within systems makes certain causal effects and notions of harm difficult to discern.

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<sup>155</sup> Rittel, H. W. J. and M. M. Webber (1973). "Dilemmas in a General Theory of Planning." *Policy Sciences* 4: 155-169.

Coole, D. H. and S. Frost (2010). *New Materialisms: Ontology, Agency, and Politics*. Durham NC; London, Duke University Press: 9.

<sup>156</sup> Coole 2010: 9.

Rittel 1973: 159.

Hormones are not discrete actors with specific effects that can be extracted from their surrounding system. One hormone—or endocrine disruptor—can bind with more than one kind of receptor. This means that every hormone is able to influence more than one subsystem, and it can influence one subsystem in more than one way. For example, a low dose of the endocrine disruptor diethylstilbesterol (DES) in mice is correlated with increased body weight and fat, but a dose one thousand times higher is correlated with a significant decreased body weight.<sup>157</sup> A middling dose has no apparent effect. Thus, DES is an endocrine disruptor that potentially increases the chances of obesity, increases chances of being underweight, and may do nothing. This is not the kind of statement that policy makers find useful, accurate as it may be.

Likewise, one hormone does many things, and thus has many potential endpoints. Estrogens and their mimics, for example, play a role in the development of sexual organs in women, the maturation of sperm and fertility in men, the maintenance of the skeletal system, regulation of the menstrual cycle and pregnancy, the sex drive in both sexes, maintenance of memory functions, influence of fat stores, lung and heart function, promoting mental health and the regulation of metabolism, protein synthesis, blood coagulation and the immune system, salt and water retention. They do so in collaboration with other hormones, and their influence cannot be disaggregated from

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<sup>157</sup> Newbold, R. R., W. N. Jefferson, et al. (2004). "Developmental exposure to diethylstilbestrol (DES) alters uterine response to estrogens in prepubescent mice: low versus high dose effects." *Reproductive Toxicology* 18(3): 399-406.

that collaboration.<sup>158</sup> Any detected changes potentially occur through a plethora of normal hormone influences and endocrine disruptors, not to mention the influence of other genes, environmental conditions, and diet. Thus, there are multiple hormones and disruptors inextricably influencing multiple endpoints at all times. Even if you segregate an endpoint, not only have you divided up an irreducible system, you have not segregated the variables influencing the endpoint at any given moment.

This complexity is compounded by “the cocktail effect.” Biomonitoring projects have found hundreds of industrial chemicals in human bodies, all of which react with one another. This collection of “[c]hemicals may interact additively, multiplicatively or antagonistically in what is commonly referred to as the ‘cocktail effect’.” The human health risks of exposure to chemical *mixtures* are much understudied.<sup>159</sup> The cocktail effect is akin to drinking alcohol, smoking marijuana, taking a few aspirin, shooting some heroine, and sucking on a cough lozenge, all at once. Sorting out which effect is caused by which chemical is not only impossible, it is out of line with how wicked systems work because each chemical is working on similar endpoints at the same time, and each chemical is simultaneously influencing the effects of every other chemical. This cross-influence is so consistent that, one of the top endocrinologists in the field states that the

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<sup>158</sup> Note that DES is not a plasticizer, but is structurally and behaviorally similar to BPA. Nelson, L. R. and S. E. Bulun (2001). "Estrogen production and action." *Journal of the American Academy of Dermatology* 45(3, Supplement): S116-S124. Rochira, V., A. R. M. Granata, et al. (2005). "Estrogens in males: what have we learned in the last 10 years?" *Asian J Androl* 7(1): 3-20. Also see Langston for links between DES and BPA. Langston 2010.

<sup>159</sup> Meeker, J. D., S. Sathyanarayana, et al. (2009). "Phthalates and other additives in plastics: human exposure and associated health outcomes." *Philosophical Transactions of the Royal Society B: Biological Sciences* 364(1526): 2108. Emphasis added.

“low-dose effects of BPA may also be due to its additivity with other (endogenous and exogenous) estrogens present, either in the organism or in cell culture conditions.”<sup>160</sup> In short, one characteristic of BPA that scientists are increasingly sure about—low-dose effects—may a permanent side effect of having multiple chemicals and hormones interacting in the same system, rather than a characteristic of BPA itself.

The impossibility of isolating one pollutant from another is not only a problem for the body under study. Laboratories and lab equipment, designed to be spaces where variables and purity can be controlled, permanently suffer from background pollution. Labs are full of vinyl countertops, polycarbonate eyeglasses, polythene pens, latex wall paint, and countless other plastic objects off-gassing plasticizers. More than one BPA biomonitoring study has been abandoned after researchers discovered that the plastic cups used to collect urine leached BPA into the samples. A number of articles have been published that outline a methodology to differentiate between the BPA in lab equipment versus samples.<sup>161</sup> The laboratory is not the clean slate it is designed to be. It is already polluted with its object of study.

Another element of the endocrine system that problematizes clear, linear cause and

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<sup>160</sup> Vandenberg 2009: 82.

<sup>161</sup> Watabe, Y., T. Kondo, et al. (2003). "Reducing Bisphenol A Contamination from Analytical Procedures To Determine Ultralow Levels in Environmental Samples Using Automated HPLC Microanalysis." *Analytical Chemistry* 76(1): 105-109.  
Carabias-Martinez, R., E. Rodriguez-Gonzalo, et al. (2006). "Determination of endocrine-disrupting compounds in cereals by pressurized liquid extraction and liquid chromatography, mass spectrometry: Study of background contamination." *Journal of Chromatography A* 1137(2): 207-215.

effect relationships is that dose is not the factor that most determines effect. The timing of the dose, the gender and age of the person, and the overall sensitivity and state of the endocrine system, which never stands still, is more important. A specific dose of BPA to a female fetus will influence her very differently than the same dose to an adult male, or even a male fetus twin. Moreover, because hormones and their mimics influence gene expression, including how a person will develop years into the future, the effects of a dose may manifest in the person as a child, during puberty, pregnancy, or even during menopause. If a female fetus is exposed, endocrine disruptors may influence her own gametes and thereby her future offspring, effecting three generations at once.<sup>162</sup> The latency between the timing exposure and its potential effect, compounded by the gender and state of the endocrine system at the time, complicated by the low doses required in testing environments, makes correlation between cause and effect even more difficult to isolate.

A final problem for determining causal relationships is the lack of a “zero state” in a tested body. First, there is no control group of bodies that have no plasticizers in them scientists can use to compare to their test subjects. The same is true of rats, mice, and even plants. All people tested have some endocrine disruptors in their bodies. Secondly, even if a body without a body burden could be produced, the endocrine system itself is still “polluted” in the sense that there is no zero state from which to measure doses and responses. The endocrine system is already full of hormones acting like endocrine disruptors. Scientists despair: “[h]ow can there be a threshold at which no estrogen

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<sup>162</sup> Hunt 2004: 555.

responses occur for a chemical that is adding estrogenic activity to a system that is already 'on' at zero dose of the exogenous chemical?"<sup>163</sup> Plasticizers create a permanently inextricable soup in the body. The effects of an endocrine disruptor "won't [b]e caught in a commonplace way."

The common language within scientific articles on plasticizers and endocrine disruptors is one of correlation. They "suggest links" and "identify plausible mechanisms" rather than discrete and certain causes. While many policymakers, including the government agencies I discuss in the next chapter, call for certainty before setting regulation or safety laws, including linear cause and effect relationships. Endocrinology and toxicogenomics cannot produce such statements if they are true to the wicked systems they are testing. Yet, despite these calls for certainty, linear cause and effect is not the only way our technocratic system has understood pollution and harm. Smoking, for example, does not cause cancer. Rather, a smoker has a higher risk of developing cancer compared to non-smokers. The science of epidemiology investigates distributions and patterns of health and disease within a population and makes conclusions based on probability rather than how any given individual is sure to have a specific response. In short, any causal statements do not apply to individuals, but to the system as a whole and are based on probability rather than universal laws. Epidemiological studies can only prove that an agent could have caused an effect in any individual, not that it did

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<sup>163</sup> Talsness, C. E., A. J. M. Andrade, et al. (2009). "Components of plastic: experimental studies in animals and relevance for human health." *Philosophical Transactions of the Royal Society B: Biological Sciences* 364(1526): 2085-6.

cause an effect.<sup>164</sup> Epidemiology describes complex systems with a dizzying array of variables that cannot be reduced to controlled laboratory conditions, and as such, is an appropriate science for studying potential harms of plastic pollution that are not linear, guaranteed, traceable, nor readily apparent in black and white.

Even in cases where epidemiologists have correlated the presence of an endocrine disruptor with an effect in the body, the complexity problem is not necessarily solved. Some of the correlated effects of endocrine disruptors, such as cancer, delayed brain development, and early onset senility fit into categories of harm readily. Yet others, such as obesity, the feminization of male fetuses, and sexual differentiation are less simple to categorize. In her work on DES, a synthetic endocrine disruptor given to many pregnant women in the 1930s whose effects are similar to many plasticizers, environmental historian Nancy Langston cautions that “[u]nderstanding the potential for synthetic chemicals to cause birth defects requires more than medical research alone, for defining ‘normal’ and ‘abnormal’ is a social decision, not just a medical decision. When developmental changes in sexual characteristics have been linked to pollutants, distinguishing normal from abnormal is even more problematic.”<sup>165</sup> Is feminization of male fetuses abnormal, even pathological? Is it a form of harm? The LGBTQ community has argued it is not. So too, does the chemical industry. After research in 1995 found that low doses of BPA altered fetal brain tissue, “a representative from the American Plastics Council pointed out that it was not possible

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<sup>164</sup> Because of this, epidemiological findings cannot be brought to bear on an individual in a court of law, for example. See: Federal Judicial Center. (2011). *Reference manual on scientific evidence*. Washington, D.C., National Academy Press.

<sup>165</sup> Langston 2010: 140.

to say whether this was a good or a bad thing for fetal brains.”<sup>166</sup>

One of the ways our culture has traditionally identified what is normal and abnormal is to appeal to nature and map our categories onto what occurs “naturally.” However, with more than thirty percent of British freshwater fish displaying intersex characteristics, due to many of the same chemicals altering human bodies, an appeal to nature becomes complicated.<sup>167</sup> Finally, and most importantly for toxicologists studying endocrine disruption, “[t]here is no single 'normal' state for any of these [bodily and hormonal] functions, all of which vary naturally within some range in the population. This natural variability greatly increases the noisiness of the results and reduces a study's power to establish a statistically significant association of exposure with effect.”<sup>168</sup> Thus, the inability to definitively categorize harm and non-harm, normal and abnormal, adds yet another layer of complexity for definition work to the seemingly basic task of establishing relationships between exposure and effect.

### Redefining Pollution

Clearly, the definition of pollution based on assimilative capacity and allowable limits does not accurately describe plastic pollution either in the ocean or in our bodies, nor does it afford protection. Based on her anthropological research, Mary Douglas offers a universal definition of pollution, where “the difference between pollution behaviour in

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<sup>166</sup> Langston 2010: 146.

<sup>167</sup> Langston 2010: 143.

<sup>168</sup> Thornton, J. (2000). *Pandora's Poison: Chlorine, Health, and a New Environmental Strategy*. Cambridge, Mass., MIT Press: 111.



one part of the world and another is only a matter of detail,” regardless of whether the culture in question is characterized by technocracy, mysticism, or another system of evidence.<sup>169</sup>

If we can abstract pathogenicity and hygiene from our notion of dirt, we are left with the old definition of dirt as matter out of place. This is a very suggestive approach. It implies two conditions: a set of ordered relations and a contravention of that order. Dirt then, is never a unique, isolated event. Where there is dirt there is system. Dirt is the by-product of a systematic ordering and classification of matter, in so far as ordering involves rejecting inappropriate elements.<sup>170</sup>

Douglas’ “dirt” is the agent of pollution. In our present-day technocratic definition of pollution, dirt is synonymous with pollutant. In the culture-specific definition of pollution developed during the twentieth century, pollutants were only pollutants when they exceeded the quantity that nature could absorb without harm. This “arbitrary line” was the systematic ordering established by early twentieth century technocracies that plastics now systematically exceed. Thus, on the local level, the technocratic definition of pollution no longer holds. But we would assume that the universal aspect of Douglas’ definition of pollution as “matter out of place” continues to identify plastics as a source of pollution. There is still a cultural ordering that insist plastics do not belong in the bellies of plankton or the blood of fetuses. Technocratic definitions of allowable limits exist in tandem with other ideas of what does and does not belong. There are other systems of classification that can account for plastics, some of which will be explored in the next chapter.

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<sup>169</sup> Douglas, M. (1984). *Purity and Danger: An Analysis of Concepts of Pollution and Taboo*. London, Ark Paperbacks: 35.

<sup>170</sup> Douglas 1984: 36.

Yet, plastics complicate even Douglas' universal definition of pollution. No matter the culture, pollution is based on "a contravention of order." That contravention, or transgression, must be discernable. But what if it is not? What if, as the LGBTQ argument goes, a decrease in anal-genital distance and other signs of the feminization of male fetuses is not a "transgression" at all? What if we cannot tell if the presence of certain understudied endocrine disruptors have a negative effect on health? What if we cannot tell if harm has occurred?

A second hallmark of Douglas' definition of pollution "rests upon a clear notion of the prepolluted condition. A river that flows over muddy ground may be always thick; but if that is taken as its natural state, it is not necessarily said to be polluted. The technical sense of pollution... depends upon measures of change."<sup>171</sup> Synthetic polymers are in every landscape and plasticizers are in every body. My generation will be the last to experience a pre-polluted state. How do we establish categories based on a pre-polluted state if that state is strictly historical or imagined? In the twenty-first century, Douglas' universal definition may have to be amended. Without a pre-polluted state, pollution definitions need to create a systematic ordering that can describe changes that are not premised on purity. They will have to describe non-linear relationships that may not clearly contravene the established order. Moreover, because of the ubiquity of plastics, "out of place" will have to designate concentrations or densities rather than absence.

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<sup>171</sup> Douglas, M. and A. B. Wildavsky (1982). *Risk and Culture: An Essay on the Selection of Technical and Environmental Dangers*. Berkeley, University of California Press: 36.

These are just three things that a new theory of pollution needs to take into consideration to account for plastics.

### Redefining Nature(s)

The now undone technocratic definition of pollution is premised on a nature that is robust within limits. What happens to nature now? Mary Douglas identifies four myths about nature's predictability: nature is capricious, nature is fragile, nature is robust, and nature is only robust within limits.<sup>172</sup> It would seem that plastic pollution describes a nature that is capricious, "subject to change or irregularity, so as to appear ungoverned by law."<sup>173</sup> However, this is not to say that nature is actually capricious and not robust within limits at all, as "each of the ecological views is as fully justifiable as the others. Each sums up an enormous experience and vast array of learning about humans interacting in eco-systems."<sup>174</sup> Just as there are types of influential relationships beyond linear cause and affect, so too are there more natures than one that is robust within limits.

The idea of multiple natures of nature is not new. In the *Politics of Nature*, Bruno Latour asks the reader to "[r]eplace the singular with the plural everywhere. Suddenly we have natures, and it is impossible to make natures play any political role whatsoever."<sup>175</sup> The

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<sup>172</sup> Douglas, M. (1992). *Risk and Blame: Essays in Cultural Theory*. London; New York, Routledge: 262.

<sup>173</sup> Douglas 1992: 262.

<sup>174</sup> Douglas 1992: 262.

<sup>175</sup> Latour, B. (2004). *Politics of Nature: How to bring the sciences into democracy*. Cambridge, Mass., Harvard University Press: 29.

“political role” he refers to is the technocratic appeal to nature that shuts down certain conversations—if nature is robust within limits, then of course allowable levels of pollution and an industrial ecosystem makes sense, and we only need to discuss the allotment of assimilative capacity. This is why, in the previous chapter, policy makers “breathed a sigh of relief” when introduced to assimilative capacity, what made it like “a piece of wood where a nail can be fastened.”<sup>176</sup> Politicians could built on it without questioning premises. If, however, there are natures, then the conversation starts somewhere else entirely.

#### Plastics in the Wild

Both plastic pollution and its nature are wild, in both senses of the term. It’s nature, that which allows it to be defined is “full of disturbance or confusion, [is] tumultuous, turbulent, [and] disorderly,” and does not submit to cultivation or control.<sup>177</sup> It is snark-like. Another definition of wildness refers to the inability to be governed, the defiance of government. In particular, plastic pollution defies technocratic governance. Not only has it escaped an entire regime of pollution control based on minimum doses and allowable limits, its capricious nature makes it unsuitable for participation in an industrial ecosystem. Industrial ecosystems have to be reliable, invariable, and predictable.<sup>178</sup> Neither containment nor metabolism, the two main orderly technocratic approaches to waste, will work with plastics.

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<sup>176</sup> Olsson 2002: 86.

<sup>177</sup> (2012). “Wild.” *Oxford Dictionaries*, Oxford University Press. Retrieved 9/7/12, from [www.oed.com](http://www.oed.com).

<sup>178</sup> Schneider 2011: 25.

In the second sense of the term, the “nature” that plastics inhabit is wild. It is wicked, where wickedness is “akin to that of ‘malignant’ (in contrast to ‘benign’) or ‘vicious’ (like a circle) or ‘tricky’ (like a leprechaun) or ‘aggressive’ (like a lion, in contrast to the docility of a lamb).”<sup>179</sup> This nature, this environment that plastics inhabit, an open system linked to other open systems, offers “no opportunity to learn by trial-and-error, [because] every attempt counts significantly.”<sup>180</sup> Interventions will have effects. If you try to scoop the plastics from sediments, lugworms are affected. If you try to ban plasticizers, multinational corporations are affected. This is the wild nature of plastics: “Every wicked problem can be considered to be a symptom of another problem,” and intervening into a problem may cause other problems.<sup>181</sup> Nature no longer has discrete limits where harm and non-harm rest sedately on either side of a threshold. Harm lurks everywhere, in ill-defined form.

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<sup>179</sup> Rittel 1973: 160.

<sup>180</sup> Rittel 1973: 163.

<sup>181</sup> Rittel 1973: 165.

#### IV. PLASTICS IN PUBLICS: REGIMES OF PERCEPTION AND THE POLITICS OF DEFINITION

##### The Problem with Paradigms

Given that plastics have undone formerly defined categories and known pollution behaviours, it would seem plastics have inspired a paradigm shift. A paradigm "stands for the entire constellation of beliefs, values, techniques, and so on shared by the members of a given [scientific] community,"<sup>182</sup> and a paradigm shift is "a relatively sudden and unstructured event like the gestalt switch"<sup>183</sup> where by one "constellation of beliefs" is replaced by another, usually after the extended exploration of an insistent anomalous scientific finding that does not fit within the previous paradigm. That is, a phenomenon that cannot be explained by normal science, or science-as-usual, changes the foundations of understanding so that it can be accounted for. This seems to have happened in toxicology, which has retooled to accommodate low-dose effects of endocrine disruptors, and plastics are consistently challenging traditional definitions of pollution based on assimilative capacity and allowable limits.

Yet, a new paradigm has not arisen. Kuhn states that, "once it has achieved the status of paradigm, a scientific theory is declared invalid only if an alternate candidate is available to take its place...The decision to reject one paradigm is always simultaneously the decision to accept another, and the judgment leading to that decision involves the

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<sup>182</sup> Kuhn, T. S. (1996). *The structure of scientific revolutions*. Chicago, IL, University of Chicago Press: 175.

<sup>183</sup> Kuhn 1996: 122.

comparison of both paradigms with nature and with each other."<sup>184</sup> This has not occurred with plastic pollution. There is no new candidate, no new model of pollution that explains the risks, harms, and behaviours of plastics in oceans, bodies, and ecosystems. The old model is not working, and while many texts, including this one, endeavor to move forward with uncertainty and not-knowing-in-full, this is not descriptive of Kuhn's structure of scientific revolutions.

More importantly, however, the changes plastic pollution has wrought are not merely out of synch with Kuhn's theory of scientific change. Rather, they are not explained within the structure of a paradigm at all. When Kuhn says that a paradigm is "the entire constellation of beliefs, values, techniques, and so on shared by the members of a given community," he means a closed scientific community. Paradigms are sectarian. Yet, as the earlier chapter on the historical roots of technocratic definitions of pollution illustrated, and this chapter will reinforce, science is not done in a vacuum. Science and Technology Studies is premised on the assumption that science is an inherently social activity, in which politics, cultural values, and "non-scientific" elements are always already a part. Moreover, the scientific community that works on plastic pollution, from oceanographers to toxicologists, boasts a high number of self-identified researcher-activists and public intellectuals who are deeply invested in the activist potential of their science. There are also significant numbers of scientists invested in industry values and funds. This chapter looks at how politics, government agencies, environmental groups, concerned citizens, and health advocates are part of decisions about what science is

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<sup>184</sup> Kuhn 1996: 77.

done, how it is done, and how it is used, both with and without the support of scientists. This is not the “contamination” of science, but how science works.

Even if we were to humour the idea of a “strictly” scientific paradigm and artificially subtract “non-scientific” influences from the fray in an effort to keep science segregated, the scientific community is still not paradigmatic. Even scientists who are not self-identified activists cite political, financial, and other factors in their own and other's work. As this chapter will illustrate, scientists criticize each other's experimental designs, results, and intentions in ways that do conform to Kuhn's notions of a paradigm or the investigation of anomalous findings during a paradigm shift. Steve Fuller, author of *Thomas Kuhn: A Philosophical History for Our Times*, writes that, “Kuhn failed to recognize that the scientific community itself is subject to conflicting interests, each of which potentially represents a different direction in which science may go. Ultimately, Kuhn tried ... hard to minimize the presence of disagreement, or division of any sort, within a paradigm.”<sup>185</sup> He goes on to say that, “Kuhn's commitment to the paradigmatic containment of inquiry is perhaps most apparent from the pronounced absence of criticism as a regular feature of science.”<sup>186</sup> This chapter follows only a fraction of many lines of criticism taken up by scientists, non-scientists, researcher-activists and others about plastics science, and what ramifications this criticism has for defining and solving plastic pollution.

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<sup>185</sup> Fuller, S. (2000). *Thomas Kuhn: A Philosophical History for our Times*. Chicago, University of Chicago Press: 71.

<sup>186</sup> Fuller 2000: 177.



Fuller argues, and I concur, that not only is science rarely closed and paradigmatic as Kuhn envisioned, but that paradigms, should they exist as Kuhn described them, are not optimal models for inquiry to begin with: “paradigms should be seen, not as the ideal term of scientific inquiry, but rather an arrested social movement in which the natural spread of knowledge is captured by a community that gains relative advantage by forcing other communities to rely on its expertise to get what they want.”<sup>187</sup> Following Fuller, paradigmatic knowledge, that is, knowledge produced and held by a closed community, is a way of taming of wicked problems into stable matters of fact that restrict ways of knowing and acting that ought to be brought to bear on wicked environmental problems. Moreover, paradigmatic knowledge can be tamed in ways that meet the needs and desires of the community that creates or funds it, rather than a multitude of other stakeholders that paradigms, by definition, do not recognize. Kuhn's paradigms are closed because he believes science is, or ought to be, created for and by scientists driven by their dedication to pure science, the applications of which are only apparent after the science is complete. Against the structure of paradigms, several authors covered in this chapter, including Fuller, argue that opening science to public controversy allows a style of inquiry that opens up possibilities for science and knowledge, and, I would add, is particularly crucial for defining wicked environmental problems and their potential solutions.

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<sup>187</sup> Fuller 2000: 37.

Thus, this chapter will look at public-scientific controversies surrounding the status of bisphenol A (BPA), a plasticizer used in many polycarbonate plastics. Various vested parties, including citizens, artists, scientists, NGOs, multinational corporations, lobbyists, and government agencies use different techniques to define plastic pollution. In each case, the “essence” of plastic pollution is different, and even mutually exclusive, from one group to the next. These contests are not only ontological arguments about what constitutes plastic pollution, but also epistemological debates about what counts as valid knowledge and proof of the nature of plastic pollution. How we know about something influences what we know, which in turn creates a particular object of knowledge. This influences the types of solutions and interventions that seem viable and desirable if that object of knowledge turns out to be dangerous. Not only the content of the contests between definitions matter, but so, too, do the techniques of the contest.

This chapter is divided into two case studies. The first is a petition filed by the National Resource Defense Council (NRDC), an environmental advocacy NGO, requesting that the United States Food and Drug Administration (FDA) lower the allowable limit of BPA in food packaging. The FDA’s grounds for denying the petition allow an investigation of what the agency counts as evidence of harm compared to what the scientists and activists in the NRDC consider ample, even overwhelming, proof of wide-spread pollution. This case study taps into wider discussions about industry-funded science, scientific “debates,” and scientific consensus, even though neither party in the case is comprised mainly of scientists.

The second part of the chapter looks at how concerned citizens and activists use scientific samples, mainly marine bird carcasses and biomonitoring numbers, to argue for a definition of pollution based on presence rather than the discrete identification and quantification of ill-health or harm. While this line of argumentation allows for a radical, new definition of pollution, when it is harnessed to actions based on consumption, it loses much of its power. Overall, both cases show that science is carried out, influenced by, used, and shared by a wide range of actors that do not fit neatly into paradigmatic structures, and that the controversies that arise from this diversity does more to ethically ground pollution in its myriad of effects, stakes, and meanings than any “strictly” scientific community, should such a thing exist, could do on its own.

#### Regimes of Perceptibility

Again, aspects of these contests seem to resonate with some of Kuhn's writing in *The Structure of Scientific Revolutions*, particularly how “[t]he proponents of competing paradigms are always at least slightly at cross-purposes. Neither side will grant all the non-empirical assumptions that the other needs in order to make its case. ... The competition between paradigms is not the sort of battle that can be resolved by proofs.”<sup>188</sup> In both case studies, competing parties use different epistemological basis to define pollution and make their arguments about the harms of BPA, and each side refuses to grant the others' evidence the status of proof. Yet, this is more than a case of different scientific worldviews seeing past one another. Different groups have different

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<sup>188</sup> Kuhn 1996: 148.

interests and wield different amounts of power, power that is often used to attempt to control the conditions under which something can be made apparent, legible, and definitive as dangerous or not.

Rather than analyzing these controversies in terms of views from different paradigms, I will use Michelle Murphy's "regimes of perceptibility," which describes the role of power relations and evidence in cases where civilians compete with government agencies when defining new forms of pollution.<sup>189</sup> In *Sick Building Syndrome and the Problem of Uncertainty*, Murphy uses regimes of perceptibility to explain how and why some historical actors—female office employees—"saw" an illness called Sick Building Syndrome while others—usually male scientists and representatives from government agencies—thought it was a feminine delusion. Like endocrine disruptors that leach and off gas from plastics, Sick Building Syndrome was an elusive type of chemical exposure that came from everyday places and resulted in nonspecific, multiple expressions in bodies. Like current debates over endocrine disruptors, "contemporary experts disagree[d] about the import and even the existence of widespread, low-level exposures."<sup>190</sup> In fact, some of the 1950s-70s office supplies such as desk furniture and carpeting blamed for Sick Building Syndrome contained chemicals also used as plasticizers today.

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<sup>189</sup> Murphy, M. (2006). *Sick Building Syndrome and the Problem of Uncertainty: Environmental Politics, Technoscience, and Women Workers*. Durham, Duke University Press

<sup>190</sup> Murphy 2006: 9.

Regimes of perceptibility do not just describe whether or not a problem is perceived. They are about the possibility of being able to see something or not, much like Michel Foucault's notion of discourse, where material, linguistic, and social interactions produce and reproduce knowledge, truth, and patterns of subjectivity, making some things possible to say and others impossible. This resonates with Murphy's choice to call her analytical framework regime of perceptibility rather than a regime of perception; perception is about seeing something or not, while perceptibility is about the possibility of seeing something or not. Regimes of perceptibility "were often understood by the historical actors employing them as natural or inevitable outcomes of social and technical arrangements."<sup>191</sup> Like Foucault's discourses and Barad's phenomena, regimes of perceptibility constitute the nature of reality by "populat[ing] our world with some objects and not others, and they allow certain actions to be performed on those objects."<sup>192</sup> This is a form of power, particularly if certain stakeholders are aiming to make their version of plastic pollution dominant over others-- that is, if they are attempting to exercise a "paradigmatic" form of knowledge closed to certain stakeholders. The following case studies will show how controversy can bring these differences in power and regimes of perceptibility into view.

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<sup>191</sup> Murphy 2006: 24.

<sup>192</sup> Murphy 2006: 24.

## Part 1: Technocracy in Public

### The American Chemistry Council

In a post titled "Confused about BPA" on an online community bulletin board for expectant mothers, a mother-to-be wrote:

I've also noticed that there are more and more things like baby spoons etc for weaning which are BPA free!  
Does this mean that we need to chuck out everything we have that's plastic pre: 2009/2010 and start again with BPA free stuff??  
I have heard there was only ever a small risk from stuff that isn't BPA free but at point do you draw the line?!?  
I have to same [sic] I'm so confused by it all and unsure what's the best thing to do. Anyone any advise?<sup>193</sup>

In this community and others, advice runs the gamut from "[w]hen we were young there was never BPA free stuff and we turned out right" to "[confusion] is just the way industry wants it:" BPA is dangerous.<sup>194</sup> The variety of advice hardly quells confusion, and people continue to ask questions. Should I breastfeed knowing that my breast milk has toxic chemicals in it? Should I return all the plastic baby toys? How dangerous is it to drink plastic bottled water compared to tap water? Are BPA-free bottles safe, or just BPA-free? These questions are asked on electronic bulletin boards, on blogs, in doctor's waiting rooms, and between friends. And the answers from experts, from laypeople, and from politicians often contradict one another.

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<sup>193</sup> white\_wild\_roses. (2011). "Confused about BPA." Baby Center. Retrieved 9/12/12, from [http://community.babycentre.co.uk/post/a11746125/confused\\_about\\_bpa](http://community.babycentre.co.uk/post/a11746125/confused_about_bpa).

<sup>194</sup> Anonymous. (n.d.). "The BPA Diaries: Confused about BPA? That is just the way industry wants it." Retrieved 9/12/12, from <http://cleanwater.org/blog/bpa-diaries-confused-about-bpa-just-way-industry-wants-it>.

To assuage her confusion, the expectant mother quoted above might have Googled “information on plastics.” She would have found plasticsinfo.org, whose opening page states, “[e]very day, plastics help make our lives better, healthier and safer in countless ways. PlasticsInfo.org provides useful tips and simple solutions to help you make the most of the innovation and convenience plastics have to offer.”<sup>195</sup> She might have been reassured to read that, “[b]ecause plastics serve so many purposes in the kitchen, many consumers get confused about which products are right for the microwave. This list of FAQs will help you decide which plastics to use and how to use them properly.” She might have learned that the email about the dangers of freezing water bottles is a hoax, about the proper way to recycle plastic containers, and a host of other ways to stay safe and environmentally friendly while still using the plastics that have made her life “better, healthier and safer.”

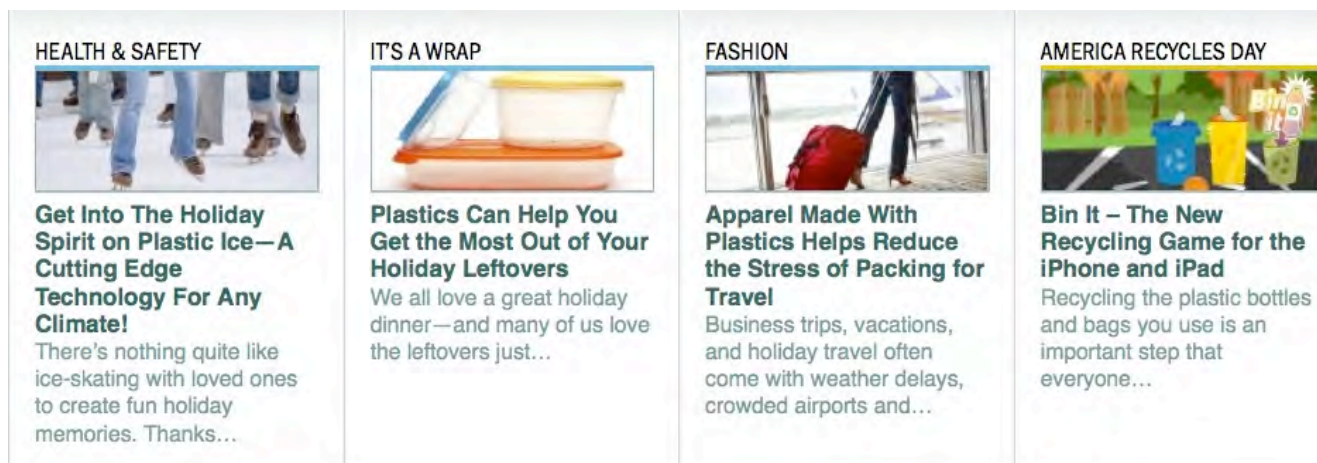


Figure 3.1: Footer of plasticsinfo.org by the American Chemistry Council. November 2011.

<sup>195</sup> American Chemistry Council. (2011). "Plastics and Your Life." *Better Living with Plastics*. Retrieved 12/11/11, from <http://www.plasticsinfo.org/>.

Plasticsinfo.org is written and maintained by the American Chemistry Council, a respectable sounding organization. Yet, in the spirit of astroturfing, it is the largest chemical industry lobby group in the United States. The website aims to create a regime of perceptibility whereby plastics can only be seen as troublesome if consumers are careless or misinformed. The American Chemistry Council works to redefine relationships between individuals and plastics (plastic pollution is a litter or recycling problem), plastics and science (“studies consistently demonstrate that the low-dose hypothesis is not valid for BPA”), and plastics and the media (the media express opinions while plasticsinfo.org states facts). The website uses aesthetics of expertise and trust, including their clean, clear informational web design, their url (besides having “info” in the title, they also have a .org domain popular with non-profits and other groups working for the public good), the authoritative name of the American Chemistry Council, and a commanding knowledge of government agency rulings, scientific reports, and best environmental practices. Through plasticsinfo.org, the American Chemistry Council and their clients aim to create certain things in the world: plastics that are safe within boundaries, good and bad consumer practices, and a confused media. They are one of the major players funding and advocating for a definition of plastics whose essence is benign.

In their FAQ on “the safety of food containers made with polycarbonate plastic,” plasticsinfo.org assures readers that, “[t]he use of polycarbonate plastic in food-contact applications continues to be recognized as safe by the U.S. Food and Drug



Administration.”<sup>196</sup> Perhaps the expectant mother would not go to the U.S. Food and Drug Administration website to confirm, but if she did, she would find that it said something slightly, though significantly, different: “FDA is continuing its research and monitoring of studies to address uncertainties raised about BPA.”<sup>197</sup> Perhaps she would be confused again, and rightly so.

#### The FDA and the NRDC petition

In 2008, the National Resource Defense Council (NRDC), an environmental action group, submitted a citizen petition underwritten by its senior scientist Dr. Sarah Janssen to the Food and Drug Administration (FDA). The petition asked the FDA to “establish a regulation prohibiting the use of BPA (4-4'-isopropylidenediphenol, CAS Reg. No. 80-05-7) in human food and revoke all regulations permitting the use of a food additive that results in BPA becoming a component of food.”<sup>198</sup> The NRDC cited over fifty studies and reports that found health effects at low levels of BPA, including some of the studies cited in the previous chapter. These studies used a wide variety of endpoints, doses, animals, and methods of ingestion. For the NRDC, this collection of studies constituted a density of proof for an emerging yet consistent relationship between BPA and negative health effects under a range of circumstances.

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<sup>196</sup> American Chemistry Council 2011.

<sup>197</sup> Food and Drug Administration. (2012b). “FDA Continues to Study BPA.” *For Consumers*. Retrieved 7/12, 2012, from <http://www.fda.gov/ForConsumers/ConsumerUpdates/ucm297954.htm>.

<sup>198</sup> Natural Resources Defense Council. (2008). “Citizen Petition,” Division of Dockets Management, Food and Drug Administration: 1.

The NRDC's petition highlighted the Chapel Hill Bisphenol A Expert Panel Consensus Statement. This statement was drafted by thirty-eight of the world's leading scientists on BPA in 2007 following a meeting to assess "concerns about the potential for a relationship between BPA and negative trends in human health that have occurred in recent decades."<sup>199</sup> The group concluded:

The published scientific literature on human and animal exposure to low doses of BPA in relation to in vitro mechanistic studies reveals that human exposure to BPA is within the range that is predicted to be biologically active in over 95% of people sampled. The wide range of adverse effects of low doses of BPA in laboratory animals exposed both during development and in adulthood is a great cause for concern with regard to the potential for similar adverse effects in humans.<sup>200</sup>

For the NRDC, the strength of this statement comes from its origin within an expert scientific community and its basis in consensus. The NRDC's perception of BPA as a dangerous chemical is not merely the result of accumulation formed by an increasing number of studies, but that the accumulation has been reviewed, curated and finally interpreted by experts. The NRDC also referenced review articles in its petition, a genre of scientific publication that does not present new data, but provides a synopsis and evaluation of recent published experimental results. Review articles provide a snapshot of a niche issue within a discipline. Usually, they contain a literature review and a judgment about how the overall issue is taking shape, constituting a second tier of peer review for articles that have already appeared in peer-reviewed journals. In each review article submitted by the NRDC, BPA was seen as a "cause of concern."

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<sup>199</sup> vom Saal, F. S., B. T. Akingbemi, et al. (2007). "Chapel Hill bisphenol A expert panel consensus statement: Integration of mechanisms, effects in animals and potential to impact human health at current levels of exposure." *Reproductive Toxicology* 24(2): 3.

<sup>200</sup> vom Saal 2007: 12.

On March 30, 2012, the FDA wrote the NRDC to say they were “denying your citizen petition in its entirety.”<sup>201</sup> The FDA “reviewed [the NRDC's] citizen petition and has determined that it failed to provide sufficient data and information to persuade FDA to initiate rulemaking ... to revoke regulations permitting the use of BPA in food contact materials.”<sup>202</sup> Their fifteen-page response to the NRDC, only two pages shorter than the original petition, disaggregated the NRDC’s density of studies by reviewing them one by one, line by line. They found that each had a fatal flaw: “the subcutaneous [injected] administration of [BPA], the small sample size, and the limitations on controls preclude reliance on these data;” “a clear progression of the findings is unclear;”<sup>203</sup> the health effect in question “cannot be described to be an adverse event... or detrimental to the organism;”<sup>204</sup> the “dosing method ... cannot currently be compared to oral exposure for BPA;”<sup>205</sup> the study has “an inadequate sample size;” “an inappropriate statistical analysis;” “[fails] to establish relevance to a human health effect;”<sup>206</sup> and so on, for each of the forty-eight submitted studies. They found that the evidence of each article lead to uncertainty in relation to the study’s own conclusion or to the study’s relevance to BPA in food and food packaging, the proper domain of the FDA. The FDA concluded that

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<sup>201</sup> Food and Drug Administration. (2012a). “Re: FDMS Docket No. FDA-2008-P-0577-0001YCP.” Health and Human Services, Washington, DC: 2.  
Note that their response was three and a half years late and was only issued after the U.S. District Court compelled the Food and Drug Administration (FDA) to respond to the NRDC’s citizen petition as required by law.

<sup>202</sup> FDA 2012a: 2.

<sup>203</sup> FDA 2012a: 6.

<sup>204</sup> FDA 2012a: 9.

<sup>205</sup> FDA 2012a: 8.

<sup>206</sup> FDA 2012a: 8.

"[d]ue to these uncertainties, FDA is unable to find adequate scientific basis... for establishing a no-observed adverse effect level for BPA at 10tg/kg-bw/day" as requested.<sup>207</sup>

The FDA and the NRDC operate within different Regimes of perceptibility. Rather than seeing an emerging relationship between BPA and harm, the FDA saw inconclusive or unrelated conclusions in disparate studies. They maintained that evidence was in the details, not the accumulation of different types of studies with similar concluding statements. Keeping with their version of proper evidence, the FDA repeatedly admonishes the NRDC for including review articles in their petition. They write, "[t]his publication is a review article that contains no new data," over and over, like a mantra. The FDA then disaggregates the review articles into the studies they cover, and evaluates them one by one, each time coming to the conclusion that they do not "add up."

The Chapel Hill Bisphenol A Expert Panel Consensus Statement is also dismissed as a non-valid form of evidence: "You also cite the Chapel Hill bisphenol A expert panel consensus statement, which, based on an assessment of selected studies and review articles, expresses the opinion of a group of scientists, many of whom had contributed to the literature reviewed. Many studies or reviews included were not directly relevant to human oral exposures."<sup>208</sup> One of the few rebuttals written in non-technical terms,

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<sup>207</sup> FDA 2012a: 9.

<sup>208</sup> FDA 2012a: 14.

this statement is loaded with judgments about what makes something a relevant matter of fact for the FDA. What is particularly interesting is how a technocratic agency has stated that scientists may not make statements about their science—this is strictly the domain of the regulators. According to the FDA, scientists do not interpret studies. Rather, they create raw data. Any statements made by scientists about their science are opinions, not facts. This is a radical division of labour and knowledge within a technocracy.<sup>209</sup>

The NRDC petition fits within a technocratic framework. First, they are asking to lower the allowable limit of BPA in food containers, not eliminate BPA. They start their “conversation” premised on a nature that is robust within limits, and focus on where to draw the line for that robustness. They are not challenging assimilative capacity, nor are they redefining pollution. Secondly, the foundation for all the NRDC’s claims are scientific, written in the language that technocracies are known to respond to. Some of their sources are even from government laboratories. The NRDC researched not only the scientific aspects of BPA levels, but also the legal and policy frameworks through which the FDA makes decisions. They went through all the correct channels. Finally and most notably, the NRDC has chosen to go to a federal regulatory agency to make the

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<sup>209</sup> Note that the FDA’s procedure for determining a matter of fact is nearly the opposite of what Steven Shapin and Simon Schaffer write about in *Leviathan and the Air-pump*, where the problem of determining which scientific findings were valid in the seventeenth century was solved in part by having a group of “legitimate” scientists observe an experiment and reach consensus on what they saw. The Chapel Hill Bisphenol A Expert Panel is a type of twenty-first century laboratory court with similar methods of determining matters of fact. Shapin, S., S. Schaffer, et al. (1985). *Leviathan and the Air-pump: Hobbes, Boyle, and the experimental life*. Princeton, N.J., Princeton University Press.

changes they feel are necessary for their health and safety rather than using other avenues to meet their goals.

Thus, it would at first glance appear that the FDA has rejected the NRDC petition on technocratic grounds they share. Yet, though it appears that the NRDC and the FDA are engaged in a technical discussion centered on endpoints, variables, experimental designs, and proper thresholds for BPA, they are actually engaged in an epistemological debate. The NRDC and the FDA may both be operating within the general framework of a technocracy, but they fundamentally disagree on what counts as valid evidence and proof of harm within a shared definition of pollution as something that exceeds allowable limits. The NRDC clearly sees BPA as a dangerous entity that must be acted upon, especially because an accumulation of studies find that ill effects may result from levels that are already in the population. The FDA is still wed to pollution heuristics developed along the lines of the Streeter-Phelps equation with definite, defined, well-bounded categories and linear causal proofs of effect. They seek a phenomenon that is already clearly defined and find none.

Each institution and its actors occupy different but overlapping Regimes of perception, and while they both discuss endpoints and thresholds, they differ on what counts as evidence, and what sort of objects are possible given the knowledge systems they are part of. The NRDC clearly sees a dangerous object, while the FDA sees an uncertain one. Yet, Regimes of perceptibility are not only about looking from different paradigms. They are also about power. Is perceptibility about the ability to see or not see something as

evidence, or about the willingness to do so? Kuhn suggests that groups in different paradigms really cannot see from the other's point of view because people who subscribe to different paradigms live on different worlds, and the logic of one world does not follow in another. Things would literally not make sense. However, in the NRDC-FDA tête-à-tête, the public and the media tended to state perceptibility in terms of willingness rather than ability.

### Controversy

When the FDA released its denial of NRDC's citizen petition on March 30, 2012, public and private discussions rarely mentioned metabolic pathways and dose thresholds. Instead, they talked politics. The Watch Dog Report from the *Journal Sentinel*, a long time NRDC supporter, alleged that "as federal regulators hold fast to their claim that a chemical in baby bottles is safe, e-mails obtained by the *Journal Sentinel* show that they relied on chemical industry lobbyists to examine bisphenol A's risks, track legislation to ban it and even monitor press coverage."<sup>210</sup> The environmentally minded *Huffington Post* warned that, "Americans are waking up to the stark reality that our food supply is controlled by corporate entities with powerful influence over our political system."<sup>211</sup> An online commenter to the report responded, "[t]he FDA is an incompetent and ineffective agency because it is under corporate control. Whatever they say, do the

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<sup>210</sup> Rust, S. and M. Kissinger (2009). "FDA relied heavily on BPA lobby: Regulators actively reached out to industry, e-mails show." *JS Online*. Milwaukee, Journal Sentinel, May 23. Retrieved 9/25/12, from <http://milwaukee-journal-sentinel.vlex.com/vid/fallout-watchdog-relied-bpa-actively-74508396>.

<sup>211</sup> Simon, M. (2012). "BPA Is FDA's Latest Gift to Food Industry." *The Huffington Post Online*, April 5. Retrieved 9/25/2012, from [http://www.huffingtonpost.com/michele-simon/bpa-ban\\_b\\_1403343.html](http://www.huffingtonpost.com/michele-simon/bpa-ban_b_1403343.html).

opposite and you'll be fine."<sup>212</sup> The public debate was further fuelled by the FDA's seemingly schizophrenic behaviour; they both claimed a lack of evidence to rule BPA unsafe, yet dedicated several pages on their website to telling consumers, particularly parents, how to avoid BPA. The FDA responded to criticisms of "confusion" and hypocrisy by stating they "do have some concern [about BPA], which is why we're conducting more research. I think that's the clearest statement we can make." Yet, the public interpreted the split as an artifact of corruption and loyalty to industry rather than a desire for more or better knowledge.<sup>213</sup>

On the other side of the debate, *Forbes* published an op ed entitled, "Leaked Secret Natural Resources Defense Council Memo Disses Science: 'How do we get the FDA to ban Bisphenol A when the evidence is against us?'" The article alleged that the NRDC was running a campaign of mass deception as they tried to ban BPA even while they recognized such a ban was scientifically unsupported.<sup>214</sup> The chosen genre of a "leaked memo" was meant to imply that the NRDC's regime of perception was dishonestly manufactured, not merely the result of a different scientific worldview. In a matter of hours the "leaked memo" was pulled from *Forbes*. It was a spoof, or, in the words of the author, a "satire."<sup>215</sup> Yet the article, satirical or fake as it may be, used a number of

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<sup>212</sup> Simon 2012: comments. Comment from Oginikwe made at 12:23 AM on 04/06/2012.

<sup>213</sup> Food and Drug Administration. (2010). Public Stakeholder Call Transcript. Health and Human Services, Washington, DC: 13.

<sup>214</sup> Entine, J. (2012). "Leaked Secret Natural Resources Defense Council Memo Disses Science: 'How do we get the FDA to ban Bisphenol A when the evidence is against us?'" *Forbes*, April 5, 2011: removed.

<sup>215</sup> For particulars on the "memo," including its retraction and the legal and public response to it, see: Philpott, T. (2012). "Chemical-Industry Apologist Botches NRDC Satire." *Environment, Food*



arguments common to pro-plastic, pro-industry, and anti-matter-of-concern discussions already circulating in the public sphere which accuse groups like the NRDC of fear mongering, overreacting, and corruption from environmental groups and other interested parties.

What matters in public discourse is that regardless of the side of the debate, both accuse the other of corruption. The FDA is corrupt and under the influence of corporations, and that is why they did not grant the NRDC petition. The NRDC is corrupt and under the influence of environmental groups, and that is why they filed an unfounded and misleading petition. If the written discussion between the FDA and NRDC was about the perceptibility of evidence within a regime of perception with an emphasis on perception, then the public discussion about the petition and its denial has emphasized the regime aspect of regimes of perceptibility. That is, they have isolated power, interests and stakes as the salient aspects of perceptibility, not epistemological positions. While such a view initially seems to support a division between science and politics—good science is used well or misused based on the corruption of those appropriating it—scientists themselves are telling a different story.

#### Funding Bias

These debates about power, endocrine disruptors and bad-faith tactics of not-seeing are not exclusive to the public sphere, nor did they begin on March 30, 2012, when the FDA

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*and Ag.* Retrieved 7/14/12, from <http://www.motherjones.com/tom-philpott/2012/03/nrdc-entine-bpa-satire>.

denied the NRDC's citizen petition. Frederick vom Saal, a scientist in the Division of Biological Sciences at the University of Missouri and one of the scientists involved in the Chapel Hill Bisphenol A Expert Panel Consensus Statement, co-published an article with Claude Hughes in 2005 that used quantitative empirical methods to demonstrate funding bias in BPA studies. They found that "[f]or government-funded published studies, 94 of 104 (90%) report significant effects at doses of BPA < 50 mg/kg/day. No industry-funded studies (0 of 11, or 0%) report significant effects at these same doses."<sup>216</sup>

| Source of funding     | All studies |          | CD-SD rat studies |         | All studies except CD-SD rats |         |
|-----------------------|-------------|----------|-------------------|---------|-------------------------------|---------|
|                       | Harm        | No harm  | Harm              | No harm | Harm                          | No harm |
| Government            | 94 (90.4)   | 10 (9.6) | 0 (0%)            | 6 (100) | 94 (96)                       | 4 (4)   |
| Chemical corporations | 0 (0)       | 11 (100) | 0 (0%)            | 3 (100) | 0 (0)                         | 8 (100) |

Values shown are no. (%).

Figure 3.2: Biased outcome due to source of funding in low-dose in vivo BPA research as of December 2004.

The reviewed studies were conducted in North America, Europe and Japan, and included animal experiments, cell culture studies, and microarray analysis of gene expression (toxicogenomics). In each case, funding bias was evident. This study is cited more times than any of vom Saal's other well-known publications, including the co-published Chapel Hill Bisphenol A Expert Panel Consensus Statement. In most cases, the citations do not reference the funding bias. Rather, other scientists use the document as a more traditional review article and cite the health effects of BPA the article names and

<sup>216</sup> vom Saal, F. S. and C. Hughes (2005). "An Extensive New Literature Concerning Low-Dose Effects of Bisphenol A Shows the Need for a New Risk Assessment." *Environ Health Perspect* 113(8): 928.

accumulates as part of its literature review. Indeed, the main topic of the article and its title focus on establishing a robust framework for standardizing studies and maintaining "scientific integrity" in the laboratory. As such, the article lists several methodological imperatives when carrying out BPA studies that many of the eleven chemical corporation studies lacked. This is the content the scientific community focuses on almost exclusively.

On the other hand, the press and plastic industry lobbyists focus exclusively on the single paragraph about funding bias. Steven G. Hentges, executive director of the polycarbonate business unit of the American Plastics Council, responded to the article's publication by saying, "[t]he sum of weak evidence does not make strong evidence"<sup>217</sup> and "[y]ou can have 1,000 studies, but if they're all weak, adding up weak evidence doesn't necessarily give you strong evidence of anything."<sup>218</sup> Like the FDA, Hentges calls the review article an "op ed" piece rather than a scientific paper. The tactic of redefining political work by scientists as a genre of writing based on opinion rather than expertise is increasingly common in public debates about environmental issues. The second type of industry response was to reiterate that studies other than those covered by vom Saal have shown that BPA has no harmful effects. The mainstream print and online reporting venues that covered the report, most of them left-leaning institutions, used the report

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<sup>217</sup> Cone, M. (2005). "Scientists say evidence mounting that chemical in plastic is dangerous." *Los Angeles Times*, 4/13/05. Retrieved 9/25/11, from <http://community.seattletimes.nwsources.com/archive/?date=20050413&slug=plastic13>

<sup>218</sup> Weise, E. (2005). "Debate over a leaching chemical heats up." *USA Today*. Online, USA Today, 4/14/05. Retrieved 9/25/12, from [http://usatoday30.usatoday.com/news/health/2005-04-14-leaching-chemical\\_x.htm](http://usatoday30.usatoday.com/news/health/2005-04-14-leaching-chemical_x.htm).

to further their conviction that industry has corrupted state agencies via the “tobacco tactics” of scientific misinformation.

The majority of responses to vom Saal and Hughes’ review of BPA studies, however, has remained in the scientific community, which has called for “the application of systematic and transparent methodologies to vet the science, including explicit recognition of the potential bias introduced by funding source.”<sup>219</sup> A remarkable aspect of vom Saal’s article is that, contrary to efforts within science to purify science from politics for centuries, vom Saal and Hughes’ empirical methods include politics as a viable scientific variable. That is, they show that funding sources are a factor that determines the findings of a scientific study. As such, they argue that this variable must now be included in experimental designs and reports. Truth and good science will follow. This is a surprising proposal to solve the problem of funding bias because the scientific method is already supposed to constitute a robust regime of perceptibility that inevitably leads to truth and matters of fact rather than politics, power, and intentional misinformation. In fact, vom Saal and his allies still have faith in this empirical regime. They imply that it is only through “bad methods” that funding sources have populated our world with safe BPA rather than dangerous BPA. Their inclusion of funding sources in the scientific method may seem both scientifically logical—if there is a variable that has been proven to affect results, then obviously include it—as well as radical—science and politics are not separate, and there is a place to systematically engage with politics

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<sup>219</sup> Sutton, P., T. J. Woodruff, et al. (2011). "Conrad and Becker's "10 Criteria" Fall Short of Addressing Conflicts of Interest in Chemical Safety Studies." *Environmental Health Perspectives* 119(12): A 506.

within laboratory experimental design. They, and many other scientists and advocates outside of science, are demanding that funding sources be brought into a scientific regime of perceptibility.

### The Role of Controversy in Definition

Michel Callon, Pierre Lascoumes and Yannick Barthe, authors of *Acting in an Uncertain World*, believe that controversies "make possible the exploration of what we propose to call overflows engendered by the development of science and techniques. Overflows are inseparably technical and social, and they give rise to unexpected problems by giving prominence to unforeseen effects."<sup>220</sup> While Callon and his colleagues do not explicitly explore power, we can see how controversies challenge and aim to expand dominant Regimes of perceptibility so that objects in question, such as BPA, are seen as particular types of objects caught in power relations. In the BPA controversy, and particularly in the articulation of funding bias, the chemical is not merely a (potential) endocrine disruptor, but also "one of the highest volume chemicals produced worldwide, with over 6 billion pounds produced each year"<sup>221</sup> with "over 90% ... made by Bayer, Mitsubishi, Teijin Chemicals, Dow Chemicals, and GE Plastics."<sup>222</sup> These producers hire groups such as the American Chemical Council to advocate for their profit-generating chemicals. Some of these industries directly or indirectly fund scientific studies that show BPA is

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<sup>220</sup> Callon, M., P. Lascoumes, et al. (2009). *Acting in an Uncertain World: An Essay on Technical Democracy*. Cambridge, Mass., MIT Press: 28.

<sup>221</sup> Vandenberg, L. N., M. V. Maffini, et al. (2009). "Bisphenol-A and the Great Divide: A Review of Controversies in the Field of Endocrine Disruption." *Endocrine Reviews* 30(1): 76.

<sup>222</sup> Adkins, T. (2008). *Bisphenol-A (BPA) Fact Sheet*. Algalita Marine Research Foundation.

benign. Through controversy, some of these relationships that might have remained hidden are clarified; controversies make certain things perceptible.

As stakeholders such as the American Chemistry Council emerge, the object called BPA takes on a new form that includes "overflows" to the technical discussion in the FDA's rejection letter to the NRDC. These overflows are taken up and fleshed out by the media, by vom Saal and Hughes, and by other stakeholders: "The controversy carries out an inventory of the situation that aims less at establishing the truth of the facts than at making the situation intelligible."<sup>223</sup> Despite the controversy between parties such as the American Chemistry Council, the FDA, the NRDC, scientists and media reporters, BPA is not becoming intelligible as a matter of fact. Rather, power relations and the regime-like aspects of perception, evidence, and bias become intelligible. The situation is simultaneously complicated and clarified. Instead of becoming matters of fact, endocrine disruptors become even more rooted as matters of concern.

Bruno Latour differentiates between matters of fact and matters of concern. Matters of fact, or what he also calls "risk-free objects" have "clear boundaries, a well-defined essence, [and] well-recognized properties. [They belong] without any possible question to... a world made up of persistent, stubborn, nonmental entities defined by strict laws of causality, efficacy, profitability, and truth."<sup>224</sup> The techniques that define "matters of fact," are invisible in public, as they remain relegated to the laboratory and government

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<sup>223</sup> Callon 2009: 28.

<sup>224</sup> Latour 2004: 22-23.

boardrooms. In 1982, BPA was considered a matter of fact according to the National Toxicology Program. It caused low body weight in rats, but not cancer. In 1998, Patricia Hunt launched its recategorization as a matter of concern when her rats showed genetic abnormalities after exposure to low doses of BPA. Latour's "matters of concern" are quite different:

Unlike their predecessors, they have no clear boundaries, no well-defined essences, no sharp separation between their own hard kernel and their environment. It is because of this feature that they take on the aspect of tangled beings, forming rhizomes and networks. In the second place, their producers are no longer invisible, out of sight; they appear in broad daylight, embarrassed, controversial, complicated, implicated, with all their instruments, laboratories, workshops, and factories.... Finally, and this may be the strangest thing of all, they can no longer be detached from the unexpected consequences that they may trigger in the very long run, very far away, in an incommensurable world.<sup>225</sup>

In 2012, BPA remains a matter of concern, particularly in public controversy.

Controversy brings the "instruments, laboratories, workshops, and factories," as well as the funders and the lobbyists into "broad daylight." Recall that Bruno Latour defines essences as entities "obtained by institution[s] at the end of an explicit process that gives them durability and indisputability by attaching attributes to their substance."<sup>226</sup>

Controversies bring out the institutions and processes that create essences upon which definitions depend.

Steve Fuller extends his criticism of Kuhn and joins Latour, Callon, and others in arguing that institutions of science should not only welcome controversy, but should model it.

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<sup>225</sup> Latour 2004: 24.

<sup>226</sup> Latour 2004: 241.

He argues that we ought to “regard inquiry as an especially focused form of political action. Whereas a paradigm-based approach to knowledge would declare politics to be vulgar metaphysics, a movement-based approach treats metaphysics as an inchoate politics. Thus, a stable body of knowledge is simply what political action becomes once the public space for contestation has been restricted.”<sup>227</sup> Fuller’s paradigmatic knowledge is akin to Latour’s matters of fact, issues withdrawn from the public and other stakeholders, detached from the entanglements that make them wicked. All three authors that argue for controversy—Fuller, Latour, and Callon—do so in response to the current, dominant regime of perceptibility that systematically shuts out stakeholders to produce secure matters of fact.

Following Foucault, power is not a force one holds over another, but a complex set of strategic relations within a society. It includes the relationships and techniques of perceptibility by which the NRDC must frame its petition to the FDA, and by which the FDA can refuse it. The BPA debate is not a discussion from which all speakers start from equal ground with equal capacity to be heard and taken seriously. Even the scientists and their consensus statement, working within the discipline of science and its methods for producing truth, do not have the same power as the FDA to make statements that stick. This is because the BPA debate, a microcosm of the greater plastic pollution debate, is not about truth itself, but the status of truth and the roles it plays in politics and the economy.

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<sup>227</sup> Fuller 2000: 402.



In July 2012, the FDA banned BPA in baby bottles and cups. Had they reversed their decision over the NRDC's petition? Had they inventoried studies according to vom Saal's criteria? When the ruling was made public, I had already written this chapter and thought I would have to interrogate and amend my arguments. Alas, the ban only reinforces the relationship between industry, power, and definitions of pollution. The ban was instated by the FDA "because these uses [of BPA in infant bottles and cups] have been abandoned [by the plastics industry]. The action is in response to a petition filed by the American Chemistry Council."<sup>228</sup> In effect, because the plastics industry has ceased using BPA in baby bottles and cups for several years due to "consumer concern," the ruling was meant to reduce confusion for consumers, not as an indication of the safety or harm of BPA. In fact, Michael Taylor, deputy commissioner for foods at the FDA, told the *New York Times* reporter covering the ruling that the FDA "has been looking hard at BPA for a long time, and based on all the evidence, we continue to support its safe use"<sup>229</sup> despite the ban. So BPA is now partially banned, but still safe. New and expectant mothers will be forgiven their confusion.

## Part 2: Citizens, Activists, Consumers

Not all definitions of pollution are susceptible to the powers of industry and government, a key point for activists who despair at the massive conglomerate power of

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<sup>228</sup> FDA (2012). "Indirect Food Additives: Polymers. A Rule by the Food and Drug Administration on 07/17/2012." Department of Health and Human Services, Federal Register. Docket No. FDA-2012-F-0031: 41899 -41902.

<sup>229</sup> Travernise, S. (2012). "F.D.A. Makes It Official: BPA Can't Be Used in Baby Bottles and Cups." *The New York Times online*. Retrieved 9/12/12, from <http://www.nytimes.com/2012/07/18/science/fda-bans-bpa-from-baby-bottles-and-sippy-cups.html>.

corporations backed by state agencies. The premise of Mary Douglas' anthropological work on pollution is that all cultures have theories and protocols of pollution, "and that the difference between pollution behaviour in one part of the world and another is only a matter of detail."<sup>230</sup> Scientifically determined or otherwise, pollution marks the boundaries of tolerable and intolerable conditions, "cherished classifications," and matter in or out of place. This section will look at how those outside of technocratic circles—that is, outside of scientific, government, and industry interest groups—define plastic pollution. These outside groups are not ignorant of technocratic definitions and controls for pollution, and often read scientific reports or the news that draw on them; yet, their stakes, evidence, and techniques are of a different sort.

### Theatres of Proof

The artist Chris Jordan picks his way carefully along edge of a beach on Midway Island, an isolated atoll in the North Pacific Ocean without human inhabitants. Until recently, Jordan's artistic production focused on the visual quantification of consumption and waste. His *Venus* is a photograph that depicts 240,000 plastic bags, equal to the estimated number of plastic bags consumed around the world every ten seconds; *Tuna* includes 20,500 tiny photos of tuna, the average number of tuna fished from the world's oceans every fifteen minutes.<sup>231</sup> Today, Jordan has almost exclusively turned into a sort

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<sup>230</sup> Douglas, M. (1984). *Purity and Danger: An Analysis of Concepts of Pollution and Taboo*. London, Ark Paperbacks: 35.

<sup>231</sup> Jordan, C. (2012). "Chris Jordan: Photographic arts." Web. Retrieved April 25, 2012, from [www.chrisjordan.com](http://www.chrisjordan.com).

of wildlife photographer, though his focus remains on consumption and waste. He is on Midway Island to photograph albatrosses because they ingest large quantities of plastic.

**TABLE 1**  
Incidence of plastic ingestion by Laysan Albatross chicks, Midway Island, North Western Hawaiian Islands.

| Date      | Number of chicks with plastic<br>(No./No. examined) | %    |
|-----------|---|------|
| Aug. 1982 | 3/4   | 75.0 |
| Apr. 1983 | 16/17   | 94.1 |
| May 1983  | 5/5   | 100  |
| July 1983 | 21/24   | 87.5 |
| Totals    | 45/50   | 90.0 |

Figure 3.3: Incidence of plastic ingestion by Laysan Albatross chicks, Midway Island, North Western Hawaiian Islands. Fry 1985

Between 1982 and 1983, ninety percent of all dead albatross chicks on Midway Island were found with plastics in their digestion tracts.<sup>232</sup> The graph above is based on necropsies performed by scientists on chick carcasses. Chicks do not forage for food on their own. They eat what their parents bring them, meaning adult albatross ingest and regurgitate plastic objects they find in the ocean near the island. While many marine animals ingest plastic, the albatross tends to eat more than other species. Jordan is currently completing a documentary called *Midway: Message from the Gyre* about ocean plastics, and when he goes to Midway Island to photograph birds, he also counts the plastics in their carcasses to pass on to interested scientists.

<sup>232</sup> Fry, D. M., S. I. Fefer, et al. (1987). "Ingestion of plastic debris by Laysan Albatrosses and Wedge-tailed Shearwaters in the Hawaiian Islands." *Marine Pollution Bulletin* 18(6, Supplement B): 339-343.

Ingestion studies are one of the main ways that scientists measure ocean plastics.<sup>233</sup>

Marine bird ingestion is a good way to monitor ocean plastics because birds tend to die on or near land, so their bodies can be recovered in sufficient numbers for statistical analysis. Many marine birds, like the albatrosses on Midway Island, live in remote locations, including middle of the North Pacific Ocean, and make testing these remote areas feasible. Gathering ingestion data on land is cheaper than going into the ocean to do trawls or submersible studies. Marine birds have discernible territories that can be calculated by the known distance they fly while looking for food, allowing researchers to estimate the area the plastics come from. Finally, ornithologists have been performing necroscopies long before ocean plastics were a known problem, so scientists have records of ingested plastics and other ingestion trends from the past to compare current records to.

Through ingestion studies scientists have found that plastic ingestion, and therefore ocean plastics, has increased steadily since the 1960s. Ingestion studies have also determined that nurdles, the raw plastic production pellets that enter the ocean directly from manufacturing plants, have decreased in number between the late 1980s and the mid 1990s, possibly owing to new campaigns in the United States for plastic production workers to include pellet clean up and containment practices in their daily routines.<sup>234</sup>

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<sup>233</sup> Ryan, P. G., C. J. Moore, et al. (2009). "Monitoring the abundance of plastic debris in the marine environment." *Philosophical Transactions of the Royal Society B: Biological Sciences* 364(1526): 1999–2012.

<sup>234</sup> Ryan, P. G. (2008). "Seabirds indicate changes in the composition of plastic litter in the Atlantic and south-western Indian Oceans." *Marine Pollution Bulletin* 56(8): 1406–1409.

While nurdle counts may have decreased, however, the overall amount of plastic found in their digestive systems has not. This is one of the drawbacks of ingestion studies: once the bird is full of plastic, they can no longer indicate any changing amounts of ocean plastics above their saturation point.

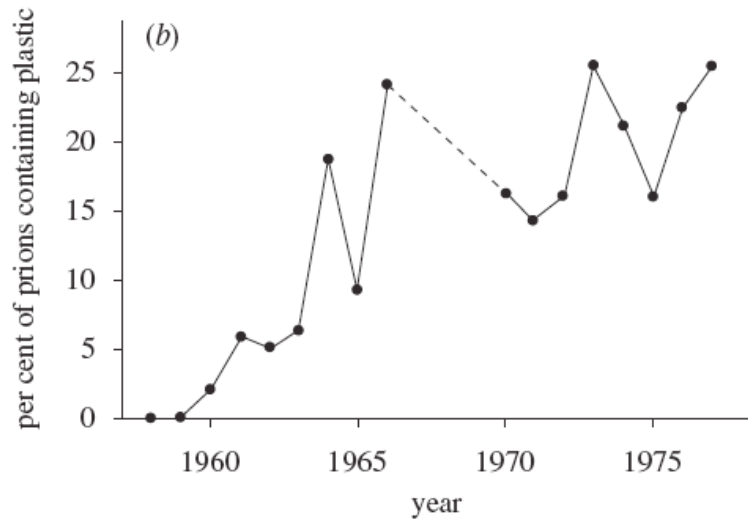


Figure 3.4: Long-term trends in proportions of prions *Pachyptila spp.* from New Zealand beaches that had plastics in their stomachs, 1958-1977.

None of these nuances or trends are evident in Chris Jordan's photographs nor his captions, even though he photographs the sources of scientific data. None of it is mentioned in the campaigns that use his images.

Figure 3.5: Photograph by Chris Jordan from the series *Midway: Message from the Gyre*, 2009-present.







Figure 3.6 (above)& 3.7 (below): Photograph by Chris Jordan from the series *Midway: Message from the Gyre*, 2009-present.







Figure 3.8: Photograph by Chris Jordan from the series *Midway: Message from the Gyre*, 2009-present.

Though the graphs contain the data that the bird carcasses provide, and though they amalgamate, compare, and nuance that data, they are not nearly as communicative as the "samples" –bird carcasses— from which their data originates.

Bruno Latour uses the term "theater of proof" to describe settings where a phenomenon is immediately apparent, in black and white, and the entire situation is understood at once.<sup>235</sup> He used the phrase to explain how Louis Pasteur proved his inoculation technique against anthrax by using a laboratory stage. Pasteur erected two

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<sup>235</sup> Latour, B. (1988). *The Pasteurization of France*. Cambridge, Mass., Harvard University Press.



corrals full of sheep injected with the anthrax bacilli. One corral of sheep was inoculated, while the other was not. At and at the end of the “theater,” all the sheep he not inoculated were lying dead, and those he had inoculated were standing, chewing their cud. In that moment, the truth of inoculation became obvious to onlookers. They may not know about the intricacies of the new germ theory or the mechanism by which inoculation worked, but it was obvious that it did, indeed, work. Observers can run to tell their neighbours about the miracle of inoculation. The photographs of albatross carcasses work the same way. It is obvious that ocean plastics exist and are a problem. They are harmful. They kill animals. Something must be done. Run and tell your neighbours.

The albatross images have a terrible charisma. They are terrible in that the phenomenon depicted is distressing; it inspires dread, fear, a horrible feeling in your gut. This terribleness is also what makes it charismatic. I use “charisma” in its original religious sense, in which someone or something possesses a special influence to inspire enthusiasm and devotion in others.<sup>236</sup> The terrible charisma of Jordan's photographs move people to action. Albatross ingestion samples are both affective and completely understandable, and become a platform from which to launch action, while the graphs of the same specimens produce are merely informative. The images have become veritable tropes in ocean plastic activism, and are even accompanied by confessions of lifestyle changes by those who witness them.

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<sup>236</sup> (2012). “Charisma.” *Oxford Dictionaries*, Oxford University Press. Retrieved 9/7/12, from [www.oed.com](http://www.oed.com).

The charisma of Jordan's photographs, that is, the ability to inspire action based on a theatre of proof, offer a different kind of evidence with a different goal than the ingestion data gathered by scientists from those same bodies. The way the images make the problem plain, in black and white (and brightly coloured plastics), gives them an epistemological power: suddenly, the viewer knows that there are ocean plastics, and that they cause harm. As such, the strength of these photographs has repercussions for the ontology of plastic pollution. Ocean plastics become colorful, floating micoplastics that kill marine birds.

In science, there is only anecdotal evidence that plastic ingestion harms marine animals such as whales and birds. Moreover, systemic studies of plastic ingestion have found evidence to the contrary. One study of albatross chicks found that "mechanical lesions from ingested plastic were the cause of death of one of 45 Laysan Albatross chicks examined in 1986, but were not the cause of death of 93 individuals examined in 1987.... In general, ingested plastic was not a significant cause of death in nestlings, but there was some evidence that it may have affected survival in 1986, when the volume of plastic ingested was highest."<sup>237</sup> A study that aimed to determine a plastic ingestion mortality rate by feeding plastics to chickens did not find unusual mortality rates at all, but did propose that "plastic-loaded birds...ate less and grew slower than did control birds... [R]educed food consumption may limit the ability of seabirds with large plastic

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<sup>237</sup> Sievert, P. R. and L. Sileo (1993). "Plastic on The effects of ingested growth and survival of albatross chicks." *National Wildlife*: 212.

loads to lay down fat deposits, and thus reduce fitness."<sup>238</sup> Based on these findings, scientific studies about the harms of ingestion tend to focus on chemical, rather than mechanical, pathways for harm, such as endocrine disruption. As we know from the last chapter, endocrine disruption has a complicated relationship with harm, but rarely ends in death. Thus, the link between plastic ingestion and death is not as obvious, or even considered a proper frame for harm, in scientific circles as it is in plastic pollution campaigns based on Chris Jordan's photographs.

Does the tension between scientific and activist forms of evidence matter if the goal of the photographs is to raise awareness and launch action? During a guest lecture in an environmental policy class on this topic, a woman at the back of the room asked this very question. Would I advise activists to use theaters of proof to initially attract people to the cause, and then use more nuanced methods to explain the problem in detail, or did I recommend campaigns abandon theaters of proof that might obfuscate important elements of pollution? In one sense, using theatres of proof does not matter if the goal is to launch any kind of action against plastics. On the other hand, one of the premises of my research is that activism based on the materiality and specific wickedness of the problem is more ethical, well-formulated, and most likely to succeed because of the way it can match problems and solutions. Inspired by Chris Jordan's photos, people have launched beach clean ups and individuals have promised to reduce purchasing disposable plastics. The trailer for *Midway* has been called, "[b]eautiful, sad, frightening,

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<sup>238</sup> Ryan, P. G. (1988). "Effects of ingested plastic on seabird feeding: Evidence from chickens." *Marine Pollution Bulletin* 19(3): 125.

hopeful, and motivating... The world's a better place with people like Chris in it. Now, if we can all just be inspired and motivated to consume and create less junk – maybe things will be even better.”<sup>239</sup> Yet, individually consuming and creating less “junk” does not make an appreciable difference in ocean plastics (covered further in chapter four). Mismatching problems and solutions is a classic problem in environmentalism, and theatres of proof do not help the situation.

At another guest lecture, after I had finished a discussion about how the albatross photographs can make it difficult for people and non-profits to understand the variety of harms caused by ocean plastics so that their actions could best address these issues, an undergraduate approached me as I was packing up. She wanted to know if I had any good pictures of dead turtles with plastics in their stomachs. She wanted to use them in an awareness campaign she was putting together. I tried to engage her in a conversation about why she would choose images of dead turtles instead of other kinds of images, what kind of change she was trying to raise, and how she might best couple images with particular changes, to no avail. By the end of the conversation, she decided that I hated turtles.

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<sup>239</sup> Chase. (2011). "The Dream of a Dying Albatross: More Powerful Work from Chris Jordan." *chasejarvis blog*: public comment. Retrieved 7/14/12, from <http://blog.chasejarvis.com/blog/2011/11/the-dream-of-a-dying-albatross-chris-jordan/>. Comment made by squarepegier on November 27, 2011 at 9:10 am.

### Not in My Body (NIMB)

For many stakeholders, including the undergraduate who loved turtles, nuance can be difficult to prioritize over action-in-general. This is as true for body burdens as it is for ocean plastics. In 1987, a lab technician in Quebec City named Evelyne Pelletier was analyzing breast milk samples. In one archived batch from the freezer,

the concentrations of chemicals were off the charts—literally. In a normal test, technicians find individual, needlelike peaks, like those on an electrocardiogram. Instead, the peaks had overloaded the lab's equipment, running off the page. Pelletier showed the charts to the lab director, Jean-Philippe Weber. He had never seen his lab's equipment overloaded by a sample. The concentrations were about thirty times higher than anything he had ever seen before. When he saw that the samples were the milk of Arctic women, making the results even more improbable, he called Dewailly. "We have a problem here," he said.<sup>240</sup>

Soon, a flurry of concern and contradictory information erupted about whether or not Arctic women should breastfeed their babies. Though some of the chemical loads could classify the breast milk as hazardous waste, the general advice to northern mothers was to continue to breastfeed because the known health advantages of breast milk outweighed the known disadvantages.<sup>241</sup> Such advice caused unease for obvious reasons. A preexisting lack of trust between government agencies and indigenous communities, differing definitions of pollution and harm, and language barriers kept the confusion over whether or not to breast feed fuelled for years. This unease, along with indecision, fear, distrust, and anger, continue today as scientists around the world find plasticizers such as phthalates, flame retardants, BPA and PCBs in breast milk. Breast milk is only one endpoint for body burdens. Every single person tested for industrial

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<sup>240</sup> Cone, M. (2005). *Silent Snow: The Slow Poisoning of the Arctic*. New York, Grove Press: 30-31.

<sup>241</sup> Cone 2005: 32, 112-114.

chemicals in their fat, urine, breast milk, or blood, a process called biomonitoring, has had positive results for some industrial chemicals.<sup>242</sup>

According to two scientists working for ChemRisk Inc., a consulting firm that specializes in “pioneering risk assessment methods to characterize and understand complex exposures involving chemicals,” biomonitoring “data are often presented without proper context, which can lead people to the understandable but erroneous conclusion that the low levels of chemicals found in our tissues are harmful, simply by virtue of their presence.”<sup>243</sup> The ChemRisk Inc. employees, in the spirit of Streeter and Phelps, differentiate between a contaminant and a pollutant, between presence and harm. They believe that citizens are prone to irrational fears about chemicals and confuse contaminants with pollutants. The satirical *Forbes* article agrees, “[i]t was stupendous to watch the hysteria [certain BPA studies] generated.”<sup>244</sup>

The concerns of the ChemRisk Inc. scientists and the *Forbes* author can be located in a particular definition of pollution based on thresholds and safe-until-proved-harmful, while many members of the public subscribe to a rather different definition. The public is neither irrational nor hysterical, but is making a statement about what pollution is and

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<sup>242</sup> Centers for Disease Control and Prevention (2009). *Fourth National Report on Human Exposure to Environmental Chemicals*. Department of Health and Human Services. Washington DC.

<sup>243</sup> ChemRisk. (2012). "Welcome to ChemRisk®." Retrieved 4/25/12, from <http://www.chemrisk.com/>.

Paustenbach, D. and D. Galbraith (2006). "Biomonitoring and Biomarkers: Exposure Assessment Will Never Be the Same." *Environmental Health Perspectives* 114(8): 1143.

<sup>244</sup> Entine 2012.

how it works from their position. They articulate a chemical's presence, that is, "mere" contamination, as an intolerable and harmful condition. This is often referred to as the NIMB concept. NIMB stands for Not in My Body, an adaptation of the more popular NIMBY movement (Not In My Backyard). NIMBY is a pejorative description of local residents' opposition to sighting polluting infrastructure near their homes. The radical potential of NIMB politics is that it redefines pollution.

Mary Douglas' definition of pollution in *Purity and Danger* is "matter out of place," "a contravention of order," the designation of tolerable and intolerable conditions within a social system, and, most importantly, as a way "to force one another into good citizenship."<sup>245</sup> That is, pollution is a manifestation of the vision of a good society. "Thus," she writes, "we find that certain moral values are upheld and certain social rules defined by beliefs in dangerous contagion, as when the glance or touch of an adulterer is held to bring illness to his neighbours or his children."<sup>246</sup> In this framework, the presence of BPA in more than ninety percent of Americans and plasticizers in mothers' breast milk make sense as an instance of pollution proper rather than "mere" contamination. For NIMB, there is no difference between contamination and pollution. Proponents of NIMB are not "crazed" or unreasonable. They are just drawing "the arbitrary line" of pollution at zero when it comes to their and their family's bodies. They do not have to know the metabolic pathways and etiology of each chemical. The

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<sup>245</sup> Douglas 1984.

Douglas, M. and A. B. Wildavsky (1982). *Risk and culture: an essay on the selection of technical and environmental dangers*. Berkeley, University of California Press.

<sup>246</sup> Douglas 1984: 3.

presence of such chemicals is a contravention of order and moral values. Industrial chemicals do not belong in bodies, full stop. Of course, a zero level is impossible to attain, but NIMBists are not making a scientific argument. A desire for zero levels of pollutants is an expression of their vision of an ideal society.

Most people do not self-identify as NIMBists, though its framing and values are quite common. A popular book on cancer calls body burdens a “toxic trespass.”<sup>247</sup> The California Body Burden Campaign (calBBC) states that “breast milk – though still the best food for infants – has been unacceptably compromised by synthetic chemicals and industrial pollutants.”<sup>248</sup> The campaign newsletter does not discuss this unacceptable compromise in medical terms, as the presence of synthetic chemicals in itself is deemed unacceptable. Likewise, the United Nation's Safe Planet Campaign Body Burden Forum launched in May 2011 featured the biomonitoring test of Norwegian professional golf champion Suzann Pettersen. The results showing that she had hundreds of chemicals in her body was seen as an appropriate rallying point for the forum, regardless of what the presence of those chemicals may mean medically.<sup>249</sup> Within NIMB, forms of evidence from medical, scientific, toxicological forums are irrelevant because they are beside the point.

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<sup>247</sup> Armstrong, L., G. Dauncey, et al. (2007). *Cancer: 101 solutions to a preventable epidemic*. Gabriola Island, BC, New Society Publishers.

<sup>248</sup> The California Body Burden Campaign (CalBBC). (n.d.). “SB1168 & Breastfeeding.” Breast Cancer Fund.

<sup>249</sup> SafePlanet. (2012). “United Nations Body Burden Forum.” Web. Retrieved 4/25/12, from <http://safepla.net/bodyburden.html>.



How are body burdens contraventions of moral order? People have not consented to having chemicals in their bodies, and this is considered an unacceptable and even unethical situation. Many studies on risk find that "people rank risks according to their ability to control that risk, that is, the extent to which the risk is voluntary."<sup>250</sup> The less control people have over exposure, the "riskier" and less acceptable the risk appears. Technically, this is not how risks are calculated by in policy, insurance, or pollution control, among other fields. A pollution control textbook stresses that a risk factor is calculated by its consistent association to its adverse effect.<sup>251</sup> That is, like Streeter and Phelps' techniques of definition, variables of harm are quantified, and then compared. Since NIMB is not based on the medical or technical demonstration of adverse effects, but rather presence and normative states, technocratic risk calculations are as extraneous as dose-response arguments. Rather than a calculus of risk, NIMB mobilizes a politics of risk based upon the non-consensual, unfair, and uneven distribution of risk burdens to the public.

The NIMB definition of pollution includes a vision of a good society through notions of good citizenship and the transgression of social agreements by powerful actors and their experts. A foundation of Douglas' anthropological work on pollution is that "pollution ideas are the product of an ongoing political debate about the ideal society"<sup>252</sup> and that

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<sup>250</sup> Du Puis, E. (2000). "Not in my body: BGH and the rise of organic milk." *Agriculture and Human Values* 17(3): 291.

<sup>251</sup> Peirce, J. J., R. F. Weiner, et al. (1998). *Environmental pollution and control*. Boston, Butterworth-Heinemann: 17.

<sup>252</sup> Douglas 1982: 36.

taboos are "attempts to force one another into good citizenship."<sup>253</sup> Within a NIMB framework, industry and government are not being good worldly citizens because they propagate and allow pollution to occur ubiquitously, in bodies, without consent.

In *Risk and Culture*, May Douglas writes that, "[a] cultural theory of risk perception would be trivial if it shirked considering the distribution of power in relation to the pattern of risks incurred by Americans."<sup>254</sup> Like pollution, risk aversion, whether defined by NIMB civilians or pollution textbooks, is a way to organize social relations. Being able to determine those relations is a form of power. NIMB contests the power that governments and industry have traditionally held to define risk as a calculable cost-benefit relationship and takes issue with knowledge claims made by powerful actors and their experts such as the FDA and the American Chemistry Council. Their challenge to dominant, naturalized methods for defining pollution makes NIMB inherently political, where politics refers to the contest of power. Thus, NIMB can be a radical platform from which to define pollution and change practices of pollution control. Moreover, because the distribution of body burdens is uneven, it can leverage environmental justice arguments in favour of its zero tolerance for bodily pollutants.

However, as Melanie DuPuis has noted, NIMB differs from NIMBY in that it is usually expressed through reflexive consumerism. NIMB is an idea rather than a social movement like NIMBY, where diverse stakeholders came together against a common

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<sup>253</sup> Douglas 1984: 3.

<sup>254</sup> Douglas 1982: 8.

cause (with the exception of environmental justice groups who strategically use body burden monitoring as a sort of popular epidemiology of chemical presence).<sup>255</sup> For the most part, however, NIMB leads to self-protective behaviours such as buying non-plastic containers or BPA-free plastics: "A reflexive consumer is not a social activist, nor is he or she necessarily committed to a particular political point of view."<sup>256</sup> Change is personal, based on consumption choices, and does not cause a change in the state of plastic pollution at large nor in the power of industries to pollute. Green consumerism is not the only ways that protest happens in the US, of course, yet its individualist framework is pervasive and familiar enough that biomonitoring and NIMB fold easily into a regime of perception where individual people and their consumer choices become a main means of change and protection from pollution, regardless of how radical that definition of pollution may be. Moreover, plasticizers such as BPA are so pervasive that removing all foods in contact with plastics only reduces one's BPA body burden by about fifty to sixty percent.<sup>257</sup> This is another instance where understanding the wicked materiality of plastics can lead to a better match between problem—chemicals are in all bodies and not ought to be—with viable solutions.

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<sup>255</sup> For example, Coming Clean uses body burden monitoring as part of their community monitoring campaigns for environmental justice.

<sup>256</sup> Du Puis 2000: 289.

<sup>257</sup> Rudel, R. A., J. M. Gray, et al. (2011). "Food Packaging and Bisphenol A and Bis(2-Ethylhexyl) Phthalate Exposure: Findings from a Dietary Intervention." *Environmental Health Perspectives* 119(7): 914-920.

## Conclusion

The US. Food and Drug Administration (FDA), the National Resource Defense Council (NRDC), the American Chemistry Council, media outlets from the *Huffington Post* to *Forbes*, scientists, artists, mothers, students who love turtles, artists, and advocates of all stripes, including myself, are in a contest of representations concerning plastic pollution. A central facet of this contest are the Regimes of perception that dictate what is representable and under what conditions, because accepted representations work towards sanctioning the evidence, techniques, and values that created them. Some of the stakeholders making the case for their definition of pollution are conscious of this and aim to strategically manipulate the public sphere, while others appear to be less intent on power relations between definitions and are intent on changing their own or others' behaviours.

The choice between competing definitions of pollution, like the choice between competing paradigms, is not merely based upon which material properties are the most likely to be the case, but “proves to be a choice between incompatible modes of community life.”<sup>258</sup> Theories of pollution are examples of social, material, and political relations, and plastic pollution is a microcosm of how these elements “ought” to go together within different community lives. The ethical issue of community relations further complicates (and clarifies) matters of concern. None of the groups covered here put forward plastic pollution as a matter of concern per se. No one advocated for a complicated, radically contingent, not-quite-known version of plastic pollution. Instead,

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<sup>258</sup> Kuhn 1996: 94.

each group tries to forward different matters of fact about plastics based on their knowledge communities or stakes. The next chapter will consider what has to be taken into account for a definition of plastic pollution based on a matter of concern rather than contests of matters of fact.

## V. SCALES OF PLASTIC POLLUTION

A synthetic plastic soup floats in the center of every ocean. To measure the density of this soup, scientists trawl nets behind boats and count the plastics they catch. In every ocean in the world, trawls bring up plastic.<sup>259</sup> They invest considerable time and energy determining whether a particular object among the thousands they have scooped from the water is a human hair or monofilament fishing line.<sup>260</sup> Once back in their laboratories, scientists try to estimate the half-life of plastics that will outlive the scientists themselves.<sup>261</sup> They worry their fleece jacket might contaminate the sample.<sup>262</sup> For the scientists, the most frustrating part of ocean plastics is that they must constantly look down, into trawl nets and microscopes, working with tiny pieces of plastic, while their eyes continually stray to the horizon: "My impression during this time [of research] was that the pollution problem was getting away from us...going farther out to sea."<sup>263</sup>

This is the problem: plastic pollution is not a single, legible, global phenomenon even

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<sup>259</sup> Cummins, A. (2011). "Press Release: Plastic found in all 5 Gyres." *Our Blog: The Latest on Plastic Pollution*. Retrieved 10/10/11, from <http://www.5gyres.org/posts/2011/04/28/>.

<sup>260</sup> Weisman, A. (2007). "Polymers are Forever." *Orion* (May/June). Retrieved 9/25/12, from <http://www.orionmagazine.org/index.php/articles/article/270/>.

<sup>261</sup> Andrady, A.(2011). "Microplastics in the marine environment." *Marine Pollution Bulletin* 62: 1596-1605.

<sup>262</sup> Thompson, R. C. (2011). "Plastic in the Marine Environment." Presentation at *Accumulation: The material and ecological economies of plastic*. London, Goldsmiths, University of London.

<sup>263</sup> Moore , C. (2011). *Plastic Ocean: How a Sea Captain's Chance Discovery Launched a Determined Quest to Save the Oceans*. New York, Avery: 8.

though plastics have been found in every ocean in the world. The global is not readily apparent. The scientist standing on the beach collecting samples cannot point to global plastic pollution, though she knows it exists. At best, she can point to the plastic she sees on the ground, in the water, and on her body, which is hardly global in nature. How can she bring global marine plastic pollution into view, make it clear enough to learn from and act upon, even as the world's oceans and their plastics cannot be viewed from one vantage point, even as scientists acknowledge they cannot account for, or estimate, all marine plastics such as those on the ocean floor or in the bellies of plankton? How can scientists and advocates stitch together local observations to describe a worldwide phenomenon that is otherwise invisible? How can we dedicate ourselves to action based on how the materiality of plastics and their larger social, technical, industrial and political systems relate when we cannot even point to the problem? These questions of phenomenon failing to appear, issues of perspective, problems of missing parts, and relating parts to wholes are questions of scale. In this chapter I argue that scale is one way to frame the wicked materiality of plastics so problems and potential solutions can be as well matched as possible given the emergent nature of the problem. I propose that my theory of scale can be used in many other contexts to the same effect.

First, I will look at scientific techniques used to make global phenomenon apparent. I will then follow the efforts of scientists who work with ocean plastics to replicate these techniques. Yet, because plastics continue to behave unpredictably in the wild, it becomes evident that even thousands of data points are not sufficient to map global

ocean plastics. Rather than see this as a defeat, most scientists who work with ocean plastics move past the data issue and use different scalar techniques that may not initially seem scientific. The main finding of this case study is that at different scales, different solutions to plastic pollution “appear to view” while others do not. That is, there are different things and processes, ontologically, at difference scales, rather than merely larger or smaller objects. This allows activists to analyze the scalar processes that contribute to certain environmental problems, and match a solution to the appropriate scale. These are the stakes of scale.

### Getting To Global

How do phenomena become global in the first place? The example *par excellence* of planet-wide environmental phenomena is climate change. Weather is a local, short-term event, while climate has a broader perspective and can extend thousands of years into the past and future. In his work on climate change modeling, Paul Edwards describes two necessary steps in extrapolating from local parts to global wholes that plastics scientists will have to follow. First, they must “make global data,” or gather massive amounts of information from around the world and then standardize it. Secondly, they must “make data global,” or “[build] complete, coherent, and consistent global data sets from incomplete, inconsistent, and heterogeneous data sources.”<sup>264</sup> The overall process of making data global for climate change involves transforming observed weather data according to known relationships between them into inputs, usually

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<sup>264</sup> Edwards, P. N. (2010). *A Vast Machine: Computer models, climate data, and the politics of global warming*. Cambridge, Mass., MIT Press: 251.



algorithms, for a computer model. Then, scientists run the model to produce data for areas and times for which there is no observed information. This process is what makes data global. Models provide a new perspective by stitching data into a unity, defining previously unapparent processes. In the end, weather data becomes climate data through modeling: “it is models, rather than data, that are global.”<sup>265</sup> Thus, to build a global model, plastic scientists need data from all over the world, and they need to be able to articulate small-scale processes occurring at the local level in terms (algorithms) a computer program can use.

#### Scaling Ocean Plastics

Scientists go onto the North Atlantic Ocean and trawl special nets behind their boats. The mesh captures anything floating in the water while letting water pass through. Trawl net contents are removed, sorted, counted, and recorded, and the results are written up and published.<sup>266</sup> Though many different expeditions have used this method of sample collection since the 1980s, no one had attempted to make the data global until the 2010 report, “Plastic Accumulation in the North Atlantic Subtropical Gyre” lead by Kara Lavender Law with a group of scientists from Woods Hole Oceanographic Institution and the University of Hawai’i. Law and her colleagues collected, reviewed, standardized and synthesized all trawl studies conducted in the North Atlantic from 1986 to 2008. Their report includes 6,136 trawl tows and more than 64,000 pieces of

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<sup>265</sup> Miller, C. A. and P. N. Edwards (2001). *Changing the Atmosphere: Expert Knowledge and Environmental Governance*. Cambridge, Mass., MIT Press: 62.

<sup>266</sup> The volume of ocean sampled is calculated by multiplying the width of the trawl net opening by the distance the ship traveled in ten minutes at a known speed.

plastic. The image below visualizes the compiled data. The red dots are areas with the highest concentrations of plastics, and the dark blue dots have the lowest concentration.

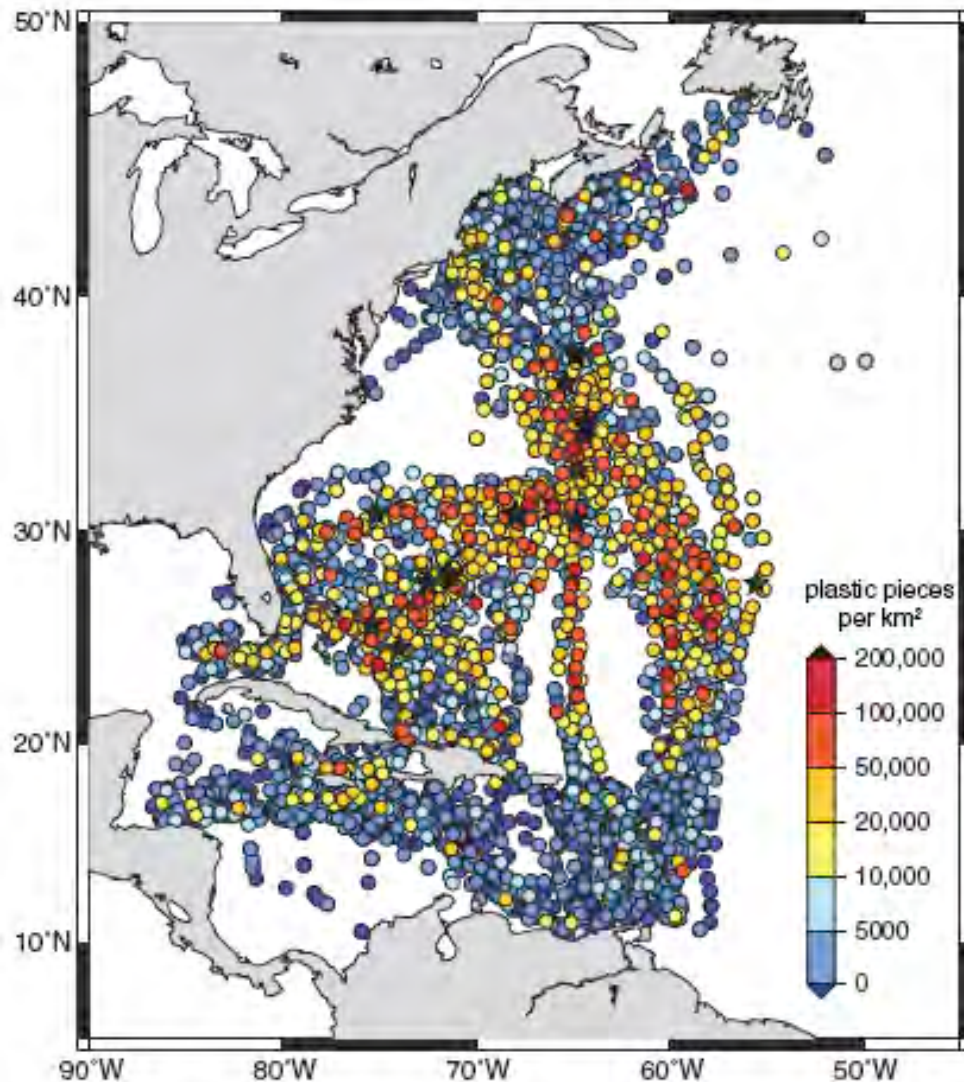


Figure 4.1: Distribution of floating ocean plastics from 6136 trawl tows between 1986 and 2008 in the western North Atlantic Ocean. Dots indicate the location of each net tow, while colour indicates the concentration of plastics per square kilometer. Black stars indicate tows with measured concentration greater than 200,000 pieces km<sup>-2</sup>. Symbols are layered from low to high concentration. From Law, K. L., S. Morét-Ferguson, et al. (2010). "Plastic Accumulation in the North Atlantic Subtropical Gyre." *Science* 329: 1185-1190: 1186.

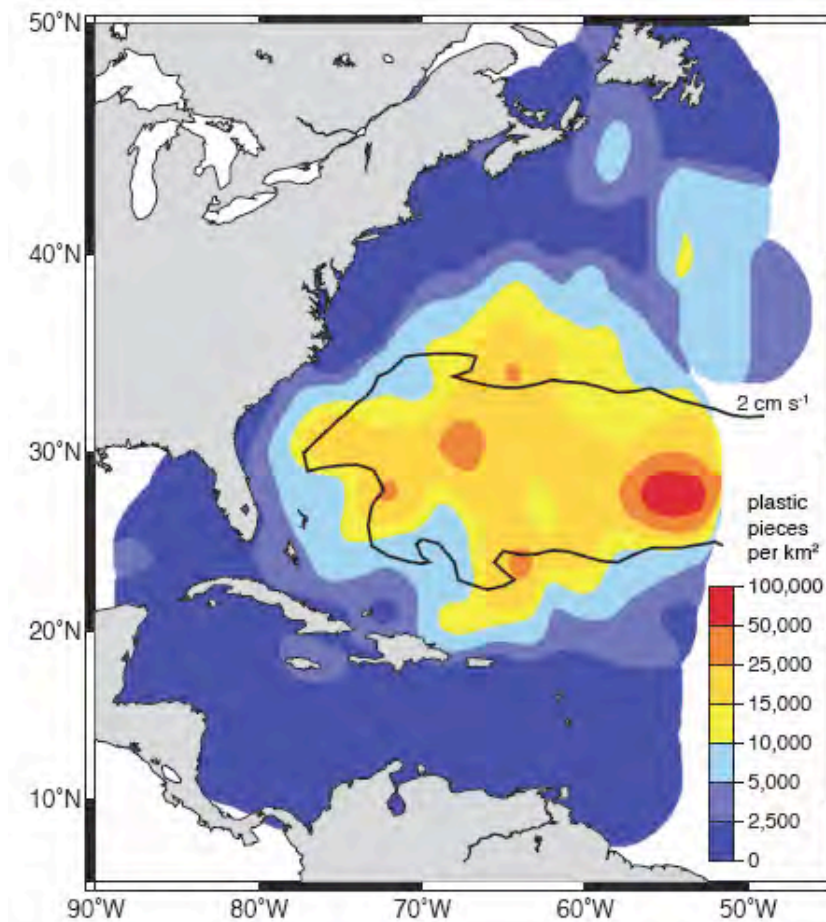


Figure 3.2: Average plastic concentration smoothed with a Gaussian filter. Black line indicates the contour of the 10-year (1993-2002) mean surface circulation. "This strong correspondence [between the location of the gyre and the presence of plastics within it] suggests that the convergence acts to concentrate plastic debris and demonstrates that floating plastic acts as a tracer of large-scale mean surface currents. The estimated total amount of plastic in the domain is  $8 \times 10^{10}$  pieces or 1100 metric tons." Law 2010:1187.

Because of the number and density of samples, a "topographical" map emerges after using a mean filter that reduces noise and smoothes data spatially. In technical terms, the "local" relationships between samples are articulated as spatial averages. The result is a smooth plastic oceanscape (below). The North Atlantic gyre, outlined in black, becomes apparent as a major plastic sink. Gyres are the centers of massive ocean currents where water cools and thus descends, leaving whatever was floating in the

water at the surface. The data aligns with gyre phenomena oceanographers already know about. It seems that Law and her oceanographers have made their data global, at least for this piece of the world.

But something is missing. Building a global model requires both spatial and temporal data, and the colorful graph of plastic concentrations above represents all twenty-two years of the study simultaneously. The graph below, shown here with its original caption, represents the temporal distribution of plastic over the study period in the region of highest accumulation (the gyre).<sup>267</sup> The gyre is thought to be a stable area for plastic accumulation since floating objects do not leave the center of the current easily.

**Fig. 3.** Annually averaged plastic concentration in the region of highest accumulation (22° to 38°N, 54° to 79°W) from 1986 to 2008, with standard error bars. Heavy dashed line indicates concurrent time series of plastic discarded in the U.S. municipal solid waste stream (24). Despite a strong increase in discarded plastic, no trend was observed in plastic marine debris in the 22-year data set.

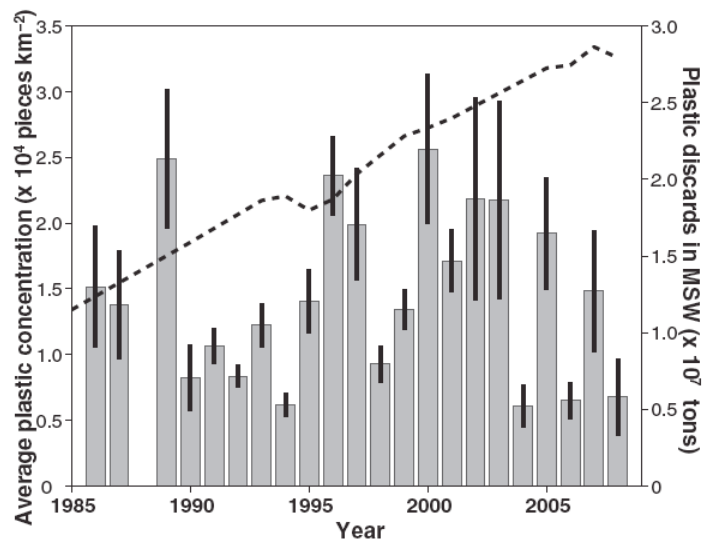


Figure 4.3: Annually averaged plastic concentration in the North Atlantic gyre from 1986 to 2008. Law 2011: 1187.

Yet the number of plastics found in the gyre, represented by thick grey columns, tells a different story. The dashed line rising from left to right on the graph indicates the rising

<sup>267</sup> Law, K. L., S. Morét-Ferguson, et al. (2010). "Plastic Accumulation in the North Atlantic Subtropical Gyre." *Science* 329: 1185-1190: 1187.

amount of plastic discarded into the US municipal solid waste stream.<sup>268</sup> Greenpeace estimates that ten percent of all plastic waste finds its way into the oceans every year.<sup>269</sup> The dotted line is meant as a baseline with which to compare ocean plastic accumulation. Scientists hypothesize that an increase in plastic production and waste will correspond to an increase in ocean plastics. It seems straight-forward enough: if plastic production and disposal is increasing steadily on land, and ten percent of that plastic ends up in the ocean where it tends to accumulate in the gyre, then one can assume that the quantity of plastics in the gyre will increase each year. However, the amount of floating plastic in the gyre from 1986 to 2008 does not show a steady accumulation. In fact, it is not falling, rising, or staying the same. There is no trend. Law's conclusion: "Despite a strong increase in discarded plastic, no trend was observed in plastic marine debris in the 22-year data set."<sup>270</sup> That is, despite the conviction—and scientific evidence—that increasing quantities of plastics from land are being steadily deposited in the oceans, none of this plastic biodegrades, and at least half of this plastic floats, it nonetheless does not seem to be accumulating according to the compiled data.

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<sup>268</sup> There is one issue with this plotted trend. MSW is only a small fraction (roughly one percent), of all waste generated in the United States. The majority is industrial, agricultural and manufacturing waste (ISW). Thus, a line for all plastic waste in the US, including ISW, would be much higher. However, an obvious increase in overall MSW plastic waste correlates to a similar increase in manufacture-side plastic waste. Therefore, the overall increasing trend holds true.

<sup>269</sup> Greenpeace. (2006) "Plastic Debris in the World's Oceans." *Defending Our Oceans*, 44.

Moore, C., G. L. Lattin, et al. (2011). "Quantity and type of plastic debris flowing from two urban rivers to coastal waters and beaches of Southern California." *Journal of Integrated Coastal Zone Management* 11(1): 65-73.

<sup>270</sup> Law et al 2010: 1187.

This is a mystery. How do we account for the random trend in temporal data when scientists are sure plastic is accumulating in the oceans? Law and other scientists believe that “loss terms must exist to offset the presumed increase in plastic input to the ocean.”<sup>271</sup> But what are these “loss terms”? Has the plastic wandered into another ocean, or onto beaches? Is the gyre not as stable as presumed? Law and her group find it “unlikely that ocean circulation could account for an export of plastic from the region large enough to offset the presumed increase in input.”<sup>272</sup> Is some of the plastic breaking down into sizes that allow it to pass through the net? Law et al write that while this is likely, “the rate of mechanical degradation is not expected to vary on the time scale of the study.”<sup>273</sup> Is the plastic sinking? Probably. But then are they floating back up again at another time? At least some are, but it is doubtful that this is a random process.<sup>274</sup> Are marine organisms eating the plastic? Absolutely. But this, too, would result in trending, rather than random, data. In the end, any explanation for plastics entering and exiting the gyre ought to result in some discernable trend, not randomness. Scientists simply do not know how plastic behaves in the wild. They cannot know if their data reflects a process that produces random temporal distribution in the gyre, or if they have missed a variable that would correct for the randomness. Either way, they cannot put random data into a global model because such models depend on articulating clear relationship between samples. The data cannot be made global.

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<sup>271</sup> Law et al 2010: 1186.

<sup>272</sup> Law et al 2010: 1187.

<sup>273</sup> Law et al 2010: 1187.

<sup>274</sup> Andrady 2011: 1599.

Some scientists, industry lobbyists, civilians, and sustainability advocates use the Law study's lack of observed "significant increase" in ocean plastic quantities to say that there is no increase in plastic pollution. Chandler Slavin, the Sustainability Coordinator & Marketing Manager at Dordan Manufacturing Co. Inc (a plastics manufacturer), directly uses the Law study to support her conviction that ocean plastics do not present the kind of dire environmental problem described in "sensationalist blogs and press:"

So what does [the Law study] mean? It means there is no floating plastic island the size of Texas; it means we have limited insight into the amount of plastics in the ocean, how it got there, and where it goes.... It means that plastics in the ocean could be in large part the result of plastic dumping at sea, which became illegal in the early 1990s. It means that the plastics industry has been proactive with this issue, implementing a program that dramatically reduced the amount of plastic pellets observed in the ocean. And, it means that CONSUMERS continue to scapegoat their irresponsible behavior i.e. littering, on the mythical plastic beast, without which, most of the conveniences we have come to depend on, wouldn't exist.<sup>275</sup>

While the Law study does not provide information, or even hypotheses, concerning the origin of ocean plastics, Slavin's conclusion, like many others, is based on what he calls "verifiable facts." The Law study does not verify an accumulation of ocean plastics. Nor, of course, does it verify a quantitative decrease or plateau of plastics; Slavin's statement that "we have limited insight into the amount of plastics in the ocean, how it got there, and where it goes" does not necessarily support his other conclusions. At most, Law's study describes a mystery and scientists' "limited insight." In the wake of Law's study, many scientists, activists, and NGOs called for more information, better facts, and future

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<sup>275</sup> Slavin, C. (2012). "Plastics are... "cheap, nasty, and toxic" HA! Investigation into plastic ocean debris." Recycling in America Sept 18. Retrieved 9/12/2012, from <http://www.recyclablepackaging.org/>.

studies, or, like Slavin, they found that a lack of proof is sufficient to disprove popular and scientific hypotheses about the accumulation of oceans plastics. It would seem that that Law study has not only undone the global nature of ocean plastics, but it has also challenged the status of ocean plastics as an environmental problem of priority.

### A Red Herring

However, Law and her group do not agree with Slavin. They conclude: “it is impossible to estimate the size of this sink,” yet maintain that, “[t]his analysis provides an important baseline for future monitoring efforts, as well as a quantitative assessment to accurately inform the public and policymakers of the scope of this environmental problem.”<sup>276</sup> Impossible yet accurate? While this tension is not resolved within the study, I will argue that each statement refers to two different globals. There are two competing techniques of definition within the study, the first explicit in the methodology, the second implicit through logic and convictions within the scientific community. The first technique of definition uses the ocean trawl data, but does not result in an apparent trend. This “failed” global estimate is based on exactitude and fitting numbers to the world. Yet ocean plastics are novel, and “we have limited insight into the amount of plastics in the ocean, how it got there, and where it goes,” so we cannot be exact enough to satisfy this particular global methodology. Law and her group must state, “it is impossible to estimate the size of this sink.”

In contrast, a second technique of definition was already in place before the study was

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<sup>276</sup> Law et al 2010: 1187-8.



conducted. It points to another type of global, which set the research agenda and the decision to compile sample reports to begin with. More plastics are being produced. The ocean is downhill from everything and is receiving plastics constantly. Plastics do not degrade in an appreciable time frame, particularly in the cold, dark, ocean. According to these undisputed facts, the logical conclusion is that ocean plastic pollution is an accumulative phenomenon. When this hypothesis, more often stated by scientists as a certainty, does not match up with the trawl data, a tension of definition occurs.

Before Law's study, the term "accumulation" appeared in sixty-three of ninety-one scientific articles about ocean plastics published between 1960 and today.<sup>277</sup> The term even appears in the title of Law's study, "Plastic Accumulation in the North Atlantic Subtropical Gyre," despite their apparent lack of evidence supporting accumulation. After Law's study was published and widely read by both scientific and activist communities, statements like, "[w]e use >240 million tonnes of plastic each year and discarded 'end-of-life' plastic accumulates, particularly in marine habitats," are not only common, but are made as a matter of course in scientific writing.<sup>278</sup> How is this dedication to accumulation maintained, even though Law's study, whose methods resonate with those used in climate change modeling, made plastic pollution apparent as a non-trending, non-accumulative phenomenon? There is clearly more to the definition of a phenomenon than merely making some aspect of it apparent through an

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<sup>277</sup> These ninety-one reports are drawn from both Algalita Marine Research Foundation's and my own archive of scientific reports that deal specifically with ocean plastics.

<sup>278</sup> Browne, M. A., P. Crump, et al. (2011). "Accumulation of Microplastic on Shorelines Worldwide: Sources and Sinks." *Environmental Science & Technology* 45: 9175.

accepted scientific method.

Many scientists who work with plastic pollution, often self identified as researcher-activists, are increasingly arguing against judgments of uncertainty and calls for further research. The demands from US policy makers, politicians, and industries for high-resolution data that results in certain and unshakable definitions of environmental problems are deemed inappropriate to scientific methods and the environmental problems themselves, including plastic pollution. Calls for more research are even seen as red herrings, a conscious strategy by which industry and its allies postpone and derail effective action against plastic pollution.<sup>279</sup> Instead of calling for more research, many scientists are convinced of the dangerous, global status of plastics by their tacit experiences in laboratories, on beaches, and in the water. Everywhere that they look, they find plastic. This plastic was not present fifty years ago. Therefore, they argue, plastic pollution is accumulative. Despite the conclusions of Law's study, scientists, including those in Law's group, continue to "know" that plastic pollution is a global, accumulative problem. The phenomenon has already come into view for them, though not through a high-resolution computer model. This is the "global" phenomenon that allows Law and her group to say "[t]his analysis provides an important ... quantitative assessment to accurately inform the public and policymakers of the scope of this environmental problem."

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<sup>279</sup> Oreskes, N. and E. M. Conway (2010). *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming*. New York, Bloomsbury Press.

### A Theory of Scale

How are there two “globals”? This is a question of scale. The concept of scale in academia, from geography to the social sciences, has evolved over the past twenty years, mainly through efforts to theorize globalization. A pressing question has been how global capitalism manifests in local sites, and, more importantly, how local areas devastated by the effects of globalization can resist them. These are interscalar problems that require theories of scale to relate global processes to local patterns, and visa versa. However, there is still no consensus on what scale means or how it should be used methodologically. Yet there is agreement that scale, or how one draws boundaries and posits relationships within and between those boundaries, have implications for politics, power, and the objects or subjects under study. The following framework describes what I mean when I use the term scale.

Scale is not about being big or small. At different scales, different relationships matter. Scale is a way of organizing which processes are dominant and meaningful within certain sites. For example, looking at a skin cell under a microscope, you would notice cell division and nutrient circulation, among other processes. When you look at the surface of someone's skin with your eyes, you may notice goose bumps, scars and skin colour, none of which were apparent under the microscope and all of which have entirely different social and medical connotations. In both cases, there are two parts to scale. First, there is a perspective of observation: your eyes, the microscope, and the edges of that perspective in both space and time. Second, there are processes or relationships that are important at those perspectives that are not apparent at other

perspectives, such as cell division and goose bumps.

Ecological geographer Nathan Sayre calls the first part of scale its epistemological aspect, referring to methodologies of observation of objects or sites. He calls the second part the ontological element of scale, meaning the description of “complex interactions within and among social and natural processes.”<sup>280</sup>

If the epistemological moment involves choosing a grain [spatial or temporal resolution] and extent [size and/or duration] that capture the processes through which these relations are revealed over time, the ontological moment considers these relations as objective realities.<sup>281</sup>

The epistemological moment of looking at a skin cell includes the resolution of the microscope and how much time it takes for the processes under observation to occur (seconds, hours, or days, for example). The ontological moment includes processes such as osmosis, active nutrient transport, and cell division. But notice that Sayre implies that the ontological moment is also an issue of epistemology: “the ontological moment *considers* these relations as objective reality” (emphasis added). The ontological level is apparent, and this apparentness is the result of background knowledge. This is not to say that ontological levels are not real, but that they are learned and understood rather than given in advance.

For clarity, I will call the epistemological moment “perspective” to indicate the boundaries and resolution of observation. I will call the ontological moment “processes”

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<sup>280</sup> Sayre, N. F. (2005). “Ecological and geographical scale: parallels and potential for integration.” *Progress in Human Geography* 29(3): 276.

<sup>281</sup> Sayre 2005: 281.

to mean patterns of complexity and activities. “Scale” refers to the processes that are discernible and important within a given perspective. Scale is a method of definition because perspectives draw boundaries and create limits within which certain “essential characteristics,” or processes, become apparent. Thus, scale is a central analytical and constitutive aspect of all phenomena. Karen Barad’s argument concerning the inextricable relationship between phenomena and the apparatuses used to investigate it is at the heart of scale.<sup>282</sup> Recall that the term phenomenon comes from the Greek *phainomnenon*, the “thing appearing to view,” based on *phainen*, “to show.”<sup>283</sup> Different apparatuses and their perspectives will result in different things “appearing to view.”

Within this theory of scale, the distinction between perspective and processes is crucial because change happens ontologically—new phenomena are created— through different perspectives.<sup>284</sup> This is my STS addition to other theories of scale. Not only do

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<sup>282</sup> Barad, K. M. (2007). *Meeting the Universe Halfway: Quantum physics and the entanglement of matter and meaning*. Durham, Duke University Press.

<sup>283</sup> (2012). "Phenomenon." *Oxford Dictionaries*, Oxford University Press. Retrieved 9/7/12, from [www.oed.com](http://www.oed.com).

<sup>284</sup> There are many other examples of how different things exist at different levels in science. Agricultural ecologists Samuel Fuhlendorf and Fred Smeins found that grazing “can have a positive, negative, or no influence [on ecological health of a grazing site], depending on the scale of the observation.” At three different scopes in the same study area they had three different results. Fuhlendorf, S. D. and F. E. Smeins (1999). "Scaling effects of grazing in a semi-arid grassland." *Journal of Vegetation Science* 10(5): 731-738. Likewise, zoologists Stephen Carpenter and James Kitchell studied how algal production of nutrients contributed to the amount of zooplankton in an area. If they looked in their aquarium every third day, algal production was negatively correlated with the amount of zooplankton. But if they looked every sixth day, a different pattern emerged and algal production was positively correlated with the amount of zooplankton. Carpenter and Kitchell (1987) in O’Neill, R. V. and A. W. King (1998). “Homage to St Michael; or, why are there so many books on scale?” *Ecological scale: theory and applications*. D. L. Peterson and V. T. Parker. New York, Columbia University Press, 4-5.

different perspectives allow one to see different things, different things are made manifest through those perspectives. A skin cell does not automatically "scale up" to the level of an arm. It needs an apparatus. This has acute ramifications for action. Imagine if the person found bleeding from the arm was rushed to the hospital and placed in a six-foot Petri dish with a nutrient solution to hydrate and stabilize her. Or, if a scientist saw a skin cell in distress under her microscope, she placed a Band-aid on it. These examples are not silly: people often believe that scaling up or down is a quantifiable, additive process. A person is something completely different than many, many cells, even though she is, in fact, made almost entirely of cells. Yet, she does not act like a collection of cells. Nor do collections of cells act like arms. Scale is not just about adding together smaller parts to make wholes or breaking wholes into constituent parts, but how certain patterns of relationships and processes emerge at specific perspectives.

Using this theory of scale and how it relates to action we can see why researcher-activists that study plastic pollution are dedicated to defining the scale of plastic pollution. Global plastic pollution will be something quite different than plastic fragments on the beach and in a fish stomach. Scientists and advocates cannot think globally and act locally. In fact, no one can; regardless of their specific contexts, local and global refer to fundamentally different perspectives and processes. Attempting to address global issues by acting locally is like putting a Band-aid on a skin cell or placing an arm in a Petri dish. The question for plastic pollution is, given that scientists find plastic in every ocean in the world, how do these bits of local plastics relate to a global process, if at all? How are global processes of plastic pollution different than local ones?

How can scientists define plastic pollution as a global phenomenon so that solutions appropriate to global processes can be found?

### Precision Versus Accuracy

These scientists and their allies use methods that allow local processes to scale into global phenomena without recourse to computer models by leveraging precise descriptions. Historian Lorraine Daston distinguishes between precise and accurate quantitative techniques of definition. Precision is “the clarity, distinctness, and intelligibility of concepts; accuracy refers to the fit of numbers to some part of the world, to be ascertained by measurement.”<sup>285</sup> Daston writes about how early modern scientists often employed precise rather than accurate definitions for “strange” or novel phenomena. She argues that Van Leewenhoek’s early claim “that there ‘were no less than 8 or 10,000’ living creatures teeming in a drop of water...spoke to this penchant for precision without accuracy.”<sup>286</sup> Precise definitions convey scale in terms of orders of magnitude, point to processes discernable within new perspectives, and can provide the basis for comparison with more familiar phenomenon at similar scales. On the other hand, global climate change models and their algorithmic phenomena are accurate. They are based on “the fit of numbers to some part of the world.” The desire for accuracy within ocean plastics studies expressed by Slavin and others is only useful for making accurate global models rather than precise ones. Plastic pollution, even with its

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<sup>285</sup> Daston, L. (1998). The Language of Strange Facts in Early Modern Science. *Inscribing Science: Scientific Texts and the Materiality of Communication*. T. Lenoir. Stanford, Stanford University Press: 35.

<sup>286</sup> Daston 1998: 35-36.

disappearing, reappearing parts is a clear, distinct, and intelligible phenomenon even if its details are not understood in their entirety. Such precise descriptions provide perspectives and processes, the necessary elements to scale, even if they are not immediately available to measurement and total understanding.

Daston's two modes of quantitative description refer to two different ways of relating parts to each other, and parts to wholes. Each type of analysis results in a different perspective, and thus different processes. This is how two (and many more) globals are not only possible, but always already in operation.<sup>287</sup> Within the general topic of "plastic pollution," or even "ocean plastics," more than one phenomenon is at play, since there is more than one apparatus for measuring and describing plastic pollution in use. Often, as in the case of Slavin and Law's group, these phenomena are in direct opposition to one another. Many ocean plastic researchers have decided that the accurate apparatus of computer-based global modeling is not currently useful for describing plastic pollution, and so they have changed to a more tacit, distributed, precise method.

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<sup>287</sup> Though note that Paul Edwards also writes about different globals that emerge from accurate models as well. As spatial and temporal data sets and other variables change, so too does the perspective of the global model. He calls this "shimmering." There is not one definitive global picture that emerges, even within accurate models with hundreds of thousands of data points.



### Everywhere and Forever

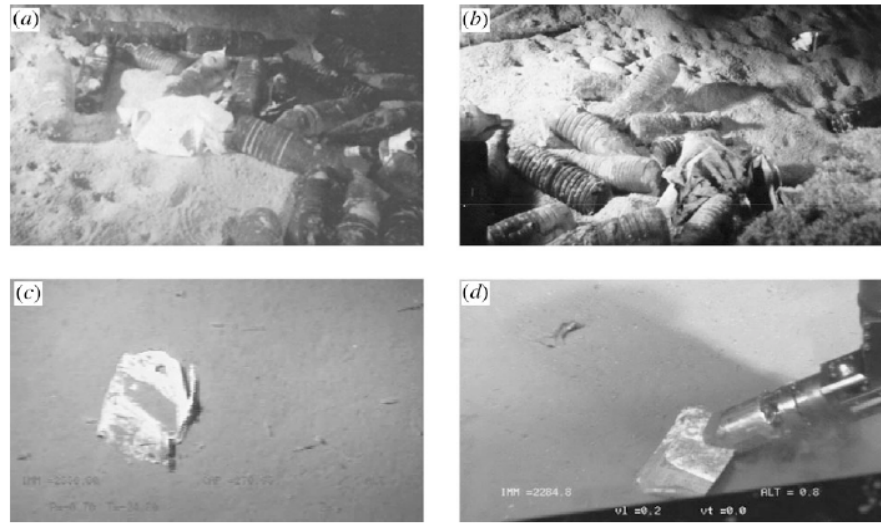


Figure 4.4: Photographs of plastics in deep-sea environments, including plastic bottles in Mediterranean canyons (a and b), and plastic bags at Hausgarten, the Fram straight, in the polar circle (c and d).

Plastic exists 1000 meters under the Mediterranean Ocean, and 2,600 meters beneath arctic ice floes:<sup>288</sup> “[P]lastics turn up in bird nests, are worn by hermit crabs instead of shells and are present in turtle stomachs.”<sup>289</sup> In their report on “Plastic accumulation and fragmentation,” David Barnes and his international co-authors state, “plastic mega- and macrodebris is routinely observed from boats everywhere on the planet.”<sup>290</sup> Scientific papers such as, “Trashed: across the Pacific Ocean, plastics, plastics everywhere”<sup>291</sup> and, “Here, there and everywhere, small plastic fragments and pellets

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<sup>288</sup> Barnes, D. K. A., F. Galgani, et al. (2009). “Accumulation and fragmentation of plastic debris in global environments.” *Philosophical Transactions of the Royal Society B: Biological Sciences* 364(1526): 1985–1998.

<sup>289</sup> Barnes 2009: 1995.

<sup>290</sup> Barnes 2009: 1988.

<sup>291</sup> Moore, C. (2003). “Trashed: across the Pacific Ocean, plastics, plastics, everywhere.” *Nat. Hist.* 112, 46–51.

on beaches of Fernando de Noronha”<sup>292</sup> testify in their titles to the ubiquity of their objects of study. There are plasticizers on Mars due to plastic components of NASA equipment leaching during exploratory work.<sup>293</sup> Plastic chemicals are also found in fetuses, umbilical cords, breast milk, house pets, and every American tested by the Center for Disease Control.<sup>294</sup> Scientific laboratories are full of plastics, and laboratory technicians must differentiate between the plastics under study and their own “background” pollution, including the scientist’s fleece jacket, as mentioned at the beginning of the chapter. Plastic is everywhere. “Everywhere” is a precise, low-resolution perspective, meaning its sources of data are significantly dispersed. “Everywhere” includes all five of the world’s oceans, but also the entire planet, its human and non-human inhabitants, and even Mars.

However, the precise perspective of “Everywhere” is not so low-resolution that it becomes a homogenous, abstract space devoid of details. Different parts of “Everywhere” have different concentrations of plastics, chemicals, and the harms they produce. These differences allow a topography of “Everywhere” to be brought into view. We know that the highest concentration of ocean plastics occur in the center of

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<sup>292</sup> do Sul, J., A. Spengler, et al. (2009). "Here, there and everywhere. Small plastic fragments and pellets on beaches of Fernando de Noronha " *Marine Pollution Bulletin* 58(8): 1236-1238.

<sup>293</sup> Flory, D. A., J. Oro, et al. (1974). "Organic Contamination Problems in the Viking Molecular Analysis Experiment." *Origins of Life* 5: 443-455.  
Mahaffy, P. R., D. W. Beaty, et al. (2004). *Science Priorities Related to the Organic Contamination of Martian Landers*, Mars Exploration Program Analysis Group (MEPAG), NASA: 32.

<sup>294</sup> Centers for Disease Control and Prevention (2009). *Fourth National Report on Human Exposure to Environmental Chemicals*. D. o. H. a. H. Services. Washington DC.

the world's five gyres.<sup>295</sup> The most polluted place on the planet is the Arctic, though there are no sources of industry near by. This occurs when plasticizers biomagnify in top predators along long marine food chains and when plastic chemicals follow water and air currents to the north, then condense in the cold air and settle in northern ecosystems. As a result, polar bears and northern Native populations with traditional diets are the most toxic living beings on the planet. Their bodies carry so many foreign industrial chemicals, including plasticizers, that they can be classified as toxic waste when they die.<sup>296</sup>

The majority of ocean plastics are disposable packaging.<sup>297</sup> Northern countries produce and consume far more plastic disposables than countries in the global south, an unevenness that maps onto the northern hemisphere and its densely plasticized oceans and people compared to the global south.<sup>298</sup> Because of business conglomerations, relatively few companies, such as DuPont, produce most of the world's plastic stock.<sup>299</sup> Thus, environmental and social justice can be "made apparent" at low-resolution perspectives. The premise of environmental injustice is that inequitable distributions of environmental burdens, particularly on those who do not produce the burden such as low-income, indigenous, and fetal populations, are wrong. Plastic pollution may be "Everywhere," and it may affect everyone, but it affects everyone differently. This

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<sup>295</sup> Moore, C., S. L. Moore, et al. (2001). "A Comparison of Plastic and Plankton in the North Pacific Central Gyre." *Marine Pollution Bulletin* 42(12): 1297-1300.

<sup>296</sup> Cone, M. (2005). *Silent Snow: The Slow Poisoning of the Arctic*. New York, Grove Press.

<sup>297</sup> Barnes 2009: 1995.

<sup>298</sup> Barnes 2009: 1988.

<sup>299</sup> Freinkel, S. (2011). *Plastic: a toxic love story*. Boston, Houghton Mifflin Harcourt.

makes a link between local and global processes of plastic pollution apparent, as well as indicating points of intervention.

The uneven distribution of plastics “Everywhere” covers the spatial aspect of perspective, but what of the temporal dimension? What is the time scale of plastic pollution? Though many common plastic polymers were invented by the turn of the twentieth century, they were not mass-produced until the 1940s and ‘50s.<sup>300</sup> Most studies of plastic pollution are shorter than the two generations plastics have existed. The oldest piece of plastic found in the ocean was piece of a U.S. Navy patrol plane downed during the Second World War, which was eaten by an albatross and recovered from its carcass.<sup>301</sup> Some of the longest studies on plastic pollution, including Law’s, go back only twenty-two years.

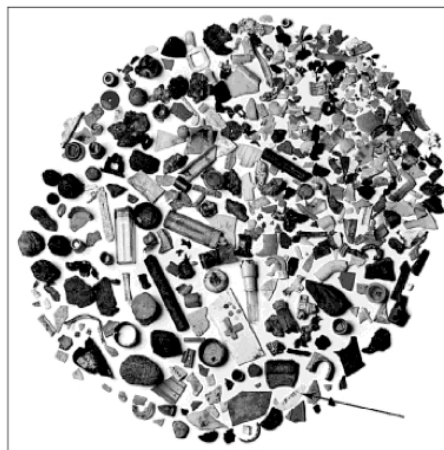


Figure 4.5: Image of plastics recovered from the carcass of an albatross chick in 2007, including a plastic tag traced to a naval patrol bomber downed in 1944. Ebbesmeyer 2009: 212.

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<sup>300</sup> Meikle, J. L. (1995). *American Plastic: A Cultural History*. New Brunswick, N.J., Rutgers University Press.

<sup>301</sup> Ebbesmeyer 2009: 212.

Plastics last longer than any plastic has been on the planet, and longer than any study has attempted to track them. Older plastics are fragmenting, but not breaking down into their constituent molecules. That is, they are turning into smaller and smaller pieces, but these fragments retain all the characteristics of plastic.<sup>302</sup> Estimates of plastic's longevity, which range from hundreds to thousands of years, are based on estimates extrapolated from ideal laboratory conditions.<sup>303</sup> Yet most plastics do not exist in ideal laboratory conditions. They exist in landfills or oceans, where the lack of oxygen, heat, and light inhibit any degradation whatsoever.<sup>304</sup> Moreover, some of the chemicals added to plastics, called plastizers, are persistent organic pollutants (POPs), a chemical classification based on a lack discernable half-life. For comparison, nuclear waste has a half-life of about 30,000 years. Many plastics and their chemicals will outlive nuclear waste and, quite probably, our species, not because our species is ecologically doomed to self-extinction as the apocalyptic environmental narrative goes, but because plastics exist in geological time frames, not shorter time frames characteristic of species and human experience.

Geological time measures events during the existence of the earth and extends into the past more than four and a half billion years. Plastics have become as permanent as minerals and fossils, and more permanent than nuclear waste (though less contained). This means that a timescale that takes the entire life of plastics into account has a low

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<sup>302</sup> Andrady 2011.

<sup>303</sup> Barnes 2009: 1993.

<sup>304</sup> Andrady 2011: 1599-1601.

resolution. This timeframe makes predicting plastics' behaviour difficult, if not impossible: "We are probably no better at predicting changes and events over the next 10,000 years than were people beginning plant and animal domestication in Mesopotamia 10,000 years ago at predicting our world."<sup>305</sup> For all intents and purposes, we can describe this low-resolution temporal perspective of plastic pollution as "Forever." Using the lifespan of plastic as a perspective, plastic pollution is brought into view as a permanent phenomenon, a new characteristic of the earth.

"Everywhere and Forever" constitute a precise, quantitative scalar perspective though they do not define the same global phenomenon that Law's group of ocean scientists were attempting to describe. Because "Everywhere and Forever" is a different perspective than the one used by Law and her group, the processes that become apparent at this perspective are different than those Law's group sought to define. One of the great scalar fallacies that plagues efforts to define environmental problems is the idea that there is a single global environment. Even accurate models of climate change do not model the same "global." Different models include different variables, data and algorithms—that is, different perspectives and local processes—that result in different global processes when they are scaled up through the model. Paul Edwards calls the products of these different models a "shimmering rather than fixed" global

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<sup>305</sup> Benford G, Kirkwood C W, Otway H, Pasqualetti M J, 1991, "Ten thousand years of solitude? On inadvertent intrusion into the waste isolation pilot project repository", in Bloomfield, B. P. and T. Vurdubakis (2005). "The secret of Yucca Mountain: reflections on an object in extremis." *Environment and Planning D: Society and Space* 23(5): 735-756.

environment.<sup>306</sup> Every change in perspective results in a change in apparent and meaningful processes. This is the nature of scale. There is not one, but many globals.

### Scale, Plastics, and Action

Now that we have a perspective of “Everywhere and Forever” and an idea of the uneven and permanent processes within that perspective, let us return to Law’s graph of temporal distribution of plastics in the North Pacific gyre.

**Fig. 3.** Annually averaged plastic concentration in the region of highest accumulation (22° to 38°N, 54° to 79°W) from 1986 to 2008, with standard error bars. Heavy dashed line indicates concurrent time series of plastic discarded in the U.S. municipal solid waste stream (24). Despite a strong increase in discarded plastic, no trend was observed in plastic marine debris in the 22-year data set.

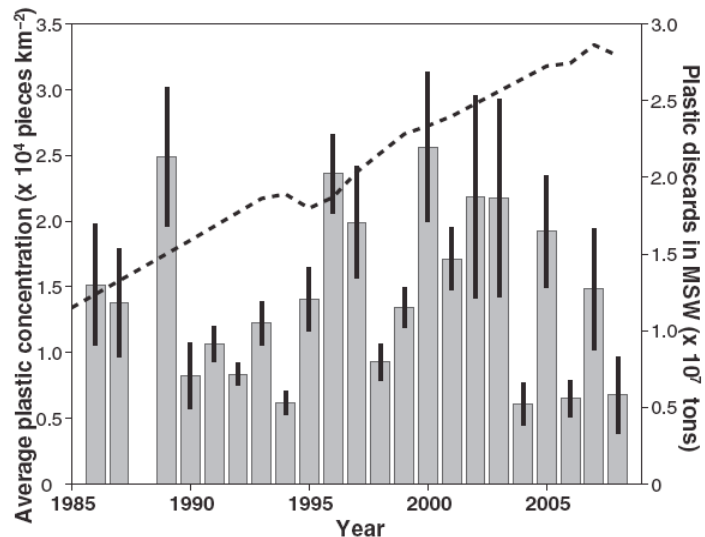


Figure 4.6: Annually averaged plastic concentration in the North Atlantic gyre from 1986 to 2008.

Instead of focusing on the bottom portion of the graph and the random temporal distribution of floating plastics in the gyre—we know if they are not there, they will be somewhere, forever, after all—we can pay attention to the dotted line rising steadily from left to right across the top of the graph. Increasing amounts of plastic waste discarded in the municipal waste stream, which is only about one percent of waste

<sup>306</sup> Edwards 2010: 352.

produced in the United States (the other ninety-nine percent is industrial waste), reflects the increasing amounts of plastics produced by industry. Given that we know plastics are Everywhere and they last Forever, this graph works to define plastic pollution as an acute stock and flow problem. Stocks and flows are analytical tools used to describe two aspects of a dynamic system. Stocks tend to be accumulative and are stable over time. Flows represent rates of change measured over time. Since we know that plastics and many plasticizers exist in geological time, all plastics that already exist become plastic stock. The dotted line at the top of the graph represents the flow of more plastics into this stock. If we choose to focus our attention on incinerating, picking up, or constructing technological fixes for our stock of plastics, we do little to augment the overall problem as the flow continues. It is akin to bailing out a boat before you've stopped the holes in its hull. Thus, our process of concern becomes the flow.<sup>307</sup>

When plastic pollution comes into view as a stock and flow problem, the point of intervention for action also becomes apparent. We must intervene in the flow of plastics. Below is a graph of plastics production in Europe and around the world from 1950 to 2009. It shows the sorts of intervention that have stemmed the production, and

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<sup>307</sup> Solutions that aim to mitigate current plastic stocks include storage and confinement (landfilling plastics properly), but any sink for plastics is likely to be temporary given plastics' longevity. Other options such as incineration can change the molecular structure of plastics, but the POPs are still permanent, and must be stored or released into the atmosphere. Yet both of these sorts of solutions assume that plastics can be removed from the environments they already occupy, such as the bottom of the ocean, the bellies of plankton, or the blood of fetuses. One of the unique challenges of plastic pollution is that plastics and their chemicals are already part of the ecosystems we want to save them from, and removal would damage these ecosystems. These issues will be taken up in the next chapter.



therefore the flow, of plastics over time. Recycling programs began in the 1970s and began accepting plastics in the early to mid 2000s. This has not affected a decrease in the production of plastics. Ireland taxed plastic bags in 2002, resulting in a ninety-four percent drop in plastic bag use, a carrier bag-free landscape better suited to tourism, and a social trend that finds plastic bag use unacceptable.<sup>308</sup> These are the processes the bag tax effected on the national scale, but you can see by the graph that it did not affect the production of plastics in Europe or the world.



Figure 4.7: Original caption from *PlasticsEurope* 2010: "Growth in plastics production, 1950-2009. After five decades of continues growth in world plastics production, there was a drop in production in 2008 due to the economic downturn.... PET, PA and poluacryl fibers are not included [in this graph]."

There are two moments where the production of plastics has waned. The first, most obvious reduction in worldwide production, but also European production, occurs in

<sup>308</sup> Rosenthal, E. (2008). "By 'bagging it,' Ireland rids itself of a plastic nuisance." *New York Times*, 1/31/08. Retrieved 9/25/11. From <http://www.nytimes.com/2008/01/31/world/europe/31iht-bags.4.9650382.html?pagewanted=all>.

1974 and again in 1979 during the US oil and energy crisis. About eight percent of oil is used in the feedstock and production of plastics worldwide.<sup>309</sup> Another, more dramatic dip in plastic production occurs in 2008, which the graph's original caption identifies as the worldwide economic depression. Thus, according to this graph, the processes that most affect the mitigation of plastic pollution are economic. These are points of intervention for alleviating the flow of global plastic pollution.

This scalar understanding of plastic pollution as a stock and flow phenomenon differentiates grassroots and researcher-activist campaigns against plastic pollution. Research-activist organizations such as the Algalita Marine Research Center and 5 Gyres, both of whose trawl data was used in Law's study and both of whom continue to use the term "accumulation" to describe ocean plastic trends, advocate for world-wide bans of disposable plastics, national and international legislation against plastic pollution, and producer responsibility for corporations and industries that produce plastics and plastic goods. According to these NGOs, such interventions address the processes that create plastic pollution and that matter at a global scale.

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<sup>309</sup> Andradý, A. L. and M. A. Neal (2009). "Applications and societal benefits of plastics." *Philosophical Transactions of the Royal Society B: Biological Sciences* 364:1977–1984: 1980.



Figure 4.8: Screenshot of 5 Gyres' "Solution" page, which outlines how to scale up solutions to ocean plastics by "taking it to a higher level" via legislation. [www.5gyres.org](http://www.5gyres.org)

Contrary to this framing, most American mainstream environmentalism is rooted in individual actions: how can I help save the planet?<sup>310</sup> Using a theory of scale, this question proposes an impossibility: the processes that individuals can influence and control are likely quite different than processes of earthly environmental harm. When actions available to individuals do not match the spatial or temporal scales of environmental problems, fear, depression, helplessness, and apathy can result. This is a crisis of scale. Crises of scale are part and parcel of large-scale environmental problems such as climate change and plastic pollution. 5 Gyres' "Solution" page is proposing a method for individuals to scale up as citizens. By writing, calling, and emailing

<sup>310</sup> Maniates, M. (2002). "Individualization: Plant a Tree, Buy a Bike, Save the World?" In *Confronting Consumption*. Eds. T. Princen, M. Maniates and K. Conca. Cambridge, Mass.; London, MIT Press.

legislators, 5 Gyres argues that individuals can affect the processes of plastics flow in the stock and flow phenomenon.

In contrast, the processes that American grassroots activists advocate for usually involve an entirely different scale. The image below is characteristic of grassroots advocacy:



Figure 4.9: Endangered Wildlife Fund campaign against plastic pollution: "If you don't pick it up, they will." The photograph is of an Albatross on Midway Island that has ingested large amounts of ocean plastics, taken by artist and activist Chris Jordan.

In this image, what most readily comes to view is the harm to wildlife and the plastic consumer goods that do this harm. Viewers can identify a plastic golf ball, a soda bottle lid, and other consumer items they recognize from their daily lives. Moreover, the text identifies plastic pollution as a litter problem: "If you don't pick it [plastic waste] up,

they [the birds] will.” This image brings consumption and disposable practices into view. This image, like the majority of grassroots campaigns against plastic pollution, makes plastic pollution a consumer phenomenon. The perspective of these campaigns is narrowly focused on the moments after plastics are already created and in the hands of consumers, and stop after the consumer has properly binned his or her plastic disposable. As such, responsible consumption and disposal practices become the most logical point of intervention from which to combat plastic pollution. Yet, littering is not a process that bears upon the problem of plastic pollution (though it does bear upon other processes that might matter to people). Even if every person stopped littering, and even if all people remembered to bring their reusable bag to the grocery store, plastic pollution would not be affected. As a stock and flow issue, plastic is already part of the stock by the time it gets to individuals. Individuals acting as individual consumers simply cannot scale up to address the problems that produce plastic pollution. This is activism without a theory of scale. It is the equivalent of putting a Band-Aid on a skin cell or an arm in a Petri dish. The next chapter will look in depth at the scalar relationships between proposed problems with and solutions to plastic pollution.

## VI CONCLUSION: WHAT IS TO BE DONE?

### Problems, Solutions, and Imaginaries



Figure 5.1: An architectural rendering of Recycled Island by WHIM Architecture. From [www.recycledisland.com](http://www.recycledisland.com).

A small, colourful island bobs in the middle Pacific Ocean. Seagulls fly overhead while the island's human inhabitants sit in cafes overlooking the natural shallow pools that form

in the center of the island. The motion of the waves produce

sustainable energy as food is grown locally on plastic flats radiating out from the island.

This WHIM Architecture's vision for Recycled Island™, "a research project on the potential of realizing a habitable floating island in the Pacific Ocean made from all the plastic waste that is momentarily floating around in the ocean."<sup>311</sup> One of the ongoing issues with proposed solutions to plastic pollution—exemplified by Recycled Island™--is they often do not address the core characteristics and problems of plastic pollution. Problems and proposed solutions are misaligned, and as such, not only fail to solve plastic pollution, but often allow it to continue unabated.

Recycled Island™ is based on what liberation ecologist Richard Peet calls an "environmental imaginary" of ocean plastics as wayward resource, born of the well-

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<sup>311</sup> WHIMArchitecture. (2010). "Recycled Island." Web. Retrieved 3/3/11, from <http://www.recycledisland.com>.



established American ethics of “picking up” and resource efficiency. Environmental imaginaries are ways of thinking about human-nature and pollution-nature relationships, “including visions of those forms of social and individual practice which are ethically proper and morally right with regard to nature.”<sup>312</sup> Mary Douglas’ four myths about nature’s predictability covered in chapter one and two, such as “nature is robust within limits” and “nature is capricious,” as well as my insistence on plural natures, are three environmental imaginaries. One of the major areas of study within environmental communication is a study of critical rhetorics that challenge “dominant discourses [and imaginaries] that define the relationship between nature and society.”<sup>313</sup> This dissertation does some of this work, but also offers new imaginaries that, based on research, are more appropriate for matching the problems of plastic pollution to potential solutions.

In WHIM’s environmental imaginary, foreign bits of plastic nestled in ocean surface ecosystems like so many bits of dirt in a great blue shag carpet that can—and ought to be—be cleaned up and used. We know how to clean dirt from carpets: suck it up, collect it in the dust bag, and toss it out. The innovation of Recycled Island™ is that instead of throwing away the collected dirt, it is refashioned into useable land in situ. The plan has immense popularity, with 1,500 Facebook likes and a regular presence at sustainability conferences. Yet, Recycled Island™ is completely divorced from the materiality of ocean

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<sup>312</sup> Peet, R. and M. Watts (2004). *Liberation Ecologies: Environment, Development, Social Movements*. London ; New York, Routledge: 263.

<sup>313</sup> Cox, R. (2012). *Environmental Communication and the Public Sphere*. Thousand Oaks, Sage Publications: 16.

plastics. Not only is it impossible to gather up “all the plastic waste that is momentarily floating around in the ocean,” but plastics both leach and attract industrial chemicals, which would make Recycled Island™ an especially toxic place to live. It would also be an ideal place for macroplastics to become microplastics, and would continue to contribute to the ingestion of plastics by marine animals, as well as the biomagnification of toxins in the food chain that can result from plastic ingestion. In short, Recycled Island™ does not address issues characteristic of marine plastic pollution such as bioaccumulation, degradation into microplastics, body burdens associated with plastic leachates, or animal entanglement and ingestion. It does, however, attest to the power of “cleaning up” and resource efficiency imaginaries in popular culture.

Plastics have exceeded not only scientific methods of definition such as computer models and traditional toxicology measures, but have also transgressed environmental imaginaries that link proposed solutions to pollution. Albert Einstein is famously quoted as saying “If I had an hour to solve a problem, I’d spend fifty-five minutes thinking about the problem and five minutes thinking about solutions.” Like many other scholars, I propose that defining a phenomenon and its attendant problems simultaneously defines solutions. Horst Rittel and Melvin Webber, authors of “A Dilemmas in a General Theory of Planning,” take this one step further and caution that problems born of complex open systems are impossible to “definitely describe” because of the relationship between problem and solution:

in order to *describe* a wicked-problem in sufficient detail, one has to develop an exhaustive inventory of all conceivable *solutions* ahead of time. The reason is that every question asking for additional information



depends upon the understanding of the problem—and its resolution—at that time. Problem understanding and problem resolution are concomitant to each other.... The formulation of a wicked problem *is* the problem! The process of formulating the problem and of conceiving a solution (or re-solution) are identical, since every specification of the problem is a specification of the direction in which a treatment is considered.<sup>314</sup>

The problem with most proposed solutions to plastic pollution is not the frustration born of not being able to describe the problem-solution relationship in sufficient detail in an effort to ensure the problem is not radically misidentified, made too simple, or fails to account for multiple stakeholders, effects, and influences.<sup>315</sup> Rather, the problem with most proposed solutions to plastic pollution is that they start and stop at the solution. They are too tame. The wickedness, or systemic complexity of phenomena, is not acknowledged. In this concluding chapter, I will show how most proposed solutions to plastic pollution often leave out the wickedness of either the materiality or systemic nature of plastics (or both), and how this taming not fails to account for the characteristics of plastic pollution I have outlined in this dissertation, namely: how plastics are folded into living systems; their ubiquity, permanence, and ability to travel; their unique toxicity, including the non-linear relationships between presence and harm; the unequal distribution of harms on a global scale; plastics' nature as a stock and flow problem; and the central roles that industry profit plays in how pollution has been defined, how it circulates, and how it scales. Moreover, in many cases these tamed problem-solutions not only fail to account for plastics in the wild, they also allow them to continue unabated. There are, however, a few approaches that both account for the

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<sup>314</sup> Rittel, H. W. J. and M. M. Webber (1973). "Dilemmas in a General Theory of Planning." *Policy Sciences* 4: 161. Emphasis in original.

<sup>315</sup> Rittel 1973: 155-169.

wickedness of plastic pollution and the way it can never be “definitely described.” These will be covered at the end of the chapter.

### Beach Clean Ups

Like many organizations and individuals, the creators of Recycled Island™ are deeply disturbed by and invested in dealing with ocean plastics and their seemingly endless proliferation. Two days before writing this section, NOAA Fisheries’ Pacific Islands Fisheries Science Center removed fifty metric tons of derelict fishing gear from the shores of the Northwestern Hawaiian Islands. They do this annually, removing roughly the same amount each time.<sup>316</sup> San Diego’s Coastkeeper’s annual cleanups also find the same tonnage of debris on its beaches, almost all of it plastic. The amount collected varies only in proportion to the number of volunteers.<sup>317</sup> There is always a steady quantity of plastic to remove. While beach clean ups certainly have positive effects on tourism and community-building in addition to other important local phenomena, for our purposes the question is whether this constant removal of ocean plastics, either in situ like Recycled Island™ or on the beach via beach clean ups, affects plastic pollution generally?

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<sup>316</sup> Parker, D. (2012). "NOAA removes 50 metric tons of debris from Northwestern Hawaiian Islands." *Marine Debris Blog*. Retrieved 9/20/12, from <http://marinedebrisblog.wordpress.com/2012/07/20/noaa-removes-50-metric-tons-of-debris-from-northwestern-hawaiian-islands/>.

<sup>317</sup> San Diego Coastkeeper. (2012). "Data from San Diego Beach Cleanups." Retrieved 9/20/12, from <http://www.sdcoastkeeper.org/learn/marine-debris/data-from-san-diego-beach-cleanups.html>.

Both ocean and beach clean ups remove ocean plastics and store them temporarily in landfills. To use Mary Douglas' terminology, clean ups take "out of place" plastics and put them "in place," but they merely defer plastic pollution. Plastics last forever in dark, airless landfills, and, as time progresses, are likely to end up back in the ocean. However, one boon of beach clean ups is that hot, sunny beaches are a main site where plastics fragment into smaller and smaller pieces and wash back into the ocean.<sup>318</sup> Though most beach clean ups only take larger macrodebris that are easy for volunteers to identify and carry, and while moving the plastics to a landfill might be temporary, they defer fodder for one of the most dangerous sizes of ocean plastics for marine life.

While beach clean ups may seem ineffective but harmless in terms of solving plastic pollution, some activists take issue with the symbolic and rhetorical work of "successful" clean ups. Stiv Wilson, an environmental journalist that works with the plastic pollution research NGO 5 Gyres, writes:

As an activist, I can get downright angry about the notion of gyre cleanup, and when I see stories in the media about it, it often elicits a visceral response from me. Obviously, this is not a helpful vantage in the grand scheme of things, but the motivation for my response is simple: selling the idea of gyre cleanup to the public actually makes the problem worse. If a barge full of plastic comes back from the gyre, and helicopters take pictures of it, and newspaper headlines read, 'gyre

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<sup>318</sup> Barnes, D. K. A., F. Galgani, et al. (2009). "Accumulation and fragmentation of plastic debris in global environments." *Philosophical Transactions of the Royal Society B: Biological Sciences* 364(1526): 1985–1998.

cleanup group's first mission to clean plastic from the gyre is successful,'  
the ocean is in for a world of hurt.<sup>319</sup>

Wilson and others criticize clean ups for fueling an environmental imaginary that works against more effective forms of intervention. As discussed in earlier chapters, ocean plastics are dispersed in a heterogenous, living soup in the ocean rather than creating a discrete mess or a well-defined island, making “mining” for them costly as well as deadly to plankton and other microscopic ocean life. On the beach, plastics become much more discrete, but remain part of subsoil ecosystems. They simply cannot be properly cleaned up, nor will cleaning up stave off the continued flow of plastics from land. Moreover, it does not address the flow of plastics into the ocean. It focuses on the stock and is already there and is paramount to bailing out a sinking ship using a thimble.

Stiv Wilson does not believe that this material impossibility is where the problem with beach clean ups stop, however. Environmental problems are not just material, but also social, culture, economic and political. As political scientist Deborah Stone reminds us, problems “are not given, out there in the world waiting for smart analysts to come along and define them correctly. They are created in the minds of citizens by other citizens, leaders, organizations, and government agencies, as an essential part of political maneuvering.”<sup>320</sup> Wilson is concerned that beach clean ups shift the environmental

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<sup>319</sup> Wilson, S. (2010). The Fallacy of Gyre Cleanup: PART ONE, SCALE. 5 Gyres. Retrieved on 9/25/11, from [http://5gyres.org/posts/2010/07/05/the\\_fallacy\\_of\\_gyre\\_cleanup\\_part\\_one\\_scale](http://5gyres.org/posts/2010/07/05/the_fallacy_of_gyre_cleanup_part_one_scale).

<sup>320</sup> Stone, D. A. (1988). *Policy Paradox and Political Reason*. Glenview, Ill., Scott, Foresman: 121-122.

imaginary from issues of scale, ecosystems, and toxicity to “how do we clean up the ocean?”

### Recycling

Unlike beach clean ups, recycling is meant to address the flow of plastics by maintaining, rather than increasing, the amount of plastic material created by industry. People concerned about plastic pollution often see recycling as their contribution to mitigating plastic pollution, and define “good” and “bad” plastics in terms of whether they were recyclable or not. Yet recycling is not a viable solution to plastic pollution. In fact, municipal recycling schemes in their present form do not only fail to address plastic pollution, but allow it to continue unabated, particularly in terms of maintaining the production and consumption of plastic disposables. Recycling is an industrial practice that collects used or abandoned materials and transforms them into their constituent parts to create raw materials for new products. Often, reuse and recycling are used interchangeably in popular culture and even green advertising, but they are quite different processes. Recycling involves material transformations, and thus any environmental gains are contingent on the processes used. Plastics, in particular, do not recycle well. One of the reasons is the heterogeneity of the many plastics and plasticizers used in consumer goods, and the second is the economics of municipal recycling programs. First, I will discuss the way plastics recycling works on a material level, then I will turn to the more systemic nature of recycling.

Roughly half of plastics are recyclable in the sense they can be melted down to constitute a similar product. Thermoplastics make up the majority of plastics produced today and are recycled by shredding, heating, then forcing the material through a die that makes long thin strands of plastic. The strands are cut into pellets that are shipped as raw materials to manufacturers (these are also the nurdles that end up in the ocean). Thermosetting plastics, including polyurethane and epoxy, cannot be melted once they are cured. They are not recycled into new plastic. They are usually chopped or ground down into smaller parts and used as fillers in asphalt or insulation.<sup>321</sup>

Despite the ability of thermoplastics to be turned into new plastics, many recycling programs do not accept all thermoplastics. For example, New York City accepts only thermoplastic bottles or firm containers whose necks are narrower than their bodies. Plastic clamshells, Styrofoam, plastic film and other thermoplastics are not accepted. This selectivity is due to the heterogeneity of plastics and plasticizers and the affect heterogeneity has on recycling processes. The physical attributes of plastics are determined by their synthetic polymers and plasticizers as well as the process by which they were created. The way a plastic object is made—blown, extruded, injected, rolled or stamped—changes the material structure of the plastic, in addition to its resin type and plasticizers as each influence the melting temperature of thermoplastics. Thus, “number two” plastic tub and a “number two” plastic bottle have to be separated in order to remanufacture them into similar end products because they will have different

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<sup>321</sup> Pickering, S. J. (2006). "Recycling technologies for thermoset composite materials--current status." *Composites Part A: Applied Science and Manufacturing* 37(8): 1206-1215.

melting temperatures.<sup>322</sup> Putting all plastics all together would result in an amorphous, partly melted, partly burned slab that would not be recyclable itself.

Sometimes this is what happens. Integrigo Composites, for example, which works closely with the American Chemistry Council, creates plastic railroad ties from “landfill-bound plastic waste” because rail ties do not have to be flexible, fire resistant, or have other nuanced qualities.<sup>323</sup> Recycling something into a product that loses the qualities of its raw material is called downcycling, and it happens often with plastics and other recyclables. To make plastic waste into plastic products with identical properties (flexibility, clarity, flame resistance, or strength, for example), stock has to be homogenous, raw materials have to be in high supply, and costs of production have to be reasonable in comparison to using cheap virgin materials. For plastics, these conditions are rarely met, with the exception of clear plastic soda pop bottles (PET). Even in these circumstances, as an industrial process, recycling uses virgin materials such as new plasticizers and water, uses energy, and produces pollution.

The material challenges plastics pose for the recycling process is only one reason that recycling is not a viable option for controlling plastic pollution. First there is the issue of scale. Not that much plastic is recycled. In the United States, around thirty percent of all recyclables—glass, paper, metals, and plastics—are recovered from the municipal waste

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<sup>322</sup> Andrady, A. L. (2011). "Microplastics in the marine environment." *Marine Pollution Bulletin* 62(8): 1596-1605.

<sup>323</sup> Integrigo Composites. (2012). "Welcome to Integrigo Composites." Retrieved 9/20/12, from <http://integrigo.com/>.

stream. For plastics, this number is closer to eight percent, often because there are fewer recycling programs that deal with plastics than with other recyclables due to the issues mentioned above.<sup>324</sup> These figures only deal with municipal solid waste, which is one to two percent of all waste produced in the United States.<sup>325</sup> The rest is industrial solid waste, some of which is plastic, though because industry disposes of waste onsite or through private contracts and they are not required to report on the composition of their waste, we do not know how much of industrial waste—or industrial recycling—is made of plastics or plasticizers.<sup>326</sup> Thus, plastic recycling addresses a tiny amount of plastic pollution at the same time it is heralded as a sound environmental solution. Moreover, because virgin materials are often subsidized by the US government but stock made from recyclables is not, “two-thirds of glass containers and plastic soda and milk bottles are trashed instead of recycled” when the market price of recyclables makes disposal more cost efficient than recycling.<sup>327</sup>

Another systemic problem with recycling is that it naturalizes disposables. It makes plastic wastes seem benign, and even “environmentally friendly” because they can be put back through an industrial process. Recycling continues to allow industry to externalize environmental costs such as waste management and plastic pollution. In

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<sup>324</sup> Environmental Protection Agency. (2012, 07/24/2012). “Plastics.” *Common Wastes and Materials* Retrieved 9/22/12, from <http://www.epa.gov/wastes/conserve/materials/plastics.htm>.

<sup>325</sup> MacBride, S. (2012). *Recycling Reconsidered: The Present Failure and Future Promise of Environmental Action in the United States*. Cambridge, Mass., MIT Press: 100.

<sup>326</sup> MacBride 2012.

<sup>327</sup> Rogers, H. (2005). *Gone Tomorrow: The Hidden Life of Garbage*. New York; London, New Press: Distributed by W.W. Norton & Company: 177.



fact, industry is an ongoing supporter, both legally and financially, of recycling programs because the alternatives, such as using returnable bottles, are more costly. The American Chemistry Council (ACC), the plastics industry lobby group discussed in previous chapters, supported the New York State Plastic Bag Reduction, Reuse, and Recycling Act in 2008 because it left the responsibility for plastic pollution with retailers rather than producers. They also testified in favour of expanding curbside plastics recycling in New York City in 2010.<sup>328</sup> For industry, recycling is financial damage control and greenwashing rolled into one. Plastic pollution is a stock and flow problem, where the longevity and ubiquity of plastics means they accumulate in the environment while production and disposal of plastics is increasing exponentially. Recycling deals with the stock while enabling the flow of plastics. Championing recycling over other options actually enables plastic pollution rather than mitigating it at a meaningful scale in an effective way.

Samantha MacBride, sociologist of trash, former New York City Department of Sanitation employee, and author of *Recycling Reconsidered*, calls plastics, electronic waste, and household chemicals "modern" trash. Modern wastes "are synthetic, unpredictable, and above all heterogeneous" compared to other forms of trash, and these characteristics make them unique pollutants and pose problems for recycling. She writes,

In ecological terms, [problems with plastics] include risks to workers and communities during production of plastics; risks to consumers from ingestion

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<sup>328</sup> MacBride 2012: 197.

and inhalation of plastic products; risks to terrestrial and marine ecosystems and species from accumulation of plastic litter; risks to communities in the developed world from combustion of plastic wastes in modern incineration; and risks to workers and communities in the developing world from the export of mixed plastic wastes for processing....It is important to acknowledge that, with the possible exception of mitigating litter that migrates from landfills and diverting some plastics from incineration, plastic recycling as we know it addresses none of these problems.<sup>329</sup>

Recycling is a prime example of the importance of weighing the material and systemic aspects of problems and solutions. In fact, if one follows the spirit of Rittel and Webber and considers recycling a way to further define the problem of plastics, we can see that plastic pollution is heterogeneous, a poor fit with current recycling infrastructure and practices, potentially has a greater source in industrial rather than municipal arenas, and is supported by industry.

### Bioplastics

In 2011, Coca-cola launched its PlantBottle™: "The first ever recyclable PET plastic beverage bottle made partially from plants. PlantBottle™ packaging looks, functions and recycles just like traditional PET plastic, but does so with a lighter footprint on the planet and its scarce resources."<sup>330</sup> Instead of using oil as the raw stock to make plastic, PlantBottle™ also both corn and oil. Yet whether the stock is oil or corn (or both), plastic polymers are produced, and the polymer chains in a PlantBottle™ are identical to those made through regular synthetic processes. What problems does PlantBottle™ solve? It provides Coca-Cola with an alternative stock for polymer production should we reach

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<sup>329</sup> MacBride 2012: 211.

<sup>330</sup> Coca Cola Company. (2012). "Introducing PlantBottle." *Sustainability* Retrieved 9/22/12, from <http://www.thecoca-colacompany.com/citizenship/plantbottle.html>

peak oil. It mitigates Coca-Cola's poor environmental track record in the public eye by providing a green branding strategy. But because PlantBottle™ is made of synthetic polymers and plasticizers, which behave exactly like polymers and plasticizers in other PET plastics, it does not solve any of the problems associated with plastic pollution.

PlantBottle™ is just one of many products called "bioplastics," which range from plastics produced with alternative stock, such as PlantBottle™, to thin plastic strands held together with cornstarch that appear to compost but in fact quickly create microplastics, to actual plastic alternatives that are not made of plastic polymers but have similar characteristics to plastics. In the popular imaginary, bioplastics often correspond to a combination of characteristics of such products that none actually possess completely: a plastic polymer that degrades into non-plastic components in a compost heap. Such a thing does not exist, but the ideal is sustained because it pivots on the main problem bioplastics are meant to address: the permanence of plastics.

Technically, all plastics degrade. Chemically, degradation means that compounds break into smaller compounds, usually in well-defined stages with identifiable intermediary products. When scientists say that nuclear waste has a fifty-thousand year half life, for example, this is a measure of degradation. The problem with plastic degradation is threefold. First, it happens over geological time frames. Second, even for products designed to degrade in a shorter time frame, there is a lack of data and long-term studies about the degradability of "environmentally degradable plastics" (EDPs). When EDPs degrade, the fates and toxicity of resulting products and metabolites have to be

monitored. They may not be significantly better than the original plastics they are meant to replace. Thirdly, there is considerable confusion over standards and meanings of different forms, products, and rates of degradation, including terms like “compostable” and “degradable,” not unlike the early twentieth century's contest over and proliferation of definitions for "pure" or "unpolluted" water.

There is no legal or other binding definition of "bioplastics" in the United States, and sorting products that reproduce plastic pollution under a green banner from viable plastic alternatives is not easy, or often even possible, without a laboratory and a lot of time. Nor is there a legal differentiation between the terms “degradable,” “biodegradable,” or “compostable.” Some “compostable” bioplastics merely fragment. Others will only compost in an industrial facility under extreme heat, and some probably genuinely turn into carbon, hydrogen and oxygen in an appreciable time frame. The American Society for Testing and Materials (ASTM) and the International Organization for Standardization (ISO) define degradation as “an irreversible process leading to a significant change of the structure of a material, typically characterized by a loss of properties (e.g. integrity, molecular weight, structure or mechanical strength) and/or fragmentation. Degradation is affected by environmental conditions and proceeds over a period of time comprising one or more steps.”<sup>331</sup> Yet, without a time frame included in the definition, all carbon-based materials, from coal to oil spills to plastics, can be defined as degradable because their chemical structures will change over indefinite time

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<sup>331</sup> ISO (1993). *Plastics e vocabulary, amendement 3. General terms and terms relating to degradable plastics*. ISO. Geneva; ASTM N.A. (1991). *Standard terminology relating to plastics*. ASTM.

periods.<sup>332</sup> Degradation is not an automatic environmental good. We know that fragmentation and the creation of microplastics is not a benign process for ocean plastics, and in fact makes them more dangerous. For bioplastics meant to be environmentally benign, time frames, toxicity, and the fate of degradation products have to be considered. Solutions have materialities all their own.

One of the chief concerns in current bioplastics research is the toxicity and fate of the products of degradation. This concern carries over into the science-fiction cousin of plastics degradation, biodegradation. In 1975, a small team of Japanese scientists found a strain of bacteria in waste ponds outside a nylon factor. The *Flavobacterium* was digesting some of the manufacturing waste of nylon-6, substances that were created only fifty years earlier. The team isolated the enzyme in *Flavobacterium* responsible for breaking down the nylon byproducts, and found it differed from any other enzyme the bacteria produced, and that it only worked on a specific nylon byproduct.<sup>333</sup> Since then, there have been dozens of similar findings. Scientists from the University College of Dublin found strains of fungus living in a PET bottled processing plant that digested PET.<sup>334</sup> Students from Yale found that *pestalotiopsis microspora*, an Amazonian fungus,

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<sup>332</sup> Roy, P. K., M. Hakkarainen, et al. (2011). "Degradable Polyethylene: Fantasy or Reality." *Environmental Science & Technology* 45(10): 4220.

<sup>333</sup> Kinoshita, S., S. Kageyama, et al. (1975). "Utilization of a Cyclic Dimer and Linear Oligomers of E-epsilon;-Aminocaproic Acid by *Achromobacter guttatus* KI 72." *Agricultural and Biological Chemistry* 39(6): 1219-1223.

<sup>334</sup> Kenny, S. T., J. N. Runic, et al. (2008). "Up-Cycling of PET (Polyethylene Terephthalate) to the Biodegradable Plastic PHA (Polyhydroxyalkanoate)." *Environmental Science & Technology* 42(20): 7696-7701.

eats polyurthane.<sup>335</sup> There have even been two high school students—Daniel Burd in Canada and Tseng I-Chen in Taiwan—who used bacteria to degrade plastics for their school science projects. A recent article in *Nature* covered the as of yet unpublished finding by a group of marine microbiologists at Woods Hole Oceanographic Institution in Massachusetts that bacteria in the ocean may digest ocean plastics.<sup>336</sup> The scientists speculated that these bacteria may account for the temporal gaps in Law’s study of “Plastic accumulation in the North Atlantic subtropical gyre” mentioned in the previous chapter. However, this hypothesis has not yet been tested, and there is significant debate about whether the bacteria are merely hitchhikers on fragmenting plastics rather than actively digesting the polymers. The Woods Hole team, along with many other scientists, caution that the digestion may produce harmful by-products, and toxins ingested by the bacteria may enable chemicals to move into the food chain more readily.

At the end of online reports of biodegrading fungus, bacteria, or enzymes, public comments reliably turn to science fiction B-movie scenarios where laboratory plastic-biodegraders escape their test tubes and fail to differentiate between plastic trash and vital plastic infrastructure in the outside world. The reason this fear is unfounded is one of the same reason plastic-eating entities do not currently constitute a solution to plastic pollution: they do not scale. Bacteria and fungus do not subsist on a diet of

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<sup>335</sup> Russell, J. R., J. Huang, et al. (2011). "Biodegradation of Polyester Polyurethane by Endophytic Fungi." *Applied and Environmental Microbiology* 77(17): 6076-6084.

<sup>336</sup> Dickey Zaikab, G. (2011). "Marine microbes digest plastic." *Nature*. Retrieved 9/22/2, from <http://www.nature.com/news/2011/110328/full/news.2011.191.html>.

plastics alone, and often prefer other food sources, though they will eat mainly or only plastic if there are no alternatives (which currently only happens in the laboratory). They only eat one type or one byproduct of plastic, which, like recycling, presents a problem because of plastics' varied types, forms, and additives. In many ways, plastic-eating bacteria and fungi are akin to composting organic wastes, which make up the majority of municipal solid waste. Yet most cities do not have extensive composting systems. It is simply not profitable, and requires a massive amount of space to carry out. This is compounded by the already low recovery rate for all recyclables, and particularly plastics, in the United States. Most importantly for mitigating plastic pollution, an industrial ecosystem of plastic-eaters deals only with the stock of plastics that have already been made, and does not address increasing plastic production.

At the moment, most types of bioplastics and organisms capable of biodegradation address few of the characteristics of plastic pollution, and some, like PlantBottle™, offer a solution in the guise of continuing the problem unabated. Yet, bioplastics have the potential to affect the permanence of plastics and the flow of synthetic polymers into the environment by providing viable plastic alternatives that do not behave like plastics over the long term. At the same time, bioplastics aim to “fix” plastic pollution through methods rooted in disposability and deferred risk. In other words, like recycling, bioplastics offer a technological fix while ignoring, or in the worst cases, reinforcing, the systemic aspects of plastic pollution

### The Technological Fix

A neutral definition of a technological fix might focus on the use of technology to overcome social, environmental, or economic problems. However, the phrase is usually used dismissively or pejoratively "to describe a quick, cheap fix using inappropriate technology that creates more problems than it solves."<sup>337</sup> Within the environmental arena, the critique of technological fixes began as early as the 1960s, when many believed that "it is our reliance on technological fixes that throws the system still more out of balance [with nature in the first place] and has prevented us from finding true solutions to environmental issues."<sup>338</sup> Some environmentalists, such as deep ecologists, ecological Marxists, and others, including myself, who believe our environmental crises are due to systemic problems, argue that technology is one small part of larger cultural, economic and political issues, and potential solutions have to take these systems into account. Other types of environmentalism, including the spirit of most green business, are premised on the belief that a collection of technological fixes can stem the environmental crisis the way smokestack scrubbers significantly decreased acid rain in the 1990s while industrial processes continued unabated.

If plastic pollution is a problem with both material and systemic elements, what is the role of well-intentioned technological fixes? Are they "integral part[s] of the solution but not the entire solution" that "will only work if combined with education on reducing our

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<sup>337</sup> Rosner, L. (2004). *The Technological Fix: How People Use Technology to Create and Solve Problems*. New York, Routledge: 1.

<sup>338</sup> Rosner 2004: 6.



consumption,” as Daniella Russo of the Plastic Pollution Coalition says?<sup>339</sup> Or does “selling the idea of [utopian technological fixes like] gyre cleanup to the public actually [make] the problem worse,” as Stiv Wilson of 5 Gyres believes? Educators and activists working with the public will always have to deal with technological fixes in the dominant American environmental imaginary—such fixes are historically a central part of how Western cultures have related to the environment—but should we frame them as “small steps” or distractions? Is focusing on the symptoms instead of the disease a viable form of environmental action? These questions might be more difficult to answer if solutions that aimed to deal with both the material and systemic aspects of plastic pollution were plentiful. But they are not. From a point of view focused strictly on solving (or mitigating) plastic pollution, solutions that aim to address all parts of the problem are far superior to technological fixes.

### REFUSE!

The Plastic Pollution Coalition (PPC) “is a global alliance of individuals, organizations and businesses working together to stop plastic pollution and its toxic impacts on humans, animals and the environment.”<sup>340</sup> It has thousands of members made up of both individuals and groups, including the Algalita Marine Research Foundation and 5 Gyres mentioned in earlier chapters, and is headed by a small group of people in California who work to inspire, connect, support and expand their coalition members' efforts. The Plastic Pollution Coalition is probably best known for its REFUSE! campaign, often

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<sup>339</sup> Russo, D. (2012). Email Communication. August 28.

<sup>340</sup> Plastic Pollution Coalition. (2011). "Plastic Pollution Coalition." Retrieved 5/25/11, from <http://plasticpollutioncoalition.org/>.

promoted by celebrities holding up a sign that says "I will REFUSE disposable plastic" and a pledge individuals can sign that states they will refuse single use plastics in their own lives. Such refusal is designed to plug individuals into larger systems of production and distribution in a way that makes "real change." I asked Daniella Russo, director of the PPC, how refusing plastics in one's own life addresses plastic pollution in general.

She replied,

Individual behavior change is essential to reducing our plastic footprint as a society. Most of the items causing plastic pollution are specifically created for personal use, and to be discarded. Each of us can contribute immensely to the problem, and therefore to the solution. Personal participation in the problem solving is essential for people to feel engaged and empowered to create change.<sup>341</sup>

Personal participation is, indeed, "essential for people to feel engaged and empowered to create change." It is foundational to personal politics. Yet, individual consumer habits do not *necessarily* scale to effect plastic pollution. There is no automatic mechanism by which individuals become "immense" contributors to either the problem or solution of plastic pollution.

One of the major scalar fallacies in American environmentalism is that systemic environmental degradation is created, and can be combated, through individual consumer choice. I have often assigned students to avoid plastic disposables for an entire week. It simply isn't possible. Even plastic pollution celebrity Beth Terry, author of *My Plastic Free Life* blog and *Plastic Free: How I Kicked the Plastic Habit and How You Can Too*, has only radically reduced the consumption of plastic products in her life

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<sup>341</sup> Russo 2012.

rather than eliminating them entirely, and she is the reigning expert on alternatives to consumer plastics<sup>342</sup>. The problem of plastic pollution is not whether we choose to use disposables or not, but an economic and industrial system that builds and wraps almost everything, including basic needs like food and clothing, in plastics. Avoidance is not a tactic that works to keep plastic out of our lives. Nor does it affect plastic pollution on a larger scale.

Michael Maniates, author of “Individualization: Plant a Tree, Buy a Bike, Save the World?” in *Confronting Consumption*, cautions that “when responsibility for environmental problems is individualized, there is little room to ponder institutions, the nature and exercise of political power, or ways of collectively changing the distribution of power and influence in society.”<sup>343</sup> To use the terminology of scale developed in the last chapter, the perspective or site of REFUSE is one’s own consumption habits, personal politics, and morals. This is an important site of change in terms of engagement and empowerment, as Russo states, but the processes you affect as an individual who brings a reusable bag to the grocery store are not the processes at work in plastic pollution writ large. REFUSE! does not affect the toxicity of plastics, nor does it significantly affect the amount of plasticizers in your body.<sup>344</sup> It does not affect the

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<sup>342</sup> Terry, B. (2012). *Plastic-free: How I Kicked the Plastic Habit and How You Can Too*. New York, N.Y., Skyhorse Pub.

<sup>343</sup> Maniates, M. (2002). “Individualization: Plant a Tree, Buy a Bike, Save the World?” *Confronting Consumption*. T. Princen, M. Maniates and K. Conca. Cambridge, Mass.; London, MIT Press: 33.

<sup>344</sup> Rudel, R., J. M. Gray, et al. (2011). “Food Packaging and Bisphenol A and Bis(2-Ethylhexyl) Phthalate Exposure: Findings from a Dietary Intervention.” *Environmental Health Perspectives* 119(7): 914-920.

production or circulation of plastics; ample research has shown that non-plastic alternatives provide a healthy market niche for environmentally-conscious consumers while plastic production continues to rise.<sup>345</sup> “Lost” plastic sales move to other local or global markets. Historically, consumer boycotts have produced change in products, but, with the shift to global capitalism, with multinational corporations moving their production and markets into a global perspective, this has changed.<sup>346</sup>

This does not mean that individuals cannot scale to affect the process of global plastic pollution. For example, as mentioned in the previous chapter, NIMB has political potential when it is not individualized as consumer choice. People can affect different processes when they are voters, protesters, teachers, business owners, legislators, scientists, activists, and are part of other scaled networks. In fact, the REFUSE! Campaign can scale through the PPC’s Plastic-Free Towns and Plastic-Free Campuses initiatives. New York University has nearly 51,000 students, so a plastic-free campus has a much wider impact than if even an optimistic twenty percent of students took part as individuals in the REFUSE campaign. However, the same rule of scaling holds for institutions such as NYU—this new, more expansive site for change, while it includes many more people, does not guarantee that the processes that create plastic pollution will be affected. Even if student entrepreneurs and designers graduate to become best practice, plastic-free practioners, there is no automatic mechanism by which these

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<sup>345</sup> MacBride 2012.

<sup>346</sup> Dauvergne, P. (2008). *The Shadows of Consumption: Consequences for the Global Environment*. Cambridge, Mass., MIT Press.  
Cohen, L. (2003). *A Consumers' Republic: The Politics of Mass Consumption in Postwar America*. New York, Knopf: Distributed by Random House.

efforts directly address the stock and flow of plastics. The problem remains how to bring personal, business, and design politics into global industrial, economic, and governance systems that fuel the production of plastics. While REFUSE! may adequately address problems of personal politics, morals, and empowerment, how does a refusal framework affect plastic pollution through the processes and at the scales at which it occurs?

#### Extended Producer Responsibility

Extended producer responsibility (EPR) is a possible way to scale business and design practices to affect plastic pollution. The core idea of extended producer responsibility is to cease the externalization of waste costs by producers. The financial or operational burden of managing waste, including solid waste disposal and recycling, becomes the full responsibility of the producer of the products in question, rather than a burden assumed and paid for by individuals and municipalities. The assumption is that this increased responsibility, and the financial costs associated with it, will lead to better design and management decisions. If plastic pollution is fundamentally economic, as I argue, then intervening in profit margins has great potential to make change. Moreover, EPR contains an inherent critique of the externalization of the financial and environmental costs of pollution by industry upon which assimilative capacity and other “free gifts” to capital in the form of allowable limits of pollution are based. EPR does not challenge allowable limits, but it does reframe this “gift” as part of the commons rather than a place for industry to process its pollutants. In theory, extended producer responsibility can scale to address processes of increasing production of plastics (flow),

its stock, its ubiquity, and even its toxicity if producers had to pay the fines and management of these aspects of pollution. Yet, in practice, the outcomes of EPR are mixed.

As You Sow Foundation is a member of the Plastic Pollution Coalition. As an institution acting as “investor representatives,” it promotes environmentally conscious business practices, including elective extended producer responsibility, to large corporations. Through their efforts, “[l]eading brands like Coca-Cola Co., Nestle Waters North America, and PepsiCo have taken responsibility for a majority of their post-consumer bottles and cans, setting an example for other consumer product companies.”<sup>347</sup> In effect, this means recycling. As You Sow frames trash as a wasted resource and as a revenue stream for industry, and the solution is to recover material for recycling. Their aim is to have producers such as Coca-Cola reach a fifty-five percent recycling rate in the next few years. Thus, EPR, a potentially radical notion, particularly if industry had to account for the entire life cycle of plastics whether or not they made it to the recycling room floor, for the entirety of geological time, as well as assuming responsibility for plastic toxins in the far north and fetuses, is reduced to the industry-favoured practice of recycling. The end result is support for the continued flow of plastics.

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<sup>347</sup> As You Sow. (2012). "Why We Are Promoting EPR for Packaging." *EPR Issue Brief*. Retrieved 9/21/12, from <http://www.asyousow.org/sustainability/EPR%20Issue%20Brief.shtml>

## Bag Bans

If a NIMB supporter wanted to eradicate plasticizers from her body, avoiding plastics in her own life would not be enough. There would have to be far less plastic in the world for her body burden to reach as close to zero as it possibly can, given that some plasticizers are persistent organic pollutants and therefore permanent. Bans are one way to deal with the ubiquity of plastics. Bag bans are the most popular, but bottled water bans are also in effect in many municipalities and schools around the world.<sup>348</sup> There are several actions that fall under the term “bag ban” including outright bans, bag fees, and bans on certain thicknesses of plastic, and they are becoming increasingly common in cities, states, and even countries, such as Ireland and India.

The plastics industry supports recycling, and even extended producer responsibility that requires them to pick up the tab for recycling in the face of plastic bans.<sup>349</sup> According to Samantha MacBride, bans are more damaging to industry because plastic alternatives are made by entirely different industries, so plastics manufactures cannot create the alternative products to fill the profit gap with processes it already has at its disposal. Scholars such as Peter Dauvergne, author of *Shadows of Consumption*, which investigates how markets merely shift globally when one market boycotts a product, might argue that local bans do not significantly decrease global production of a banned

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<sup>348</sup> Plastic Free Times. (2012). "Plastic Reduction Map." *Plastic Free Campaigns*. Retrieved 9/21/12, from <http://theplasticfreetimes.com/plastic-free-campaigns>.

<sup>349</sup> MacBride 2012: 187.

An unexpected ally in bag bans is recycling companies, since bags tend to fly around and jam up equipment. Moreover, as already discussed, plastics are not a lucrative material for recyclers, and reducing costs from fixing jammed machinery may well outweigh the commodity value of recycled bags.

product. Yet when entire countries like India ban a product, particularly when they are a central site for market expansion, bans may slow the rate of overall plastics production. However, without data, it is hard to know how bans affect plastic production, local and global toxicity levels, and the ubiquity of plastics. Based on a theory of scale, bans at different sites—San Francisco versus India, for example—will include different processes and thus affect plastic pollution differently.

### BPA Bans

Like bag bans, there is no qualitative or quantitative data about how bisphenol A (BPA) bans effect overall or even local levels of plastic pollution. Canada and the United States have banned BPA in baby bottles. However, BPA bans overlook two characteristics of plastic pollution. First, banning one product or chemical does not address the ubiquity of plastic pollution. Recall that a under controlled experimental conditions, families who avoided BPA in all foodstuffs cut their body burdens of water-soluble BPA roughly in half.<sup>350</sup> They were constantly exposed to other, unknown sources of BPA that maintained a significant level of the chemical in their bodies despite their very local ban. Plastics and plasticizers are everywhere, and piecemeal bans, particularly if they only address one product like baby bottles, do not impact the overall processes of plastic pollution. Secondly, BPA-free products still have plasticizers. In most cases, BPA is replaced with BPS, a plasticizer with a similar structure to BPA that may well be an

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<sup>350</sup> Rudel 2011.



endocrine disruptor.<sup>351</sup> There are few studies that assess the health effects, longevity, and circulation of BPS.

Thus, bag, bottle and BPA bans do not always scale. Scale is not about being big or small or covering more or less area, including greater or fewer numbers of people, but about the relationships that matter at different sites of intervention. The bodies of all US-born babies, or all Canadians, still carry burdens of BPA because the fundamental processes characteristic of plastic pollution have not changed. Piecemeal bans do not address ubiquity, and alternatives to plastics and plasticizers are not truly alternatives if they are produced in the same system with similar chemicals that characterize plastic pollution.

#### Registration, Evaluation, Authorisation, and Restriction of Chemicals (REACH)

In 2007, Europe launched the Registration, Evaluation, Authorisation, and Restriction of Chemicals (REACH) program. Under REACH, "[m]anufacturers and importers are required to gather information on the properties of their chemical substances, which will allow their safe handling, and to register the information in a central database run by the European Chemicals Agency (ECHA) in Helsinki."<sup>352</sup> That is, in alignment with strict hazardous chemical regulations, all chemicals and objects made from chemicals have to be "proven safe" by manufacturers, posted in a public forum, and any that are

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<sup>351</sup> Hamilton, J. (2012). "Legal Battle Erupts Over Whose Plastic Consumers Should Trust." *All Things Considered*, NPR. Retrieved 9/25/12, from <http://www.npr.org/blogs/health/2012/07/30/157592882/legal-battle-heats-up-over-whose-plastic-consumers-should-trust>.

<sup>352</sup> European Commission. (2012). "REACH." *Environment*. Retrieved 9/22/12, from [http://ec.europa.eu/environment/chemicals/reach/reach\\_intro.htm](http://ec.europa.eu/environment/chemicals/reach/reach_intro.htm).

not deemed safe are banned or restricted. Based on the data and research compiled, REACH has resulted in a "priority list" of chemicals of concern under particularly strict tracking and regulation. The first list, published in 2011, includes phthalates and flame retardants found in plastics.

REACH is a more robust model of action that incorporates elements of extended producer responsibility (EPR) and chemical bans. Most importantly, it scales. It addresses all chemicals in all EU countries by all producers and industries so that consumers will never be faced with the task of learning which products are potentially dangerous and which are not. In fact, it addresses chemicals beyond "mere" plastic pollution. DDT, for example, the pesticide of *Silent Spring* fame, is an endocrine disruptor but not a plasticizer. Under REACH, it would be banned or heavily restricted. The plastic pollution is only one kind of pollution within a wider landscape of constant exposure from chemicals from agricultural practices, mining, non-plastic products, and other sources. REACH takes this entire panoply into account.

One of the mechanisms that allows REACH to scale is governance. REACH has advantages over forerunners such as the 2004 Stockholm Convention on Persistent Organic Pollutants (POPs). The Stockholm Convention is "a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have adverse effects to human health or to

the environment,"<sup>353</sup> focusing mainly on broadcast chemicals such as insecticides, but also includes chemicals used in plastics. Yet the Convention is elective, and suffers from a lack of enforcement. REACH is mandatory and enforced by each member state in the EU, though penalties are different in each state.<sup>354</sup> Enforcement allows REACH to effect processes that the elective Stockholm Convention does not.

In the United States, it is up to the underfunded and industry-friendly Environmental Protection Agency (EPA) or Food and Drug Administration (FDA) to prove that chemicals indisputably cause harm. Another mechanism that allows REACH to address all chemicals, goods, and companies is form of producer responsibility whereby the burden of proving something safe is shifted to producers rather than government agencies. REACH also calls for the progressive substitution of the dangerous chemicals when suitable alternatives have been identified. BPS cannot be automatically substituted for BPA. Thus, research, development, production, sale, consumption and disposal are implicated in an entire chemical regulatory system. Because many producers are international or multinational, some products are being sold to non-EU countries with safer chemicals mandated under REACH. Moreover, since air and water-borne chemicals in the northern hemisphere tend to migrate north, REACH has the potential to slow the growing concentration of chemical in the world's circumpolar regions. This ripple effect whereby REACH influences places and processes not under its immediate domain is part

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<sup>353</sup> Stockholm Convention. (2008). "About the Convention." Retrieved 9/22/12, from <http://chm.pops.int/Convention/tabid/54/Default.aspx>.

<sup>354</sup> European Commission. (2012, 14/09/2012). "REACH Enforcement." *Environment*. Retrieved 9/22/12, from [http://ec.europa.eu/environment/chemicals/reach/enforcement\\_en.htm](http://ec.europa.eu/environment/chemicals/reach/enforcement_en.htm).

of scaling up. It can be difficult, and even impossible, to know what environmental, economic, political, and material processes are dominant in sites as extensive as the European Union, but we can follow the effects of REACH to find out how this legislation scales.

### Green Chemistry

Green chemistry is “the utilisation of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemical products,” and it has the opportunity to flourish under legislation like REACH.<sup>355</sup> Usually, chemists, biologists, toxicologists, and higher administrators in manufacturing companies and government agencies work independently to mandate, create, and evaluate chemicals or products. Their work rarely overlaps or informs one another. As one chemist put it:

"I have synthesized over 2,500 compounds! I have never been taught what makes a chemical toxic! I have no idea what makes a chemical an environmental hazard! I have synthesized over 2,500 compounds! I have no idea what makes a chemical toxic! We've been monkeys typing Shakespeare."<sup>356</sup>

Green chemistry takes the monkey out of science. It's a type of interdisciplinary science for understanding—and avoiding—adverse effects when chemicals inadvertently but predictably leak into the wild. Instead of creating a compound and sending it off to others to see how it can be used in products, a green chemist asks whether the chemical

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<sup>355</sup> Anastas, P. T. and J. C. Warner (1998). *Green Chemistry: Theory and Practice*. Oxford; New York, Oxford University Press.

<sup>356</sup> Grossman, E. (2009). *Chasing Molecules: Poisonous products, human health, and the promise of green chemistry*. Washington, DC, Island Press/Shearwater Books: xxiii.

is hazardous. How does it affect bodies? Is it persistent in the body or environment? Can it travel easily? Is it persistent? Such questions are central to green chemistry. Rather than the laborious process of proving that each substance is dangerous or toxic, green chemistry tends to look at the characteristics of the chemical. If it is “persistent, highly mobile, and can't be contained, you have a problem you can't rectify.”<sup>357</sup> It is time to go back to the drawing board. The premise of green chemistry is that preventing a problem is better than containing or controlling it. Thus, green chemistry aims to ultimately redirect pollutant regulatory energy away from setting precise exposure limits and towards eliminating the hazard in the first place.

#### The Precautionary Principle

Both REACH and green chemistry use versions of the precautionary principle. While there are various manifestations and interpretations of the precautionary principle, the main precept is if an action, policy, or material may cause harm to the public or environment, but these consequences are uncertain or lack scientific consensus, either the action, policy or material should be abandoned, or, in some formulations, the burden of proof that harm will not result falls on those taking the action or creating the substance rather than those who may suffer from its effects.<sup>358</sup> Yet the precautionary approach does not end at establishing the level of harm or evidence needed before action against a chemical can be taken. Potentially, this would be another manifestation

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<sup>357</sup> Grossman 2009: 29.

<sup>358</sup> Marchant, G. E. (2003). "From General Policy to Legal Rule: Aspirations and Limitations of the Precautionary Principle." *Environmental Health Perspectives* 111(14): 1799–1803.

of early nineteenth century debates over “arbitrary limits,” this time for thresholds of proof. Instead, a robust use of the precautionary method, such as that spelled out in the German Clean Air Act of 1985, includes early detection of harms, promoting alternative chemicals through green chemistry, and the commitment to preventative rather than reactionary action.<sup>359</sup> In short, it is a preventative environmental imaginary that assumes all chemicals and interventions into the environment have both known and unknown risks, and seeks to mitigate their harm.

Within the precautionary principle, the burden of proof for harm shifts from danger to safety, and from the public to industry. If the United States governed its pollution according to the precautionary principle, the FDA would never deny the NRDC’s petition “[d]ue to... uncertainties”<sup>360</sup> as detailed in previous chapters. Uncertainty is not a hurdle for the precautionary principle. If a chemical has uncertain effects on health and the environment, it is either abandoned or requires more research to prove it safe, funded by those who wish to introduce the chemical. It is not allowed into the wild. The argument vom Saal makes about funding bias in science would still be an issue, but it would be based on how industry was fraudulently proving chemicals safe, rather than how industry studies reliably concluded a lack of evidence of harm, thus prolonging the “debate” about the harmful effects of chemicals. Lack of proof of harm is not the same

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<sup>359</sup> Harremoës, P. (2002). *The Precautionary Principle in the 20th Century: Late Lessons from Early Warnings*. London; Sterling, VA, Earthscan Publications.

<sup>360</sup> Food and Drug Administration (2012). Re: FDMS Docket No. FDA-2008-P-0577-0001YCP. Department of Health and Human Services. Washington, DC, Food and Drug Administration: 9.

as proof of safety.<sup>361</sup>

As a methodology for dealing with toxicity and knowledge—or, put more simply, as a risk framework—the precautionary principle can deal with both the stock or flow of a substance such as plastic pollution, and as a guiding ethos for “modern wastes.” While the precautionary principle is more widely used in Europe than the United States, as historian Nancy Langston has pointed out, in the early nineteenth century, Harvey Wiley, chemist, consumer advocate and founder of the Bureau of Chemistry, which later became the Food and Drug Administration, based his work on the precautionary principle. He “held that a foreign substance should be presumed guilty until proven innocent [while] industry believed the opposite.”<sup>362</sup> Despite Wiley’s work to define pollution according to chronic affects and the presence of “abnormal constituents of food” rather than acute and immediate poisoning, in 1927, the Bureau of Chemistry “opted a ‘tolerance’ policy based on the assumption that below a certain threshold a substance could not penetrate the body’s defenses and become toxic. Harmful additives and toxic residues were permitted in foods up to certain quantitative limits called tolerances.”<sup>363</sup> This is obviously another manifestation of the concept of assimilative capacity and allowable limits so central to definitions of pollution in the twentieth century covered in chapter one. Wiley resigned in frustration and was replaced by

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<sup>361</sup> Proof of safety is a mind-boggling concept in itself, and merits an entire dissertation of its own. Proving safety is in essence a negative proof of harm, and proving a negative is generally thought to be a scientific impossibility.

<sup>362</sup> Langston, N. (2010). *Toxic Bodies: Hormone Disruptors and the Legacy of DES*. New Haven, Yale University Press: 21.

<sup>363</sup> Langston 2010: 23.

Walter Campbell, who used an industry partnership model to “attempt to educate industry about potential problems, then alert them to violations, and finally negotiate with them to stop the worst abuses.”<sup>364</sup> In every proposed solution considered so far, economic and industrial priorities have figured as significant systems that produce, and maintain plastic pollution.

### Capitalism

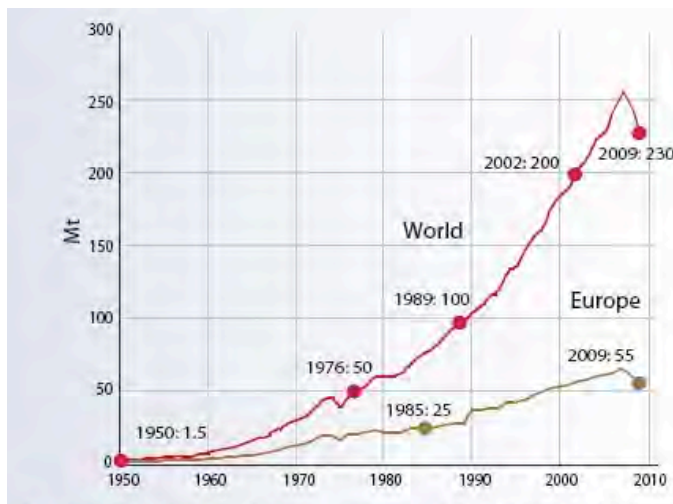


Figure 5.2: Original caption from *PlasticsEurope* 2010: "Growth in plastics production, 1950-2009. After five decades of continues growth in world plastics production, there was a drop in production in 2008 due to the economic downturn.... PET, PA and polyacryl fibers are not included [in this graph]."

Perhaps the most obvious, though difficult to envision, appropriately scaled solution to plastic pollution is to cease the increasing production of plastics altogether. Ecological Marxists argue that capitalism is inherently unsustainable because the drive for profit requires more production, and therefore more raw materials, energy, and waste on a

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<sup>364</sup> Langston 2010: 25.



planet with a finite number of resources.<sup>365</sup> The graph above shows a steady growth in plastic production with drops only during oil or financial crises. This upwardly trending line is a visual representation of the growth imperative for capitalism's premise on profit. How to constantly increase production and consumption to drive profit became an acute problem in the 1920 and 30s in the United States. Markets for goods were saturated, and consumption, and thereby production, was leveling off for many types of goods. Historians such as Susan Strasser and cultural critics of the time such as Vance Packard document the rise of disposables, fashion, advertising, planned obsolescence, and other tactics to promote "forced consumption" and thereby increase stagnating markets.<sup>366</sup> In 1955, economist and retail analyst Victor Lebow famously stated that, "We need things consumed, burned up, worn out, replaced, and discarded at an ever increasing pace" to support "[o]ur enormously productive economy."<sup>367</sup> Plastics and packaging played, and continue to play, a central role in increasing consumption and production.

Throughout this dissertation, I've made the argument that dominant definitions, measurements, and detection methods used for pollution serve economic interests.

These economic interests are in turn premised on profit, and therefore also growth, cost

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<sup>365</sup> O'Connor, J. (1998). *Natural causes: Essays in Ecological Marxism*. New York, Guilford Press.

Also see the Marxist Ecology section of *The Monthly Review*:

<http://monthlyreview.org/content-areas/marxism-ecology>

<sup>366</sup> Strasser, S. (1999). *Waste and Want: A Social History of Trash*. New York, Metropolitan Books.

Packard, V. (1960). *The Waste Makers*. New York, D. McKay Co.

<sup>367</sup> Lebow, V. (1955). "The Real Meaning of Consumer Demand." *Journal of Retailing*: 1-7.

savings, and externalizing as many costs as possible. The most significant systemic change in notions of pollution that can deal with plastics is a change in the economic structure to one that is not dependant on growth and profit, an economic system that would result in a differently shaped graph than the one that began this chapter. This is not to say that all non-capitalist systems are sustainable, since scholars such as Zsuzsa Gille have aptly shown this is not the case, but that there are models for development without growth that can profoundly address the flow of plastic pollution.<sup>368</sup> What solutions to plastic pollution would be possible if corporations, driven by the desire for profit, did not affect the governance of pollution? How could pollution be redefined, and at what scale, if it beholden to a different set of economic goals? As I said in the introduction, plastic pollution is only an “impossible” problem insofar that it is impossible to adequately address within business-as-usual. NRDC is foiled by industry control of the FDA. Attempts at dealing with the stock of plastics and chemicals in our oceans and bodies are futile against the continued flow into those same places. Recycling is offered as a diversionary tactic over and over, often supported and even funded by industry, despite the way it allows the continued production of the pollutant and externalization of solid waste costs under an environmental banner. By identifying where the “impossible” parts of the problem occur, we also identify where business-as-usual needs to change. Again and again, the interests and systems of capitalism trump the most viable solutions to global plastic pollution.

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<sup>368</sup> Gille, Z. (2007). *From the Cult of Waste to the Trash Heap of History: The Politics of Waste in Socialist and Postsocialist Hungary*. Bloomington, IN, Indiana University Press. See: Daly, H. E. (1973). *Toward a steady-state economy*. San Francisco, W. H. Freeman.

|  | clean ups | Recycling | Bioplastics | Biodegradation | REFUSE! | EPR | Bag Bans | BPA Bans | REACH | Green Chem | Alternatives to capitalism | Precautionary Principle |
|--|-----------|-----------|-------------|----------------|---------|-----|----------|----------|-------|------------|----------------------------|-------------------------|
| Inextricable from bodies/ ecosystems   |           |           |             |                |         |     |          |          |       |            |                            | X                       |
| Ubiquity                               |           |           |             |                |         |     |          |          | X     | X          | X                          | X                       |
| Longevity                              |           |           | X           | X              |         |     |          |          | X     | X          |                            | X                       |
| Ability to travel                      | X         |           | X           | X              |         |     |          |          | X     | X          |                            | X                       |
| Toxicity                               |           |           |             |                |         |     |          | X        | X     | X          |                            | X                       |
| Non-linear dose/ response relationship |           |           |             |                |         |     |          |          | X     | X          |                            | X                       |
| Unequal distribution of harm           |           |           |             |                |         | X   |          | X        |       |            | X                          |                         |
| Global scale                           |           |           |             |                |         | X   |          |          | X     |            | X                          |                         |
| Stock and flow                         |           |           | X           |                |         | X   |          |          | X     | X          | X                          |                         |
| Economic nature                        |           |           |             |                |         |     | X        |          | X     |            | X                          | X                       |

Table 5.3: A chart of the systemic characteristics of plastic pollution, on the left, and proposed solutions to plastic pollution, above. Note that no single solution addresses all characteristics that lead to problems, but some solutions have greater potential than others.

## Conclusion

Using plastic pollution as a case study, I have developed a theory of intervention based on what has to be taken into account when solving “wicked” environmental problems, including the materiality of the problem, how the definition of phenomena and problems affect proposed solutions, the differences between dominant and competing definitions, and the importance of matching the scale of the problem with the scale of solutions. In many of the examples of proposed solutions above, particularly fixes such

as recycling or avoidance, the characteristics of plastic pollution are not taken into account at all. Though both address problems, they are not problems related to plastic pollution itself. If problem definition dictates the forms of solutions that are deemed plausible and possible, and common practice proposes before they are investigated in terms of the problems they are meant to solve and thus become less likely to impact problems as intended, then a dedication to focusing on environmental problems for both scholars and practioners is integral given the sort of “wicked,” “impossible” environmental issues facing us in the twenty-first century.

This framework moves us towards a particular definition of sustainability. In 1987, the Brundtland Commission of the United Nations defined “sustainable development [a]s development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”<sup>369</sup> This definition has been widely adopted in popular culture, green business, activism, and other areas. It focuses on the literal meaning of “sustain” to indicate endurance. The UN’s definition can be rephrased as a problem: “How can we continue business-as-usual without inhibiting business-as-usual in the future?” How, in short, can capitalism continue to flourish so it does not impede its own progress in the future? How can we stretch this finite earth? In 2005, the World Summit redefined “sustainable development in its economic, social and environmental

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<sup>369</sup> United Nations General Assembly (1987). *Report of the World Commission on Environment and Development: Our Common Future*. United Nations General Assembly. Annex to document A/42/427.

aspects.”<sup>370</sup> This definition is said to have a “triple bottom line” of economic, social and environmental justice. Since business-as-usual has not achieved any of these forms of justice on a wide scale, and many believe that capitalism is in fact premised on economic injustice, this wider, justice-based definition allows different sorts of solutions to follow. The triple bottom line approach to sustainability always already acknowledges that environmental problems are inextricably intertwined with social and economic systems. It acknowledges the inherent wickedness of such problems. Within this definition of sustainability, pollution comes closer to revitalizing pollution control according to its anthropological roots whereby pollution is defined through the vision of a good—and in this case, just—society.

I advocate for an ethos of defining environmental problems that include the materiality, complex systems, scientific apparatuses, political debates, aspects of economic, social, and environmental justice and other sources of conflict within the phenomenon rather than reaching for solutions before these have been considered as a central component of the issue. Environmental problems are rarely, if ever, matters of fact. They are matters of concern, and they require controversy and criticism to flesh out. Based on my research, and particularly the analysis of this chapter, I argue that problems are more likely to be addressed and their effects mitigated (or even solved) if they are framed as complex, wicked problems that cannot be definitively defined compared to problems

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<sup>370</sup> United Nations General Assembly (2005). *2005 World Summit Outcome, Resolution A/60/1*. Retrieved on: 2009-02-17: 2.

that have been made tame. An environmental imaginary such as the one I have aimed to develop throughout my dissertation, based on problem definition and the impossibility of “definitively describing” problems—what at first seems like a paradox rather than a way to take complex systems seriously—will do more work for human and ecological health and just sustainability than imaginaries based on straightforward human-environment relationships.

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## APPENDIX

### List of Acronyms

ACC: American Chemistry Council, a lobby group for various chemical industries, including plastics.

BPA: Bisphenol A, a plasticizer.

CLRTAP: Convention of Long Range Transport of Air Pollutants, a European convention to control transnational air pollutants.

DES: Diethylstilbesterol, an endocrine disruptor prescribed to pregnant women and given to cattle in the early and mid twentieth century.

EPA: Environmental Protection Agency, the American state agency charged with overseeing and upholding pollution regulations.

EPR: Extended Producer Responsibility, a concept whereby producers of waste and other products are responsible for the effects of those goods after they have been sold.

FDA: Food and Drug Administration, the American state agency charged with overseeing and upholding regulations relating to the health and safety of food, drugs, cosmetics, and medical devices.

LOAEL: Lowest Observed Adverse Effect Level, the smallest quantity of a toxin at which an ill effect is observed.

NIMB: Not in My Body, the name for a zero tolerance for industrial chemicals in bodies, regardless of whether there is proof they cause harm or not, a conviction often held by concerned citizens.

NOAA: National Oceanic and Atmospheric Administration. a federal agency focused on the condition of the oceans and the atmosphere.

NOAEL: No Observable Adverse Effect Level, the quantity of a toxin at which no ill effects are observed.

NTP: National Toxicology Program, an inter-agency program run by the United States Department of Health and Human Services to coordinate, evaluate, and report on toxicology within agencies.

PET: Polyethylene terephthalate, a type of resin plastic used in many plastic goods, including soda pop bottles.

POP: Persistent Organic Pollutant, chemicals resistant to degradation, persist in the environment, have the ability to travel long distances, can bioaccumulate in bodies and biomagnify in food chains, and are toxic.

PPC: The Plastic Pollution Coalition, a non-profit anti-plastic pollution group based in the United States.

REACH: Registration, Evaluation, Authorisation and Restriction of Chemicals, the European Community Regulation on chemicals and their safe use.

RfD: Reference Dose, a numerical estimate of a daily oral exposure to humans that is not likely to cause harmful effects during a lifetime.

WHIM: An architecture firm that created Recycled Island™.