Submitted via E-mail

July 25, 2018

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RE: Microplastics Data Submitted in Response to State of Oregon Water Quality Data Request for 2018 Integrated Report

Dear Mr. Emerson,

The Center for Biological Diversity appreciates the opportunity to submit data regarding microplastics in the state waters of Oregon, in response to the State of Oregon Department of Environmental Quality's ("DEQ") request for water quality data for the 2018 Oregon Integrated Report. By submitting this data we hope to inform the Oregon DEQ and the public on the prevalence of and the urgent need for the state to reduce microplastic pollution in Oregon's surface waters.

I. Water Quality Standards Applicable to Microplastic Pollution

Oregon should list its marine and fresh waters as impaired as required by section 303(d) of the Clean Water Act because existing pollution controls are insufficient for state waters to meet the state's water quality standards (33 U.S.C. § 1313(d)). On its impaired waters list, Oregon must include all water bodies that fail to meet "any water quality standard," including numeric criteria, narrative criteria, water body uses, and antidegradation requirements (40 C.F.R. § 130.7 (b)(1),(3), & (d)(2)).

There are several water quality standards that must be used to gauge if waters with microplastic pollution are impaired.

The following water quality objective applies to the waters under the jurisdiction of Oregon DEQ: [T]he highest and best practicable treatment and/or control of wastes, activities, and flows must in every case be provided so as to maintain [...] overall water quality at the highest possible levels and [...] toxic materials [...] and other deleterious factors at the lowest possible levels. ("Statewide Narrative Criteria", OAR, § 340-041-0007)

Oregon has a general policy of water quality antidegradation for waters within its jurisdiction, the purpose of which is to "prevent unnecessary further degradation from new or increased point and nonpoint sources of pollution, and to protect, maintain, and enhance existing surface water quality to ensure the full protection of all existing beneficial uses." ("Antidegradation", OAR, § 340-041-0004)

The High Quality Waters Policy ensures that "[w]here the existing water quality meets or exceeds those levels necessary to support fish, shellfish, and wildlife propagation, recreation in and on the water, and other designated beneficial uses, that level of water quality must be maintained and protected." (OAR, § 340-041-0004 (6))

Further, the Outstanding Resource Waters Policy states that "[w]here existing high quality waters constitute an outstanding State or national resource such as those waters designated as extraordinary resource waters, or as critical habitat areas, the existing water quality and water quality values must be maintained and protected (OAR, § 340-041-0004 (8))

Waters of the state must also be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities. ("Biocriteria", OAR, § 340-041-0011)

Toxic substances may not be introduced above natural background levels in waters of the state in amounts, concentrations, or combinations that may be harmful, may chemically change to harmful forms in the environment, or may accumulate in sediments or bioaccumulate in aquatic life or wildlife to levels that adversely affect public health, safety, or welfare or aquatic life, wildlife or other designated beneficial uses. ("Toxic Substances Narrative", OAR, § 340-041-0033 (1))

Human health must also be protected: waters of the state must "protect Oregonians from potential adverse health effects associated with long-term exposure to toxic substances associated with consumption of fish, shellfish and water." ("Human Health Numeric Criteria", OAR, § 340-041-0033 (3))

Beneficial uses are designated for each water of the state and include fishing, aesthetic quality, fish and aquatic life, and wildlife and hunting for all coastal basins. ("Mid Coast Basin", OAR, § 340-041-0220, "North Coast Basin", OAR, § 340-041-0230, "South Coast Basin", OAR, § 340-041-0300)

Oregon must evaluate the attainment status of each of these standards with respect to microplastics pollution. To do so, Oregon should be evaluating all readily available information about microplastics pollution. There are increasingly comprehensive data sets that contain information on microplastics pollution, and Oregon must evaluate these data to assess its marine and fresh waters for impairment by microplastics.

II. Microplastics Threaten Water Quality and Ecosystem Health

Microplastics, generally defined here as plastic particles that are less than 5 millimeters ("mm"), are emerging as a major threat to marine wildlife and water quality. The sources of microplastics pollution include industrial and domestic cleaning products, medicines including consumer care products and cosmetics, and synthetic textiles (Browne et al. 2011; Browne 2015; Boucher & Friot 2017). They also originate from plastic products such as Styrofoam, plastic grocery bags, plastic bottles, or other packaging that breaks down when plastic products fragment or degrade by either photo-, thermal, or biological degradation (Morret-Ferguson et al. 2010; Browne 2015). Another common source of microplastics is plastic pellets, or nurdles, that are used to manufacture plastic products.

Microplastics are ubiquitous to coastal and marine environments, found at sites worldwide from the poles to the equator (Bergmann et al. 2015*a*). Microplastic pollution covers the ocean's surface, floor, is frozen in sea ice, and permeates shoreline sediments and the water column (Barnes et al. 2009; Browne et al. 2011; Ivar do Sul & Costa 2014). Microplastics are rapidly being dispersed globally and accumulating in remote locations far from population centers, including in Arctic (Cózar et al. 2017) and Antarctic (Isobe et al. 2016) waters. It was recently discovered that both Arctic Sea ice and deep-sea sediments from the Atlantic Ocean, Mediterranean Sea and Indian Ocean contain concentrations of microplastics several orders of magnitude greater than those previously reported in highly contaminated surface waters, such as those of the North Pacific Gyre

(Obbard et al. 2014; Woodall et al. 2014), indicating that deep-sea sediments and sea ice are major sinks for microplastics.

Unfortunately, the amount of plastic available to enter the world's oceans is on the rise, with a predicted increase by an order of magnitude by 2025 without dramatic source reduction efforts and improvements in waste management (Jambeck et al. 2015). Global trends indicate that accumulations are increasing in aquatic habitats (Thompson et al. 2004; Goldstein et al. 2013), consistent with trends in plastic production–increasing 560 fold in just over 60 years (Thompson et al. 2004). The rapidly growing body of research suggests that there is not one square mile of surface ocean anywhere on earth that is not polluted with microplastics (M. Eriksen, pers. comms.). Tragically, under a business-as-usual scenario, the ocean is expected to contain one ton of plastic for every three tons of fish by 2025, and more plastics than fish (by weight) by 2050 (Ellen Macarthur Foundation 2016).

Microplastics comprise the majority of plastic pollution in the world's oceans. For instance, a study by Moore et al. (2011) on plastic particles flowing from two rivers into coastal areas and beaches in southern California found that plastic particles less than five millimeters in size were 16 times more abundant and had a cumulative weight three times greater than larger particles. Global estimates indicate somewhere between 15 and 51 trillion plastic particles currently floating in the world's oceans (van Sebille et al. 2015), 92 percent of which are microplastics (Eriksen et al. 2014).

While secondary microplastics–those which originate from the degradation of large plastic waste into smaller fragments once exposed to the marine environment–make up a significant portion of microplastics in the ocean, a recent report by the International Union for Conservation of Nature demonstrates that primary microplastics are globally responsible for a major source of plastics in the oceans (Boucher & Friot 2017). The study estimates that primary sources of microplastics–microplastics that are directly released into the environment as small plastic particles–account for between 15 and 31% of all of the plastic in the oceans. The overwhelming majority of the losses of primary microplastics (98%) are generated from land based activities. One of the largest contributors of these particles stem from the laundering of synthetic textiles, which enter the marine environment through wastewater treatment systems (*Id*).

A growing number of studies demonstrate that microplastics harm a wide range of aquatic species. Ingestion of microplastics by wildlife was first brought to light in 1987, when surveys of Laysan Albatross and Wedge-tailed Shearwaters on Midway and O'ahu Island, Hawai'i identified 90% of 50 chicks surveyed had plastic fragments, toys, bottle caps, and other plastics in their upper gastrointestinal tract (Frye et al. 1987). 12 of 20 adult shearwaters surveyed ingested plastic fragments or pellets 1-3 mm thick and 2-7 mm long (*Id*). More recent studies suggest seabirds are particularly sensitive to plastic pollution due to high frequency of ingestion, impacts on body condition and transmission of toxic chemicals (Wilcox et al. 2015). More than 90% of seabird species are believed to have ingested plastic globally, and by 2050 the percentage is estimated to increase to

99%, resulting in increased mortality and decreased reproduction (Wilcox et al. 2015). Consistent with this prediction, Donnelly-Greenan et al. (2014) documented a dramatic increase in the amount of ingested plastic in Pacific northern fulmars (*Fulmarus glacialis rogersii*) washed up on beaches in Monterey Bay, California between 2003 and 2007. Sea turtles are also highly vulnerable to plastic pollution. A recent study found that over 50% of sea turtles worldwide are expected to have ingested plastic, which can lead to starvation due to false sense of satiation, intestinal blockage, and transfer of dangerous chemicals (Schuyler et al. 2012).

A quickly growing body of evidence points to bioaccumulation of plastics and adsorbed pollutants as an increasing ecological threat to marine organisms as well as humans (Engler et al. 2012). For example, Setälä et al. (2014) demonstrated the potential of microplastic particles to transfer via planktonic organisms from one trophic level (mesozooplankton) to a higher level (macrozooplankton), suggesting a clear pathway for the bioaccumulation of microplastics and associated pollutants within the marine food web. Higher trophic-level organisms such as fish-eating birds, omnivorous birds, and marine mammals are exposed to toxic compounds via their consumption of prey. Even baleen whales, among the largest animals on earth, are exposed to micro-litter ingestion as a result of their filter-feeding activity; a recent study documented the presence of phthalates traced to microplastic pollution in the tissue of stranded fin whales (Fossi et al. 2012). Generally, typical polychlorinated biphenyls ("PCB") levels increase by a factor of 10- to 100-fold when ascending major consumption levels in a food chain (Gobas et al. 1995). Specifically, Wasserman et al. (1979) reported that for marine food webs, concentrations of PCBs in zooplankton range from < 0.003 to 1 $\mu g\ g^{-1}$, whereas top consumers, such as seals and fish, had ranges of PCBs from 0.03 to 212 $\mu g\ g^{-1}$. Therefore, if PCBs and other contaminants are abundant in lower trophic levels, they will be amplified through the food chain to levels that can adversely affect higher trophic-level organisms. As a result, people who ingest fish may be exposed to dangerous levels of PCBs (EPA 2006). Due to the toxin's accumulation properties, many scientists believe there is no safe level of exposure to PCBs (*Id*).

Large pelagic fishes, including many consumed by humans, have been shown to ingest microplastics (Romeo et al. 2015). Choy & Drazen (2013) report that 19% of fishes sampled from 10 species captured by the Hawaiian longline fishery had ingested plastic particles. Similarly, Rochman et al. (2015) discovered that approximately a quarter of fish sold at markets in California and Indonesia for human consumption had ingested anthropogenic debris, primarily in the form of microplastics and microfibers from textiles. Considered in conjunction with the findings of Rochman et al. (2013*b*), which demonstrate the transfer of adsorbed pollutants from ingested plastics to the tissues of fishes, ingestion of plastic by fishes targeted for human consumption has potentially serious human health implications that have yet to be thoroughly investigated (Bergmann et al. 2015*a*).

Because of microplastics' size they are also available to invertebrates, including deposit feeders such as sea cucumbers (Graham & Thompson 2009), the lug worm, that feeds by stripping organic matter from particulates (Moore et al. 2011), gooseneck barnacles (Goldstein et al. 2013), oysters (Green 2016), clams (Davidson & Dudas 2016), and shore crabs (Watts et al. 2014). A recent study of sceletarian corals on Australia's great barrier reef indicates ingestion rates of microplastics similar to the rate of plankton ingestion (Hall et al. 2015). Ingested microplastics were found in the coral gut cavity, suggesting that ingestion of high concentrations of microplastic debris could potentially impair the health of corals (Hall et al. 2015).

A third of shellfish found in seafood markets in Indonesia and California contained anthropogenic debris, primarily in the form of microplastics (Rochman et al. 2015). Mussels ingest microscopic plastic of less than 1 mm, accumulate it in the gut and transfer it to the circulatory system (Brown et al. 2008). Microplastics persist in mussels for over 48 days despite transfer to clean water, suggesting similar fates for these particles in predators like birds, crabs, starfish, and even humans (Brown et al. 2008). European researches found microplastics present in two bivalve species cultured for human consumption, with an average load of 0.36 particles per gram of tissue (Van Cauwenberghe & Janssen 2014). They conclude that the annual dietary exposure of European consumers can be up to 11,000 microplastics (*Id*). Planktonic Pacific oyster (*Crassostrea gigas*) larvae readily ingest waterborne nanoplastic and microplastic polystyrene particles (Cole & Galloway 2015). Nano-sized polystyrene particles may permeate into the lipid membranes of organisms, altering the membrane structure, membrane protein activity, and therefore cellular function (Rossi et al. 2014). Acute exposure to microplastics results in significant biological effects including weight loss, reduced feeding activity, increased phagocytic activity and transference to the lysosomal (storage) system (Von Moos et al. 2012; Wagner et al. 2014; Browne et al. 2013; Lee et al. 2013; Rochman et al. 2013*b*).

Ecological impacts from plastic pollution on nearshore environments, such as sandy beaches, include ingestion by a variety of organisms (Graham and Thompson 2009), sediment contamination from leached plasticizers (Oehlmann et al. 2009), and adsorbed persistent organic pollutants (Rios et al. 2007). Carson et al. (2011) demonstrated how the presence of microplastics on Hawaiian beaches can alter the physical properties of beaches such as heat transfer and water movement, and noted that the observed effects may have broad ecological implications for a wide variety of beach dwelling organisms and their eggs, including crustaceans, mollusks, polychaetes, fish, interstitial meiofauna, and sea turtles. Emerging research suggests microplastic pollution is capable of driving shifts in ecological communities. A study by Green (2016) indicates that repeated exposure to high concentrations of microplastics could alter community assemblages in important marine habitats by reducing the abundance of benthic fauna.

The ability of plastics to adsorb hydrophobic pollutants from the marine environment is well documented (Rios et al. 2007; Teuten et al. 2009). Many plastics adsorb PCBs, organo-chlorine pesticides, polybrominated diphenyls (“PBD”), polycyclic aromatic hydrocarbons (“PAH”), metals, and petroleum hydrocarbons, some of which may desorb in acidic stomachs resulting in uptake by the animal (Teuten et al. 2009; Van et al. 2012; Rochman et al. 2013*b*). Indeed, it has been shown that seabirds that ingested plastic demonstrate higher PCB concentrations in their fat tissues (Ryan et al. 1988), and seabird chicks fed plastics showed increasing PCB concentrations (Teuten et al. 2009). Polybutylene terephthalates ("PBT"), found on recovered plastic debris globally (Hirai et al. 2011), bioaccumulate in foodwebs (Teuten et al. 2009) and are linked with adverse ecological effects including endocrine disruption, decreased fish populations and reduced species richness (McKinley & Johnston 2010; Rochman et al. 2013*a*). Plastic fragments can concentrate organic pollutants up to 10^6 times that of the surrounding seawater, with release rates in an endotherm gut 30 times higher than in seawater (Bakir et al. 2014). Plastic additives, such as Bisphenol A ("BPA"), phlalate plasticizers and alkylphenol can also leach from ingested plastics into the tissue of organisms inducing adverse effects including estrogenic mimicry and reduced testosterone levels (Teuten et al. 2009; Rochman et al. 2013*b*). Small and microscopic plastic fragments in particular present a likely route for the transfer of toxic chemicals to marine organisms because of their large surface area to volume ratio, allowing for an increased uptake of contaminants (Rios et al. 2007).

Finally, because plastics do not readily degrade and are long-lived they provide an effective invasive species dispersal mechanism (Barnes et al. 2009; Gregory 2009). Pelagic plastic items are commonly colonized by a diversity of encrusting and fouling epibionts, including barnacles, tube worms, foraminifera, coralline algae, and bivalve mollusks (Gregory 2009) as well as unique pathogen assemblages (Zettler et al. 2013). The environmental importance of this process is widely recognized, as pelagic plastic, (including nano- and microplastics) may be vectors in the dispersal of aggressive and invasive marine organisms that could endanger endemic biota (Barnes et al. 2009).

III. Summary of Data on Microplastic Pollution in Oregon*

Oregon's marine waters and beaches are significantly impacted by microplastic pollution and violate numerous water quality standards. The following is a brief summary of studies documenting the presence of microplastics in Oregon state waters:

1. Sea Turtles Forever 2012 - All four beaches sampled demonstrated elevated levels of microplastics, with an average of 228, 453, and 467 microplastic pellets/m^2 at Cape Blanco, China Beach, and Whiskey Beach respectively. The average number of plastic pellets collected on Crescent Beach increased dramatically from 95 pellets/m^2 in 2010, to 343 in 2011 and to 721 in 2012.

2. Sea Turtles Forever 2014 - 11,616 plastic pellets, and over 3180g of microplastic were collected on one square meter of beach at Fort Stevens State Park.

3. Jauregui 2017 - 494 plastic microfibers were found in 30 oysters reared for human consumption from six oyster vendors along the Oregon coast.

*See Appendix A for a summary of microplastics data, water bodies to be designated as impaired, and water quality standard violations. These data demonstrate water body impairments that are described below.

IV. Water Bodies to Be Listed as Impaired and Water Quality Violations

1. State marine waters off Crescent Beach

The marine waters off Crescent Beach warrant listing because sediment samples from Sea Turtles Forever (2012) indicate various water quality violations summarized in Appendix A. Sea Turtles Forever found that the level of microplastics on Crescent beach increased dramatically from 2010 to 2012. High volumes of microplastics on beaches indicate elevated concentrations of microplastics in adjacent waters (*e.g.* Wessel et al. 2016), suggesting waters off the Crescent Beach are laden with microplastics and are impaired.

These data, which demonstrate a dramatic increase in microplastic pollution and associated degradation of water quality, indicate waters off Crescent Beach listed above violate the state's Antidegradation water quality standards, which "prevent unnecessary further degradation from new or increased point and nonpoint sources of pollution, and to protect, maintain, and enhance existing surface water quality to ensure the full protection of all existing beneficial uses." (OAR, § 340-041-0004)

Data presented by Sea Turtles Forever (2012) reveal that Crescent Beach is inundated with significant amounts of visually offensive plastic trash. High concentrations of plastic pellets are certainly offensive to the sense of sight and inhibit aesthetic enjoyment when sunbathing, beachcombing, sightseeing, and studying tide-pool marine life. The recurrence an increase of microplastic on Crescent Beach, year after year, shows that the adjacent waters are polluted. Therefore, the marine waters off Crescent Beach violate the aesthetic quality beneficial use of the North Coast Basin and should be listed as impaired. (OAR, § 340-041-0230)

Elevated and increasing levels of microplastics on Crescent Beach pose a threat to marine wildlife including in shellfish, sea turtles, fish and seabirds.

Bour et al. (2018) recently demonstrated how environmentally relevant concentrations of microplastics (25 mg/kg of sediment) negatively impact two species of sediment dwelling bivalves. Several other studies have demonstrated how environmentally relevant concentrations of microplastics be deleterious to marine fauna. For example, Green (2016) demonstrated how microplastic concentrations of 80 $\mu g\ L^{-1}$ harmed a variety of marine benthic organisms including periwinkles, isopods, and clams in lower intertidal to shallow subtidal zones on temperate beaches, indicating that numerous species of marine life on Oregon beaches and in surrounding waters are likely to encounter detrimental concentrations of microplastics. Indeed, Jauregui (2017) documented nearly 500 microplastic fibers in 30 Pacific oysters (*Crassotrea gigas*) from various oyster farms along the Oregon coast, raising alarms about potential impacts of microplastic pollution on commercial shellfish operations and marine wildlife in Oregon waters, as well as on the health of Oregonians who consume locally sourced shellfish.

The tendency for microplastics to concentrate toxic POPs is well documented, and discussed at length above. Various studies have documented elevated levels of POPs on microplastics found on West Coast beaches (*e.g.* Rios et al. 2007; Ogata et al. 2009; Van et al. 2012). Microplastics prevalent on Oregon beaches exhibit significant levels of persistent organic pollutants, including PCBs (Marc Ward, Sea Turtles Forever, pers. comms.). Evidence suggests microplastics and associated adsorbed pollutants are capable of bioaccumulating and pose an increasing ecological threat to marine organisms, including commercially harvested fish and shellfish (Rochman et al. 2013*b*; Rochman et al. 2015), as well as humans (reviewed by: Chae & An 2017).

Rochman et al. (2013*b*) showed that fish exposed to microplastics with chemical pollutants sorbed from the marine environment bioaccumulate these chemical pollutants and suffer liver toxicity and pathology. Fish fed virgin microplastics also showed signs of stress (*Id*).

The harm to sea turtles from plastic pollution is discussed above. Considering three species of federally endangered sea turtle (Loggerhead turtle (*Caretta caretta*), Green turtle (*Chelonia mydas*), and Leatherback turtle (*Dermochelys coriacea*) (Oregon Dept. of Fish and Wildlife)) frequent waters off the Oregon coast, it is highly likely that endangered sea turtles encounter microplastic pollution off of the beaches considered here.

As discussed previously, Carson et al. (2011) demonstrates how the presence of microplastics on beaches may have broad ecological implications for a wide variety of beach dwelling organisms. Therefore, data presented by Sea Turtles Forever (2012) indicate shellfish and other benthic and sediment dwelling organisms on Crescent Beach encounter concentrations of microplastics that could potentially negatively influence their ecology. It is likely that fishes, sea turtles and seabirds also encounter potentially damaging levels of microplastics in marine waters off Crescent Beach. The water body in question therefore violates the High Quality Water Policy which protects beneficial uses and water quality necessary to support fish, shellfish and wildlife propagation (OAR, § 340-041-0004 (6)) and various beneficial uses of the North Coast Basin including fishing, fish and aquatic life, and wildlife (OAR, § 340-041-0230) and should be listed as impaired.

DEQ must also evaluate whether the data presented here demonstrate that marine waters off Crescent Beach violate the Toxic Substances Narrative which states "[t]oxic substances may not be introduced above natural background levels in waters of the state in amounts, concentrations, or combinations that may be harmful, may chemically change to harmful forms in the environment, or may accumulate in sediments or bioaccumulate in aquatic life or wildlife to levels that adversely affect public health, safety, or welfare or aquatic life, wildlife or other designated beneficial uses (OAR, § 340-041-0033 (1)), as well as the Human Health Numeric Criteria which protects "Oregonians from potential adverse health effects associated with long-term exposure to toxic substances associated with consumption of fish, shellfish and water." (OAR, § 340-041-0033 (3))

2. State marine waters off Cape Blanco, China Beach, Whiskey Beach and Fort Stevens State Park

The marine waters off Cape Blanco, China Beach, Whiskey Beach, and Fort Stevens State Park warrant listing because sediment samples from Sea Turtles Forever (2012; 2014) indicate various water quality violations summarized in Appendix A. Sea Turtles Forever discovered 228, 453, 467, and 11,616 microplastic pellets/m^2 at the four beaches, respectively (Table 1).

Year	**Beach**	**Plastic Pellets (#/m^2)**	**Plastic Pellets (g/m^2)**
2010	Crescent Beach	95.33	1.96
2011	Crescent Beach	343.50	7.35
2012	Crescent Beach	721.50	15.42
2011	Cape Blanco	228.00	4.62
2011	China Beach	453.50	10.14
2011	Whiskey Beach	467.00	8.15
2013	Fort Stevens State Park	11616	212

Table 1. Summary of microplastic collected at five Oregon beaches. For detailed reporting see Appendix B.

As noted above, high volumes of microplastics on beaches indicate elevated concentrations of microplastics in adjacent waters (*e.g.* Wessel et al. 2016), suggesting waters off the beaches listed above are impaired.

Microplastics particles have been shown to accumulate in gut tissue of mussels (*Mytilus edulis*), and subsequently translocate to the circulatory system, indicating microplastics and associated toxins may bioaccumulate in food chains (Browne et al. 2011). A third of shellfish found in seafood markets in California contained anthropogenic debris, primarily in the form of microplastics (Rochman et al. 2015). Jauregui (2017) has documented high levels of plastic microplastic fibers in Pacific oysters (*Crassotrea gigas*) reared for human consumption at oyster farms along the Oregon coast.

Taken together, these studies, in conjunction with data from Sea Turtles Forever (2012; 2014) demonstrate that shellfish on and off the beaches considered here could be negatively impacted by harmful concentrations of microplastics, and humans ingesting shellfish collected from the region are likely being exposed to microplastics and associated pollutants.

Choy and Drazen (2013) found that 19% of pelagic game fish sampled in the North Pacific had ingested plastic. Rochman et al. (2013*b*) demonstrated how chemical pollutants sorbed from the marine environment, as well as hazardous chemicals from the material itself are able to transfer from microplastic particles to the tissue of fishes and bioaccumulate, inducing liver toxicology and pathology.

Additionally, the work of Green (2016) illustrates how environmentally relevant concentrations of microplastic are capable of harming a variety of marine organisms, indicating that repeated exposure to high concentrations of microplastics could alter assemblages in marine habitat by reducing abundance of benthic fauna. Therefore, ocean surface waters off the Oregon beaches listed above violate beneficial uses protecting and water quality necessary to support fish, shellfish and wildlife propagation (OAR, § 340-041-0004 (6)) and various beneficial uses of the South Coast Basin including fishing, fish and aquatic life, and wildlife (OAR, § 340-041-0300) and should be listed as impaired.

DEQ must also evaluate whether the data presented here violate the Toxic Substances Narrative (OAR, § 340-041-0033 (1)), as well as the Human Health Numeric Criteria. (OAR, § 340-041-0033 (3))

Lastly, DEQ must consider whether the elevated concentrations of microplastics found in ocean waters off the beaches considered here violate the State's Antidegradation water quality standards, which "prevent unnecessary further degradation from new or increased point and nonpoint sources of pollution, and to protect, maintain, and enhance existing surface water quality to ensure the full protection of all existing beneficial uses." (OAR, § 340-041-0004) Beneficial uses adversely impacted by microplastic pollution, as argued above, include fish, shellfish and wildlife propagation fishing, fish and aquatic life, and wildlife.

4. <u>Other water bodies should be considered</u>

Data from studies that are conducted within Oregon State waters and along shorelines or adjacent areas must be considered. A selection of data compiled by Kapp et. al (2018) demonstrate significant levels of microplastic pollution in the Columbia river. This river should be evaluated for violation of state water quality standards including relevant beneficial uses, the High Quality Water Policy, and Antidegradation.

Further, DEQ should evaluate data currently being collected by Dr. Elise Granek at Portland State University on levels of microplastics in Pacific razor clams (*Siliqua patula*) to determine whether marine waters off Oregon beaches violate various water quality standards.

VI. CONCLUSION

We urge DEQ to designate as impaired the specific water bodies identified in this letter. The Department must consider all readily available data on the impacts of microplastics on the State of Oregon’s waters for its water quality assessment and consider the attainment status of all of Oregon's relevant water quality standards. Additionally, due to the unique properties of microplastics, DEQ should adopt a water quality criterion particular to microplastics. A criterion of “less than one item of microplastic ($\leq$5mm) m^{-2} for sediments or m^{-3} in the water column and no more than one synthetic fiber 50 mL^{-1} sediment for subtidal sediments” is appropriately based upon the measurement standards noted by Hidalgo-Ruz et al. (2012). Finally, we urge the state to improve its own monitoring program so that it can effectively detect microplastics-related water quality problems.

Sincerely,

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Appendix A. Summary of Water Quality Violations for Water Bodies of the State of Oregon

Waterbody/ Beach	Measurement	Reference	Methodology	Violation of Applicable Water Quality Standard
Marine waters off: Crescent Beach	2010:95 pellets/m^2 2011:343 pellets/m^2 2012:721 pellets/m^2	Sea Turtles Forever 2012	Beach transect	OAR, § 340-041-0004 OAR, § 340-041-0004 (6) OAR, § 340-041-0230
Marine waters off: Cape Blanco China Beach Whiskey Beach Fort Stevens State Park	228 pellets/m^2 453 pellets/m^2 467 pellets/m^2 11,616 pellets/m^2	Sea Turtles Forever 2012, 2014	Beach transect	OAR, § 340-041-0004 OAR, § 340-041-0004 (6) OAR, § 340-041-0300

Appendix B. Microplastics Data and Methodology for Water Bodies of the State of Oregon (Hyperlinked)

Relevant Studies:
- Sea Turtles Forever 2012
- Sea Turtles Forever 2014
- Jauregui 2017

Data:
- Sea Turtles Forever 2012
- Sea Turtles Forever 2014
- Jauregui 2017

Methodology:
- Sea Turtles Forever 2012 (please see pg. 3 manuscript for detailed methodology)
- Sea Turtles Forever 2014 (please see pg. 2 of manuscript)
- Jauregui 2017 (please see pg. 10 of manuscript)

References (Hyperlinked)

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