Marine Pollution Bulletin xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Foraging preferences influence microplastic ingestion by six marine fish species from the Texas Gulf Coast

Colleen A. Peters*, Peyton A. Thomas, Kaitlyn B. Rieper, Susan P. Bratton

Department of Environmental Science, Baylor University, Waco, TX 76798-7266, United States

A R T I C L E I N F O

Keywords:
Microplastic ingestion
Water pollution
Texas Gulf Coast
Marine fish
Foraging preferences
Fiber

A B S T R A C T

This study evaluated the influence of foraging preferences on microplastic ingestion by six marine fish species from the Texas Gulf Coast. A total of 1381 fish were analyzed and 42.4% contained ingested microplastic, inclusive of fiber (86.4%), microbead (12.9% %), and fragment (< 1.0%) forms. Despite a substantial overlap in diet, ordination of ingested prey items clustered samples into distinctive species groupings, reflective of the foraging gradient among species. *Orthopristis chrysoptera* displayed the lowest overall frequency of microplastic ingestion and the most distinctive ordination grouping, indicating their selective invertebrate foraging preferences. Cluster analysis of *O. chrysoptera* most closely classified microplastic with the ingestion of benthic invertebrates, whereas the ingestion of microplastic by all other species most closely classified with the ingestion of vegetation and shrimp. *O. chrysoptera*, as selective invertebrate foragers, are less likely to ingest microplastics than species exhibiting generalist foraging preferences and methods of prey capture.

1. Introduction

Plastics are synthetic materials constructed of organic polymers and composed of a variety of elements, such as carbon, oxygen, nitrogen, and sulfur (American Chemistry Council, 2005). The composition and structure of plastic causes it to be lightweight, durable, and cheap, properties that promote its utilization by all sectors of industry. Since its commercial development in the 1930′s and 1940′s, plastic has become dominant throughout the consumer marketplace, and as its use has continued to increase, so has its presence and impact on the environment (Jambeck et al., 2015).

The improper disposal of plastic traces back to the early 1900′s, however, the incidence of plastic pollution does not appear within the scientific literature until the 1960′s (Kenyon and Kridler, 1969). Currently, worldwide plastic production exceeds 299 million tons per year, an estimated 22–43% of which ends up in landfills (Gourmelon, 2015). The United States produces approximately 32.5 million tons of plastic annually and discards approximately 29.6 million tons (U.S. EPA, 2015). While the proportion of plastic waste that ultimately ends up in aquatic systems is unknown, estimates predict that 10% of all plastic waste enters the sea each year, 80% of which is attributed to terrestrial based sources (Thompson, 2006; Jambeck et al., 2015).

Once released into aquatic systems, plastic undergoes mechanical, chemical, and photolytic degradation processes, resulting in the formation of secondary microplastics (Wagner et al., 2014; Mathalon and Hill, 2014). Microplastics may also be released directly into the environment (i.e. primary microplastics), and include materials such as plastic abrasives utilized for boat cleaners. While the proportion of literature examining microplastic pollution has increased, the variation in the physiochemical properties of different types of plastic has limited the available knowledge pertaining to the relative availability, transport, and settling of microplastics throughout aquatic systems (Eerkes-Medrano et al., 2015). Despite this, microplastic pollution has been reported in coastal waterndowed Fund for Excellence in (Ng and Obbard, 2006), surface waters (Eriksen et al., 2013), rivers (Moore et al., 2011), estuaries (Sadri and Thompson, 2014), and suspended throughout the water column (Lattin et al., 2004).

In addition to microplastic pollution, studies have also examined the interaction between wildlife and microplastic, resulting in microplastic ingestion. Current studies investigating fish ingestion of microplastic report frequencies of ingestion ranging from 2.6% to 68%, however, these reports vary widely per the species and locations examined and the methodologies utilized for analysis (Lusher et al., 2013; Romeo et al., 2015; Nadal et al., 2016; Possatto et al., 2011; Sanchez et al., 2014; Vendel et al., 2017). Major variations in methodologies include: the organ of examination (i.e. stomach or gastrointestinal tract), the size of filter utilized for the lower bound of -micro categorization, and the inclusion of microplastic fibers reported within the results. Furthermore, there is a lack of research regarding microplastic ingestion by fish species from North America, and very few studies have examined

* Corresponding author at: Department of Environmental Science, Baylor University, One Bear Place #97266, Waco, TX 76798-7266, United States.
E-mail address: Colleen_Peters@baylor.edu (C.A. Peters).

http://dx.doi.org/10.1016/j.marpolbul.2017.06.080
Received 20 May 2017; Received in revised form 28 June 2017; Accepted 29 June 2017
0025-326X/

Please cite this article as: Peters, C.A., Marine Pollution Bulletin (2017), http://dx.doi.org/10.1016/j.marpolbul.2017.06.080

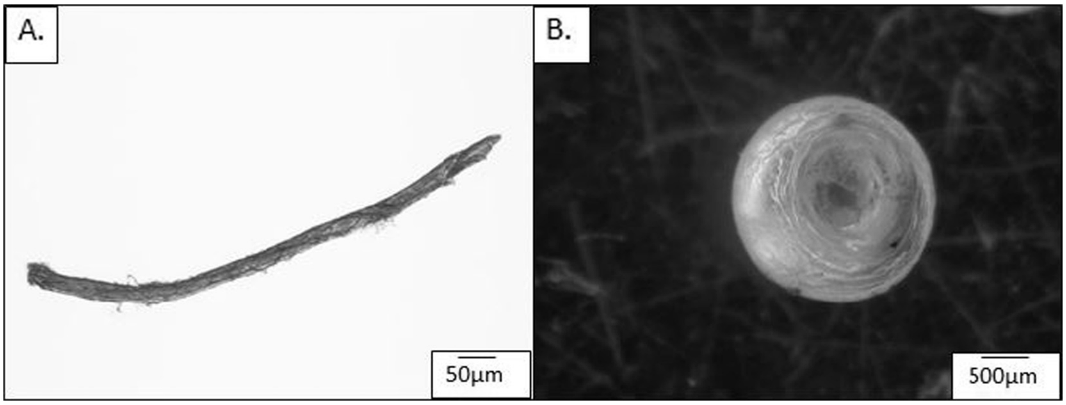

Fig. 1. Photographs of microplastic fibers (A) and spheres (B) collected from the stomach content of marine fish.

microplastic ingestion by fish from the Gulf of Mexico. Available research includes a study by Peters and Bratton (2016) which reports microplastic ingestion by 45% of freshwater sunfish within the Brazos River basin (a drainage basin into the Gulf of Mexico), and a study by Phillips and Bonner (2015) which reports microplastic ingestion by 8% of freshwater fish from Gulf of Mexico drainage systems and 10% of marine fish from Laguna Madre, a bay system of the Gulf of Mexico.

This study was conducted in response to the limitation of research examining microplastic ingestion by fish from North America and defines microplastics as plastics, artificial polymers (e.g. polyester or nylon), and manufactured products (i.e. manufactured natural and non-natural material), that range in size from 50 to 5000 μm (Masura et al., 2015; Peters and Bratton, 2016). The aims of this study were to examine the occurrence and frequency of microplastic ingestion by six marine fish species from the Texas Gulf Coast, and to evaluate whether ecological factors (i.e. foraging preferences and methods of prey capture) influence microplastic ingestion by species of a shared ecological guild.

2. Methods

2.1. The study region and species

The present study was conducted along the Texas (TX) Gulf Coast, spanning from the Galveston Bay (29.4720° N, 94.7692° W) to Freeport (28.9541° N, 95.3597° W), TX. Local land use includes a variety of natural systems (e.g. barrier island interior wetlands and tidal fringe wetlands), protected state and city parks, and industrialized and urban areas. Water bodies include estuarine and marine environments, which support a variety of commercial and sport fish species. Six fish species were examined for the purposes of this study: Southern kingfish (*Menticirrhus americanus*), Atlantic croaker (*Micropogonias undulates*), Atlantic spadefish (*Chaetodipterus faber*), Sand trout (*Cynoscion arenarius*), pinfish (*Lagodon rhomboids*), and grunt (*Orthopristis chrysoptera*). These species occupy a benthivore ecological guild, whereas they are mainly demersal foragers, and a large proportion of their diet is inclusive of benthic invertebrates. Variations among species, per foraging preferences and methods of prey capture, include Southern kingfish and Sand trout, which include piscivory within their diet; Atlantic croaker and pinfish which include vegetation within their diet and utilize suction feeding to capture prey; Atlantic spadefish which forage for both benthic and water column invertebrates around manmade structure, and grunt which are selective benthic invertebrate foragers. These fish species were selected for investigation due to their abundance throughout the study area, accessibility for collection, shared ecological guild, and varying foraging preferences and methods of prey capture.

2.2. Sample collection and laboratory analysis

Between September 2014 and September 2015, 1381 fish, inclusive of six species, were collected from seven sample locations. Sample locations were organized from the gulf side of barrier islands, to inlets and passes, and bays behind offshore barrier islands. The collection locations included: 1) the Galveston Beach Front on the Gulf of Mexico; 2) the Surfside Jetty facing the Gulf of Mexico; 3) San Luis Pass, connecting the Gulf of Mexico to west Galveston and Christmas Bays; 4) Pelican Island, facing the Galveston/Houston ship channel connecting the Gulf of Mexico to Galveston and Trinity Bays; 5) the Brazos River estuary, a channelized section of the Brazos river located within Freeport, TX; 6) North Galveston Bay near LaPorte, TX; and 7) Bastrop Bayou, a river fed area surrounded by extensive tidal wetlands, on the landward side of Bastrop Bay. The sample sites located within Galveston, Freeport, and upper Galveston Bay are the most heavily urbanized, while Bastrop Bayou is the most isolated, located just outside of Brazoria National Wildlife Refuge. Specimens were collected via hook and line, from a pier, dock, or shoreline, and were immediately euthanized via pithing and cutting through the spinal column. Animal use followed the American Veterinary Medical Association guidelines on euthanasia and was approved by the Baylor University Institutional Animal Care and Use Committee. Following euthanasia, fish were placed into sealed freezer bags, labeled with the location, date, and time, and transferred to the laboratory for storage in a -4° C freezer.

All laboratory analysis, including dissection and stomach content separation (minimum bound of filter mesh size: 53 μm), replicated the protocol of Peters and Bratton (2016). Following dissection and stomach content separation, all resultant material was categorized as natural or anthropogenic. Natural items were classified into one of eleven general taxonomic and functional prey groups: vegetation, wood, fish, sand, shrimp, crab, mollusk, squid, annelid, midge, and egg. Items determined to be anthropogenic were further characterized, via morphology, into size (i.e. macro and micro), form, and color categories. Microplastic form was comprised of fibers (Fig. 1A), particles slender or elongated in appearance; spheres (microbeads) (Fig. 1B), particles round or ball-like in shape; and fragments, particles angular in appearance (Hidalgo-Ruz et al., 2012). Microplastic color was classified utilizing the Munsell Color System, a universally standardized system categorizing color per hue, value, and chroma. Hue is the dimension which distinguishes between color families, value is the dimension measures the lightness or darkness of color, and chroma is the dimension which measures the intensity of color. Microplastic fibers were classified via hue, value and chroma due to the overall evenness of color throughout the entirety of the particle, while microbeads and fragments were only classified via hue, as color often varied throughout the particle.