Special Study Proposal: Microplastic in San Francisco Bay Sport Fish

Summary: In the fall of 2019, SFEI will complete a three-year project to characterize microplastic in San Francisco Bay, funded by the Gordon and Betty Moore Foundation and others. The project provides information to address many of the management questions articulated in the RMP Microplastic Strategy. A key element not included in the Moore project was the characterization of microplastic in sport fish. Sport fish are an important food source to humans and Bay wildlife and are integrators of contaminants present in Bay water, sediment, and prey fish. In summer 2019, as part of RMP Status and Trends monitoring, sport fish will be collected and analyzed for a suite of contaminants. In 2018, the Steering Committee approved funding to collect and archive sport fish for microplastic analysis. This proposal is to fund the analysis of the archived samples for microplastic.

Estimated Cost: $78,400

Oversight Group: Microplastic Workgroup

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Time sensitive: No. The samples will be archived in the freezer; however, the sportfish complement the existing work with the Moore project and may provide valuable insight into foodweb uptake. Waiting too long to analyze these samples run the risk of not being to build off the momentum of the Moore project and may jeopardize being able to have the samples analyzed in a timely manner because of capacity issues with the laboratory.

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	***Due Date***
Task 1. Field collection (funded through 2019 project)	Summer 2019
Task 2. Laboratory analysis	Spring/Summer 2020
Task 3. Review of data	Fall 2020
Task 4. Manuscript	Spring 2021

Background

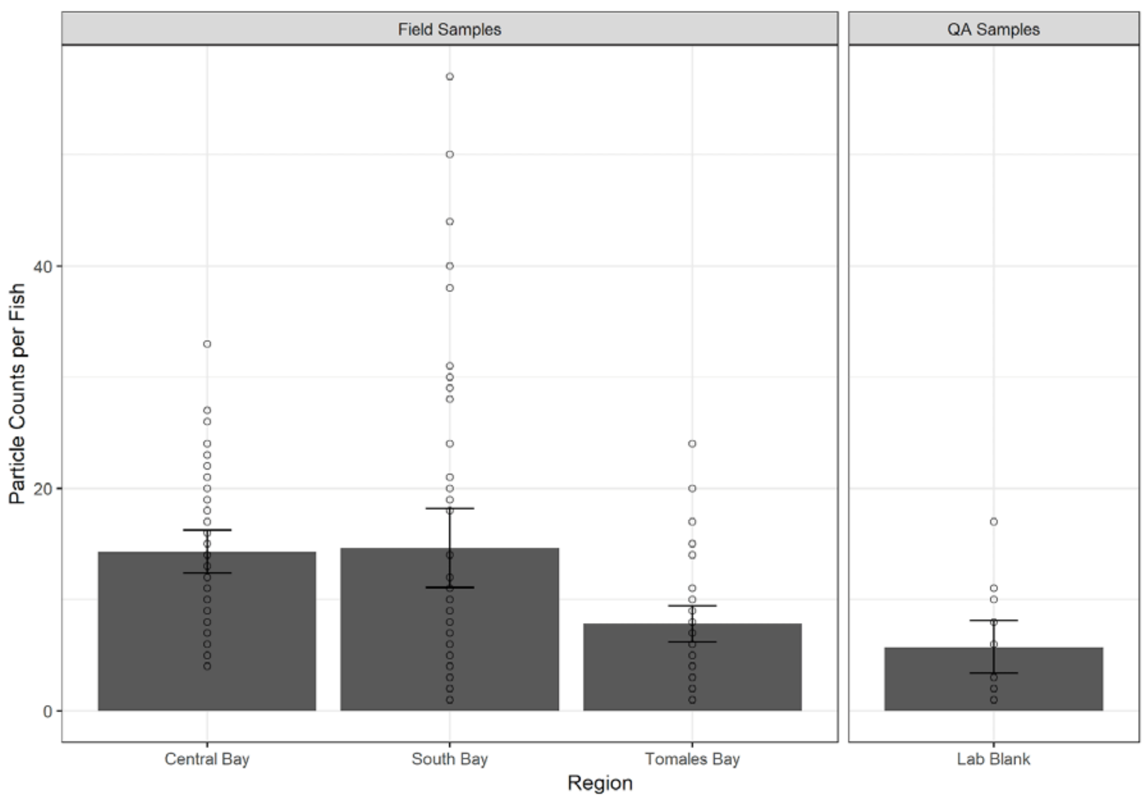
Plastic is ubiquitous in modern life. Global plastic production was estimated to be 299 million tons in 2013 (Gourmelon 2015); nearly a third of plastic production is used for plastic packaging, including single-use items (Andrady and Neal 2009) that are discarded after use. For the last two decades, society has focused on macroplastic in the ocean, such as the Pacific Ocean Garbage Patch, but recently attention has turned to the plastic particles < 5 mm in diameter, referred to as microplastic.

Based on a small screening study that identified microparticles in Bay surface water and effluent, the RMP developed a RMP Microplastic Strategy (Sutton and Sedlak 2017). Many elements of the first two years of the Strategy are currently being addressed through the San

Francisco Bay Microplastics project (primarily funded by the Gordon and Betty Moore Foundation), including surface water, sediment, prey fish and pathways to the Bay. A high priority for the Strategy is to assess the extent to which microplastic is taken up into biota.

The San Francisco Bay Microplastics project is evaluating the presence of microplastic in two important prey fish species, northern anchovy and topsmelt. Microparticles—including microplastic—have been identified in both species at all six of the Bay Area sites sampled (ten fish of each species were analyzed at each site). Microparticles were ubiquitous, and detected in all but two fish samples out of 150. Average concentration of microparticles from topsmelt and anchovies from San Francisco Bay was 14.5 particles/fish, and ranged up to 57 microplarticles/fish. Fibers represented 85% of microparticles in sampled fish from San Francisco Bay. Not all microparticles are plastic; chemical analyses conducted on these samples found that many are anthropogenic fibers for which a polymer identification could not be made due to spectral interferences from the dye. Plastic type identified included polyester, acrylic and polypropylene. San Francisco Bay fish were found to be statistically significantly different from the reference fish collected from two sites in Tomales Bay and the laboratory blanks (Figure 1).

Figure 1 Preliminary results of microparticle analyses in prey fish (Points represent individual particle counts per fish; bars represent average number of particles for all fish from the same region and error bars represent two times the standard error.)



The Moore microplastic project did not evaluate larger sport fish that are consumed by humans and wildlife. Microplastic has been detected in sport fish (Rochman et al. 2015;

Collard et al. 2017; Neves et al. 2015; Compa et al. 2018); however, to date, no study has measured microplastic in Bay sport fish. This is important because microplastic can be an important vector for transferring chemicals, such as flame retardants and plasticizers present in the plastic to the fish (Rochman et al. 2013). There are also likely human health risks associated with ingestion of plastic and contaminant exposures from fish consumption.

The presence of microplastic in fish may have adverse effects. Recent research suggests that the presence of microplastic particles (< 300 microns) may result in reduced growth and body condition of fish (Critchell and Hoogenboom 2018). Rochman et al. (2013) identified an increase in liver toxicity in fish associated with the presence of microplastic.

Microplastic accumulates in the digestive organs of fish; however, recent research on fish suggests that microplastic particles may translocate from the gut to other organ systems (Collard et al. 2017). This finding is important because it suggests the potential for human exposure to microplastic as well as the contaminants that may be present in the microplastic. In a laboratory feeding study of fish, Rochman and colleagues demonstrated the bioaccumulation of PBDEs in fish from a dietary intake of microplastic coated with contaminants (Rochman et al. 2013).

It is important to assess uptake of microplastic into sport fish for four reasons. First, assuming microplastic is detected and the RMP continues to monitor sport fish for microplastic over time, this study may provide a baseline for an important trend indicator. This may allow us to see the efficacy of management actions such as microbead, plastic bag, and polystyrene foam bans. Second, because this project is targeting sport fish that have multiple foraging behaviors, this project will help us understand whether microplastic accumulation is limited to fish that maintain a high site fidelity in the margins of the Bay and consume benthic invertebrates, or whether it is also present in piscivorous Bay fish that forage more widely. Third, this project will complement the existing work being conducted on the Moore project in the Bay margins assessing microplastic in prey fish and sediment. A comparison among sediment, prey fish, and sport fish may provide insight on the potential for food web transfer of microplastic and contaminants that may be adsorbed to the surface of microplastic or present in the microplastic as an additive (e.g., plasticizers or flame retardants). Lastly, evaluating the concentration of microplastic in Bay sport fish will help us understand the potential health risk to humans and other animals that consume sport fish.

The urgency of monitoring sport fish has increased with the ubiquitous detection of microplastic in Bay prey fish and the observation that microplastics can translocate from the gut to liver tissue of fish (Collard et al. 2017). It is important to understand the uptake of microplastic in higher trophic level fish both for implications for human health, as well as the health of larger predators such as cormorants and harbor seals.

Study Objectives and Applicable RMP Management Questions

The purpose of this study is to monitor sport fish gut contents for the abundance of microplastic and explore whether concentrations and patterns vary by habitat and fish species. We will also collect data to evaluate the correlation between microplastic in sediment and microplastic in prey fish and sport fish.

Table 1. Study objectives and questions relevant to RMP Microplastic Strategy management questions (Sutton and Sedlak 2017).

Management Question	Study Objective	Example Information Application
1) How much microplastic pollution is there in the Bay?	Assess concentration in an important upper trophic organism.	Assess the potential for uptake of microplastic into the food web. Use this information to update the conceptual model for microplastic in the Bay.
2) What are the health risks?	Compare concentrations in Bay sport fish to published toxicity studies.	Assess magnitude of potential impact on fish and higher trophic level organisms.
3) What are the sources, pathways, loadings, & processes leading to microplastic pollution in the Bay?	Compare different species that forage in the margins vs open bay.	Assess variation among species and sites to gain insight into the importance of local sources.
4) Have the concentrations of microplastic in the Bay increased or decreased?	Establish a baseline for future trend analyses.	Assess change in microplastic concentration in fish in future years based on the baseline established with this study.
5) Which management actions may be effective in reducing microplastic pollution?	Characterize chemical composition and particle type of microplastic present in sport fish.	Understanding the type and composition of microplastic accumulating in biota will be important for prioritizing appropriate management actions.

Approach

The 2019 RMP Status and Trends sport fish collections present an opportunity to measure microplastic particles in sport fish. The RMP monitors sport fish every five years at five popular fishing locations in the Bay. We propose to collect two species of sport fish at three sites in the Bay. One species will be shiner surfperch (*Cymatogaster aggregata*), an abundant and popular sport fish that feeds on invertebrates in the benthic zone and exhibits high site fidelity, useful for assessing regional differences in contaminants. The other species will be striped bass (*Morone saxatilis*), another popular sport fish species that is higher in the food chain than shiners and provides an integrated signal for the Bay as a whole as a result of its wide foraging behavior and opportunistic consumption of lower trophic level fish. As part of the RMP Status and Trends Program, striped bass samples will be collected at two sites in the Bay, targeting popular fishing sites in the Lower South Bay (near Artesian Slough) and Central Bay. Shiner surfperch will be collected at two popular fish locations in the Bay (Central Bay and San Leandro Bay).

It is not possible to collect both fish species at every site. For this study, we will collect approximately 10 fish of each species at the Central Bay site; and then ten of one species at the remaining two sites. Fish gut samples will be analyzed for microplastic. The samples will be shipped to University of Toronto for micoplastic analyses. After receipt in the laboratory, the fish are thawed, weighed and measured. They are then dissected to remove gut and gut contents for digestion, consistent with previously published protocols (Dehaut et al. 2016; Foekema et al. 2013; Corcoran 2015). The guts are individually weighed and the contents are placed in a jar filled with a 20% KOH solution. The amount of KOH added is typically three times the volume of biological tissue. The material is left at room temperature for up to 14 days to facilitate the digestion. The jars are not stirred to avoid damage to plastic from hard materials such as rocks and shells. After digestion, the samples are filtered through a 10-micron polycarbonate filter. Samples are then analyzed under a microscope and particles are picked out of the samples. Raman and/or FTIR spectroscopy is used to identify the chemical composition of each of the particles and particle sizes.

This project will benefit from additional chemical analyses of similar sport fish from the same locations. In addition, this project will leverage the findings from the Moore Microplastic project by comparing microplastic analyses in sediment and prey fish such as anchovy and topsmelt to sport fish to assess food web uptake as well as spatial distribution of microplastic. The data will be subjected to rigorous quality assurance-quality control review before being uploaded to CEDEN and CD3.

The final deliverable will be a manuscript prepared by University of Toronto with assistance from SFEI. A draft of the manuscript will be provided for Workgroup and TRC review.

Budget

The following budget represents estimated costs for this proposed special study (Table 2).

Table 2. Proposed Budget.

Expense	Estimated Hours	Estimated Budget
Labor		
Data review & report writing	76	$11,000
Senior review /input	3	$400
Data Management	86	$11,000
Subcontract		$56,000
University of Toronto Microplastic Analyses		
Total		**$78,400**

Budget Justification

Data Management and QA Costs
The data will be reviewed by RMP staff and uploaded into CD3 using existing CEDEN formats. Based on our experience with the Moore data sets, it is fairly labor-intensive to review the microplastic data.

Reporting Costs
The contracting laboratory will prepare a manuscript summarizing the findings of this work. RMP staff will assist in writing the manuscript.

Laboratory Costs
SFEI is currently working with the University of Toronto on the Moore project. The Rochman Laboratory uses state of the art instrumentation to conduct microplastic analyses and is recognized as a pioneer in the field of microplastic research. The cost to analyze each sample is $1,000 due to the labor intensive nature of the extraction process, identification, enumeration, and analysis associated with spectroscopy. We will include laboratory blanks in our analyses (approximately 10 percent of the samples collected). The collection of ten fish of each species at each site will provide information on the variation observed in field samples.

Reporting

The results of this project will be summarized in a manuscript prepared by the University of Toronto with assistance from SFEI. A draft of the manuscript will be provided for Workgroup and TRC review.

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