Special Study Proposal: Microplastic in San Francisco Bay Sport Fish

Summary: With external funding from the Moore Foundation and the RMP, SFEI has just completed the first year of a two-year study to characterize microplastic in San Francisco Bay. The project will provide information to address many of the management questions articulated in the RMP Microplastic Strategy. A key element that was 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 2019, as part of RMP Status and Trends monitoring, sport fish will be collected, and analyzed for a suite of contaminants. This project proposes to augment the existing RMP efforts by including microplastic analyses.

Estimated Cost: $110,300

Oversight Group: Microplastic Workgroup

Proposed by: Chelsea Rochman (University of Toronto), Meg Sedlak, and Rebecca Sutton (SFEI)

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	***Due Date***
Task 1. Field collection	Summer 2019
Task 2. Laboratory analysis	Fall/ Winter 2019
Task 3. Review of data (available for microplastic workgroup meeting)	Spring 2020
Task 4. Manuscript and RMP Sport fish Report	Summer 2020

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 smaller plastic particles, < 5 mm in diameter, referred to as microplastic.

The RMP conducted a microplastic screening study in 2015 that identified particles < 5 mm in San Francisco Bay water and wastewater effluent (Sutton et al. 2016). At the time, spectroscopic identification of plastic polymer type was not conducted for each particle. Based on this small screening study, the RMP convened a Microplastic Workgroup in June 2016 and developed a RMP Microplastic Strategy (Sutton and Sedlak 2017). A high priority for the Strategy is to develop robust methods for monitoring microplastic and to assess the extent to which microplastic is taken up into biota. As part of the Moore project, we will quantify the abundance of microplastic in prey fish; however, the scope does not include

larger sport fish that are consumed by humans and wildlife. This information is important for assessing impacts to fish and uptake of microplastic into the food web.

This project will focus on two species – one that has high site fidelity (shiner surfperch) and a second that ranges and forages more broadly (striped bass). The two species also differ in their trophic position: striped bass are higher trophic level piscivores, while shiner surfperch primarily consume benthic invertebrates. The data will facilitate comparisons among foraging behaviors as well as site location. The Moore study will assess microplastic concentrations in prey fish, anchovy and topsmelt, at six locations in the Bay and two locations in Tomales Bay, a reference site. In addition to fish data, the Moore project will measure concentrations of microplastic in sediment for all of the prey fish locations as well as margin and Bay sites. This information may be used to explore the relationship between microplastic concentrations in sediment and in fish.

Microplastic has been detected in fish (Rochman et al. 2015); 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) and because of the human health risks associated with contaminant exposures from fish consumption. Microplastic accumulates in the digestive organs of fish; however, recent research on mussels and crabs suggests that microplastic particles may translocate from the gut to other organ systems (Browne et al. 2008; Brennecke et al. 2015). In a laboratory feeding study of fish, Rochman and colleagues demonstrated the bioaccumulation of PBDEs from a dietary intake of microplastic coated with contaminants (Rochman et al. 2013).

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 associated with the presence of microplastic in fish.

It is important to assess uptake of microplastic into sport fish for four reasons. 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 plastic bag and polystyrene foam bans. Second, because this project is targeting sport fish with varying foraging behaviors, this project will help us to 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 Bay fish that forage more widely and are piscivores. 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 bioaccumulation 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 to understand the potential health risk to humans and other animals which consume sport fish.

The RMP Status and Trends sport fish monitoring program will analyze fish throughout the Bay for chemical contaminants such as PCBs PAHs, and PBDEs. This affords an

opportunity to assess to microplastic in fish along with concentrations of contaminants in fish, although not in the same fish. Depending on the timing of this project, it is possible that University of Toronto may have an opportunity to conduct additional *pro bono* analyses of some of the fish tissue for plastic-associated chemicals and microplastic particles.

Study Objectives and Applicable RMP Management Questions

The purpose of this study is to monitor sport fish for the abundance of microplastic and explore whether concentrations and patterns vary by habitat and fish species. The project will also collect data that can be used 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 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 literature studies.	Assess magnitude of potential impact on fish.
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	
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 element presents 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 two 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 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, fish will be collected at two sites in the Bay, targeting popular fishing sites in the South and Central Bay (e.g., San Leandro Bay and Lower South Bay near Artesian Slough). For this study, we will collect approximately 10 fish of each species at two sites. Historically striped bass have not been observed in San Leandro Bay. If they are not found in San Leandro Bay, we will substitute another Central Bay site.

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, shells, etc. After digestion, the sample 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 augment the existing sport fish work by collecting additional samples for microplastic analyses and benefit from the chemical analysis of similar sport fish from the same locations. In addition, this project will leverage the findings from the Moore 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 and presented to the Microplastic Workgroup in the Spring before being uploaded into CEDEN.

The final deliverable will be a manuscript prepared by University of Toronto with assistance from SFEI. In addition, SFEI will incorporate the results into the RMP Sportfish Technical Report.

Budget

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

Table 2. Proposed Budget.

Personnel	**Budget**
Sample Collection	$4,000
Data Management and QA	$20,000
Reporting	$20,400
Laboratory Analyses and manuscript	$62,000
Direct cost (shipping, field supplies)	$3,900
Total	$110,300

Add-on: Tissue Analyses

Analysis of sportfish tissues can be conducted on fish that have high particle counts in their digestive tracts. The cost to conduct this is $1,000 per fish. We propose that up to half of the fish that are collected at the two sites (26 fish) have the tissue analyzed for microplastic (assuming that there are high particle counts in the gut). The cost for this additional analyses is $26,000.

Add-on: Additional Sites

The workgroup recommended that an additional site from the North Bay be included in the study (e.g. San Pablo Bay). One additional site consisting of 26 fish (total: 13 of each species) will cost $26,000 for the digestive tract analyses. A lower cost option would be to collect the fish and archive the sample for future analyses when funds are available (an additional $10K for storage and shipping).

Phased Approach

To reduce the financial impact in 2019, the project can be phased over two years with the first year consisting of sample collection and laboratory analyses ($70.3K in 2019) and data review and report in the second year ($40K). If additional sites are requested for future analysis, archiving will be necessary, the second year will be $10K more (i.e. 50K).

Budget Justification

Sample Collection Costs
Field costs are reduced by leveraging the RMP's sport fish sampling efforts. We will also leverage the prior work conducted on the Moore project analyzing prey fish and sediments for microplastic. The budget includes staff hours to coordinate with the laboratory, to assist in the writing of the SAP, and to coordinate with field crew (approximately 30 hours of staff time total).

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 (approximately 95 hours of staff time).

Reporting Costs
The contracting laboratory will prepare a manuscript summarizing the findings of this work. RMP staff will assist in writing of the manuscript, and will incorporate the results in the RMP Sport fish report (approximately 130 hours of staff time).

Laboratory Costs
SFEI is currently working with 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 the 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.

Direct Costs
The budget will cover the cost to purchase sample containers and to ship the samples overnight (frozen) from SFEI to the University of Toronto. The overnight courier costs are more expensive because the samples are being shipped to Canada and need to clear customs in an expedited manner.

Reporting

The results of this project will be summarized in a manuscript prepared by University of Toronto with assistance from SFEI. In addition, the results will be presented in the RMP Sport Fish report.

References

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