REGIONAL MONITORING PROGRAM FOR WATER QUALITY IN SAN FRANCISCO BAY
sfei.org/rmp

RMP Microplastic Workgroup Meeting

May 22, 2019
San Francisco Estuary Institute
4911 Central Avenue, Richmond, CA

Meeting Summary

Attendees

Science Advisor	Affiliation	Present
Kara Lavender Law	Sea Education Association	Yes
Chelsea Rochman	University of Toronto	Yes
Anna-Marie Cook	US Environmental Protection Agency	Yes

Others Present

Anna Cummins (5 Gyres)
Autumn Cleave (SFPUC)
Barbara Baginska (SFB RWQCB)
Cambria Bartlett (Heirs to Our Ocean)
Cameron Kostigen Mumper (City of Sunnyvale)
Carolynn Box (5 Gyres)
Chris Sommers (BASMAA)
Dale Bowyer (SFB RWQCB)
David Williams (BACWA)
Diana Rosenberg (Gap)
Emily Bartlett (Heirs to Our Ocean)
Emma Hinojosa (City of Sunnyvale)
Eric Dunlavey (San Jose)
Holly Wyer (Ocean Protection Council)
Karin North (Palo Alto)
Kelly Moran (TDC Environmental)
Kevin Messner (Association of Home Appliance Manufacturers)
Krystle Moody Wood (materEVOLVE)
Lorien Fono (BACWA)
Luisa Valiela (USEPA)
Mary Lou Esparza (CCCSD)
Nirmela Arsem (EBMUD)
Reinhard Hohlwein (CalRecycle)
Robert Nuñez (Californians Against Waste)
Rusty Holleman (University of California Davis)
Samantha Harper (SFB RWQCB)
Scott Coffin (SWRCB)
Shelly Moore (SCCWRP)
Simona Balan (DTSC)
Stephanie Karba (Patagonia)
Sutapa Ghosal (CDPH)
Adam Wong (SFEI)
Alicia Gilbreath (SFEI)
Amy Franz (SFEI)
Becky Sutton (SFEI)
Diana Lin (SFEI)
Don Yee (SFEI)
Jay Davis (SFEI)
Meg Sedlak (SFEI)
Melissa Foley (SFEI)
Tony Hale (SFEI)
Warner Chabot (SFEI)
Amy Herrin - Remote (Milwaukee and Jinan University)
Katie Graham - Remote (Sanford University)
Miriam Diamond - Remote (University of Toronto)
Violet Renick - Remote (Orange County Sanitation District)

The last page of this document has information about the RMP and the purpose of this document.

1. Introductions and Welcome

Melissa Foley commenced the Microplastic Workgroup meeting by reviewing the meeting's agenda and summarizing the context of the Microplastic Workgroup within the San Francisco Bay Regional Monitoring Program. Brief introductions followed.

2A. Information: Overview of Moore Microplastic Deliverables and Timeline

Meg Sedlak gave an overview of the microplastics work, providing the context for the Moore Microplastic project and the Bay RMP's role within this broad issue. She summarized the Moore project deliverables and timeline and foreshadowed an important discussion topic for the day: method development and quality assurance for microplastic analysis.

2B. Information: Overview of Methods and Nomenclature

Dr. Chelsea Rochman presented definition of microplastic including morphology, size, and polymer types, and extraction and analysis methods used for the Moore project. She provided an overview of best practices used by her lab, including quality assurance techniques as well as the training protocols used to standardize their methods. The Rochman lab aims for spike recovery of 80% of artificially-made particles. She walked through their workflow: (1) extraction and size fractionation, (2) characterization and quantification, (3) and spectroscopy using the Raman (smaller particles) and Fourier Transform Infrared (FTIR) technology (larger particles). Results are reported by quantity, size, color, morphology, and polymer identification (on a subset of particles). Chelsea highlighted several challenges associated with microplastic analysis, including working with fibers, spectrometry challenges, time-intensivity of the analyses, and the potential for bias among technicians. Chelsea and her lab have developed a polymer library for Raman spectroscopy and will make this library open-access and free of charge.

Chelsea answered several clarifying questions regarding method specifics and referred to the Moore project report for further information. Topics included decisions made during method development, Raman automation, fibers, and classification of particles with multiple polymer signals. Participants were eager to further discuss how field techniques affect particle characterization.

3. Discussion of Pathways: Wastewater and Stormwater

Meg Sedlak presented key findings from the "Microparticles in Effluent" chapter of the draft Moore project report. Effluent was collected during two separate events from eight wastewater treatment plants (WWTP) with varying flow, treatment, and spatial location. All facilities had

microparticles in their effluent. Fibers were the most common morphology (55%) followed by fragments (23%). The findings suggested that, annually, an estimated 47 billion microparticles are discharged from Bay treatment plants, 21 billion of which are likely to be plastic.

Dave Williams recommended collecting flow-weighted samples in the future to gain a more accurate estimate of microparticles released in wastewater effluent and noted that, because the samples from the present study omit this consideration, the estimates are likely conservative.

Alicia Gilbreath summarized results from the “Microparticles in Stormwater” draft chapter of the Moore project report. Twelve watersheds, representing 11% of the total Bay Area watershed, were sampled; the watersheds represented a range of sizes, land uses, and geographical locations. Microparticles were present in all samples. Annual estimated loads to the Bay were around 10.9 trillion microparticles (about 200x higher than effluent) with plastics comprising anywhere from 63–90%. Rubber fragments comprised 47% of microparticles, which are suspected to originate from tires. Use of these data as inputs to the Regional Watershed Spreadsheet Model suggest that industrial areas may account for a disproportionately high fraction of the load.

A question was asked on how the Rochman lab handles disintegration of brittle particles to which Chelsea indicated that this has not been a significant issue in her lab and, when encountered, those particles that shatter are ignored in results. Most of the discussion focused on the black rubber particles: what management action could entail, uncertainty in whether these particles originate from tires, and possible sources and transport of these particles to the Bay. Kelly Moran mentioned that based on the development of a conceptual model aimed at understanding transport of metals in tire due to vehicle wear, she thought that the size of rubber particles observed in the Moore study are too large to be transported by air and are likely to stay close to their source. She also indicated that they are too small to be effectively captured during cleaning methods like street sweeping. She emphasized the difficulty in understanding the linkages between observed rubber particles and tires due to gaps in literature, complexity of tire composition, and industry involvement.

Action Items:

- Address external review comments made on the effluent chapter of the Moore report from the Microplastic Workgroup. (Meg Sedlak, 6/30/19)
- Address external review comments made on the stormwater chapter of the Moore report from the Microplastic Workgroup. (Alicia Gilbreath, 6/30/19)

4. Discussion: Surface Water and Small Fish

Carolynn Box presented preliminary results from the surface water samples collected as part of the Moore project. The main objectives were to understand ambient conditions and to assess

spatial and temporal variations in surface water. Samples were collected during wet and dry seasons at 16 Bay sites and 11 sanctuary sites using a manta trawl and one-liter grab samples. Results revealed the highest abundances of microparticles in Central and South Bay and showed an increase in microparticle occurrence during wet weather. Carolynn indicated that the draft surface water chapter would be released for workgroup review soon.

The absence of tire rubber microparticles led participants to suspect that particles large enough for analysis (>125 µm sieve screen) are settling to sediments. Sediment samples and modeling will help elucidate the fate of rubber particles. Dr. Kara Lavender Law cautioned against quantifying fibers in manta trawl samples as the trawls were not designed to capture fibers (i.e., the orientation of the fiber influences whether it is caught on the net). However, if fibers in Manta trawls are discussed in the report, she recommended that the fiber discussion be kept separate from the other morphologies. In addition, she recommended seeing whether the presence of biological matter noted in field notes correlated with more fibers were observed in the net (i.e. clogging the net would increase numbers of particles captured). Kara was pleased to hear that there were one-liter grab samples from which concentrations of fibers will be quantified.

The group noted the disconnect between identification of foam particles in surface water samples and near absence in stormwater samples. Several workgroup members speculated that stormwater sampling methods (i.e., size of the pump mouth and sub-surface depth integrated sampling) might be a cause; however, it is more likely that trash discharged to tributaries weathers in the Bay and undergoes fragmentation in the Bay as the time in the tributaries is relatively short. This caused another participant to suggest that wastewater samples which were not depth-integrated could yield unrepresentative, heterogeneous results if they are sampled from a quiescent layer.

Diana Lin presented preliminary results from the analysis of approximately 160 prey fish collected as part of the Moore project from six sites in the Bay and two sites in a reference area to the north of San Francisco Bay (Tomales Bay). Ten fish of two species (anchovy and topsmelt) were collected at each site and the digestive tract analyzed for the presence of microparticles. The main objectives were to quantify abundance of microparticles in prey fish, characterize their composition, and identify sites of concern. Microparticles were detected in 99% of prey fish and fibers comprised 85% of these particles. There was no observed spatial fluctuations in microparticle concentration within the Bay; however, Bay fish had significantly higher counts of microparticles than fish from the control site at Tomales Bay.

Discussion took place around fish diet (anchovy vs topsmelt), differences in fiber composition compared to other matrices (e.g., higher fraction of anthropogenic unknown fibers), and similarity in morphologies observed in both species. Others commented that similar studies also found no distinction between different species regarding contaminant concentrations such as mercury and PFOS. One participant recommended comparing the compositions seen in the prey fish to those of the 1 L surface-water samples. Another noted that surface water and sediment were sampled but water column samples are a data gap in this study.

5. Discussion: Identification of Source Contribution

Chelsea presented preliminary findings from a masters student from Chelsea's lab, Alice Zhu, who has modeled existing data to assess potential sources of microplastic to the Bay using principal component analyses and other similar methods. Her main objectives were to (1) assess any patterns in surface water sites that vary by season, depth, and velocity, and (2) characterize any relationships among surface water samples and the two monitored pathways: WWTP effluent and stormwater. She determined there are patterns among surface water sites and wet- and dry-season samples: season was correlated with different morphologies but not color. She reaffirmed that fibers are the most ubiquitous morphology found across all matrices and highlighted the importance of analyzing sediment samples to provide an idea of accumulation of microparticles over time.

6. Update from Stakeholders

Several microplastic stakeholders provided brief overviews on current, related microplastic work:

- Holly Wyer with the Ocean Protection Council (OPC) explained that, in 2018, California passed a bill that mandated the OPC develop both a comprehensive research plan and a risk assessment framework for microplastic by 2021. In addition, the OPC is required to facilitate method standardization and validation for measuring microplastic in the environment. Shelly Moore and her colleagues are leading a study to evaluate laboratory analytical methods for microplastics to help standardize laboratory methods.
- Shelly Moore with the Southern California Coastal Water Research Project (SCCWRP) spoke about how SCCWRP's two-day microplastic workshop revealed the need for method development and standardization. Subsequently, SCCWRP embarked on developing a laboratory intercomparison exercise with, to date, twenty labs to evaluate five different microplastic-analysis methods: microscopy, microscopy with stain, Raman, FTIR, and Pyrolysis-gas chromatography-mass spectrometry (GC–MS). Methods are being tested on clean and dirty water, sediment, and fish tissue. SCCWRP hopes to finish the methodology within the two-year deadline and is purchasing equipment to become a training facility for any interested labs. Lastly, Shelly solicited submission of any related applied spectroscopy papers for an upcoming special issue in the journal Applied Spectroscopy (shellym@sccwrp.org).
- Dr. Anna-Marie Cook with the US Environmental Protection Agency (USEPA) presented on the EPA's microplastic method development for analysis of influent and effluent of primary, secondary, and tertiary treatment plants. The USEPA is working to get this method ASTM certified. As such, the agency is working with a microplastic subcommittee put together by the ASTM D-19 (wastewater) committee and the D-1906 (organics) committee to develop three best practices on sample collection, preparation, and reference samples, and a methodology that includes three different

polymer-identification methods: Raman, FTIR, and Pyrolysis-GC-MS. The EPA's intention is to have an internationally-applied method available by 2020 and that commercial labs and treatment plants will refine the method over the coming five years.

- Cambria Bartlett with Heirs to Our Oceans, a global youth empowerment organization focused on empowering incoming generations to protect our oceans, provided a summary of current and planned work. Heirs to Our Oceans focuses on policy, testifying at local, state, and federal levels, as well as education. Heirs to Our Oceans convenes international youth to learn about global aquatic issues and strategize on how to best address these issues. This year's camp is in California and will have a focus on microplastics. Cambria's email is cambria@heirstoouroceans.org for those who may know of someone who might be interested in their camp.

7. Discussion: Modeling Results to Date

Rusty Holleman summarized recent work on incorporating microplastic data into a Bay and Coastal Ocean model. The aims of this task are to (1) link measured pathways to ambient conditions, (2) understand the regional microplastic budget, and (3) highlight potential hotspots, sources, and sinks. Dr. Holleman used empirical relationships generated by Walschlägger and Schüttrumpf, 2019, to estimate settling velocities of different morphologies in order to understand the fate of microplastic that has entered SF Bay. Rusty used the Bay hydrodynamic model to visually demonstrate the transport and fates of microplastics with a range of buoyancies released in Central Bay. His findings showed that the buoyancy of the particles has large implications on their fate. He determined settling particles such as rubber fragments and fiber bundles most frequently found in stormwater samples primarily sink and tend to stay in the Bay, whereas foams, films, and some fibers found in WWTP effluent that typically float can have widely distributed fates, including export to the open ocean. Results will be presented in a draft report to be distributed in July. The ultimate goal of the modeling effort is to simulate, simultaneously, realistic unit concentrations from actual release points to gain a more quantitative understanding of microplastic budgets.

Discussion centered around how to model resuspension of particles, challenges and limitations associated with the model, and other release scenarios in addition to the demonstrated Central Bay release. Rusty explained that the farther a release is from the mouth of the Bay, the more likely particles are to be trapped in Bay. Some participants recommended analyzing microplastics in sediment cores to elucidate long-term temporal trends. This idea could also help understand other factors like burial rate and resuspension.

8. Discussion: Policy Issues and Communications

Carolynn Box reported out on ten science-based policy recommendations developed by an advisory committee comprised of twenty-two partner organizations. These recommendations covered policy options as well as recommended innovations, product design, research needs, and household interventions. They are summarized as follows:

1. Develop microfiber sheddability standards
2. Prioritize microfiber filtration intervention points
3. Better understand microplastic sources and pathways within stormwater systems
4. Support a Bay area and statewide comprehensive packaging bill
5. Explore green stormwater infrastructure (GSI) to reduce microplastic entering SF Bay
6. Better collaboration between trans and microplastic efforts
7. Support innovation to address microplastic pollution in SF Bay
8. Address additional research needs
9. Educate consumers to decrease microfibers entering SF Bay
10. Support SF Bay Microplastic Management Strategy to reduce microplastic

Deliverables resulting from this effort will include a SF Bay Microplastic Policy Recommendations Report, a SF Bay Microplastic Policy Brief, educational materials, and a project fact sheet. Final steps include incorporating comments and finalizing the Policy Recommendations report, discussing results at the October 2019 Microplastic Symposium, and disseminating conclusions to partners through factsheets, a policy brief, and distribution of educational resources.

Krystle Moody with materEVOLVE reported that in the week preceding this meeting, the American Association of Textile Chemists and Colorists (AATCC) developed a cross-industry agreement with the European apparel industry to prepare a standardized test method for microfibers shedding on fabrics. Krystle indicated that the California chapter of the AATCC will host a conference in October 2019 (after SFEI's microplastic symposium) to discuss fiber biodegradability, standards, and current testing methods. The AATCC will engage SFEI and 5 Gyres to share their findings.

Kelly Moran shared two thoughts on microplastic management action. The first was an observation that treatment (e.g., green stormwater infrastructure) is a common way for managers to address pollution. So, work to understand treatment is often prioritized over source identification. For microplastic, however, Kelly recommended that managers also prioritize studying sources because a more developed understanding of sources could lead to more effective pollution management. The second idea stems from the potential for small microplastics, with relatively large surface areas, to transfer chemical pollutants into the environment and organisms. The formulation of products has huge environmental implications so, while issues of distribution and exposure to microplastic are important, work to understand the reformulation of products should also be considered and elevated. Kelly also mentioned that the California Stormwater Quality Association filed a petition to request that the Department of Toxic Substances Control (DTSC) requires manufacturers to examine alternatives to zinc in tires. As part of the petition-evaluation process, DTSC is broadly examining zinc in tires, specifically its resulting environmental exposure and bioavailability.

Anna-Marie highlighted the importance of developing methods that report both synthetic and natural particle types; and assessing the ultimate fate and accumulation of microplastic through analysis of sediment samples. Anna-Marie indicated that a large fraction of microplastic particles identified in the environment are polyethylene and polypropylene and she wondered whether efforts could be made to assess which products these plastics are used in to target source control or reformulation.

Workgroup participants provided the following comments on the report:

- Besides recommending policies, will the report address the suitability of policies that have been proposed, such as microfiber shedding warning labels on clothing, or biodegradable textiles?
- Re-word recommendation #1 to ensure the recommendation is for *all* relevant parties to work together to develop *and standardize* sheddability standards rather than the current wording which could vaguely imply a 5-Gyres-led effort.
- Add a recommendation to invest in microplastic source identification.
- Add a recommendation to investigate whether products should be reformulated to phase out the use of more harmful chemicals.
- Explicitly state why presence of microplastics is a problem. Mention climate impacts, persistence, and uniqueness; and include arguments around toxicity and uncertainty used by the European Union (EU) to classify microplastics as a “non-threshold contaminant.” Summarize the current state of knowledge around ecological harm.
    - Recommend next steps around hazard assessment and describe the scientific needs necessary to develop methods aimed at understanding toxicological risk and subsequent impacts on human health and ecological harm.
- Provide a brief blueprint on how these recommendations came to fruition and the uniqueness of the process, including linking a regional scientific study with efforts to engage a diverse stakeholder group to develop policy recommendations. Other regions can learn from this process.

Action Item

- Address comments provided by the Microplastic Workgroup. (Carolynn Box, 6/30/19)

9. Discussion: Microplastic Strategy and Multi-Year Plan

Meg Sedlak presented on the revised Microplastic Strategy. Meg summarized the RMP’s tiered risk framework used to assess contaminants of emerging concern (CEC) and highlighted that microplastic currently falls in the “possible concern” category. Considering the EU’s recent determination of microplastic as a “non-threshold contaminant,” as well as the projected increase in the global manufacture of plastics, increased public awareness and concern, microplastic persistence, fragmentation, bioaccumulation, and difficulty associated with removal

of microplastics, the RMP recommended moving microplastic up to the “moderate concern” category. Workgroup participants supported the recommendation. Further discussion occurred after the meeting (see appendix).

For the Multi-Year Plan, discussion centered on the planning budget. Participants were eager to re-assess what could be brought to the TRC with the $120,000 planning budget for 2020. The workgroup discussed whether and how the RMP could sustain a microplastic monitoring effort and called for discussion and determination of long-term goals and related study priorities. Participants recommended seeking out funding from other sources, possibly from interested parties in the textile industry like Patagonia.

Decision

- Move microplastic to the “moderate concern” category in the RMP’s tiered risk framework for CECs (Consensus).

10. Discussion: Microplastic Proposals for 2020

Meg Sedlak presented on the $10,000 microplastic strategy proposal, followed by the $78,400 proposal for analysis of microplastic in San Francisco Bay sport fish. Then Alicia Gilbreath presented on a $30,000 study to develop a stormwater conceptual model for microplastic, which was written as a proposal targeted for Supplemental Environmental Project (SEP) funds.

Discussion mostly focused on the three proposals brought forward to the workgroup. However, Chelsea suggested an additional study idea which gained interest but ultimately was not prioritized for 2020 funding: development of guidance around field collection best practices. This would include a description of the methods used, lessons learned, and recommendations for similar monitoring. Chelsea mentioned that additional quality assurance analyses could and should be done to aid in the development of this guidance document. This guidance could dovetail nicely with SCCWRP’s effort to develop standardized methods for microplastic analysis. Interest in the utility of this type of guidance was re-expressed during the closed session.

The budget for the Microplastic Strategy was doubled (from $10,000 to $20,000) to plan future ecological impact work, maintain an awareness of current work, and collaborate with relevant partners.

Participants considered the conceptual model an urgent need necessary to inform future work. Discussion led to realizing this conceptual model as a key piece necessary to develop a longer-term microplastic strategy and subsequent ranking of time-sensitive projects. The workgroup decided to prioritize the conceptual model second (after the microplastic strategy). Kelly Moran offered to help with the redrafting and highlighted the alignment of this conceptual model with the ongoing CECs in stormwater study. Recommended revisions included:

- Do not focus solely on stormwater. The aim should be to understand sources and products to inform policy and regulation that could ultimately reduce negative impacts caused by microplastic. Include wastewater and air deposition as pathways to be investigated. Change the title to reflect this shift and better appeal to regulators.
- Provide a more detailed and robust description of study objectives, intended tasks, and deliverables. Tasks could include extensive literature work on sources, transport, and fate; numerical modeling; production of drawings of sources and different microplastic categories; and development of future monitoring recommendations. A deliverable should address linkages to microplastic management opportunities and identify key scientific questions that would help inform management decisions.
    - Consider planning a study that compares microplastic runoff from impervious surfaces with outflow from GSI *(proposed during closed session).*
    - Consider zero waste initiative included in the municipal separate storm sewer systems (MP4) permit for 2026 and how RMP microplastic work could accompany this goal. *(proposed during closed session).*
- Rewrite the proposal as a typical RMP special study to be in the running for RMP funds.
- Phase over two years with a $30,000 budget each in 2020 and 2021 ($60,000 total).

Participants were also interested in prioritizing the sport fish work to better understand human exposure to microplastic and to fill a data gap that would help round-out the Moore project. The workgroup recommended phasing this study over two years in order to give it a decent shot of 2020 funding and immediate analysis of sport fish samples.

Action Items

- Revise the microplastic strategy to include description planning for ecological studies. (Meg Sedlak, 6/3/19)
- Revise stormwater conceptual model based off of recommendations listed in the discussion. (Alicia Gilbreath, 6/3/19)
- Revise the sport fish proposal by phasing it between 2020 and 2021 (follow notes in the table below). (Meg Sedlak, 6/3/19)

11. Closed Session - Decision: Recommendations for 2020 Special Studies Funding

Project leads exited the conference room and Eric Dunlavey led the closed session discussion. Studies were prioritized as summarized in the table below. One participant recommended listing the conceptual model on the microplastic multi-year plan to allow maximum chances for RMP funding.

Priority	Study Name	Budget	Modified Budget	Comments

1	Microplastic strategy	$10k	$20k	Increased budget to allow for scoping and planning the ecological impact study slated in 2021; stay up-to-date on current science; and continue to track OPC efforts on field sampling methods.
2	Stormwater conceptual model for microplastics	$30k	$30k x 2	Expanded effort? Include linkage to air? Expand proposal to hone in on sources that enter stormwater pathway. Phase over two years - $30k per year.
3	Microplastics in SF Bay sport fish	$79k	$57k	Analysis in year 1 ($57k) and data analysis and report writing in year 2 ($22k); save additional samples from 2019 for additional analyses. Should be rewritten as a SEP if not prioritized for 2020 funding.

About the RMP

RMP ORIGIN AND PURPOSE

In 1992 the San Francisco Bay Regional Water Board passed Resolution No. 92-043 directing the Executive Officer to send a letter to regulated dischargers requiring them to implement a regional multi-media pollutant monitoring program for water quality (RMP) in San Francisco Bay. The Water Board's regulatory authority to require such a program comes from California Water Code Sections 13267, 13383, 13268 and 13385. The Water Board offered to suspend some effluent and local receiving water monitoring requirements for individual discharges to provide cost savings to implement baseline portions of the RMP, although they recognized that additional resources would be necessary. The Resolution also included a provision that the requirement for a RMP be included in discharger permits. The RMP began in 1993, and over ensuing years has been a successful and effective partnership of regulatory agencies and the regulated community.

The goal of the RMP is to collect data and communicate information about water quality in San Francisco Bay in support of management decisions.

This goal is achieved through a cooperative effort of a wide range of regulators, dischargers, scientists, and environmental advocates. This collaboration has fostered the development of a multifaceted, sophisticated, and efficient program that has demonstrated the capacity for considerable adaptation in response to changing management priorities and advances in scientific understanding.

RMP PLANNING

This collaboration and adaptation is achieved through the participation of stakeholders and scientists in frequent committee and workgroup meetings (see Organizational Chart, next page).

The annual planning cycle begins with a workshop in October in which the Steering Committee articulates general priorities among the information needs on water quality topics of concern. In the second quarter of the following year the workgroups and strategy teams forward recommendations for study plans to the Technical Review Committee (TRC). At their June meeting, the TRC combines all of this input into a study plan for the following year that is submitted to the Steering Committee. The Steering Committee then considers this recommendation and makes the final decision on the annual workplan.

In order to fulfill the overarching goal of the RMP, the Program has to be forward-thinking and anticipate what decisions are on the horizon, so that when their time comes, the scientific knowledge needed to inform the decisions is at hand. Consequently, each of the workgroups and teams develops five-year plans for studies to address the highest priority management questions for their subject area. Collectively, the efforts of all these groups represent a substantial body of deliberation and planning.

PURPOSE OF THIS DOCUMENT

The purpose of this document is to summarize the key discussion points and outcomes of a workgroup meeting.

Appendix

Microplastic: Moderate Concern?

Comments from Advisors:

There was unanimous support from the advisors to move microplastic to the moderate concern category. Below are the individual responses.

Dr. Anna-Marie Cook

This designation is not easy in my mind, and I've written down some "stream-of-consciousness" thoughts that I've grappled with over the past few years of attempting to tackle the question of microplastic risk from the EPA Superfund perspective (keeping in mind I come at this not as a toxicologist or ecologist, but from years of dealing with risk management).

Using the RMP risk framework definitions of levels of concern,

- High Concern – Bay occurrence data suggest a high probability of a moderate or high level effect on Bay wildlife (e.g., frequent detection at concentrations greater than the EC10[1]).
- Moderate Concern – Bay occurrence data suggest a high probability of a low level effect on Bay wildlife (e.g., frequent detection at concentrations greater than the PNEC[2] or NOEC[3] but less than the EC10 or another low level effects threshold).
- Low Concern – Bay occurrence data suggest a high probability of minimal effect on Bay wildlife (i.e., Bay concentrations are well below toxicity thresholds and potential toxicity to wildlife is sufficiently characterized).
- Possible Concern – Uncertainty in toxicity thresholds suggests uncertainty in the level of effect on Bay wildlife. Bay occurrence data exist; in some cases, they may be constrained by analytical methods with insufficient sensitivity.

Microplastic as a contaminant appears to simultaneously meet both the designations of "moderate" and "possible": occurrence/exposure is almost guaranteed to continue to increase in the Bay, yet uncertainty in toxicity thresholds is likely to remain.

There have been no microplastics toxicity thresholds established and it's difficult to imagine that any can be: I believe that the approach the EU has taken is the only practical approach, i.e. the threshold is zero:

- Establishing a risk threshold would be a massive undertaking given the confounding factors of polymer type, age of plastic, entrained plasticizer toxicities, preferentially sorbed POPs toxicities, varying toxicities/physiological-inflammations (along the lines of asbestos fibers) related to size of particles, exposure pathways varying by media and by receptor, etc;
- Teasing out measurable and environmental representative adverse impacts that can definitively be attributed to plastic exposure versus other exposures is very challenging and with current methodologies perhaps not possible;
- Deciding how many particles, of what type and size, and contaminated with what chemicals could constitute the "acceptable" lower boundary, and determining how to evaluate those threshold levels for adverse impacts on coral reefs against the threshold levels for adverse impacts on sport fish and on humans for example is daunting. Usually we set a threshold value for a single contaminant in each media to protect the most sensitive receptors, but in this case the adverse impacts can potentially be more wide-ranging and species-specific than anything we have dealt with (e.g. size of particle may be the most critical factor for some receptors (e.g. coral) while sorbed or entrained chemicals may be critical for others (e.g. Hawaiian Monk Seal)).
- The SFEI study shows an abundance of plastic particles in the Bay. Demonstrating a correlation between the types and sizes of plastic found in 1) the water column samples taken from stormwater inputs after rain events and the fish feeding from the water column (pelagic? although nearshore) in the Bay, and 2) in sediment data and demersal fish, would show exposure (although not necessarily adverse impact) on Bay wildlife even in the absence of having any toxicity threshold to measure.

As the EU report points out, the quantity of this contaminant is only going to increase in the environment. SFEI can support this assertion by continuing periodic sampling of the Bay showing temporal trends. Plastic essentially has no half-life and cannot be considered inert which would seem to make it an increasing threat, however that is defined. I remain supportive of considering this a contaminant of moderate concern.

Dr. Chelsea Rochman

I agree with Anna-Marie that I am supportive of the "moderate" classification.

I am not sure I agree with the EU about a non-threshold, but that is because it's impossible to keep all microplastics out of the environment and out of our drinking water. They have become part of the dust with all of our plastic-usage in everyday life. I'm sure there is actually a threshold, although I agree with Anna-Marie that it's complicated and will vary by type, shape, mixture of additives, etc...

I have no doubt about the large concentrations (obviously! - given I have 20 students counting this stuff because there is so much plastic), increasing concentrations and their persistence. I also

agree with potential for impact. My student and I just completed a systematic review and meta-analysis about the impacts of plastic pollution, with a focus on microplastics, and there is certainly evidence of effect across all levels of biological organization. BUT, there is also plenty experiments that do not detect an effect and thus I don't agree with the non-threshold. I think it's too simplistic.
BUT for SFEI, I do agree with the jump to moderate based on these things aside from the EU decision of how to consider it.

Dr. Kara Lavender Law
I very much appreciate Anna-Marie's thoughtful discussion of her thought process on this classification decision, as well as Chelsea's comments, which are important and well-taken.

At the stage, given the very high concentrations of microplastics in the Bay and the strong likelihood that this will increase, I see a high probability of encounter with (contamination by) microplastics by Bay wildlife. Yet, clearly there is uncertainty in the level of effect, as both Anna-Marie and Chelsea point out, with little hope for a broadly applicable set of toxicity thresholds given the heterogeneous nature of the contaminant (and the wildlife that encounter it).

Because I do not come from a background in toxicology or risk management, I have to defer to my colleagues and their expert opinion in support of the "moderate" classification. I think there is sufficient reason for concern to justify this classification.

Dr. Derek Muir
Thanks for including me in the discussion. It is an interesting case. On the one hand MPs don't fit the "moderate" definition very well ie high probability of a low level effect on Bay wildlife (e.g., frequent detection at concentrations greater than the PNEC[2] or NOEC since there are presumably no threshold values for the polymer particles themselves). On the other hand I gather from reading a Chemical Watch article on this (I don't have the actual ECHA dossier) the decision refers to extreme persistence in the environment and degradation through the formation of nanoplastics. Also the presence of additives at parts per thousand or % levels needs to be considered. In fact some possible additives (alkyl phenols) are already on the moderate list for other reasons while others (BPA, phthalates) are listed in Table 2B as possible concern. So all things considered I think it argues for "moderate".

Dr. Kelly Moran
While I'm no microplastics expert, I've been trying to organize my thinking about how to approach microplastics hazards. Here are some thoughts for your consideration (and for the group's reactions if they like).

As I see it, on a very simple level, microplastics raise two kinds of issues:
(1) <u>They are small physical things littering the environment</u>.
As small physical things, they pose two hazards:
(a) Their physical presence degrades the aesthetic and potentially other qualities of aquatic ecosystems. This is akin to the Water Board's thinking about trash. The fact they don't belong is more than aesthetic, but like trash, aesthetics can drive the public policy reaction to them. (There is the yuck factor of knowing they are in fish we eat or water we drink, and the shock of seeing beaches with itty bitty colored plastic particles among the sand grains). The SF Bay Water Board members voted to make trash a priority based primarily on policy (aesthetics). Many people in the regulated community continue to question whether one can prove that the simple presence of trash actually harms ecosystems, even though there are plentiful data that some of it harms individual organisms. Trash has the same problem of no PNEC or NOEC for either individual species or whole ecosystems.

(b) Unlike trash, the microplastics can be a food substitute. Ignoring the contaminants they contain for the moment, microplastics pose the hazard of reduced nutrition for organisms that consume things in the microplastic size class. [You can tell from this sentence that I'm a chemist and not a biologist ;-)]. Again, at this point, we don't have a threshold concentration for individual species or ecosystem harm from this food-substitute physical hazard.

(2) <u>They are transport pathways for contaminants inside their source material</u>.
As Derek mentioned, some plastics contain relatively high concentrations of CECs on the Moderate and Possible concern lists. I'd add the currently unknown tire ingredient causing pre-spawn mortality to Coho salmon to that list (when Ed & Jen figure it out <*referring in part to stormwater work at University of Washington that the RMP is helping to fund*> [I'm assuming they will because they are both clever and persistent], that pollutant will probably be on the "moderate " list at least for creeks). Until we understand the sources of plastics in the ecosystem and the chemical formulations of the sources, we can't identify all the pollutants that are involved in the microplastics exposure pathway.

For this hazard, microplastics are part of an exposure pathway. They aren't the original source (that's the product they came from), nor are they the ultimate hazard (that's the toxic chemical they contain). They have several ways of facilitating organism exposure to the toxic chemicals they contain:

- They are small, so they move readily through watersheds and into the Bay
- They have a lot of surface area, which makes it easy for the chemicals they contain to become bioavailable in water, sediment, or inside organisms
- They can be taken up by organisms, providing a direct exposure to the pollutants they contain

- They can fall into sediments, where sediment-dwelling organisms can be exposed through consumption and/or leaching into sediment pore water

The fact that they are a pathway rather than an individual pollutant is one of the challenges I'm having with wrapping my mind around the RMP concern level.

Whatever the formal classification of them (although I support "moderate concern," they might merit a special classification due to their unique and combined hazards), understanding microplastics better seems essential if we are to identify the full threat that CECs pose in SF Bay. Plus, if someone asked policy makers "should we minimize microplastics?" I'm pretty sure they would say "yes" for the reasons in #1.

Although we don't know the priorities because of the shortage of information linking plastics to their original sources and not knowing which of these contain the most hazardous pollutants, the control options all fit within the existing Bay & watershed frameworks:
—Source control - safer formulations once we know the pollutants of concern (e.g., tires), reducing plastics
—Treatment control - already a long-term goal for urban runoff (green infrastructure), maybe some new pathway interventions (e.g., washer filters, better dryer lint control)

As I'm still very much a microplastics novice, I'm curious if this thinking aligns with the experts' knowledge of the topic - and I would love to be straightened out if my simplistic approach isn't right!

Dr. Miriam Diamond
My reasons align with what's been said:
- high persistence
- fate leads to fragmentation into nanoplastics rather than true degradation
- modelling presented at the meeting shows net accumulation in the Bay as opposed to loss through flushing through ocean currents (which is solving the problem of pollution through dilution). Rather, the "loss" process in the Bay is accumulation in sediment which enables exposure to both pelagic and benthic communities. In addition, emissions are projected to increase. In total, these two factors suggest increases in microplastic and nanoplastic concentrations of time, and hence likelihood of increased exposures.
- as Derek pointed out, some microplastics are conveyors of elevated concentrations of some compounds already assigned as moderate concern or that are on the "watch list". These are the plastic additives that are most likely to transfer to biota upon ingestion (as opposed to chemicals that sorb to the plastics from ambient waters and are unlikely to transfer to biota).

Here are my additional reasons:

History should teach us to be cautious about a ubiquitous, persistent pollutant for which adverse effects are difficult to determine. Risk assessment is a useful but uncertain instrument to guide decision making. We seldom probe the uncertainty of risk assessment (RA) decisions. However, we do know that some RA decisions can yield "protective" decisions based on traditional toxicity assessments, that stand in contrast to field and epidemiological studies that suggest otherwise (e.g., evidence of adverse effects to populations at ambient exposures). Risk assessment is unable to deal with the complexities of real exposures of mixtures to wild animal experiencing "real life" multiple stresses.

I suspect that finding "reliable" toxicological benchmarks for, microplastics, which is a complex mixture of polymers and additives, will be elusive. We want to find that benchmark(s) so that we can fit a decision into our risk assessment paradigm for decision making.

So at this point, I believe in making a precautionary decision to treat microplastics as a moderate concern, to trigger abatement and remedial actions, rather than waiting for the risk assessment answer. I believe a precautionary decision is warranted based on the points summarized from this thread.

Review of the ECHA Annex XV Restriction Proposal Report -Validity of toxicological conclusions

ECHA's initial literature screen identified approximately 900 articles (from the scientific and grey literature) relevant in some respect to the risk assessment of microplastics. They also held discussions with stakeholders and scientific experts during the report development to identify additional relevant studies that were not highlighted in the literature screening, particularly recently published studies. While they may have missed some literature by using only Scopus and not cross-checking with other scientific databases, this potential issue is offset by their consultation with experts.

From the approximately 900 article identified in the literature screening, a more detailed analysis of key review papers on the topic (both from the peer reviewed and grey literature) and the 25 most influential primary research articles (chosen by number of citations, cross referencing with reviews, and reporting effects in organisms related to microplastic exposure). These articles were chosen objectively using established, peer-reviewed methods, and while identifying influential articles based on citations gives preference to older articles, this limitation is acknowledged and balanced with the use of recent reviews and discussion with scientific experts. Each of the reviews and influential articles are evaluated individually (details in the Annex to the Annex XV Restriction Report), and a weight of evidence approach was used when synthesizing information across the studies. This is the preferred approach for considering risk in ecological assessments,

especially when considering data from nonstandard toxicity testing experiments, which is the case for nearly all current microplastics toxicity studies.

Studies that report results contrary to the majority (e.g., reports of no effects at high exposure concentrations) are presented along with the majority conclusions, indicating no cherry-picking of results. Similarly, discussion of published species sensitivity distributions (SSDs) includes not only why the calculated hazard thresholds (e.g., HC5s or hazardous concentration for 5% of species, PNECs) do not meet REACH criteria, but also which species and analyses were included and usefulness of the results. Many data gaps are identified to help support the conclusion that there is not enough evidence to prove a lack of risk at any exposure (few reported dose-response curves, little chronic data, little translation from lab studies to field effects, few species studied, little work in freshwater and terrestrial systems, little work on nanoplastics, etc.).

The recommendation to classify microplastics as non-threshold contaminants is based not only on the lack of ecotoxicity data for calculation of risk thresholds, but also includes clear evidence of microplastic persistence and uncertainty in regards to bioaccumulation potential. Under REACH, other contaminants have been assessed for risk based on the PBT/vPvB (persistent, bioaccumulative, and toxic / very persistent and very bioaccumulative) perspective, so this logic is not new or unprecedented. ECHA is also careful to define the scope of microplastics covered by the recommendations in terms of size, material composition, origin, and degradability.

Note: Section 1.4.1 Approach to risk assessment. states "*It should also be noted that SAPEA* [Science Advice for Policy by European Academies] *are due to publish an 'evidence review report' on microplastics in nature and society in January 2019 as part of the European Commission Group of Chief Scientific Advisors work on microplastics. This review has been conducted independently from the assessment presented in this report and should be considered as complementary to it.*" This report, A Scientific Perspective on Microplastics in Nature and Society, can be found on SAPEA's website here: https://www.sapea.info/topics/microplastics/

About the SAPEA report:
A review of the scientific literature on occurrence, fate, and effects of microplastics is included (Chapter 2). However, unlike in the ECHA report, it is unclear how the literature was mined or which studies were given highest weight. The science is discussed in terms of what is known and unknown, and there is more emphasis on recent literature and modeling efforts than in the ECHA report. SAPEA's overall conclusions match ECHA's: even though 'high quality' risk assessment is not yet feasible, action to reduce/prevent/mitigate microplastic pollution is suggested to be needed, as well as development and use of risk assessment approaches to be able to prioritize mitigation actions. This report also includes a review of social and behavioral sciences and how

this research can inform microplastic policies and pollution prevention (Chapter 3) and a review of existing, emerging and potential future regulatory and legal frameworks of relevance to microplastics (Chapter 4). In a follow-up report (Environmental and Health Risks of Microplastic Pollution, April 2019), SAPEA provides another summary of the literature and provides science-driven recommendations for policy. Both reports appear to impartially present the current state of knowledge and important data gaps necessary for risk assessment.

Individual responses to comments from Tom Mumley:

Tom's concerns (copied from email) are written in Caveat. SFEI's responses are presented in Times New Roman. The toxicological portions of this response were prepared by Dr. Liz Miller, our recent addition to the SFEI team. Her area of expertise is ecotoxicology. Any mistakes or omissions are mine.

- The primary basis of the recommendation is the European Union proposal to evaluate microplastics as non-threshold contaminants, meaning any discharges to the environment would be considered harmful.

The proposed designation as a non-threshold contaminant means that increases in the environmental stock from discharges to the environment correspond to an increased risk. Risk is different from harm; harm is damage, whereas risk is the possibility to cause harm. The non-threshold contaminant designation is because a thorough scientific analysis concluded there is currently not enough data to be able to justify a conclusion that risks are adequately controlled, based on current exposures in the environment or exposures that are forecast to occur in the future. ECHA is therefore proposing that the EU take a precautionary approach because the risks arising from intentional uses of microplastics that result in releases to the environment are not currently adequately controlled. While the risks posed by microplastics in the environment are currently considered as uncertain, ECHA expects that the understanding of risks will increase significantly over the next 10 years as microplastics, nanoplastics, and their impacts continue to be further studied. As microplastics are extremely persistent and are practically impossible to remove from the environment once released, the report argues it is appropriate to take cost-effective action now, despite these uncertainties. They also assessed the risk reduction potential and socio-economic impacts of several restriction options. The proposed restrictions are considered to be proportionate to the risk, with cost effectiveness similar to previously implemented REACH restrictions.

- That's a policy-based rather than a science-based decision.

ECHA is still in the process of evaluating microplastics risks and has proposed, but not implemented, policy changes to address these risks. The Annex XV Restriction Proposal Report,

while designed to inform policy, is science-based. The report was written in cooperation with the EU Group of Chief Science Advisors, which are part of the EU Scientific Advice Mechanism and provide the Commission with independent scientific advice on specific policy issues. The report includes a comprehensive literature screening and review, and the risk assessment was conducted using a weight of evidence approach, which is the accepted scientific standard for risk assessments when conventional toxicity studies are not available or not comprehensive.

- We can make a similar argument for other classes of contaminants, e.g., pesticides and pharmaceuticals.

Risk assessment of chemicals under REACH can be performed in several ways, depending on the hazard properties of the substance. As the hazard properties of microplastics are complex and in many instances uncertain (e.g., issues surrounding particle size, persistence, degradation), the report considered a range of risk assessment paradigms, including 'conventional' (eco)toxicological risk assessment based on the derivation of an effects threshold (PNEC) and quantitative risk characterization (PEC/PNEC or RCR approach), PBT/vPvB (persistent, bioaccumulative, and toxic / very persistent and very bioaccumulative) perspective, and case-by-case assessment according to para 0.10 of Annex I of REACH. Other environmental contaminants (such as pesticides and pharmaceuticals) must undergo the same scientifically-driven risk assessment process before policy decisions are made. The difference is that in the case of microplastics, ECHA has determined that since there is not enough data to determine adverse effect thresholds for risk assessment, and due to their extreme persistence and lack of remediation possibilities, microplastics should be treated in a similar manner to PBT/vPvB substances, whereas most other emerging contaminants are not as persistent and/or have more readily available toxicology data (especially in regards to dose-response relationships for multiple species), and can therefore be assessed using 'conventional' methods.

- The non-threshold assertion that any discharges of microplastics to the environment would be considered harmful would justify classifying microplastics as a "High Concern".

Definition of High Concern – Bay occurrence data suggest a high probability of a moderate or high level effect on Bay wildlife (e.g., frequent detection at concentrations greater than the EC10).

The non-threshold assertion does not mean that any discharges would be considered harmful because risk is not the same thing as harm. The non-threshold designation is because we do not currently have enough data to calculate safe thresholds and we know microplastics are extremely persistent. Discharges of microplastics to the environment therefore alter the relevant risk characterisation in terms of **when** safe thresholds will be exceeded, rather than **if** safe thresholds

will be exceeded. A designation of high concern would only be warranted if we knew that microplastic concentrations were already high enough to be likely to cause "moderate or high level" adverse effects.

- The "Moderate Concern" tier is for contaminants with exposure (Bay) levels below (but approaching) harmful levels.

Definition of Moderate Concern – Bay occurrence data suggest a high probability of a low level effect on Bay wildlife (e.g., frequent detection at concentrations greater than the PNEC or NOEC but less than the EC10 or another low level effects threshold).

Current scientific consensus is that the best available evidence suggests microplastics and nanoplastics do not currently pose a widespread risk to humans or the environment, but that evidence is limited and the risks are unknown. We do know that the trend for plastic waste is on a steep upward trend and that removal of these microscopic particles from the environment is for all intents logistically impossible and cost-prohibitive. In addition, as Kelly mentions in her response, we have evidence that stormwater from roadways is causing toxicity to a species of interest (salmon). We do not understand the mechanism but we believe there is sufficient evidence to warrant moderate concern as we support those who are sleuthing out the mechanism.

- "Microplastics" is a broad term encompassing lots of different types and different of synthetic materials, and their exposure, fate and effects vary or likely vary by type and shape.

The ECHA Annex XV Restriction Proposal Report acknowledges the complexity of the term "microplastics." There is no standardized understanding of what substances, and in what physical form, the term microplastics actually refers to. ECHA defines microplastics as a material consisting of solid polymer-containing particles, to which additives or other substances may have been added, and where ≥ 1% w/w of particles have (i) all dimensions 1nm ≤ x ≤ 5mm, or (ii), for fibres, a length of 3nm ≤ x ≤ 15mm and length to diameter ratio of >3. Polymers that occur in nature that have not been chemically modified (other than by hydrolysis) are excluded, as are polymers that are (bio)degradable. The EU is specifically focused on intentionally added microparticles ("primary" microplastics), not microplastics formed in the environment ("secondary" microplastics), as these can be regulated and also have been the subject of more (eco)toxicological hazard assessments. However, the ECHA literature review documented in the Restriction Proposal Report considered studies on both primary and secondary microplastics in their recommendation to classify microplastics as a non-threshold contaminant.

- Lumping all microplastics into the moderate (or high) concern tier could result in diluting attention on certain microplastics that merit more attention than others.

Until we have enough scientific understanding to distinguish risks from different types of microplastics, why not keep them as one category? We do not currently have enough scientific evidence to know which types of microplastics are most harmful. Also, it is likely that mixture effects will be important in any adverse effects to ecosystems.

- Microplastic Workgroup participants and advisors have limited knowledge of and experience with the Framework, particularly its scientific basis.

Many MPWG and ECWG stakeholders and meeting attendees overlap, so this may be less of an issue. As you can see from the input from our three MP advisors and three ECWG advisors, microplastics are a somewhat unique contaminant given its diversity in size, morphology and composition. However, I think the advisors have made a compelling argument based on the science as to why we should list microplastics as of moderate concern.

- Any recommendation that affects the Framework should be vetted by the Emerging Contaminants Workgroup.

We have asked for the three ECWG advisors who have experience with microplastics to weigh in on this issue (see responses above). In addition, we would be happy to share this email with the ECWG if you think it would be informative.

- There may be an expectation that microplastics will get more attention if we classify them as "Moderate Concern", but they are already getting a lot of attention.

As you note, microplastics are getting a lot of attention (and regulatory actions both in California and the EU) which is part of the driver for us to consider how to prioritize this chemical in our framework. That is there may be times when there is interest in a contaminant such as PBDEs or pyrethroids for which we have evaluated the risk to the Bay and determined that for us it is not warranted that these chemicals be placed in a higher tier category. The RMP community is looking to us to provide some guidance based on the state of the science.

- It certainly doesn't mean the RMP will commit more funding to microplastics, given the reality that the RMP has insufficient resources to attend to the other moderate concern contaminants.

It is widely acknowledged that the RMP has limited dollars and cannot begin to address all of the monitoring and research needs for all of the contaminants that are of concern. However, we very often seek external funding for our projects to augment RMP funds and as such the external funders are looking to us to see how we have prioritized this class of compounds. If our tiered framework does not reflect our concern for this contaminant, it makes it challenging or at least confusing to external funders as to why we perceive this to be an issue of concern.

- We also have to consider that a moderate concern classification will likely invite scrutiny of the classification by naysayers and could undermine the current level of attention and management efforts.

The rationale for the classification is based on science and in keeping with the EC strategy document to use threshold values derived by other scientific institutions (e.g., ECHA). The value of the RMP is an honest and open dialogue about the science of these contaminants. We are happy to engage the naysayers and to have a discussion about this. We are committed to the scientific process that promotes open and transparent dialogues.

- The Draft Policy Recommendations Document contains an incorrect statement = "if the RMP identifies microplastics to be a Moderate Concern, the Regional Water Quality Control Board would lead development of a regional Action Plan". The Framework lists "action plan/strategy" as a water quality management action, but as an author of the management action aspects of the Framework, I can state with certainty that it does not mean the Regional Board would lead development of a regional Action Plan. We are not prepared nor able to do so for microplastics even if we wanted to.

We will revise this statement; Barbara Baginska also brought this inaccurate language to our attention.

- Another issue is whether the RMP can or will sustain a separate microplastics strategy rather than incorporating into its emerging contaminants strategy given the limited resources available for workgroups and special projects.

This is a good point and is something that we should discuss further as it relates to workloads, funding, opportunities to reach a diverse and new set of stakeholders, external, expertise, etc.