Title
Protocol for a Scoping Review of Microplastics in Marine Mammals

Authors
Garudadri, Prathima A
Lang, Jackelyn
Fausak, Erik D.
et al.

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Protocol for a scoping/systematic review: Scoping Review of Microplastics in Marine Mammals

Author(s) Garudadri, P.A.[1] , Lang, J.[1] , Fausak, E.D.[2], Gjeltema, J.[1]

Dept/School:
[1]Veterinary Medicine & Epidemiology, UC Davis School of Veterinary Medicine
[2]University Library, UC Davis

Correspondence: Prathima Garudadri, pgarudadri@ucdavis.edu

Author contributions:

- Prathima Garudadri is the guarantor, Jackelyn Lang and Jenessa Gjeltema will contribute to risk of bias and selection criteria, Erik Fausak will help develop the search strategy.

Abstract:

Background: Pollution of the environment by microplastics is a growing global concern. Microplastics are plastic particles smaller than 5mm that come from a wide variety of sources including physical breakdown of larger plastics into smaller pieces over time in the environment as well as from direct production of small plastic pieces for use in cosmetics, toy fillings, cleaning agents, and many industrial processes. Recent studies have documented the presence of microplastics in wild animal and human stool samples (Liebmann 2018) as well as food, posing a potential human and environmental health risk. Marine mammals have been suggested as a potential indicator species for the amount of microplastics present in marine environments (Perez-Venegas, 2018). The few studies that have looked into the presence of microplastics in marine mammals have primarily looked for larger particle sizes, studied animals in captivity, and used acid digestion methods that likely deteriorated plastics of certain polymer types. In this review, we will explore the available literature to determine what we currently know about microplastic pollution in marine environments used by marine mammals, its effect on the health of marine mammals, and help direct future research into this topic.

Objectives: The focus of the literature review will be to compile and compare previously published data in the literature about the amounts, types, and sizes of microplastics found within tissues/fecal/gastric samples of different marine mammal species, prey items, and/or geographic regions. This will help us evaluate whether certain marine mammal species or populations may be at risk due to differing feeding strategy or differences in environmental exposure patterns. Factors evaluated when reviewing this literature will include QA/QC procedures followed, analysis/digestion methods used, plastic sizes and shapes evaluated for and found, plastic types found, type of sample/tissue evaluated, species evaluated, wild/captive status, feeding strategy, and geographical location. We will compile this information to determine where future research should be directed.

Design: Primary literature including stranding data on microplastics in marine mammals, their primary prey items, and key geographical locations will be considered for inclusion. The process for selection and inclusion of the studies will be reported in a flow chart according to the Preferred Reporting Items for Systematic Reviews and Meta Analysis(PRISMA). The results will be summarized in tables and charts describing study types, method of analysis, limits of detection, plastic types found, samples evaluated, species evaluated, geographical location and other population demographics.

Registration: 7/9/20 Submitted to SYREAF on this date and escholarship University of California on this date 7/9/20
Funding and Support: Students Training in Advanced Research (STAR) program at UCD is funding a summer stipend for the guarantor.
Role of sponsor/funder: The goal of the STAR program is to facilitate engagement of veterinary students in high quality mentored research experiences. The STAR program requires students to present their research findings at the end of a 10-week program.

Introduction:

Rationale: The amount of microplastics in our oceans is growing every year and may pose a threat to marine ecosystems. Microplastics are introduced into the environment from primary sources, which include small pieces of plastic that are produced intentionally as products as well as from physical breakdown of larger plastic products into smaller pieces in the environment. As plastics break down over time, it is expected that smaller particles (1-50um range) will become more abundant in the environment. It is predicted that these small microplastics could be more biologically relevant due to their larger surface areas for release of toxic compounds and ability to serve as vectors of pathogens or toxins in addition to their increased potential to traverse biological membranes and translocate to different organs. Although little is currently known about the health effects of microplastics, there is some evidence that microplastics may accumulate in tissues, cause inflammation, ascend food chains through trophic level transfer, harbor and transfer infectious agents, or serve as a vector for harmful chemicals (Anbumani 2018, Koelmanns 2016). Due to the cost and difficulty of identifying microplastics in this small size range, their presence in the environment and fate are poorly understood. The proposed scoping review will look for gaps in our knowledge of microplastics, identify areas where further research should be directed and guide our lab's pilot study in collaboration with the Marine Mammal Center.

Objectives: The primary objective of this scoping review is to provide a comprehensive overview on the presence and effects of microplastics in Marine Mammal populations globally. We hope to identify the methodology of current microplastics research, the primary plastics found, current challenges and limitations faced, and the potential health effects. As mentioned, this review will identify areas in which there is a lack of knowledge in order to direct further research.

Methods:

PRISMA-S Template (based on v1.0 retrieved from https://osf.io/2ybwn/)

Identifying literature regarding marine mammal exposure to microplastics.

Databases and Interfaces Searched:

Database	Interface	Date Coverage	Date Searched
CAB Abstracts	CAB Direct	1972 - Present	25 June 2020
Zoo Record	Web of Science	1864 - Present	25 June 2020
Scopus	Scopus	1996 - Present	25 June 2020
Aquatic Science and Fisheries Abstracts	ProQuest	1971 - Present	25 June 2020

Item 2: Other Online Resources (As Needed):

Conference Proceeding/Registry/ Web Sites or Engine	Coverage Dates	Membership Required?	URL	Date Searched:
NOAA Repository	1970 - Present	No	https://repository.library.noaa.gov/gsearch?collection=&terms=marine+mammal+microplastics	7 July 2020

Citation Searching And Text Analysis:

Article Citation:
Anbumani, Sadasivam, and Poonam Kakkar. 2018. “Ecotoxicological Effects of Microplastics on Biota: A Review.” *Environmental Science and Pollution Research* 25 (15): 14373–96.

https://doi.org/10.1007/s11356-018-1999-x.

Auta, H. S., C. U. Emenike, and S. H. Fauziah. 2017. “Distribution and Importance of Microplastics in the Marine Environment: A Review of the Sources, Fate, Effects, and Potential Solutions.” *Environment International* 102: 165–76. https://doi.org/10.1016/j.envint.2017.02.013.

Boucher, Julien, and Damien Friot. 2017. *Primary Microplastics in the Oceans: A Global Evaluation of Sources*. IUCN Gland, Switzerland.

Browne, Mark Anthony, Phillip Crump, Stewart J. Niven, Emma Teuten, Andrew Tonkin, Tamara Galloway, and Richard Thompson. 2011. “Accumulation of Microplastic on Shorelines Woldwide: Sources and Sinks.” *Environmental Science & Technology* 45 (21): 9175–79. https://doi.org/10.1021/es201811s.

Enders, Kristina, Robin Lenz, Sabrina Beer, and Colin A. Stedmon. 2016. “Extraction of Microplastic from Biota: Recommended Acidic Digestion Destroys Common Plastic Polymers.” *ICES Journal of Marine Science* 74 (1): 326–31. https://doi.org/10.1093/icesjms/fsw173.

Farrell, Paul, and Kathryn Nelson. 2013. “Trophic Level Transfer of Microplastic: Mytilus Edulis (L.) to Carcinus Maenas (L.).” *Environmental Pollution* 177: 1–3. https://doi.org/10.1016/j.envpol.2013.01.046.

Galloway, Tamara S., and Ceri N. Lewis. 2016. “Marine Microplastics Spell Big Problems for Future Generations.” *Proceedings of the National Academy of Sciences* 113 (9): 2331–2333. https://doi.org/10.1073/pnas.1600715113.

Helm, Roger C. 1984. “Rate of Digestion in Three Species of Pinnipeds.” *Canadian Journal of Zoology* 62 (9): 1751–56. https://doi.org/10.1139/z84-258.

Koelmans, Albert A., Adil Bakir, G. Allen Burton, and Colin R. Janssen. 2016. “Microplastic

as a Vector for Chemicals in the Aquatic Environment: Critical Review and Model-Supported Reinterpretation of Empirical Studies." *Environmental Science & Technology* 50 (7): 3315–26.

Liebmann, Bettina, Sebastian Köppel, Philipp Königshofer, Theresa Bucsics, Thomas Reiberger, and Philipp Schwabl. 2018. *ASSESSMENT OF MICROPLASTIC CONCENTRATIONS IN HUMAN STOOL - FINAL RESULTS OF A PROSPECTIVE STUDY*. https://doi.org/10.13140/RG.2.2.16638.02884.

Moore, Charles James. 2008. "Synthetic Polymers in the Marine Environment: A Rapidly Increasing, Long-Term Threat." *Environmental Research* 108 (2): 131–39. https://doi.org/10.1016/j.envres.2008.07.025.

Nelms, Sarah E., Tamara S. Galloway, Brendan J. Godley, Dan S. Jarvis, and Penelope K. Lindeque. 2018. "Investigating Microplastic Trophic Transfer in Marine Top Predators." *Environmental Pollution* 238: 999–1007. https://doi.org/10.1016/j.envpol.2018.02.016.

Perez-Venegas, D. J., M. Seguel, H. Pavés, J. Pulgar, M. Urbina, C. Ahrendt, and C. Galbán-Malagón. 2018. "First Detection of Plastic Microfibers in a Wild Population of South American Fur Seals (Arctocephalus Australis) in the Chilean Northern Patagonia." *Marine Pollution Bulletin* 136: 50–54.

Smith, Madeleine, David C Love, Chelsea M Rochman, and Roni A Neff. 2018. "Microplastics in Seafood and the Implications for Human Health." *Current Environmental Health Reports* 5 (3): 375–86. https://doi.org/10.1007/s40572-018-0206-z.

Wesch, Charlotte, Katja Bredimus, Martin Paulus, and Roland Klein. 2016. "Towards the Suitable Monitoring of Ingestion of Microplastics by Marine Biota: A Review." *Environmental Pollution* 218: 1200–1208. https://doi.org/10.1016/j.envpol.2016.08.076

White, Steffany C., David W. Clark, Carrie D. Day, and Robert S. Sikes. 2007. "Variation in Digestive Efficiency of Captive North American River Otters (Lontra Canadensis) on Various Diets." *Zoo Biology: Published in Affiliation with the American Zoo and Aquarium Association* 26 (1): 41–50.

Process: Key articles were identified by Principal Investigator. Descriptors and keywords were identified by locating references in relevant databases.

Limits and Restrictions

Date and Time Period: None

Language: English
Publication status: proceedings, white papers, peer review

Species Included: marine mammals

Study Design: all study designs

Search Filters:

Database	Interface	Search Filters Applied
Scopus	Scopus	Type: AR and language: English

Full Search Strategy:
Search Database:Zoo Record

Search ID	Terms (copy and paste)	Results
#1 microplastics	TOPIC: (Microplastic* OR nanoplastics OR "synthetic polymers" OR polyethylene OR polypropylene OR polystyrene OR polyester* OR polyamide* OR polyacrylic* OR acrylic* OR microfiber* OR nanoplastic* OR "synthetic polymers" OR plasticizer* OR *phthalate* OR terephthalates OR epoxies OR epoxy OR aliphatic* OR trimellitate* OR bisphenols OR BPA OR Fiber OR "Fiber bundle" OR Fragment OR Sphere OR Pellet OR Film OR Foam OR macroplastic OR "synthetic fibers" OR "synthetic fibres")	**77,728**
#2 Species	TOPIC:("Cetacea" OR "dolphins" OR "Neophocaena phocaenoides" OR	**77,912**

	"Phocoenidae" OR “Sea lion” OR seal$ OR pinniped* OR “Arctocephalus” OR walrus* OR Otter* OR otariid* OR otariidae OR cetacean OR whale* OR dolphin* OR porpoise* OR sirenian* OR dugong* OR manatee OR “marine mammals” OR “Ursus” OR “enhydra” OR “E. lutris” OR “lontra” OR “neovison” OR “Callorhinus” OR “Eumetopias” OR “E. j. jubatus” OR Neophoca OR Otaria OR Phocarctos OR Zalophus OR Odobenus OR Cystophora OR Erignathus OR Halichoerus OR Histriophoca OR Hydrurga OR Leptonychotes OR Lobodon OR Mirounga OR Neomonachus OR Ommatophoca OR Pagophilus OR Phoca OR Pusa OR **Cetartiodactyl* OR** mysticeti OR **Balaenid* OR** Balaena OR Eubalaena OR **Neobalaenid* OR Eschrichtiid* OR** Eschrichtius OR **Balaenopterid* OR** Balaenoptera OR Megaptera OR Odontoceti OR **Physeterid* OR** Physeter OR **Kogiid* OR** Kogia OR **Ziphiid* OR** Berardius OR Hyperoodon OR Indopacetus OR Mesoplodon OR Tasmacetus OR Ziphius OR **Platanistid* OR** Platanista OR **Iniid* OR** Inia OR **Lipotid* OR** Lipotes OR **Pontoporiid* OR** Pontoporia OR **Monodontid* OR** Delphinapterus OR Monodon OR **Delphinid* OR** Cephalorhynchus OR Cephalorhynchus OR Delphinus OR Feresa OR Globicephala OR Grampus OR Lagenodelphis OR Lagenorhynchus OR Lissodelphis OR Orcaella OR Peponocephala OR Sousa OR Sotalia OR Stenella OR Steno OR Tursiops OR Neophocaena OR Phocoena OR Phocoenoides OR **SIRENi* OR** Trichechus OR Hydrodamalis	
#3	**#1 AND #2**	**1517**

Search Database:CAB Direct

Search ID	Terms (copy and paste)	Results
#1 microplastics	title:(Microplastic* OR nanoplastics OR "synthetic polymers" OR polyethylene OR polypropylene OR	**447,807**

	polystyrene OR polyester* OR polyamide* OR polyacrylic* OR acrylic* OR microfiber* OR nanoplastic* OR "synthetic polymers" OR plasticizer* OR *phthalate* OR terephthalates OR epoxies OR epoxy OR aliphatic* OR trimellitate* OR bisphenols OR BPA OR Fiber OR “Fiber bundle” OR Fragment OR Sphere OR Pellet OR Film OR Foam OR macroplastic) OR ab:(Microplastic* OR nanoplastics OR "synthetic polymers" OR polyethylene OR polypropylene OR polystyrene OR polyester* OR polyamide* OR polyacrylic* OR acrylic* OR microfiber* OR nanoplastic* OR "synthetic polymers" OR plasticizer* OR *phthalate* OR terephthalates OR epoxies OR epoxy OR aliphatic* OR trimellitate* OR bisphenols OR BPA OR Fiber OR “Fiber bundle” OR Fragment OR Sphere OR Pellet OR Film OR Foam or macroplastic) OR id:("PVC" or "polythene" or "polyethylene terephthalate" or "fibers") OR de:("polyethylene" or "polyesters" or "dibutyl phthalate" or "polypropylenes" or "dimethyl phthalate" or "poly(vinyl chloride)" or "polystyrenes" or "plastics" or “foams” or “fibres” or "waste%20plastic" or "plastic%20film" or "pellets")	
#2 Species	(((((up:("Pinnipedia" or "Phoca" or "Halichoerus" or "Phocidae" or "Odobenidae" or "Mustelidae" or "Odobenus" or "Trichechidae" or "Pinnipedia" or "Enhydra" or "Otariidae" or "Zalophus") OR up:("Hydrurga leptonyx" or "Leptonychotes" or "Phocidae" or "Hydrurga" or "Monachus" or "Kogia")) OR (up:("Phocoena" or "Trichechus" or "dolphins" or "Tursiops" or "Tursiops truncatus" or "Phoca vitulina" or "Halichoerus")) OR (up:("Balaenopteridae" or "Balaenoptera" or "Cetacea" or "Mysticeti" or "Phocoenidae" or "Odontoceti")) OR (de:("marine mammals"))) OR ((title:("Lagenorhynchus" OR "Lissodelphis" OR "Orcaella" OR "Peponocephala" OR "Sousa" OR "Sotalia" OR "Stenella" OR "Steno"	**38,349**

	OR "Tursiops" OR "Neophocaena" OR "Phocoena" OR "Phocoenoides" OR SIRENi* OR "Trichechus" OR "Hydrodamalis") OR ab:("Lagenorhynchus" OR "Lissodelphis" OR "Orcaella" OR "Peponocephala" OR "Sousa" OR "Sotalia" OR "Stenella" OR "Steno" OR "Tursiops" OR "Neophocaena" OR "Phocoena" OR "Phocoenoides" OR SIRENi* OR "Trichechus" OR "Hydrodamalis")) OR (title:("Ziphius" OR Platanistid* OR "Platanista" OR Iniid* OR "Inia" OR Lipotid* OR "Lipotes" OR Pontoporiid* OR "Pontoporia" OR Monodontid*) OR ab:("Ziphius" OR Platanistid* OR "Platanista" OR Iniid* OR "Inia" OR Lipotid* OR "Lipotes" OR Pontoporiid* OR "Pontoporia" OR Monodontid*) OR title:("Delphinapterus" OR "Monodon" OR Delphinid* OR "Cephalorhynchus" OR "Cephalorhynchus" OR "Delphinus" OR "Feresa" OR "Globicephala" OR "Grampus" OR "Lagenodelphis") OR ab:("Delphinapterus" OR "Monodon" OR Delphinid* OR "Cephalorhynchus" OR "Cephalorhynchus" OR "Delphinus" OR "Feresa" OR "Globicephala" OR "Grampus" OR "Lagenodelphis")) OR (title:(Physeterid* OR "Physeter" OR Kogiid* OR "Kogia" OR Ziphiid* OR "Berardius" OR "Hyperoodon" OR "Indopacetus" OR "Mesoplodon" OR "Tasmacetus") OR ab:(Physeterid* OR "Physeter" OR Kogiid* OR "Kogia" OR Ziphiid* OR "Berardius" OR "Hyperoodon" OR "Indopacetus" OR "Mesoplodon" OR "Tasmacetus")) OR (title:(Eschrichtiid* OR "Eschrichtius" OR Balaenopterid* OR "Balaenoptera" OR "Megaptera" OR "Odontoceti") OR ab:(Eschrichtiid* OR "Eschrichtius" OR Balaenopterid* OR "Balaenoptera" OR "Megaptera" OR "Odontoceti")) OR (title:(Cetartiodactyl* OR "mysticeti" OR Balaenid* OR "Balaena" OR "Eubalaena" OR Neobalaenid*) OR ab:(Cetartiodactyl* OR "mysticeti" OR Balaenid* OR "Balaena" OR "Eubalaena" OR Neobalaenid*)) OR (((title:("Neomonachus" OR "Ommatophoca" OR "Pagophilus" OR "Phoca" OR "Pusa") OR ab:(	

	"Neomonachus" OR "Ommatophoca" OR "Pagophilus" OR "Phoca" OR "Pusa"))) or (od:("Monachus schauinslandi" or "Ursus maritimus" or "Arctocephalus" or "Enhydra" or "Callorhinus" or "Eumetopias" or "Neophoca" or "Otaria" or "Phocarctos hookeri" or "Zalophus" or "Odobenus rosmarus" or "Cystophora (Mammalia)" or "Erignathus barbatus" or "Halichoerus grypus" or "Hydrurga leptonyx") and up:("Phocidae" or "Monachus" or "Odobenidae" or "Odobenus" or "Halichoerus" or "Hydrurga"))) OR (title:("Neomonachus" OR "Ommatophoca" OR "Pagophilus" OR "Phoca" OR "Pusa") OR ab:("Neomonachus" OR "Ommatophoca" OR "Pagophilus" OR "Phoca" OR "Pusa")) OR (title:("Halichoerus" OR "Histriophoca" OR "Hydrurga" OR "Leptonychotes" OR "Lobodon" OR "Mirounga") OR ab:("Halichoerus" OR "Histriophoca" OR "Hydrurga" OR "Leptonychotes" OR "Lobodon" OR "Mirounga")) OR (title:("Phocarctos" OR "Zalophus" OR "Odobenus" OR "Cystophora" OR "Erignathus") OR ab:("Phocarctos" OR "Zalophus" OR "Odobenus" OR "Cystophora" OR "Erignathus")) OR (title:("neovison" OR "Callorhinus" OR "Eumetopias" OR "E. j. jubatus" OR "Neophoca" OR "Otaria") OR ab:("neovison" OR "Callorhinus" OR "Eumetopias" OR "E. j. jubatus" OR "Neophoca" OR "Otaria")) OR (title:("marine mammals" OR "Ursus maritimus" OR "enhydra" OR "E. lutris" OR "lontra") OR ab:("marine mammals" OR "Ursus maritimus" OR "enhydra" OR "E. lutris" OR "lontra")) OR (title:(seal$ OR pinniped* OR "Arctocephalus" OR walrus* OR Otter* OR otariid* OR "otariidae") OR ab:(seal$ OR pinniped* OR "Arctocephalus" OR walrus* OR Otter* OR otariid* OR "otariidae")) OR (title:("Cetacea" OR "dolphins" OR "Neophocaena phocaenoides" OR "Phocoenidae" OR "Sea lion") OR ab:("Cetacea" OR "dolphins" OR "Neophocaena phocaenoides" OR "Phocoenidae" OR "Sea lion")))))	
#6	#1 AND #2	**1348**

Actual search marine mammals	((((up:("Pinnipedia" or "Phoca" or "Halichoerus" or "Phocidae" or "Odobenidae" or "Mustelidae" or "Odobenus" or "Trichechidae" or "Pinnipedia" or "Enhydra" or "Otariidae" or "Zalophus") OR up:("Hydrurga leptonyx" or "Leptonychotes" or "Phocidae" or "Hydrurga" or "Monachus" or "Kogia")) OR (up:("Phocoena" or "Trichechus" or "dolphins" or "Tursiops" or "Tursiops truncatus" or "Phoca vitulina" or "Halichoerus")) OR (up:("Balaenopteridae" or "Balaenoptera" or "Cetacea" or "Mysticeti" or "Phocoenidae" or "Odontoceti")) OR (de:("marine mammals"))) OR ((title:("Lagenorhynchus" OR "Lissodelphis" OR "Orcaella" OR "Peponocephala" OR "Sousa" OR "Sotalia" OR "Stenella" OR "Steno" OR "Tursiops" OR "Neophocaena" OR "Phocoena" OR "Phocoenoides" OR SIRENi* OR "Trichechus" OR "Hydrodamalis") OR ab:("Lagenorhynchus" OR "Lissodelphis" OR "Orcaella" OR "Peponocephala" OR "Sousa" OR "Sotalia" OR "Stenella" OR "Steno" OR "Tursiops" OR "Neophocaena" OR "Phocoena" OR "Phocoenoides" OR SIRENi* OR "Trichechus" OR "Hydrodamalis")) OR (title:("Ziphius" OR Platanistid* OR "Platanista" OR Iniid* OR "Inia" OR Lipotid* OR "Lipotes" OR Pontoporiid* OR "Pontoporia" OR Monodontid*) OR ab:("Ziphius" OR Platanistid* OR "Platanista" OR Iniid* OR "Inia" OR Lipotid* OR "Lipotes" OR Pontoporiid* OR "Pontoporia" OR Monodontid*) OR title:("Delphinapterus" OR "Monodon" OR Delphinid* OR "Cephalorhynchus" OR "Cephalorhynchus" OR "Delphinus" OR "Feresa" OR "Globicephala" OR "Grampus" OR "Lagenodelphis") OR ab:("Delphinapterus" OR "Monodon" OR Delphinid* OR "Cephalorhynchus" OR "Cephalorhynchus" OR "Delphinus" OR "Feresa" OR "Globicephala" OR "Grampus" OR "Lagenodelphis")) OR (title:(Physeterid* OR "Physeter" OR Kogiid* OR "Kogia" OR Ziphiid* OR	

	"Berardius" OR "Hyperoodon" OR "Indopacetus" OR "Mesoplodon" OR "Tasmacetus") OR ab:(Physeterid* OR "Physeter" OR Kogiid* OR "Kogia" OR Ziphiid* OR "Berardius" OR "Hyperoodon" OR "Indopacetus" OR "Mesoplodon" OR "Tasmacetus")) OR (title:(Eschrichtiid* OR "Eschrichtius" OR Balaenopterid* OR "Balaenoptera" OR "Megaptera" OR "Odontoceti") OR ab:(Eschrichtiid* OR "Eschrichtius" OR Balaenopterid* OR "Balaenoptera" OR "Megaptera" OR "Odontoceti")) OR (title:(Cetartiodactyl* OR "mysticeti" OR Balaenid* OR "Balaena" OR "Eubalaena" OR Neobalaenid*) OR ab:(Cetartiodactyl* OR "mysticeti" OR Balaenid* OR "Balaena" OR "Eubalaena" OR Neobalaenid*)) OR (((title:("Neomonachus" OR "Ommatophoca" OR "Pagophilus" OR "Phoca" OR "Pusa") OR ab:("Neomonachus" OR "Ommatophoca" OR "Pagophilus" OR "Phoca" OR "Pusa"))) or (od:("Monachus schauinslandi" or "Ursus%20maritimus" or "Arctocephalus" or “Enhydra” or “Callorhinus” or “Eumetopias” or “Neophoca” or “Otaria” or "Phocarctos%20hookeri" or “Zalophus” or "Odobenus%20rosmarus" or "Cystophora%20(Mammalia)" or "Erignathus%20barbatus" or "Halichoerus%20grypus" or "Hydrurga%20leptonyx") and up:("Phocidae" or "Monachus" or "Odobenidae" or "Odobenus" or "Halichoerus" or "Hydrurga"))) OR (title:("Neomonachus" OR "Ommatophoca" OR "Pagophilus" OR "Phoca" OR "Pusa") OR ab:("Neomonachus" OR "Ommatophoca" OR "Pagophilus" OR "Phoca" OR "Pusa")) OR (title:("Halichoerus" OR "Histriophoca" OR "Hydrurga" OR "Leptonychotes" OR "Lobodon" OR "Mirounga") OR ab:("Halichoerus" OR "Histriophoca" OR "Hydrurga" OR "Leptonychotes" OR "Lobodon" OR "Mirounga")) OR (title:("Phocarctos" OR "Zalophus" OR "Odobenus" OR "Cystophora" OR "Erignathus") OR ab:("Phocarctos" OR "Zalophus" OR "Odobenus" OR "Cystophora" OR	

	"Erignathus")) OR (title:("neovison" OR "Callorhinus" OR "Eumetopias" OR "E. j. jubatus" OR "Neophoca" OR "Otaria") OR ab:("neovison" OR "Callorhinus" OR "Eumetopias" OR "E. j. jubatus" OR "Neophoca" OR "Otaria")) OR (title:("marine mammals" OR "Ursus maritimus" OR "enhydra" OR "E. lutris" OR "lontra") OR ab:("marine mammals" OR "Ursus maritimus" OR "enhydra" OR "E. lutris" OR "lontra")) OR (title:(seal$ OR pinniped* OR "Arctocephalus" OR walrus* OR Otter* OR otariid* OR "otariidae") OR ab:(seal$ OR pinniped* OR "Arctocephalus" OR walrus* OR Otter* OR otariid* OR "otariidae")) OR (title:("Cetacea" OR "dolphins" OR "Neophocaena phocaenoides" OR "Phocoenidae" OR "Sea lion") OR ab:("Cetacea" OR "dolphins" OR "Neophocaena phocaenoides" OR "Phocoenidae" OR "Sea lion")))) AND (title:(Microplastic* OR nanoplastics OR "synthetic polymers" OR polyethylene OR polypropylene OR polystyrene OR polyester* OR polyamide* OR polyacrylic* OR acrylic* OR microfiber* OR nanoplastic* OR "synthetic polymers" OR plasticizer* OR *phthalate* OR terephthalates OR epoxies OR epoxy OR aliphatic* OR trimellitate* OR bisphenols OR BPA) OR ab:(Microplastic* OR nanoplastics OR "synthetic polymers" OR polyethylene OR polypropylene OR polystyrene OR polyester* OR polyamide* OR polyacrylic* OR acrylic* OR microfiber* OR nanoplastic* OR "synthetic polymers" OR plasticizer* OR *phthalate* OR terephthalates OR epoxies OR epoxy OR aliphatic* OR trimellitate* OR bisphenols OR BPA) OR id:("PVC" or "polythene" or "polyethylene terephthalate") OR de:("polyethylene" or "polyesters" or "dibutyl phthalate" or "polypropylenes" or "dimethyl phthalate" or "poly(vinyl chloride)" or "polystyrenes" or "plastics"))	

Search Database: Scopus

Search ID	Terms (copy and paste)	Results

#1 Topic microplastics	(TITLE-ABS-KEY (microplastic OR microplastics OR nanoplastic OR nanoplastics OR "synthetic polymers" OR polyester OR polyesters OR polyamide OR polyamides OR polyacrylic OR polyacrylics) OR TITLE-ABS-KEY (microfiber OR microfibers OR nanoplastic OR "synthetic polymers" OR plasticizer OR plasticizers OR epoxies OR epoxy OR bisphenols OR bpa) OR TITLE-ABS-KEY (macroplastic))	**50,169**
#2 topic cetacea	(TITLE-ABS-KEY ("Cetacea" OR "dolphins" OR "Neophocaena phocaenoides") OR TITLE-ABS-KEY ("marine mammals" OR "Ursus maritimus") OR TITLE-ABS-KEY ("Sea lion" OR seal OR seals OR pinniped OR "Arctocephalus" OR walrus* OR otter* OR otariid OR otariidae OR cetacean OR whale OR whales OR dolphin OR dolphins OR porpoise OR porpoises OR dugong OR dugongs OR manatee) OR TITLE-ABS-KEY ("enhydra" OR "E. lutris" OR "lontra" OR "neovison" OR "Callorhinus" OR "Eumetopias" OR "E. j. jubatus" OR neophoca OR otaria OR phocarctos OR zalophus OR odobenus OR cystophora OR erignathus OR halichoerus OR histriophoca) OR TITLE-ABS-KEY (hydrurga OR leptonychotes OR odontoceti OR physeter OR kogia) OR TITLE-ABS-KEY (lobodon OR mirounga OR neomonachus OR ommatophoca OR pagophilus OR phoca OR pusa OR cetartiodactylae OR mysticeti OR balaena OR eubalaena OR eschrichtiidae OR eschrichtius OR balaenoptera OR megaptera) OR TITLE-ABS-KEY (berardius OR hyperoodon OR indopacetus OR mesoplodon OR tasmacetus OR ziphius OR platanista OR iniidae OR inia OR lipotes OR pontoporia OR delphinapterus OR monodon))	**136,735**
#3	#1 AND #2	**1600**
#4	#3 AND articles or conference	**1364**

#5	#4 AND English	**1298**

Search Database: ASFA

Search ID	Terms (copy and paste)	Results
#1	noft(Microplastic* OR nanoplastics OR "synthetic polymers" OR polyethylene OR polypropylene OR polystyrene OR polyester* OR polyamide* OR polyacrylic* OR acrylic* OR microfiber* OR nanoplastic* OR "synthetic polymers" OR plasticizer* OR terephthalates OR aliphatic* OR trimellitate* OR bisphenols OR BPA OR macroplastic OR "synthetic fibers" OR "synthetic fibres")	**18,122**
#2	noft("Cetacea" OR "dolphins" OR "Neophocaena phocaenoides" OR "Phocoenidae" OR “Sea lion” OR seal$ OR pinniped* OR “Arctocephalus” OR walrus* OR Otter* OR otariid* OR otariidae OR cetacean OR whale* OR dolphin* OR porpoise* OR sirenian* OR dugong* OR manatee OR “marine mammals” OR “Ursus” OR “enhydra” OR “E. lutris” OR “lontra” OR “neovison” OR “Callorhinus” OR “Eumetopias” OR “E. j. jubatus” OR Neophoca OR Otaria OR Phocarctos OR Zalophus OR Odobenus OR Cystophora OR Erignathus OR Halichoerus OR Histriophoca OR Hydrurga OR Leptonychotes OR Lobodon OR Mirounga OR Neomonachus OR Ommatophoca OR Pagophilus OR Phoca OR Pusa OR Cetartiodactyl* OR mysticeti OR Balaenid* OR Balaena OR Eubalaena OR Neobalaenid* OR Eschrichtiid* OR Eschrichtius OR Balaenopterid* OR Balaenoptera OR Megaptera OR Odontoceti OR Physeterid* OR Physeter OR Kogiid* OR Kogia OR Ziphiid* OR Berardius OR Hyperoodon OR Indopacetus OR Mesoplodon OR Tasmacetus OR Ziphius OR Platanistid* OR Platanista OR Iniid* OR Inia OR Lipotid* OR Lipotes OR Pontoporiid* OR Pontoporia OR Monodontid* OR Delphinapterus OR Monodon OR Delphinid* OR Cephalorhynchus OR Cephalorhynchus OR Delphinus OR Feresa OR Globicephala OR Grampus OR Lagenodelphis OR Lagenorhynchus OR Lissodelphis OR Orcaella OR Peponocephala OR Sousa OR Sotalia OR Stenella OR Steno OR Tursiops OR Neophocaena OR Phocoena OR Phocoenoides OR SIRENi* OR Trichechus OR Hydrodamalis)	**66,704**
#3	#1 and #2	**196**

Search Designers: Search Design collaboratively built with all authors, final database translation and search execution performed by librarian, Erik Fausak.

Total Records	Total Records after deduplication	Deduplication software/methodology
4365	**3968**	**Mendeley**
3968	**3962**	**Covidence**

Study Records: Search results were imported in Mendeley and deduplicated. These references were then imported into Covidence to undergo another round of screening for duplication. Inclusion and exclusion criteria were established in Covidence. Content will be reviewed based on criteria in two phases: first by examining title/abstracts and then as full text.

Selection process: We will be using a 2 step screening process for inclusion criteria. Step 1 will evaluate the title/abstract for inclusion and step 2 will be at the full text level. Publications where consensus is not reached or reviewers cannot decide, a third reviewer/arbiter will make the final decision. Two reviewers(PG and JL) will be evaluating the references independently and one arbiter (JG) will help reach a consensus on undecided/contended publications.
Criteria to pass step 1:

- Is the full text available in english?
- Is the text an original scientific report or a conference proceeding(Journal of Wildlife diseases, Marine Sciences NOAA, Stranding data)?
- Has the population in question been exposed to microplastics, macroplastics or plasticizers?
- No geographical or date restrictions
- All study designs will be included
- Includes marine mammal populations
- Exclusion
    - Studies exclusively on microplastics not referencing the effects in marine mammal populations
    - Entanglements
    - Aquatic environment
    - Improper species

Criteria to pass step 2 will include: (Same as step 1 plus population of interest, reproducibility, efficacy, reputation of journal etc)

- Is the full text available in english?
- Is the text an original scientific report or a conference proceeding(Journal of Wildlife diseases, Marine Sciences NOAA, Stranding data)?
- Has the population in question been exposed to microplastics, macroplastics or plasticizers?

- No geographical or date restrictions
- All study designs will be included
- Includes marine mammal populations
- Health effects(parasites, bioaccumulation, intestinal blockages)
- Exclusion
    - Studies exclusively on microplastics not referencing the effects in marine mammal populations
    - Entanglements
    - Improper diet
    - Aquatic environment
    - Improper species
    - Not available in english
    - Full text unavailable
    - No exposure to microplastics, microplastics or plasticizers
    - Toxicant exposure only
    - Duplicate study

Data Collection Process: Full text publications will be uploaded into the review management software Covidence. We will be analyzing the data based on publication year, region/country, study populations(including age, sex, species, wild vs captive status), measurement method used(hand counting, Raman spectroscopy etc), types of plastics found, sample type analyzed(prey, water source, tissue samples, intestinal contents, feces etc).

Outcomes and Prioritization: We hope to compare data across region and study populations to determine risk factors for higher microplastics exposure and factors that may contribute to concurrent health effects. We will prioritize data on study population demographics, microplastics types, measurement methods/techniques and health outcomes in order to produce this data.

Data Synthesis: We will only be performing a qualitative analysis.

Confidence in cumulative evidence: We plan to score each article reviewed based on methodology, quality of reporting and evidence pyramid.

- Is enough information presented in the methods to allow replication of the study?
- Were samples reflective of wild diets?
- Are quality control measures described and sufficient? Were recovery tests performed?
- How is data reported? What units are used for particle abundance/size/shape/? Are particle colors and morphological features described? Does the author adhere to common reporting terms?
- What is the minimum size limit of detection for the study?
- Were digestion methods used likely to contribute to particle damage or loss?

- What method of analysis was used? (visualization under a microscope, nile red staining, hot needle test, FTIR, micro Raman, pyro-GCMS, etc)

Discussion: In this study, we aim to provide a broad overview of the body of research available on microplastics in Marine Mammals. Our goal is to include all relevant studies on this topic to identify which population demographics might lead to a higher susceptibility for microplastic accumulation and secondary health effects. We also hope to uncover potential health effects of microplastics although this is a relatively understudied topic. Our results will uncover future research needs and highlight species and regions that should be monitored more closely. Ultimately, microplastics in our marine environments pose a threat to human and animal health alike. Performing a scoping literature review on this subject will provide a basis for important findings in this new field.

References:

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Koelmans, Albert A., et al. "Microplastic as a Vector for Chemicals in the Aquatic Environment: Critical Review and Model-Supported Reinterpretation of Empirical Studies." *Environmental Science & Technology*, vol. 50, no. 7, 2016, pp. 3315–26.

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