Australian Government
AUSTRALIAN INSTITUTE OF MARINE SCIENCE
50 YEARS 1972 - 2022 Science for tomorrow's oceans

14 December 2022

Committee Secretary
Standing Committee on Climate Change, Energy, Environment and Water
PO Box 6021
Canberra ACT 2600
e: CCEEW@aph.gov.au

Dear Committee Secretary,

The Australian Institute of Marine Science (AIMS) is pleased to make a submission to the House of Representatives Standing Committee on Climate Change, Energy, Environment and Water Inquiry into plastic pollution in Australia's oceans and waters.

AIMS is Australia's Commonwealth Government funded tropical marine science agency. Established 50 years ago, AIMS is a statutory authority under the *Australian Institute of Marine Science Act 1972* (AIMS Act). Our mission is to provide the research and knowledge of Australia's tropical marine estate required to support growth in its sustainable use, effective environmental management and protection of its unique ecosystems.

To accomplish our mission, AIMS delivers independent science to help realise long-term impacts for the nation, including: (i) an improvement in the health and resilience of marine and coastal ecosystems across northern Australia, (ii) creation of economic, social and environmental net benefits for marine industries and coastal communities; and (iii) protection of coral reefs and other tropical marine environments from the effects of climate change.

Our research is focussed on the priorities of our stakeholders, including Commonwealth, State and Territory governments, industry and Traditional Owners. AIMS was moved from the Science Portfolio to the Environment Portfolio in the 2022 Machinery of Government changes. This recognises the crucial importance of science to inform decision-making which protects our oceans and biodiversity.

AIMS has three research bases in Townsville, Perth, and Darwin, two research vessels, and a world-leading research aquarium (the National Sea Simulator) that allows AIMS' scientists to conduct world-class scientific research to support the sustainable use of Australia's tropical marine estate. AIMS' research impact is demonstrated by its consistent ranking in the top three marine research institutions globally for marine and fresh-water biology.

AIMS has a strong foundation of microplastic research and our response is specific to microplastics, operationally defined as plastic particles <5mm in size, in contrast to larger marine debris (such as ghost nets). Given the nature of our operations, our response is also focussed on the Terms of Reference point "*the environmental impacts of plastic pollution particularly in oceans and waterways*". We also provide additional comment on the information needs we consider important to the assessment of microplastic impacts and risks of microplastics in the marine environment. This data can then be used to inform guidelines and regulatory mechanisms.

TOWNSVILLE (Headquarters)
PMB No.3,
Townsville MC, QLD 4810
T: +61 7 4753 4444
E: reception@aims.gov.au

DARWIN
PO Box 41775,
Casuarina, NT 0811
T: +61 8 8920 9240
E: reception@aims.gov.au

PERTH Indian Ocean Marine Research Centre
The University of Western Australia, M096
35 Stirling Highway, Crawley WA 6009
T: +61 8 6369 4000
E: WAadmin@aims.gov.au

aims.gov.au

The environmental management of microplastics in the marine environment is limited compared to other stressors (such as nutrients and sediments). AIMS considers it would benefit from a nationally coordinated program to address research gaps and operationalise recent research findings which could then support regulators and users of marine environments to sustainability manage Australia's marine resources.

A scientific consensus about the potential ecosystem-wide impacts of microplastics is still emerging in the scientific literature, however, some general conclusions can be drawn:

1. **Microplastics are pervasive and persistent in the marine environment**. The threat they pose to marine life is variable and often difficult to predict and mitigate.
2. They are **ingested by a diverse range of marine organisms** (Guzzetti et al. 2018; Miller et al. 2020) but **with no clear evidence of bioaccumulation or biomagnification** (Miller et al. 2020). This may be because ingested microplastics can be readily discharged (Santana et al. 2021). However, gut transit times mean marine organisms can be exposed to microplastics, to their associated chemical additives and adsorbed contaminants.
3. Although **direct toxicity of microplastic polymers and associate chemicals** to marine organisms is unlikely at current environmental exposure concentrations, it is still possible at localised point sources or if microplastic releases increase in the future (Everaert et al. 2020).
4. Experimental studies have confirmed **leaching of additives** (Gulizia, Brodie, et al. 2022) **and of adsorbed contaminants** (Hongzhan et al. 2022) from microplastics under simulated environmental and biological conditions, with evidence of toxicity (Hu et al. 2022; Nobre et al. 2015). However, compared to other sources, **microplastics are considered a relatively minor route of exposure of these harmful compounds** (Koelmans et al. 2016).
5. **Only recently have microplastic risks been considered and assessed as a multiple-stressor**, whereby the organism is exposed to both the physical (particle) and chemical (additive) components together (Miller 2022) or to microplastics in combination with other environmental stressors such as seawater temperature (Santana 2021) or habitat degradation (McCormick et al. 2020).

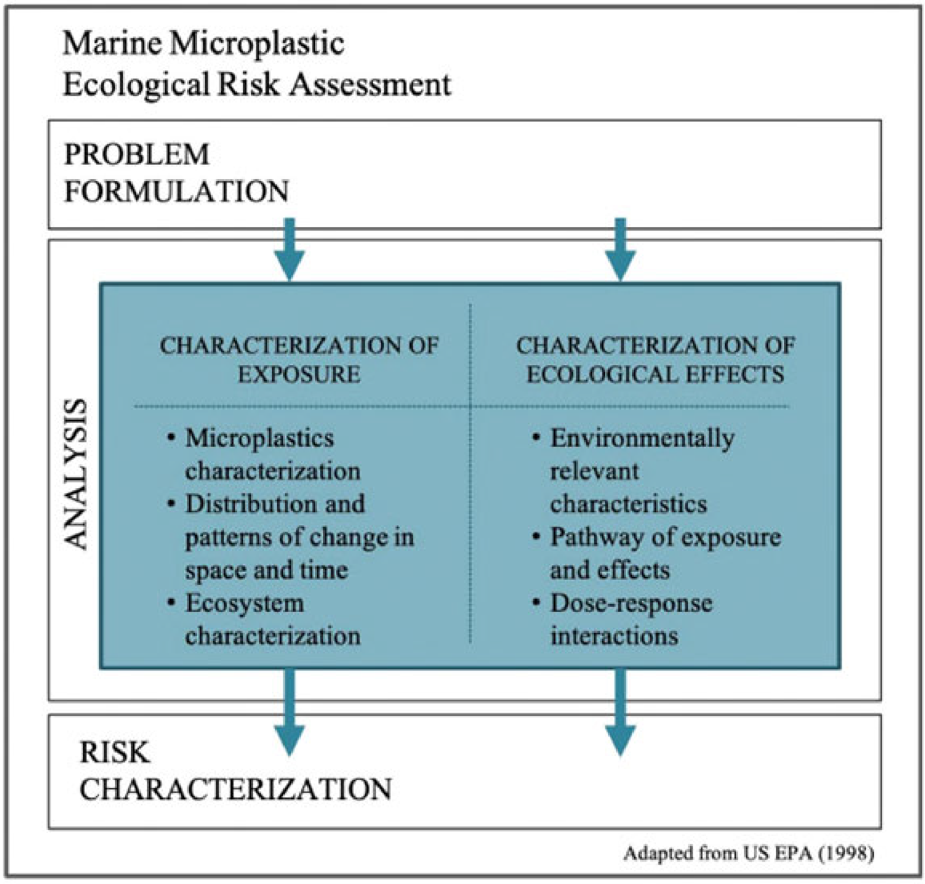

Figure 1. Workflow of an ecological risk assessment (ERA) based on the framework developed by the United States Environmental Protection Agency (Suter II 2006) and adapted for microplastic contamination. Taken from Santana (2021).

AIMS microplastic research

AIMS has undertaken research to inform all aspects of ecological risk assessments (Figure 1). Detailed research has been conducted to (1) develop methods to detect microplastics in marine systems and organisms, (2) establish baselines of microplastic contamination in marine environments, (3) understand the trophic transfer of microplastics, (4) assess the impacts of microplastics and their chemical additives to marine organisms, and (5) understand the long-term fate of microplastics in the marine environment.

1. Methods to detect microplastics in marine systems and organisms

Accurate detection and classification of microplastics in marine environments and organisms requires standardised and validated sampling and analytical procedures. AIMS has developed and validated these methods across a range of marine matrices including seawater (Kroon, Cherie Motti, et al. 2018), benthic sediment (Miller, Motti, et al. 2022; Santana 2021) and biological samples (Caron et al. 2018; Dawson et al. 2020; Kroon, Cherie A. Motti, et al. 2018; Santana, Kroon, et al. 2022; Schlawinsky et al. 2022).

2. Baselines of microplastic contamination in marine environments

Baselines of microplastic contamination are important to monitor trends in contamination levels and the effectiveness of environmental management strategies. AIMS is using the standard methods it developed to establish baselines of microplastics in marine waters around Australia and in the Southern Ocean.

AIMS has reviewed the potential sources of microplastics to the Great Barrier Reef and Torres Strait marine areas (Jensen et al. 2019; Kroon et al. 2020), and has also conducted spatial and temporal assessments to establish a Great Barrier Reef baseline (Jensen et al. 2019; Miller, Santana, et al. 2022). This has been extended Australia-wide in a new Integrated Marine Observing System (IMOS) Microplastics Facility, which aims to establish a database of microplastic contamination and type in coastal and shelf waters around Australia coupled to selected sites across the IMOS National Mooring Network, including National Reference Stations. Data from the IMOS Microplastics Facility is publicly available at Open Access to Ocean Data (aodn.org.au).

3. Trophic transfer of microplastics in marine food webs

The impact and risks of microplastics to marine organisms depends on their exposure. Marine organisms can be exposed to microplastics through direct ingestion from the environment, ingestion via prey items, or by respiration (Miller et al. 2020). In 2022 AIMS conducted the first comprehensive assessment of microplastic exposure in a representative coral reef food web. The study found that, although ingestion of prey burdened with microplastics occurs, microplastics do not biomagnify as microplastic contamination was largely due to direct uptake from seawater and sediments (Miller, Motti, et al. 2022). These results reflect a simple coral reef food web and should be extended with further laboratory and field studies encompassing a wider range of marine organisms.

4. Impacts of microplastics to marine organisms

Microplastics may cause harm to marine organisms. The mechanism of toxicity may be physical, e.g., the ingestion and retention of microplastics in digestive tracts (Wright et al. 2013); chemical, e.g., potential exposure from the leaching of plastic additives and adsorbed contaminants from microplastics; or biological, e.g., exposure to biofouling or pathogenic (disease-causing) (micro)organisms (Wang et al. 2020). In the environment, microplastics are present as complex mixtures comprising different sizes, shapes, and polymer compositions. A key challenge in understanding microplastic toxicity to marine organisms is understanding potential cumulative and interactive effects from these mixtures in association with additional abiotic (non-living, e.g. sunlight) and biotic (living, e.g. bacteria) stressors, including changes in seawater temperature (Koelmans et al. 2022).

AIMS has started investigating interactive effects of microplastics and environmental parameters on organisms across different life stages, including early and highly sensitive stages (Kulscar 2020; Santana, Motti, et al. 2022; Santana 2021; Snekkevik, 2021). AIMS is also investigating the mechanisms of plasticiser (a substance added to make the material softer and more flexible) leaching from microplastics (Gulizia, Patel, et al. 2022) and the influence exposure to these additives has on microplastic ingestion (Miller 2022). The interactive effects of cumulative stressors, including seawater temperature, are being assessed in detailed toxicological and behavioural studies applying realistic microplastic concentrations (Santana 2021; Snekkevik, 2021) based on field collected samples (Jensen et al. 2019; Kroon et al. 2020; Miller, Santana, et al. 2022).

5. Long-term fate of microplastics in the marine environment

Microplastic particles can continue to fragment in the marine environment; however, the long-term fate of plastics is not well understood. A range of physical, chemical, and biological parameters affect plastic degradation rates including temperature, UV irradiation, scouring by sediments, and biological activity (i.e., fouling and digestive abrasion) (Dawson et al. 2018; Oluwoye et al. 2021). Similarly, the distribution of microplastics in the marine environment is influenced by their chemical and physical characteristics, biological vectors (fouling), as well as environmental factors (Miller, Santana, et al. 2022).

AIMS has contributed to this body of work establishing agitation and temperature as key physical parameters accelerating leaching from microplastics (Gulizia, Brodie, et al. 2022). Building on field and experimental datasets, AIMS is also developing mathematical hydrodynamic models to understand sources and fates of marine microplastics (Jensen et al. 2019).

The regulation of microplastic impacts in marine environments

Australia's environmental regulations do not provide guidance for the specific assessment of microplastic impacts and risk in the marine environment. For example, Australia currently does not have water or sediment quality guidelines describing concentrations of microplastics above which impacts to the marine environment become likely. Australia's National Water Quality Management Strategy (Commonwealth of Australia and Department of Agriculture and Water Resources 2018) and its implementation in the Australian and New Zealand Governments Guidelines for Fresh and Marine Quality (ANZG 2018) provide an existing framework endorsed by State, Territory, and Commonwealth Governments in which guidelines for microplastics in marine environments can be developed. The development of guidelines would improve the ability of State, Territory, and Commonwealth regulators to make transparent and informed decisions about activities that generate microplastics and empower users of marine resources to better manage their microplastic discharges.

Guidelines on the impacts of microplastics in the marine environment would be beneficial to a number of industries. AIMS has identified the following recent examples:

1. The Reef Restoration and Adaptation Program, managed by AIMS, is creating an innovative suite of safe, acceptable interventions to help the Great Barrier Reef resist, adapt to, and recover from the impacts of climate change. This includes investigating the use of settlement devices to provide scalable deployment of corals to reefs. AIMS is researching the suitability of settlement devices made from degradable biopolymers.
2. Fibres represent a significant percentage of microplastics in marine environments and sources have been linked to coastal run-off and wastewater treatment plants. Preventing the introduction of fibres in the marine environment through removal is a primary concern in wastewater treatment workflows worldwide.
3. Repurposed oil and gas infrastructure, vessels and purpose-built modules have provided the foundation for artificial reefs. Much of this infrastructure contains plastic components including as epoxy coatings for corrosion protection or fibre additives to reinforce concrete. The suitability of these materials for the creation of artificial reefs is not clear. A recent interim policy from the Department of Climate Change, the Environment, Energy, and Water deemed plastic-fibres used in artificial reef modules unsuitable (DAWE 2022). This is based on uncertainty of their long-term fate and consequence to the marine environment following their release.

Key future research priorities

The development of a scientific knowledge base to understand and manage the risk of microplastics in the marine environment would benefit from national coordination. AIMS' research focus is aligned with international research priorities, including understanding the fate, behaviour, and potential impacts of microplastics in marine waters and sediments (Harris 2020; Provencher et al. 2022). AIMS is developing methodologies to extend long-term microplastic monitoring to include benthic substrates (Miller 2022; Santana 2021), while refining field and laboratory methodologies to improve assessments of microplastics presence and abundance in seawater. Identifying marine species with the potential to act as bioindicators for marine microplastic contamination (Bonanno and Orlando-Bonaca 2018) and to decouple the mechanisms of trophic transfer (Miller et al. 2020) - potentially spreading microplastics throughout the entire food chain - are new areas of interest for AIMS, as is establishing dose-response assays to determine the magnitude of the response of marine fauna to various levels of microplastic exposure. This information is critical to accurately determine concentrations of microplastics above which impacts to the marine environment become likely and will support the establishment of microplastic risk assessments and generate relevant water and sediment quality guidelines.

Mitigation of microplastics is challenging, and most effort has focussed on reducing the introduction of plastics and microplastics into the environment (Padervand et al. 2020; Prata et al. 2019). AIMS is also expanding its research into plastic degradation processes and exploring novel technologies to mineralise microplastics.

AIMS will continue to collaborate with institutions in Australia as well as overseas to improve our understanding of microplastic contamination in tropical marine waters.

AIMS welcomes the Committee's review of this submission and would be pleased to provide further information if requested.

Yours sincerely

[redacted]

Dr Paul Hardisty
Chief Executive Officer

References

ANZG (2018) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, www.waterquality.gov.au/anzguidelines.

Bonanno G and Orlando-Bonaca M (2018) 'Perspectives on using marine species as bioindicators of plastic pollution', *Marine Pollution Bulletin*, 137:209–221, doi:10.1016/j.marpolbul.2018.10.018.

Caron AGM, Thomas CR, Berry KLE, Motti CA, Ariel E and Brodie JE (2018) 'Ingestion of microplastic debris by green sea turtles (Chelonia mydas) in the Great Barrier Reef: Validation of a sequential extraction protocol', *Marine Pollution Bulletin*, 127:743–751, doi:10.1016/j.marpolbul.2017.12.062.

Commonwealth of Australia and Department of Agriculture and Water Resources (2018) *Charter: National Water Quality Management Strategy*.

DAWE (2022) *Draft Interim Policy on the use of plastics in Artificial Reefs*, Commonwealth of Australia, Canberra, ACT, Australia, https://www.dcceew.gov.au/environment/marine/sea-dumping/artificial-reefs.

Dawson AL, Kawaguchi S, King CK, Townsend KA, King R, Huston WM and Bengtson Nash SM (2018) 'Turning microplastics into nanoplastics through digestive fragmentation by Antarctic krill', *Nature Communications*, 9(1):1001, doi:10.1038/s41467-018-03465-9.

Dawson AL, Motti CA and Kroon FJ (2020) 'Solving a Sticky Situation: Microplastic Analysis of Lipid-Rich Tissue', *Frontiers in Environmental Science*, 8, https://www.frontiersin.org/articles/10.3389/fenvs.2020.563565, accessed 21 November 2022.

Everaert G, De Rijcke M, Lonneville B, Janssen CR, Backhaus T, Mees J, van Sebille E, Koelmans AA, Catarino AI and Vandegehuchte MB (2020) 'Risks of floating microplastic in the global ocean', *Environmental Pollution*, 267:115499, doi:10.1016/j.envpol.2020.115499.

Gulizia AM, Brodie E, Daumuller R, Bloom SB, Corbett T, Santana MMF, Motti CA and Vamvounis G (2022) 'Evaluating the Effect of Chemical Digestion Treatments on Polystyrene Microplastics: Recommended Updates to Chemical Digestion Protocols', *Macromolecular Chemistry and Physics*, 223(13):2100485, doi:10.1002/macp.202100485.

Gulizia AM, Patel K, Philippa B, Motti CA, van Herwerden L and Vamvounis G (2022) 'Understanding plasticiser leaching from polystyrene microplastics', *Science of The Total Environment*, 857:159099, doi:10.1016/j.scitotenv.2022.159099.

Guzzetti E, Sureda A, Tejada S and Faggio C (2018) 'Microplastic in marine organism: Environmental and toxicological effects', *Environmental Toxicology and Pharmacology*, 64:164–171, doi:10.1016/j.etap.2018.10.009.

Harris PT (2020) 'The fate of microplastic in marine sedimentary environments: A review and synthesis', *Marine Pollution Bulletin*, 158:111398, doi:10.1016/j.marpolbul.2020.111398.

Hongzhan W, Xiaowei W, Xiaoli Z, Junyu W and Lin N (2022) 'Desorption Behavior and Impacting Factors of Microplastic-loaded Pollutants in Biological Gastrointestinal Tract: A Review', *Asian Journal of Ecotoxicology*, (2):64–73, doi:10.7524/AJE.1673-5897.20220122004.

Hu L, Zhao Y and Xu H (2022) 'Trojan horse in the intestine: A review on the biotoxicity of microplastics combined environmental contaminants', *Journal of Hazardous Materials*, 439:129652, doi:10.1016/j.jhazmat.2022.129652.

Jensen LH, Motti CA, Garm AL, Tonin H and Kroon FJ (2019) 'Sources, distribution and fate of microfibres on the Great Barrier Reef, Australia', *Scientific Reports*, 9(1):9021, doi:10.1038/s41598-019-45340-7.

Koelmans AA, Bakir A, Burton GA and Janssen CR (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):3315–3326, doi:10.1021/acs.est.5b06069.

Koelmans AA, Redondo-Hasselerharm PE, Nor NHM, de Ruijter VN, Mintenig SM and Kooi M (2022) 'Risk assessment of microplastic particles', *Nature Reviews Materials*, 7(2):138–152, doi:10.1038/s41578-021-00411-y.

Kroon FJ, Berry KLE, Brinkman DL, Kookana R, Leusch FDL, Melvin SD, Neale PA, Negri AP, Puotinen M, Tsang JJ, van de Merwe JP and Williams M (2020) 'Sources, presence and potential effects of contaminants of emerging concern in the marine environments of the Great Barrier Reef and Torres Strait, Australia', *Science of The Total Environment*, 719:135140, doi:10.1016/j.scitotenv.2019.135140.

Kroon FJ, Motti Cherie, Talbot S, Sobral P and Puotinen M (2018) 'A workflow for improving estimates of microplastic contamination in marine waters: A case study from North-Western Australia', *Environmental Pollution*, 238:26–38, doi:10.1016/j.envpol.2018.03.010.

Kroon FJ, Motti Cherie A., Jensen LH and Berry KLE (2018) 'Classification of marine microdebris: A review and case study on fish from the Great Barrier Reef, Australia', *Scientific Reports*, 8(1):16422, doi:10.1038/s41598-018-34590-6.

Kulscar D (2020) *Microplastic ingestion and selectivity in anemonefish (Amphiprion melanopus) from field observations (Great Barrier Reef) and controlled laboratory exposures.* [Master of Philosophy], University of Copenhagen.

McCormick MI, Chivers DP, Ferrari MCO, Blandford MI, Nanninga GB, Richardson C, Fakan EP, Vamvounis G, Gulizia AM and Allan BJM (2020) 'Microplastic exposure interacts with habitat degradation to affect behaviour and survival of juvenile fish in the field', *Proceedings of the Royal Society B: Biological Sciences*, 287(1937):20201947, doi:10.1098/rspb.2020.1947.

Miller M (2022) *Trophic Transfer of Microplastics* [Doctor of Philosophy], James Cook University, Townsville, Queensland, Australia.

Miller ME, Hamann M and Kroon FJ (2020) 'Bioaccumulation and biomagnification of microplastics in marine organisms: A review and meta-analysis of current data', *PLOS ONE*, 15(10):e0240792, doi:10.1371/journal.pone.0240792.

Miller ME, Motti CA, Hamann M and Kroon FJ (2022) 'Assessment of microplastic bioconcentration, bioaccumulation and biomagnification in a simple coral reef food web', *Science of The Total Environment*, 858:159615, doi:10.1016/j.scitotenv.2022.159615.

Miller ME, Santana MFM, Carsique M, Motti CA, Hamann M and Kroon FJ (2022) 'Temporal patterns of plastic contamination in surface waters at the SS Yongala shipwreck, Great Barrier Reef, Australia', *Environmental Pollution*, 307:119545, doi:10.1016/j.envpol.2022.119545.

Nobre CR, Santana MFM, Maluf A, Cortez FS, Cesar A, Pereira CDS and Turra A (2015) 'Assessment of microplastic toxicity to embryonic development of the sea urchin Lytechinus variegatus (Echinodermata: Echinoidea)', *Marine Pollution Bulletin*, 92(1):99–104, doi:10.1016/j.marpolbul.2014.12.050.

Oluwoye I, Suarez LM, Higgins S and Iannuzzi M (2021) *Technical Report 1: An investigation into the degradation of non-metallic components of oil and gas infrastructure in the ocean*, Curtin University Corrosion Centre, Perth, Western Australia, https://ndriaustralia.org/wp-content/uploads/2022/09/An-Investigation-into-the-Degradation-of-Non-metallic-Components-of-OG-Infrastructure-in-the-Ocean-Report-1.pdf.

Padervand M, Lichtfouse E, Robert D and Wang C (2020) 'Removal of microplastics from the environment. A review', *Environmental Chemistry Letters*, 18(3):807–828, doi:10.1007/s10311-020-00983-1.

Prata JC, Silva ALP, da Costa JP, Mouneyrac C, Walker TR, Duarte AC and Rocha-Santos T (2019) 'Solutions and Integrated Strategies for the Control and Mitigation of Plastic and Microplastic Pollution', *International Journal of Environmental Research and Public Health*, 16(13):2411, doi:10.3390/ijerph16132411.

Provencher JF, Aliani S, Bergmann M, Bourdages M, Buhl-Mortensen L, Galgani F, Gomiero A, Granberg M, Grøsvik BE, Hamilton BM, Kögel T, Larsen JR, Lusher AL, Mallory ML, Murphy P, Peeken I, Primpke S, Strand J and Vorkamp K (2022) 'Future monitoring of litter and microplastics in the Arctic – challenges, opportunities and strategies', *Arctic Science*, doi:10.1139/AS-2022-0011.

Santana MFM (2021) *Presence, abundance and effects of microplastics on the Great Barrier Reef* [Doctor of Philosophy], James Cook University, Townsville, Queensland, Australia, doi:10.25903/9dfh-6d75.

Santana MFM, Dawson AL, Motti CA, van Herwerden L, Lefevre C and Kroon FJ (2021) 'Ingestion and Depuration of Microplastics by a Planktivorous Coral Reef Fish, Pomacentrus amboinensis', *Frontiers in Environmental Science*, 9, https://www.frontiersin.org/articles/10.3389/fenvs.2021.641135, accessed 25 October 2022.

Santana MFM, Kroon FJ, van Herwerden L, Vamvounis G and Motti CA (2022) 'An assessment workflow to recover microplastics from complex biological matrices', *Marine Pollution Bulletin*, 179:113676, doi:10.1016/j.marpolbul.2022.113676.

Santana MFM, Motti CA, Meekan M and Kroon F (2022) *The effects of microplastic contamination on mesozooplankton: a unique threat?*, Australian Institute of Marine Science, Townsville, Queensland, Australia.

Schlawinsky M, Santana MFM, Motti CA, Martins AB, Thomas-Hall P, Miller ME, Lefèvre C and Kroon FJ (2022) 'Improved microplastic processing from complex biological samples using a customized vacuum filtration apparatus', *Limnology and Oceanography: Methods*, 20(9):553–567, doi:10.1002/lom3.10504.

Snekkevik, VK (2021) *Microplastics and elevated sea temperatures affect the aggressive behaviour of spiny chromis (Acanthochromis polyacanthus)* [Master of Science], James Cook University.

Suter II GW (2006) *Ecological Risk Assessment*, 2nd Edition, CRC Press, Boca Raton.

Wang W, Ge J and Yu X (2020) 'Bioavailability and toxicity of microplastics to fish species: A review', *Ecotoxicology and Environmental Safety*, 189:109913, doi:10.1016/j.ecoenv.2019.109913.

Wright SL, Thompson RC and Galloway TS (2013) 'The physical impacts of microplastics on marine organisms: A review', *Environmental Pollution*, 178:483–492, doi:10.1016/j.envpol.2013.02.031.