Minimal meso-plastics detected in Australian coastal reef fish

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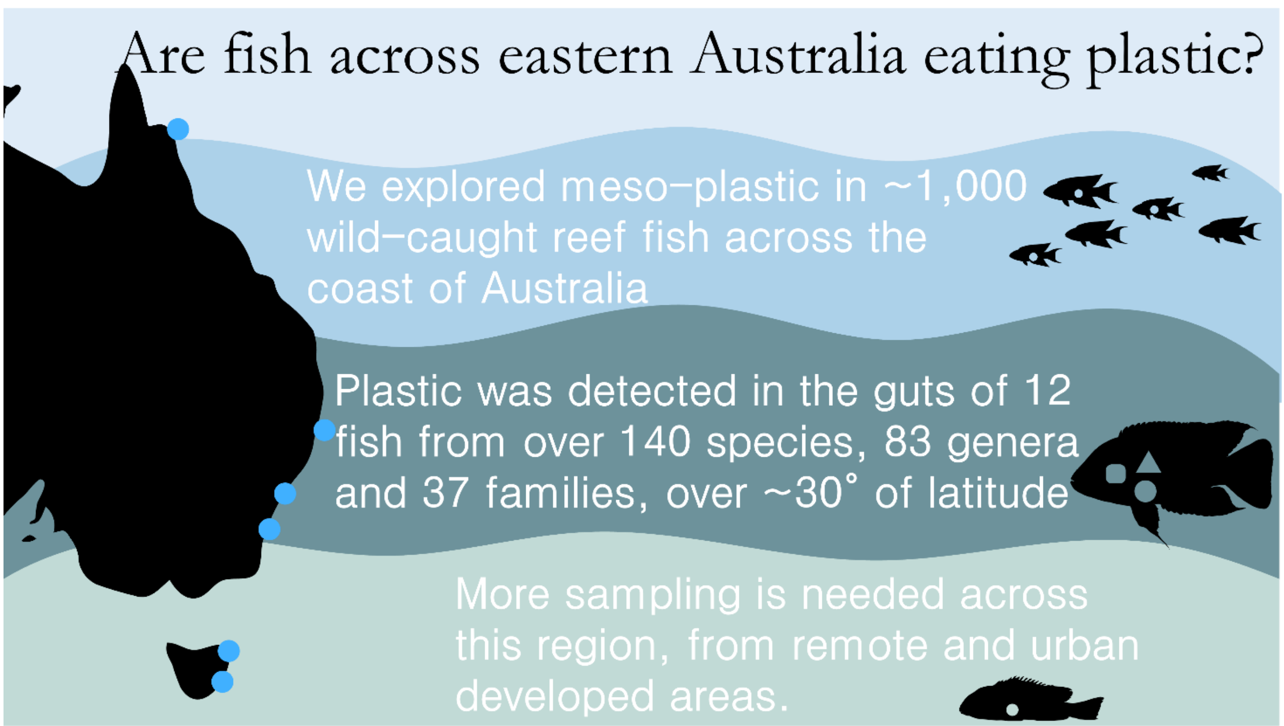
Graphical Abstract:



Abstract:

Recording plastic ingestion across various species and spatial scales is key to elucidating the impact of plastic pollution on coastal and marine ecosystems. The effect of plastic ingestion on the diets, physiologies, and behaviors are well documented in selected fish species under laboratory settings. However, prevalence of plastic ingestion in wild fish across latitudinal gradients is yet to be widely documented; with a substantial lack of research in the

Southern Hemisphere. We analyzed the gut content of reef fish across ~30º latitude of the east coast of Australia. Of 876 fish examined from 140 species (83 genera and 37 families), 12 individuals had visible (meso-plastics detectable to the naked eye) plastics present in the gut. Here, we present a first-look at plastic ingestion for coastal species with this region.

Key words: plastic pollution; diet; baseline; ingestion; coastal litter; fish

The current prevalence of plastic debris in marine environments is due to high production and disposal of plastic products, with plastic consumption increasing alongside a growing human population (Borrelle et al., 2017). Indeed, there is now in excess of 250,000 tons of plastics on the surface of the ocean (Eriksen et al., 2014). Although a majority of plastics are used and disposed of by human activities on land, plastics can enter marine environments through a number of pathways. For instance, consumer plastics typically enter the ocean from densely populated human areas, transported through river, run-off, and drainage systems (Lebreton et al., 2017). Meanwhile, shipping, fishing, and other marine industries directly account for high quantities of plastic entering the ocean (Richardson et al., 2021; Willis et al., 2021). Once in the marine environment, plastics can be transported via tides and currents, either sinking or floating depending on polymer type, shape, density, and the amount the biofouling on the plastic's matrix (van Sebille et al., 2020). Individual pieces may further fragment within the ocean, due to ultraviolet radiation, mechanical degradation, or biological processes (Dawson et al., 2018; Porter et al., 2019). Plastic fragment size-classes are generally classified as: megaplastic (>100 mm), macroplastics (>20–100 mm), mesoplastics (>5–20 mm), microplastics (1–5 mm) and nanoplastics (<1mm) (Barnes et al., 2009; Provencher et al., 2017). Plastics of all sizes have been documented in various marine environments, including remote islands, tropical reefs, coastal zones, and deep sea trenches (Bolan et al., 2020; Lamb et al., 2018; Serra-Gonçalves et al., 2019). In conjunction with its pervasiveness, the variety of sizes, colors, and densities of plastic fragments result in a wide range of marine life interacting with this pollutant. Well described negative interactions include wildlife entanglements and entrapments (Laist, 1997), and the ingestion of plastic by animals (Avery-Gomm et al., 2018). Nonetheless, plastic interactions are not always detrimental to animal survivorship, and may aid in the dispersal of rafting organisms (Zettler and Amaral-Zettler, 2020), provide refuges from predation (Barreiros and Luiz, 2009), or nest materials (Ehlers et al., 2019; Garcia-Cegarra et al., 2020). Notably, such positive interactions between animals and plastics are generally already supplied in the environment by non-anthropogenic resources, whilst the negative interactions described pose novel risks.

The ingestion of plastics is of particular concern, as this may impact animals at a range of functional scales: from the cellular, tissue, and individual, to population level effects (Rochman et al., 2016). Yet, the consumption of indigestible materials other than plastics is widely reported in animals, with examples from mammals (Schwarz and Fischer, 2006), birds (Kenyon and Kridler, 1969), and fish (Dos Santos and Jobling, 1991). Indeed, many animals either intentionally consume indigestible materials, termed 'gastroliths', to aid in the mechanical breakdown of food (such as in the gizzards of reptiles (Reilly et al., 2001) and birds (Beaune et al., 2009), or incidentally as the indigestible components of prey (bones, teeth, feathers, fur, etc.), or as the sediments that prey are found in and attached to (Wings, 2007). The presence of indigestible material is in fact so common in the scats and regurgitated pellets of animals that these evacuants are regularly examined as a non-invasive dietary analysis (Barrett et al., 2007; Wachter et al., 2012). Whether intentional or incidental, the ingestion of indigestible materials likely results in net energy loss (e.g. foraging and handling costs) given the predator receives no nutritional return (Honryo et al., 2021; Stephens and Krebs, 2019). Moreover, many predators are limited in their stomach capacity (Gill and Hart, 1998), thus indigestible material reduces the stomach space available for nutritious prey, and active regurgitation may cost both energy and the loss of digestible accompanying gut contents. However, it remains unclear if plastic ingestion results in reduced growth or body condition (Critchell and Hoogenboom, 2018; de Vries et al., 2020; Espinosa et al., 2019).

Beyond foraging energetics, ingested plastics may have other sub-lethal effects. Much of our understanding of the cellular and tissue level impact of plastics on vertebrates has come from controlled trials on laboratory and aquacultured fish species (Puskic et al., 2020). Histological examinations from these lab-based studies have linked plastic ingestion to liver stress, inflammation and mechanical tissue damage (Espinosa et al., 2019; Peda et al., 2016; Rochman et al., 2013). In addition to the intrinsic chemical and physical structure of plastic fragments, plastics may also absorb chemical pollutants including persistent organic pollutants (POPs), trace elements (TEs; Rochman et al., 2014), and per- and polyfluoroalkyl substances present in the environment (PFASs; Llorca et al., 2014). There is a growing body of research suggesting that chemicals associated with (but not intrinsic to) plastics leach inside the stomachs of seabirds (Tanaka et al., 2015) and fish (Coffin et al., 2019), and may accumulate in the animal's tissue (Szabo et al., 2020). However, emerging literature on fish argues that the uptake of chemicals through plastic ingestion may be negligible, compared to the more potent chemical vectors of water and prey (Koelmans et al., 2014; Koelmans et al., 2013). Moreover, when passed through the animal's digestive system, plastics may contrarily, aid in removing pollutants from an animal (Burns and Boxall, 2018; Mohamed Nor and Koelmans, 2019). Nonetheless, whether such impacts or effects are observed in species under wild conditions requires further research, particularly given that lab trials often use plastic doses which are not environmentally relevant (de Sá et al., 2018; Puskic et al., 2020).

Approximately 20% of the global population rely on wild-caught fish for one fifth of their dietary intake by weight (Golden et al., 2016), with fisheries contributing to a considerable proportion of the global economy through employment (~200 million full time jobs; Teh and Sumaila, 2013). Plastic ingestion has been recorded for a variety of fish species in the wild, including species destined for human consumption (Markic et al., 2020). Despite this, most studies on plastic ingestion in fishes are limited to the Northern hemisphere (Garrido Gamarro et al., 2020). Until recently, the ingestion of plastics by Australian fishes has been largely understudied, with existing research focusing on microplastic ingestion in fish species destined for human consumption (Forrest and Hindell, 2018; Wootton et al., 2021a; Wootton et al., 2021b). Considering the hazards posed by plastic pollution on animal (Roman et al., 2020), and potentially human health (Rist et al., 2018), it is important that plastic levels in marine environments are measured and monitored (Thompson et al., 2009).

Our study takes place along the east Australian coastline, a region encompassing low to high levels of plastic pollution (Eriksen et al., 2014). Pelagic seabirds which forage around the eastern coastlines of Australia have long been documented to ingest large amounts of marine debris (Roman et al., 2016). However, at present, there is a lack of research on plastic ingestion in fish from this region (Markic et al., 2020). Understanding the prevalence and consequences of plastic ingestion on coastal fish species across Australia requires documentation across habitats and regions. Here we present a first-look at mesoplastics (defined as > 5 mm) ingested by a range of fish species over 28^{o} of latitude along the east coast of Australia (Fig. 1).

The data we present were opportunistically sourced from a broader project assessing the trophodynamics (via stable isotope analysis and gut content analysis) of Australian coastal reef fish communities (Coghlan et al. unpublished data). As a consequence, the sampling regime aimed to collect individuals of locally abundant or 'common' species from basic trophic guilds at each site (herbivores, invertivores, planktivores and piscivores; derived from Stuart-Smith et al. (2013). All fish were collected within ~300 m of land, from < 15 m, with the predominant habitat type at sites transitioning from rocky algal-dominated reefs in the Sout,h to coral dominated reefs in the North. Sites varied in their proximity to human populations, from metropolitan suburbs (e.g. Little Bay, Sydney), to an island ~30 km offshore (Lizard Island). Sydney and the Solitary Island sites (~500 km north of Sydney) were sampled twice (Spring and Autumn 2019); with the remaining sites sampled in Spring (Narooma, 2018; Tasmania and Lizard Island, 2019; Fig. 1).

A total of 876 fish individuals from 140 species (83 genera and 37 species), were collected. Only adult fish were targeted to avoid the confounding effects of ontogenetic shifts in fish feeding modes. Once collected, fish were placed on ice or frozen until dissection. Fish 'gut' contents were extracted from either the stomach, anterior alimentary canal (where defined stomachs were not present), or entire digestive tract (where the separation of fore and hind guts could not be easily defined, i.e., very small < 6 cm specimens), and preserved in > 70% ethanol. Gut contents were emptied into individual glass petri dishes, with prey types sorted into broad classifications, including indigestible materials (sediment, meso-plastic, and other (e.g., wood)), for which presence/absence data were collected (Fig. 2). As some fish were dissected in field, precautions were not taken to ensure incidental clothing fibres did not contaminate the samples. Nonetheless, introduction of other foreign materials was controlled for by careful supervision of the dissection process. As a consequence, whilst microplastics < 5 mm were excluded from analysis, we recorded all visible mesoplastics, hereby defined as being > 5 mm (Barnes et al., 2009; Provencher et al., 2017). These samples were then photographed using the *Saturna Microplastics Imaging System* by Ocean Diagnostics (ODI; Fig. 2). Any plastics collected were then categorized following the protocols for plastic ingestion by marine fauna outlined by Provencher et al. (2017). Briefly, plastics are classified into general colour categories (off/white-clear, grey-silver, black, blue-purple, green, orange-brown, red-pink, and yellow) and types, either user plastics (fragment/ foam/ sheet/ thread/ other) or industrial plastics (e.g., pre-production plastic pellets or ‘nurdles’).

We assessed potential ingested plastics items using Fourier-transform infrared (FTIR). In brief Infrared spectra for the larger particles (>0.5mm) were acquired on a Bruker Vertex 70 FTIR spectrometer using a single reflection ZnSe ATR in the range of 4000-600 cm^{-1} with a spectral resolution of 4 cm^{-1}. Plastic samples were pressed to the instrument firmly to ensure consistent pressure, and where appropriate, thread-like pieces were taped down to ensure contact with the FTIR crystal was made. Smaller particles (<0.5mm) were analysed using a Bruker Macro Germanium ATR unit on a Bruker Hyperion 3000 FTIR microscope, coupled with a Bruker Vertex 70 FTIR spectrometer. A spot size of 30x30 μm^2 was used and spectra were recorded in the range of 3800-600 cm^{-1} with a spectral resolution of 4 cm^{-1}. For both techniques 32 scans were used for the background and sample measurements and spectra were treated with an atmospheric compensation within the OPUS software in addition to an extended Attenuated Total Reflectance (ATR) correction. ATR spectra were compared to and open access library (Cowger et al., 2021), to determine polymer types (best match using 80% confidence threshold; Kühn et al., 2020).

The fish examined in this study presented incidental low numbers of ingested plastic across all sites and species sampled along the east Australian coastline. Among 876 fish collected, 12 guts (1.4%) contained visible meso-plastics upon inspection (Lizard Island, n = 3 (1%); North Solitary Island, n = 4 (1.7%); Sydney, n = 2 (1.7%), Narooma, n = 3 (2.4%), Bicheno n = 0 (0%), and Cape Bougainville, n = 0 (0%)). Each fish contained a single type of plastic (Figure 2), which was either sheet (n = 4) or thread-like (n = 8). Wootton et al. (2021a) found fiber, was the dominant type of plastic found within the gut of Australian fishes. All litter in our study were between 5–20 mm (excluding one macro-plastic sheet), and were either silver (n = 1; sheet plastic), white/clear (n = 9; 2 sheet plastic, 8 thread-like plastic) or blue (n = 3; 1 sheet macroplastic plastic, 2 thread-like; Figure 2). Of the items analyzed using FTIR we confidently identified the polymer types of five particles, (Polyethylene, n =1, Polyacrylamide, n =3; and Zein, n = 1). All remaining items could not be confidently confirmed using FTIR (all <0.8 Person's r; Table 1).

Our results mirror the findings of the few available studies on Australian fish plastic ingestion (Table 3), with small quantities (Cannon et al., 2016; Crutchett et al., 2020; Wootton et al., 2021a), or no incidence of marine plastic ingestion (Lord Howe Island: Forrest and Hindell, 2018). Minimal occurrence of plastic ingestion in fish is not uncommon and reporting such observations is a valuable contribution to the emerging field of plastic pollution (Liboiron et al., 2018). Among the fish trophic guilds examined, plastics were detected in benthic invertivores (3 species; 0.9% total individuals in guild), browsing herbivores (2 species; 0.7%), and planktivores (2 species; 5.4%; Table 2). Plastic was not detected in algal farmers, corallivores, piscivores, and omnivores. There is a growing body of evidence to suggest some fish species can detect plastics as inedible, resulting in low frequencies of accidental consumption (De Sales-Ribeiro et al., 2020; Kim et al., 2019), and if ingested, nonfood may be lurched out of the buccal cavity, or defecated without harm (Mallela and Fox, 2018). Although not recorded here, sharp fragments of gastropod and bivalve shells, sea urchin spines, fish bones and otoliths, sediments and pebbles, were frequently found in the guts of the fish included in this study (A. R. Coghlan, unpublished data). Furthermore, food retention time in fish guts (hereafter 'gut-turnover rate') varies between species (from a matter of a few hours to a few days) with lower trophic level species generally having faster gut-turnover times (higher gut content turn-over) than higher trophic levels (Cleveland and Montgomery, 2003; Markic et al., 2018; Ohkubo et al., 2020). Given a majority of the fish collected in this study were from low trophic levels (herbivores, invertivores or planktivores), with few higher trophic level and no apex predators collected, gut retention time could be a factor contributing to the minimal mesoplastics detected in this study. Where available, gut retention times should be used to standardise plastic ingestion incidences when in future work comparing incidence data across fish and other animal species (Halstead et al., 2018).

This study was limited in its capacity to detect small plastics. For instance, fabric and other fine fibers (< 5 mm) were excluded from analysis as they were unable to be separated from clothing contamination during initial collection and processing of guts. Studies such as ours, which employ plastic identification methods that rely only on visual identification of plastics may underestimate the problem. Recent work from Wootton et al. (2021a) which explored microplastics of commercially targeted fish species using chemical digest methods, and a controlled laboratory environment, detected plastics in 61.6% of fish in Australian waters, and 35.3% of fish from Fiji, suggesting future work should focus on exploring these smaller fragment size ranges and using similar methods. When investigating plastic ingestion in the stomachs of commercially caught fish across southern Australia (Wootton et al., 2021b) found 35.5% of fish contained plastic, a value much lower than similar studies elsewhere. Commercially caught fish are generally large-bodied, from omnivorous or predatory trophic guilds (Pauly & Palomares 2005), which may be consequential when interpreting these findings. Here, we present the first look at common, largely non-commercially targeted reef fish species (thus covering a wider range of trophic guilds and smaller body sizes than previous studies). Additionally, all studies of plastic ingestion in fishes from the Oceania region explored gut contents from fish in relatively pristine areas. Future studies must account for locations with high plastic influx as to not under- or over-estimate the ingestion of plastic in fishes. Investigating plastic ingestion frequencies across fish species is increasingly important given to the implications for both wildlife and human health (Savoca et al., 2021). Whilst minimal mesoplastics were detected in fish across eastern Australia in the present study, we present the first large scale exploration of plastic ingestion in wild caught fish (nonspecific to those destined for human consumption), and recommend ongoing reporting of plastic occurrence in fish (even of low incidences), particularly in regions where data is lacking.

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Ethics statement

Ethics approval for this study was granted by the University of Tasmania Animal Ethics Committee (A0017225).

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Tables:

Table 1: Individual metrics and species traits for coastal fish species recorded to have ingested plastics in the present study. Polymer type was determined using ATR FTIR spectra compared to an open-source library using Pearson's R statistic (>0.80 confidence threshold indicating best match).

Species	Region	Length (mm)	Water Column Position	N per species	Polymer type	Confidence (Pearson's R)
			Benthic invertivore			
Chironemus marmoratus	Narooma, NSW	205	Benthic	5	*Undetermined*	
Notolabrus gymnogenis	Sydney, NSW	195	Demersal	38	Polyacrylamide	**0.83***
Oxycheilinus digrammus	Lizard Is., QLD	200	Demersal	2	Polyacrylamide	0.68 (low confidence)
Scolopsis margaritifer	Lizard Is., QLD	260	Demersal	1	Vinylidene chloride acrylonitrile	0.75 (low confidence)
			Browsing herbivore			
Prionurus maculatus	North Solitary Is., NSW	330	Demersal	18	Polyacrylamide	**0.84***
Siganus lineatus	Lizard Is., QLD	315	Demersal	9	*Undetermined*	
			Planktivore			
Atypichthys strigatus	Narooma, NSW	44	Pelagic	30	*Undetermined*	
A. strigatus	North Solitary Is., NSW	123			Polyacrylamide	0.74 (low confidence)
A. strigatus	North Solitary Is., NSW	190			Polyethelne	**0.95***
A. strigatus	Sydney, NSW	115			*Undetermined*	
Scorpis lineolata	North Solitary Is., NSW	256	Pelagic	31	Zein	**0.87***
S. lineolata	Narooma, NSW	186			Polyacrylamide	**0.82***

Table 2: List of species for which gut contents were analysed in the present study with the incidence of plastic ingestion.

Species	Incidence of ingested plastic	Species sample size	% Frequency occurrence of plastic injestion
Algal farmer			
Dischistodus melanotus	0	1	0
Dischistodus perspicillatus	0	3	0
Dischistodus prosopotaenia	0	1	0
Stegastes apicalis	0	3	0
		Total	0
Benthic invertivore			
Acanthopagrus australis	0	7	0

Balistapus undulatus	0	1	0
Cheilinus fasciatus	0	5	0
Cheilinus trilobatus	0	2	0
Cheilodactylus fuscus	0	30	0
Cheilodactylus spectabilis	0	11	0
Chironemus marmoratus	1	5	20
Choerodon schoenleinii	0	2	0
Cnidoglanis macrocephalus	0	1	0
Coris gaimard	0	1	0
Coris picta	0	8	0
Diagramma labiosum	0	2	0
Enoplosus armatus	0	8	0
Epibulus insidiator	0	8	0
Gymnocranius spp.	0	5	0
Halichoeres chloropterus	0	6	0
Hemigymnus melapterus	0	8	0
Latridopsis forsteri	0	1	0
Lethrinus harak	0	5	0
Lethrinus nebulosus	0	6	0
Lethrinus obsoletus	0	1	0
Lethrinus spp.	0	1	0
Nemadactylus douglasii	0	1	0
Neoniphon sammara	0	1	0
Notolabrus fucicola	0	8	0
Notolabrus gymnogenis	1	38	2.6
Notolabrus tetricus	0	7	0
Ophthalmolepis lineolatus	0	26	0
Oxycheilinus digrammus	1	2	50
Parequula melbournensis	0	1	0
Parupeneus barberinus	0	9	0
Parupeneus ciliatus	0	3	0
Parupeneus indicus	0	3	0
Parupeneus spilurus	0	10	0
Pempheris spp.	0	8	0
Pentaceropsis recurvirostris	0	2	0
Pictilabrus laticlavius	0	8	0
Plectorhinchus albovittatus	0	3	0
Plectorhinchus chaetodonoides	0	6	0
Plectorhinchus chrysotaenia	0	1	0
Plectorhinchus flavomaculatus	0	4	0
Plectorhinchus gibbosus	0	2	0
Plectorhinchus lineatus	0	3	0
Pomacanthus sexstriatus	0	5	0

Pseudocaranx georgianus	0	10	0
Sargocentron spiniferum	0	4	0
Scolopsis bilineata	0	2	0
Scolopsis margaritifer	0	1	0
Scolopsis monogramma	0	6	0
Scorpaena jacksoniensis	0	7	0
Sufflamen chrysopterum	0	5	0
Thalassoma hardwicke	0	2	0
Thalassoma lunare	0	14	0
Thalassoma lutescens	0	15	0
Zanclus cornutus	0	10	0
		Total	0.9
Browsing Herbivore			
Acanthurus dussumieri	0	9	0
Acanthurus lineatus	0	3	0
Acanthurus nigrofuscus	0	3	0
Acanthurus olivaceus	0	6	0
Acanthurus xanthopterus	0	6	0
Aplodactylus arctidens	0	6	0
Aplodactylus lophodon	0	8	0
Ctenochaetus striatus	0	6	0
Eubalichthys bucephalus	0	5	0
Eubalichthys mosaicus	0	12	0
Girella elevata	0	4	0
Girella tricuspidata	0	16	0
Girella zebra	0	8	0
Kyphosus cinerascens	0	3	0
Kyphosus spp.	0	12	0
Kyphosus sydneyanus	0	8	0
Kyphosus vaigiensis	0	4	0
Meuschenia australis	0	2	0
Meuschenia freycineti	0	12	0
Meuschenia trachylepis	0	14	0
Neoglyphidodon melas	0	1	0
Olisthops cyanomelas	0	16	0
Parma microlepis	0	19	0
Parma unifasciata	0	17	0
Prionurus maculatus	1	18	5.5
Prionurus microlepidotus	0	18	0
Siganus argenteus	0	3	0
Siganus corallinus	0	3	0
Siganus doliatus	0	5	0
Siganus fuscescens	0	8	0

Siganus lineatus	1	9	11.1
Siganus vulpinus	0	3	0
		Total	0.7
Corallivore			
Chaetodon auriga	0	2	0
Chaetodon citrinellus	0	4	0
Chaetodon flavirostris	0	6	0
Chaetodon guentheri	0	2	0
		Total	0
Higher carnivore			
Acanthistius ocellatus	0	11	0
Anyperodon leucogrammicus	0	1	0
Aprion virescens	0	1	0
Aulopus purpurissatus	0	5	0
Aulostomus chinensis	0	1	0
Carangoides fulvoguttatus	0	3	0
Carangoides plagiotaenia	0	3	0
Caranx melampygus	0	1	0
Caranx papuensis	0	5	0
Cephalopholis cyanostigma	0	7	0
Dinolestes lewini	0	10	0
Epinephelus maculatus	0	4	0
Epinephelus malabaricus	0	2	0
Epinephelus merra	0	1	0
Epinephelus ongus	0	1	0
Epinephelus quoyanus	0	4	0
Glaucosoma scapulare	0	1	0
Lutjanus carponotatus	0	8	0
Lutjanus fulviflamma	0	2	0
Lutjanus fulvus	0	1	0
Lutjanus russellii	0	8	0
Plectropomus leopardus	0	6	0
Seriola hippos	0	2	0
Seriola rivoliana	0	1	0
Trachurus novaezelandiae	0	3	0
		Total	0
Omnivore			
Acanthaluteres vittiger	0	12	0
Amblyglyphidodon curacao	0	3	0
Canthigaster spp.	0	1	0
Dascyllus aruanus	0	4	0
Naso brevirostris	0	4	0
Pomacentrus moluccensis	0	5	0

Pomacentrus spp.	0	4	0
		Total	**0**
Planktivore			
Abudefduf sexfasciatus	0	4	0
Acanthochromis polyacanthus	0	6	0
Atypichthys strigatus	4	30	13.3
Caesio cuning	0	14	0
Chromis atripectoralis	0	1	0
Hemiglyphidodon plagiometopon	0	3	0
Heniochus spp.	0	1	0
Mecaenichthys immaculatus	0	1	0
Microcanthus strigatus	0	2	0
Myripristis adusta	0	2	0
Schuettea scalaripinnis	0	7	0
Scorpis aequipinnis	0	9	0
Scorpis lineolata	2	31	6.5
		Total	**5.4**

Table 3: Records of fish species in Australian waters which have ingested meso-plastics.

Fish	Scientific Name	Trophic guild	Location	Study
Antarctic toothfish	*Dissostichus mawsoni*	Piscivore	Southern Ocean	(Cannon et al., 2016)
Sardines	*Sardinops sagax*	Planktivore	Frenchman Bay, Western Australia	(Crutchett et al., 2020)
Common coral trout	*Plectropomus leopardus*	Piscivore	Australia	(Wootton et al., 2021a)
Bluestriped goatfish	*Upeneichthys lineatus*	Invertivore	Australia	(Wootton et al., 2021a)
Paddlefish	*Lutjanus gibbus*	Invertivore	Australia	(Wootton et al., 2021a)
Sea mullet	*Mugil cephalus*	Herbivore	Australia	(Wootton et al., 2021a)
Mado	*Atypichthys strigatus*	Planktivore	Little Bay, New South Wales	This Study
Hiwihiwi	*Chironemus marmoratus*	Invertivore	Narooma, New South Wales	This Study
Black bream	*Girella tricuspidata*	Herbivore	Sydney, New South Wales	This Study
Crimson banded wrasse	*Notolabrus gymnogenis*	Invertivore	Sydney, New South Wales	This Study
Cheek-lined wrasse	*Oxycheilinus digrammus*	Invertivore	Lizard Island, Queensland	This Study

Yellow-spotted sawtail	*Prionurus maculatus*	Herbivore	North Solitary Island, New South Wales	This Study
Pearly monocle bream	*Scolopsis margaritifer*	Invertivore	Lizard Island, Queensland	This Study
Silver sweep	*Scorpis lineolata*	Planktivore	Narooma, New South Wales	This Study
Golden-lined spinefoot	*Siganus lineatus*	Herbivore	Lizard Island, Queensland	This Study

Figures:

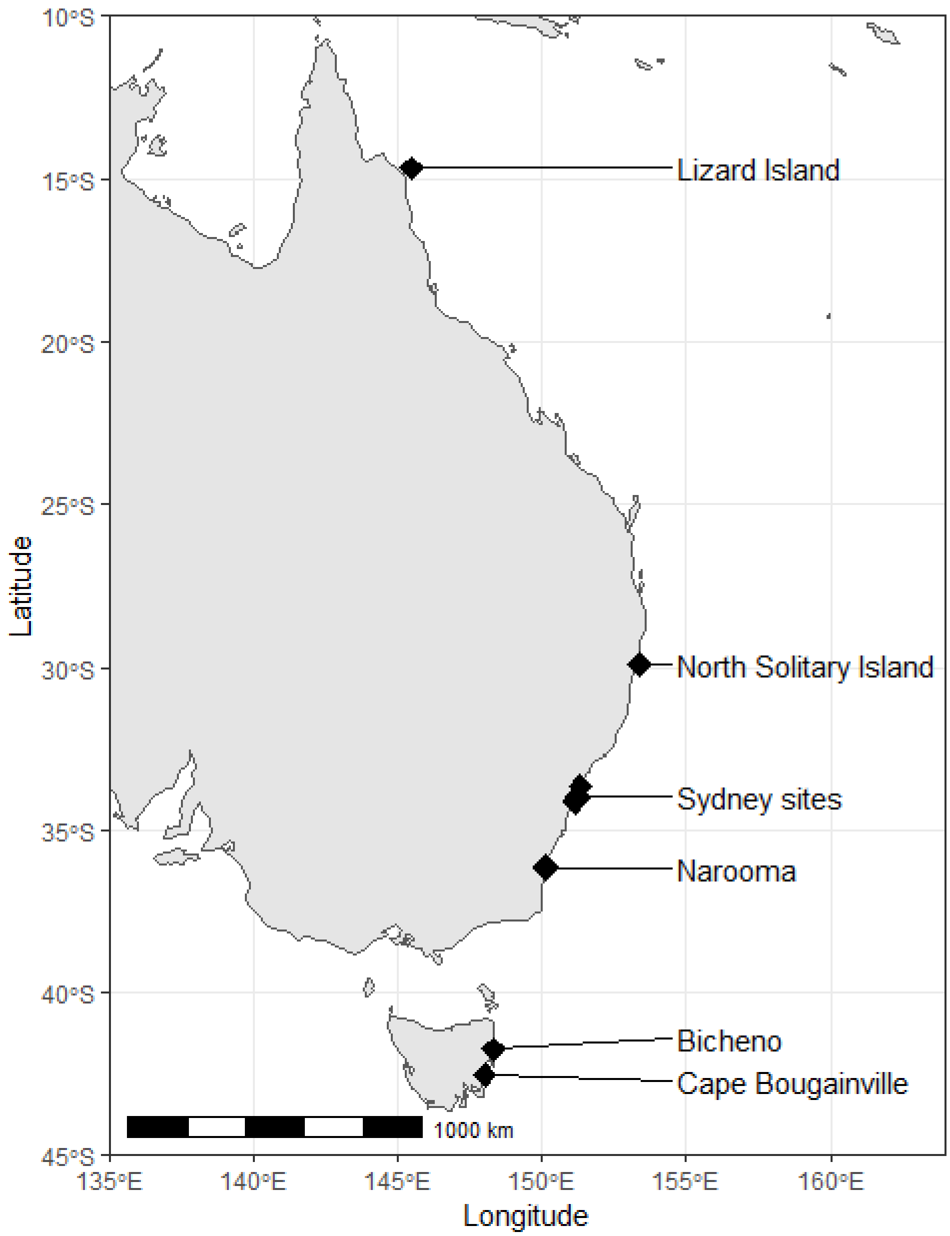

Figure 1. Fish collection sites across the eastern Australian coastline. Collections occurred throughout spring to autumn (2017 – 2019). Fish were collected from 2 sites in Tasmania; Cape Bougainville (-42.515406, 148.004027), Bicheno (-41.869787, 148.310081), 3 sites in New South Wales; Narooma (-36.227563, 150.144585), Sydney (-33.6543, 151.3264; -33.9794, 151.2545), North Solitary Island (-29.9208, 153.3864), and 1 site in Queensland; Lizard Island (-14.6796, 145.4429).

Figure 2: Litter found in Australian reef fish species: (1) *Oxycheilinus digrammus*, Lizard Island QLD; (2) *Atypichthys strigatus*, North Solitary Island; NSW, (3) *Prionurus maculatus*, North Solitary Island NSW; (4) *Scolopsis margaritifer*, Lizard Island QLD; (5) *A. strigatus*, Narooma NSW; (6) *A. strigatus,* North Solitary Island NSW; (7) *S. Lineolata*, North Solitary Island NSW; (8) *A. strigatus*, North Solitary Island NSW; (9) *Notolabrus gymnogenis,* Sydney NSW. Images were taken using a smart phone attached to a portable light box (Saturna imaging system, Ocean Diagnostics). For scale, middle white token is 25mm in diameter.