Wader Beach for Birds not Litter - Tracking the Plastic
Appendix 3

Examination of fish gut contents
Friends of Williamstown Wetlands, Wader Beach Group

Introduction

Friends of Williamstown Wetlands Incorporated (FOWW) is a group of volunteers that undertake conservation activities in the Jawbone Reserve and neighbouring areas in conjunction with the rangers from Hobson's Bay City Council (HBCC). FOWW raised concerns about the amount of litter accumulating on Wader Beach with HBCC and Parks Victoria (PV), and sought funding from the Metropolitan Waste and Resource Recovery Group (MWRRG) under the Litter Hotspots Program to identify the nature and potential source of the litter that had built up on Wader Beach.

The first litter surveys were carried at Wader Beach between December 2014 and May 2015.
A large number of small litter items were found in the surveys, in particular small plastic fragments (<5 cm). Similar small plastic fragments were found in the weed matt at Williamstown Beach and indicate that this type of litter is widespread in the north of the Bay. Multiplying up the initial counts from the Wader Beach sites (4 x 4m transects) would indicate in excess of 28 000 pieces of small plastic fragments along this small beach alone during the initial period of the litter survey. Such small plastic fragments are a potential danger to marine life in Port Phillip Bay. Ingestion of small plastic fragments by fishes (Boerger et al. 2010) and seabirds, in particular the Procellariiformes (albatrosses, petrels and shearwaters, storm petrels, and diving petrels) has been reported from major oceanic regions including an early example in the Antarctic prion *Pachyptila desolata* from Heard Island (Auman et al. 2004), and more recent local examples in flesh-footed shearwater *Puffinus carneipes* in New Zealand waters (Buxton et al. 2013) and short-tailed shearwater *Puffinus tenuirostris* in Australian waters (Acampora et al. 2014). The threat is rising (Wilcox et al. 2016).

Plastic debris is found throughout the world's oceans, lakes, and rivers (Andrady 2011). Approximately 275 million metric tons of plastics were generated in 2010, and it is estimated that 2−5% of this plastic entered the marine environment (Jambeck et al 2011). More than 270 marine species are known to have been affected by plastic entanglement or ingestion. Marine mammals are most affected by entanglement in plastic debris, while seabirds suffer the most from ingestion of plastics (Hammer et al. 2012). It has been estimated that plastic rubbish will outweigh fish in the oceans by 2050 unless the world takes drastic action to recycle the material (see: http://www.abc.net.au/news/2016-01-21/more-plastic-than-fish-in-the-oceans-by-2050-report-warns/7105936).

This project was undertaken to see if local caught sea-fishes had ingested small plastic fragments that are common on beaches in the north of Port Phillip Bay. In addition the literature on plastics in fish guts was reviewed.

Materials and Methods

Whole fish caught by local anglers were sampled between February and May 2016 and in November 2016. Most fish specimens were sampled at the Newport and Williamstown Anglers Club as the fish were landed. For each whole fish the species, fork length, and sex were recorded as the fish was processed. The whole gut was removed and sealed in a labelled plastic bag and stored on ice for subsequent dissection and examination within a few hours.

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Gut sampling methods were adapted from information supplied by CSIRO and James Cook University (see Baker et al.2014). Each gut was dissected individually and the contents floated out in water in a shallow tray. The gut contents were sorted and identified where possible under a 5x dissecting glass and recorded.

The recent literature on plastics in fish guts, much of which has been focused on the northern hemisphere species, was reviewed.

Results

To date the gut contents of 36 snapper *Pagrus auratus*, 14 flathead *Platycephalidae*, 3 Australian salmon *Arripis trutta*, 2 silver trevally *Pseudocaranx* spp., 1 King George whiting *Sillaginodes punctata*, and 1 snook *Sphyraena novaehollandiae* have been examined (Table 1). Forty three specimens had items in their gut contents ranging from fish and squid bait to polychaetes, cestodes, sea-urchin tests and spines, crustacea, miscellaneous crushed invertebrates, small whole squid, small whole fish up to 75 mm, and small vertebral columns, presumably fish. No plastic fragments, pellets or fibres were detected.

Table 1. Results of fish gut analyses

Species	No. specimens	Size range cm	No. with items in guts	Plastic fragments
snapper	36	25-73	23	0
flathead	14	28-39	13	0
salmon	3	35-36	3	0
trevally	2	24,33	2	0
whiting	1	35	1	0
snook	1	58	1	0

Plastics, microplastics, pellets, and fibres

Three categories of plastic size fractions have been recognised in environmental studies:

1. macroplastics >5 mm (e.g. bottles, shopping bags, packaging);
2. large microplastic particles 1−5 mm (e.g. fragments and plastic production pellets or “nurdles”);
3. small microplastic particles <1 mm (Wardrop et al. 2016).

Small microplastics are released into the environment from skin-cleansing soaps containing polyethylene microbeads (MBs), from plastic fibres from machine washing of clothing, and from fragmentation of larger plastics and plastic pellets used in industry. While the term “microplastics” has been applied to plastic debris <5 mm in length, there is a significant difference in the physical characteristics between plastic pellets, ~2−3 mm, and the MBs from personal care products 10−700 µm (Wardrop et al. 2016).

The term macroplastics is all encompassing and does not distinguish large whole items, such as bottles >10 cm, from smaller miscellaneous plastic fragments <5 cm which can be ingested by sea birds (Trevail et al. 2015, Wilcox et al. 2016) and fishes (Romeo et al. 2015). It is possible that large pieces of drifting plastic may be attacked by large fish. Examination of 5518 plastic items from around Kamilo Point, Hawaii Island found 15.8% to have obvious signs of bite marks, most probably by large sharks (Carson 2013).

To date, most researchers have relied on visual examinations of gut contents to detect plastics, but such methods can be subjective (Collard et al. 2015). Chemical methods are time consuming and require a dedicated laboratory, but are increasingly being applied to

detect microplastics, in particular the small microplastics < 1mm, in gut contents (Rochman et al. 2015).

Early evidence for plastic in fish guts

Most reports of plastic in fish guts have been made in the past ten years, but early observations reported that 8 of 14 fish species collected off the northeastern United States contained white, plastic spherules in their guts, with an overall incidence of 5.2% (Carpenter et al. 1972). Similarly, a study in an English estuary with a high concentration of polystyrene particles reported that 10.5% of the fishes had ingested plastic (Kartar et al. 1976). In contrast a study of >500 larval and juvenile fishes collected from the northwestern Atlantic that contained a high concentration of floating plastic debris found no evidence for plastic particles in the guts (Colton et al. 1974).

Plastics in fish guts

1. The Mediterranean Sea

The Mediterranean Sea is one of the most polluted seas worldwide, especially with regard to plastics. A review of the scientific literature on the interaction of plastic with marine biota resulted in the identification of 134 species, covering several taxa and feeding strategies, impacted by plastics (Deudero and Alomar, 2015). Different levels of ingestion were found in fishes, with pelagic fish and elasmobranchs the most likely to contain plastic fragments. In contrast, several species, such as the hake *Merluccius merluccius*, red gurnard *Chelidonichthys cuculu*, red mullet *Mullus surmuletus*, John dory *Zeus fabe*, catshark *Scyliorhinus canicula* and thornback ray *Raja clavata*, seemed to show little sign of ingesting plastic (Deudero and Alomar 2015). The large filter feeding basking shark (*Cetorhinus maximus*) is also vulnerable to microplastics in the Mediterranean Sea (Fossi et al. 2014).

Approximately 18% (22/123) of three species of large pelagic predators, swordfish *Xiphias gladius* (n = 56), bluefin tuna *Thunnus thynnus* (n = 36), and albacore *Thunnus alalunga* (n =31), collected from the Central Mediterranean Sea had plastic fragments in their guts (Romeo et al. 2015).

Examination of 26 deep-water fish species (1504 specimens) caught in the Eastern Ionian Sea found plastic debris in only 24 individuals of catshark *Galeus melastomus* (3.2%) and single individuals of the pelagic stingray *Pteroplatytrygon violacea*, dogfish *Squalus blainville*, lantern shark *Etmopterus spinax*, and black spot bream *Pagellus bogaraveo*. The occurrence of debris among their food was infrequent and included primarily plastics (86.5%) and to a lesser extent pieces of metal and wood. Among ingested plastics, fragments of hard plastic material constituted the highest proportion (56.0%), followed by fragments of plastic bags (22.0%), fragments of fishing gear (19.0%), and textile fibres (3.0%) (Anastasopoulou et al. 2013).

2. The North Pacific Ocean

The North Pacific Central Gyre (NPCG) is well known as an area that has accumulated a large amount of marine debris. The impacts of this debris on large marine animals, such as turtles and mammals, have been documented through cases of entanglement and ingestion. The first study to measure the impacts on small planktonic pelagic fishes found plastic fragments in approximately 35% of fishes examined. Five mesopelagic (200-1000 m depth range) and 1 epipelagic (0-200 m) species had an average of 2.1 pieces of plastic per fish rising to 7 pieces in 7+ cm fish; 94% of the plastic was fragments (Boerger et al 2010).

However, another study of 141 fishes from 27 species of mesopelagic fishes sampled in the North Pacific subtropical gyre found that only 9.2% contained plastic (Davidson & Asch

2011). The discrepancy between the two studies was suggested to be due to the influence of net feeding. The Manta net used by Boerger et al. (2010) to capture mesopelagic fishes was deployed for 1.5 to 5.5 hours at a time. This unusually long tow duration implies that the collected fishes may have been in contact for hours with elevated and increasing concentrations of plastic in the cod end of the net (Davidson & Asch 2011).

A study of predatory pelagic fishes from the central North Pacific found plastics in 7 out of 10 species (n = 595 individuals). Of all individuals 19% contained some form of marine debris, the majority of which was plastic or fishing-related line. Surprisingly, species with the highest incidences of debris ingestion are thought to be primarily mesopelagic and unlikely to come into contact with surface waters containing known patches of debris (Choy and Drazen, 2013).

3. Indonesia and California

Fish were sampled from markets in Indonesia (11 species) and from California (12 species), and anthropogenic debris extracted from the fish guts using a chemical extraction method and then quantified under a dissecting microscope (Rochman et al. 2015). In Indonesia, anthropogenic debris was found in 28% of individual fish and in 55% of all species. Similarly, in the USA, anthropogenic debris was found in 25% of individual fish and in 67% of all species. However, all of the anthropogenic debris recovered from fish in Indonesia was plastic, whereas anthropogenic debris recovered from fish in the USA was primarily fibres, only 9% specimens had plastic, leading the authors to conclude that the differences in plastic types likely reflect different sources and waste management strategies between countries (Rochman et al. 2015).

4. English Channel and North Sea

Ten fish species caught in the English Channel, 5 demersal and 5 pelagic feeders, were tested for plastics. Microplastics were identified in the guts of approximately one third of specimens (184/504), with no difference in amounts between pelagic and demersal species. Across all species, the average number of pieces of microplastic was just less than two per fish, although there were examples of fish ingesting up to 15 pieces (Lusher et al. 2013).

The gut contents were examined with a technique called Fourier transform infrared spectroscopy (FT-IR), which identifies what samples are made of based on how they absorb different wavelengths of light. More than half of the microplastic debris was rayon and around a third was polyamide, with polyester, polystyrene, polyethylene and acrylic making up the remainder. Polyester and polyamide are commonly used by the fishing industry (in ropes, nets and lines), whilst rayon could have come from textiles or via sewage, hygiene products, or nappies. Polystyrene, polyethylene and acrylic, which are less dense than polyester and rayon were only found in pelagic fish (Lusher et al. 2013).

In a study of seven species of North Sea fishes, plastic particles were found in five species but only in 2.6% of the examined specimens. No plastics were found in the demersal gray gurnard *Eutrigla gurnardus* and the pelagic Atlantic mackerel *Scomber scombrus*. In most cases, only one particle was found per fish, ranging in size from 0.04 to 4.8 mm. Interestingly, small fibres were initially detected in most of the samples, but their abundance sharply decreased when working under special clean air conditions. These fibres were considered to be artifacts related to air born contamination and were excluded from the analyses (Foekema et al. 2013). This rigour has not been applied to all studies reporting micro-fibres in fishes.

5. Australia

The concentrations of plastics in waters around Australia have been measured in surface net tows. 839 marine plastics were recorded, predominantly small fragments, resulting from the

breakdown of larger objects made of polyethylene and polypropylene (e.g. packaging and fishing items). Plastic contamination levels in surface waters of Australia are similar to those in the Caribbean Sea and Gulf of Maine, but considerably lower than those found in the subtropical gyres and Mediterranean Sea (Reisser et al. 2013).

There are unpublished reports of plastics in Australian fishes and several ongoing studies. Prof Emma Johnston UNSW has found evidence for microplastics in fishes caught in Sydney harbour in particular micro-fibres. CSIRO scientists have sampled small pelagic fishes off the east coast for gut content analyses. Occasionally anglers have reported finding plastic in fish guts, for example a glow-stick in a mulloway *Sciaena antarctica* caught in the Hopkins River NSW (https://www.facebook.com/scabduty/posts/472977482905232).

Summary

No evidence was found for microplastics in fish guts in fishes sampled in northern Port Phillip Bay. While this is a positive result further work is required to include a wider sample of fishes, in particular pelagic feeders, as there is some evidence from overseas studies that these feeders are more likely to ingest plastics. The observations were made under a 5x magnification and it is possible that low numbers of small particles, such as micro-fibres, would have been overlooked. The visual method would not allow the detection of microbeads, 10−700 µm, derived from personal care products.

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Peter Smith
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