birdlife
TASMANIA

9 October 2015

Committee Secretary
Senate Standing Committees on Environment and Communications
PO Box 6100
Parliament House
Canberra ACT 2600
ec.sen@aph.gov.au

BirdLife Australia submission to the Senate Standing Committee on Environment and Communications, Inquiry into "The threat of marine plastic pollution in Australia".

An introduction to BirdLife Australia

BirdLife Australia was founded in 1901 as the Royal Australasian Ornithologists' Union (RAOU). The organisation adopted the name Birds Australia in 1996 and then BirdLife Australia in 2012. There are more than 12,000 members and 65,000 supporters nationally (as of October 2015).

BirdLife Australia's efforts are directed towards the conservation of Australia's birds and their habitats. BirdLife Australia is the nationally-recognised source of professional expertise and advice regarding bird conservation and management throughout the country. Some of the longest time-series and geographically widespread biological data sets in Australia have been initiated and undertaken by BirdLife Australia's members.

BirdLife Australia welcomes this opportunity to provide the Committee with a submission to its inquiry into the threat of marine plastic pollution in Australia. As the nation's pre-eminent ornithological organisation, our submission will focus on an unrecognised threat to shorebirds (also known as waders).

BirdLife Australia can provide the Committee with copies of all of the scientific papers cited in this submission, and would welcome the opportunity to appear before the Committee to expand upon this submission if this would assist the Committee in its efforts.

Yours sincerely

Dr Eric J Woehler
Convenor, BirdLife Tasmania
tasmania@birdlife.org.au
on behalf of BirdLife Australia

BIRDLIFE TASMANIA
GPO BOX 68
HOBART
TASMANIA 7001

tasmania@birdlife.org.au
birdlife.org.au

ABN 75 149 124 774

SUMMARY OF SUBMISSION

BirdLife Australia's submission identifies a significant gap in our knowledge of the threats to shorebirds from marine microplastics. These birds feed on the marine foreshores and prey on invertebrates that are known to ingest microplastics by filter-feeding.

Of particular concern is that the shorebirds may potentially act as bio-magnifiers/bio-accumulators of the adsorbed chemicals in the same manner that Peregrine Falcons and Brown Pelicans accumulated DDT in the 1960s (coastal shades of Rachel Carsen's *Silent Spring*).

As top predators, birds accumulated the chemicals from their food and ultimately their physiology was adversely affected, reducing their capacity to breed successfully and their populations crashed to the points of near-extinction. This gap in our current knowledge provides an opportunity for directed research by Australian scientists.

SUMMARY OF RECOMMENDATIONS

Recommendation 1 BirdLife Australia requests the Commonwealth Government to support directed and detailed scientific research on the distribution, abundance and size characteristics of microplastics on Australian beaches and estuaries. This research should also investigate the rates of accumulation of microplastics and the nature of associated adsorbed POPs and metals on the microplastics.

Recommendation 2 BirdLife Australia requests the Commonwealth Government to adopt the 2009 Draft guidelines for 36 migratory shorebird species - Migratory species (EPBC Act Policy Statement 3.21) as a matter of urgency. Further, BirdLife Australia recommends the *Wildlife Conservation Plan for Migratory Shorebirds* be revised to include research on interactions between shorebirds and microplastics.

Recommendation 3 BirdLife Australia requests the Commonwealth Government to consider identifying marine microplastics as threats to Australia's resident and migratory shorebirds if scientific studies indicate it poses a potential risk to these species. This could be achieved, for example, by identifying microplastics as a key threatening process under the EPBC Act.

In the absence of empirical scientific data that may take years to obtain, there is a strong case for the application of the Precautionary Principle to identify microplastics as a key threatening process under the EPBC Act.

Recommendation 4 BirdLife Australia requests the Commonwealth Government to support directed scientific research into the interactions between shorebirds and microplastics in Australia. Based on this submission, we have identified the following initial foci:

- determine the chemical natures of the POPs and metals, and their concentrations, present on microplastics in coastal waters, in coastal sediments and on beach-washed kelps, grasses,
- determine if microplastics are present in zooplankton around Australia, and if so, are these species preyed upon by shorebirds, and do their concentrations in zooplankton increase in proximity to urban centres and manufacturing facilities (eg Wright et al. 2013),
- determine if microplastics are present in the stomachs and faeces of resident and migratory shorebirds, and if so are there differences between resident and migratory species?,

- determine the key risks to shorebirds from microplastics, and the ecological pathways involved,
- examine the relationship between microplastics levels in birds and their body POP/metals levels, with the expectation that the relationship between their levels will be correlated,
- investigate the potential for inference studies to serve as proxies for microplastics and chemical levels in shorebirds, by examining known prey species of Australian resident and migratory shorebirds; such studies would serve to minimise the need to sacrifice/collect living birds for sampling,
- investigate the potential for non-destructive methods to assess exposure and/or ingestion by shorebird (eg Hardesty et al. 2014), and
- Investigate the potential for opportunistic studies to assess the presence of microplastics in shorebirds that die from other causes (predator kills, vehicle strikes etc).

CONTEXT AND OUTLINE OF BIRDLIFE SUBMISSION

Even a preliminary search on the web for scientific papers and studies on the threats and impacts of marine plastics to seabirds produces hundreds of thousands of unique links. The overwhelming majority of these studies focus on the issues of entanglement in, and ingestion of marine plastic pollution by marine birds around the world, from the tropics to the Antarctic and Arctic.

The literature dealing with ingestion has two primary foci – ingestion by seabirds and by marine turtles. Smaller bodies of literature deal with ingestion by whales, fish and shellfish, for which there are numerous published reviews (eg Besseling et al. 2015 and Fossi et al. 2012).

This vast body of scientific knowledge continues to increase rapidly as more species (primarily but not confined to marine seabirds) are investigated, and more sites are assessed for their plastic contamination. There is no doubt as to the existence, persistence and universality of the threats to seabirds from marine plastic pollution (Wilcox et al. 2015), but perhaps the magnitude and scale of impacts are yet to be fully appreciated by the broader community and potentially, lawmakers.

It is important to differentiate from the outset between the ‘macroplastics’ that are often shown filling albatrosses’ stomachs and nests with items such as cigarette lighters, glow-sticks and various plastic fragments in excess of 1cm, and “true” microplastics – articles smaller than 0.5mm – approximately the size of the full stop at the end of this sentence**.**

Despite the extensive body of scientific literature, one group of birds has not been studied – that is the shorebirds (also known as waders) that inhabit coastal margins around the world.

Unfortunately, this group of coastal birds has been overlooked in previous syntheses and reviews (eg Kühn et al. 2015, Wilcox et al. 2015), as they are not seabirds in a scientific sense, despite their partial- to complete dependence on marine ecosystems.

Shorebirds exist in a “grey” management zone repeatedly pushed into the ‘too hard’ basket – they are deemed to be “marine” by terrestrial planners and managers, and “terrestrial” by marine planners and managers, with the result that coastal management strategies, plans and efforts often exclude these birds.

BirdLife Australia recognises impacts of ingestion of, and entanglement in marine plastic by seabirds such as albatrosses and petrels. However, as these are recognised and detailed in the *Threat abatement plan for the impacts of marine debris on vertebrate marine life* (Commonwealth of Australia, 2008), we will not address these impacts in this submission.

Nor will we address the impacts associated with the dispersion of invasive species facilitated by marine debris; plastic fragments can act as substrates to allow the transport of alien species, eg Gregory (2009), or the source(s) and types of microplastics in the marine environment.

We believe these are sufficiently well documented and expect other submissions will address these to provide the Committee with the evidence it requires.

Our submission seeks to focus on a novel, and to date un-studied facet of the discussion and assessment of the impacts of plastic pollution in the marine environment.

We seek to broaden this discussion to outline the potential threat to resident and migratory shorebirds from the ingestion of microplastics and the associated adsorbed chemicals. Based on our current understanding of coastal processes and the foraging ecologies of the shorebird species involved, BirdLife Australia believes shorebirds in Australia, and indeed globally, are highly likely to be at risk from marine microplastics.

It is perhaps only in the last three years that the threats to shorebirds from marine plastic pollution has even been considered. We are aware of just a single mention of the 'potential' threat to shorebirds from micro-plastics – a brief mention in Sutherland et al. 2012 considers microplastics as a, "possible future threat", and there is no mention of the associated adsorbed chemicals.

We are unable to locate any other mention in the scientific literature referring to shorebirds and microplastics. In preparation for this submission, we have been unable to locate any research that has been undertaken to provide any understanding of the real and potential linkages and ecological relationships, and any consequences with respect to the ingestion of microplastics by shorebirds. [1]

This is truly a remarkable and alarming situation, as it suggests that no researchers have identified this threat or have undertaken research to investigate the issue.

In the absence of shorebird-specific scientific studies that could be drawn upon for this submission, we have prepared our submission that provides the Committee with examples from closely-related species and/or from studies conducted in Australia on other species.

We will argue the ecological relationships identified in other studies on closely-related species in similar habitats are valid and directly applicable to shorebirds in Australia. Based on these studies, we propose that microplastics and associated adsorbed chemicals (POPs and metals) are highly likely to pose a significant, non-zero and previously unrecognised risk to resident and migratory species of shorebirds in Australia.

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[1] We have been provided with a copy of an internal unpublished US National Marine Fisheries Service (NMFS) report (Robards 1993) that reports on the presence of 18 plastic particles in the stomach of a "Bar-tailed Godwit" collected from drift nets in the North Pacific Ocean. The study reported the 18 pieces weighed 1.25g in total, and comprised 2 "pellets" (raw plastic used in manufacture) and 16 pieces of "user" plastic (sourced from plastic objects dumped or lost at sea). The size ranges were 11 "small" pieces (61%, 0 – 10mm), 6 "medium" pieces (33%, 11 – 20mm) and 1 "large" piece (6%, over 20mm).

No further details are provided, but as the collection method (drift net at sea) is inconsistent with the flight and foraging behaviour of Bar-tailed Godwits, there is a possibility of mis-identification of the bird. Conversely, if the identification is correct, then some other means of bird collecting was used that is not provided in the NMFS report. In either case, our statement of no publication in the scientific literature reporting on shorebirds ingesting microplastics remains valid.

Robards M (1993) Plastic ingestion by North Pacific seabirds. US National Marine Fisheries Service, Final report 43ABNF203014, 16pp.

MARINE PLASTIC POLLUTION IN AUSTRALIA

Ryan et al. (2009) and Andrady (2011) review the broad spectrum of sources, the primary types and estimated masses of microplastics in the marine environment. Reisser et al. (2012), Reisser et al. (2013) and Wilcox et al. (2015) provide Australian reviews and context, and Wright et al. (2013) is an example of a recent review into the physical impacts of microplastics on marine organisms.

Kühn et al. (2015) recently reviewed the current state of knowledge regarding the deleterious effects of plastics in the marine environment. Eriksen et al. (2014) recently estimated that more than 5 trillion pieces of plastic are floating on the world's oceans, weighing more than 250,000 tonnes, (see also Gross 2015 and Katsnelson 2015).

Unfortunately, the terminology used in various studies around the world is slightly ambiguous, with different authors using the terms microplastics and microlitter interchangeably. Andrady (2011) adopts a size criterion of 0.5mm as the upper threshold for microplastics; other studies use different criteria (eg Ryan et al. 2009, Sutherland et al. 2012, Reisser et al. 2013), including NOAA (Wright et al. 2013).

Not all sources of microplastics are anthropogenic. Davidson (2012) reported on how individual burrowing isopods (invertebrates) can generate thousands of microplastic particles by boring into Styrofoam floats used in jetties, docks and aquaculture facilities, noting that, "*… floats from aquaculture facilities and docks were heavily damaged by thousands of isopods and their burrows.*"

A significant proportion of microplastics is the result of the physical breakdown of larger ('macroplastics') fragments; the fragments become smaller and smaller, but never disappear. With each reduction in size, so the opportunity for the interaction between plastic fragments and the marine environment starts again with different species and different pathways into the marine food web. In tidal areas, tidal forces will constantly resuspend and redeposit microplastics.

Davidson's (2012) study concluded that, "*… one isopod creates thousands of microplastic particles when excavating a burrow; colonies can expel millions of particles. Microplastics similar in size to these particles may facilitate the spread of non-native species or be ingested by organisms causing physical or toxicological harm.*"

Andrady (2011) notes that micro-biota (microscopic animals and plants) overlap with the size range of microplastics in the marine environment. This overlap in size (and the commonality in colours of microplastics and marine prey species) facilitates and pre-disposes the capture and ingestion of microplastics by predators such as coastal invertebrates, fish, birds and mammals.

Many species of seabirds are acknowledged to mistake microplastic particles for prey species (eg Reisser et al. 2013), but no such consumption/ingestion studies have been undertaken on shorebirds.

In the absence of empirical studies, we are unable to state that shorebirds do or do not directly ingest microplastics during feeding in the same way that albatrosses and shearwaters do (for example), perceiving the fragments as prey. However, given the filter-feeding invertebrates do ingest microplastics, and shorebirds prey on closely-related species of invertebrates, at least one ecological pathway exists for shorebirds to ingest microplastics and their associated adsorbed chemicals and metals (see below).

ACCUMULATION OF CHEMICALS ON THE SURFACES OF PLASTIC PARTICLES BY ADSORPTION

Andrady (2011) noted, "… *persistent organic pollutants (POPs) that occur universally in seawater* *at very low concentrations are picked up by microplastics. The hydrophobicity of POPs facilitates their concentration in the microplastic litter at a level that is several orders of magnitude higher than that in seawater. When these contaminated plastics are ingested by marine species, this presents a credible route by which the POPs can enter the marine food web. The extent of bioavailability of POPs dissolved in the microplastics to the biota and their potential bio-magnification in the food web has not been studied in detail*"

Andrady (2011) reported on the scale of accumulation of pollutants on the surfaces of plastic particles, in which levels of polycyclic aromatic hydrocarbons (PAHs), PCBs, DDT and hexachloro-cyclohexanes were significantly higher than background levels. Recent work has suggested that micro- and meso-plastic debris may also concentrate metals in addition to the POPs (eg Lavers et al. 2014, Lavers and Bond in press). Micro-porous particles have enormous capacities to accumulate pollutants, due to their increased surface areas.

The research by Andrady (2011) is supported by numerous other studies (eg Mato et al. 2001 and Holmes et al. 2014), and do Sul and Costa (2014) reviewed the adsorption [ie *to hold molecules of a gas or liquid or solute as a thin film on the outside surface or on internal surfaces within the material*]of pollutants onto microplastic particles.

Organochlorines, including DDT, have been shown to accumulate in beach species, such as crabs in California (Burnett, 1971) and other invertebrates have been shown to accumulate POPs (Chua et al. 2014). As crabs and invertebrates are prey for birds, fish and mammals, there is the potential for trophic transfer, potentially reaching humans (Schlacher et al. 2014, see also Lavers et al. 2014).

Recommendation 1 BirdLife Australia requests the Commonwealth Government to support directed and detailed scientific research on the distribution, abundance and size characteristics of microplastics on Australian beaches and estuaries. This research should also investigate the rates of accumulation of microplastics and the nature of associated adsorbed POPs and metals on the microplastics.

INVERTEBRATE INGESTION OF MICROPLASTIC PARTICLES WITH ADSORBED CHEMICALS AND METALS

Many marine animals feed by filtering the surrounding seawater for food particles, known as filter-feeding. With the overlap in sizes of food and microplastic particles, this common marine feeding mechanism allows for the direct ingestion of microplastic particles from the marine environment by animals as small as crustaceans, some shorter than 1cm (Cole et al. 2013, Ugolini et al. 2013, Setälä et al. 2014) to baleen whales such as the Blue Whale, the largest animal on the planet.

Microplastics overlap with the size of the staple phytoplankton diet of zooplanktons and there is now considerable evidence that these can be ingested (eg Cole et al. 2013, Ugolini et al. 2013, Setälä et al. 2014, Watts et al. 2014 and see also Reisser et al. 2014). However, there are currently very few studies on the bioaccumulation of plastics and their associated POPs across marine trophic levels (Wright et al. 2013), ie from prey species to predator(s) to higher predator(s).

Laboratory microplastic ingestion studies have mostly focussed on invertebrates (eg Cole et al. 2013, Ugolini et al. 2013) but some vertebrates have been studied (see review in do Sul and Costa 2014).

Microplastics can be a significant carrier of POPs and a source of pollutants such as polyethylene, polypropylene, and polyphenols that can potentially affect organisms, and additional studies are required to assess the transfer mechanisms of those compounds from plastic to zooplanktonic organisms at the base of the food chain (Chua et al. 2014).

Given that lower trophic organisms, specifically invertebrates, can ingest and accumulate microplastic particles and their associated POPs, it is likely that microplastics and associated POPs are now well established in marine food webs (do Sul and Costa 2014) and further studies will likely identify additional linkages in marine food chains and webs.

A BRIEF INTRODUCTION TO RESIDENT AND MIGRATORY SHOREBIRDS (WADERS) IN AUSTRALIA

The Environment Protection and Biodiversity Conservation Act (EPBC Act) 1999 provides the Commonwealth Government with the powers to protect resident and migratory shorebirds, and their habitats, within Australia. The Act also allows the government to identify threats to these species, including key threatening processes (KTPs).

<u>(a) Resident shorebirds in Australia</u>

A total of 17 species of shorebird breed in Australia and are deemed to be resident species (Table 1). These species breed and feed on a broad range of coastal, estuarine and freshwater foreshores throughout Australia. Three are listed as threatened species and seven are listed Marine species under the Act.

Of these 17 species, four species are dependent to highly-dependent on marine coastlines (Beach Stone-curlew, Hooded Plover, Pied Oystercatcher and Red-capped Plover). Beach Stone-curlews are obligate coastal species, as is the Hooded Plover in eastern and southeastern Australia.

Coastal species such as Hooded Plovers and Pied Oystercatchers predominantly remain in their territories for life, nesting, feeding and raising their chicks on beaches and estuaries. They obtain their food from the beach, with food particles and prey species transported to the beach by waves and tides. Other prey species are living invertebrates in and on the sand and beach-washed kelps, sea-weeds and sea-grasses.

Table 1. Australian resident shorebirds, coastal species are highlighted (4 species)

Current Scientific Name	Common Name	EPBC Act
Burhinus grallarius	Bush Stone-curlew	
Charadrius australis	Inland Dotterel	
Charadrius ruficapillus	**Red-capped Plover**	**Marine**
Cladorhynchus leucocephalus	Banded Stilt	
Elseyornis melanops	Black-fronted Dotterel	
Esacus giganteus	**Beach Stone-curlew**	**Marine**
Haematopus fuliginosus	Sooty Oystercatcher	
Haematopus longirostris	**Pied Oystercatcher**	
Himantopus leucocephalus	Black-winged Stilt	Marine
Irediparra gallinacea	Comb-crested Jacana	
Pedionomus torquatus	Plains Wanderer	Critically Endangered
Recurvirostra novaehollandiae	Red-necked Avocet	Marine
Rostratula australis	Painted Snipe	Endangered, Marine
Stiltia isabella	Australian Pratincole	Marine
Thinornis rubricollis	**Hooded Plover**	**Threatened, Marine**
Vanellus miles	Masked Lapwing	
Vanellus tricolor	Banded Lapwing	

(b) Migratory shorebirds in Australia

Approximately 50 species of migratory shorebirds visit Australia, primarily within the East Asian – Australasian Flyway (EAAF) – a migratory corridor linking Australia and New Zealand with Siberia, northern and central Asia and North America.

The birds nest and breed in the Northern Hemisphere then migrate to Australia and New Zealand to spend the summer months here before returning to their northern nesting sites. One species of shorebird migrates between New Zealand and Australia.

Of these 50 or so species, 36 migratory shorebird species regularly visit Australia each year. These species of shorebirds are listed as migratory and marine under the EPBC Act, and are a matter of national environmental significance.

Two species, Eastern Curlew and Curlew Sandpiper are listed as Critically Endangered under the EPBC Act. The conservation status of a further six species are presently under consideration by the Commonwealth Government.

Migratory shorebirds undertake remarkable annual migration between the northern and southern hemispheres. The smallest species, Red-necked Stints weigh approximately 25g and migrate between Siberia and Australia in six weeks with stopovers along the way to feed and rest. They spend the summer months in Australia before returning to Siberia in six weeks. They live for up to 20 years and each year travel approximately 25,000km. Over their lifetime, these tiny birds fly farther that the distance between the Earth and the Moon.

Larger species, such as Bar-tailed Godwits fly up to 11,000km non-stop, for example between Alaska and New Zealand. When they leave Australia, they fly non-stop to China before flying on to Siberia. These long-distance migrations are only possible through intensive feeding by the birds at coastal sites *en route*.

In 2009, the Commonwealth produced draft significant impact guidelines for 36 migratory shorebird species - *Migratory species (EPBC Act Policy Statement 3.21*, Department of the Environment, Water, Heritage and the Arts, 2009) but these do not identify marine plastics or microplastics as potential or real threats to shorebirds, as these were not known at the time (see below).

Under the EPBC Act, wildlife conservation plans may be prepared for the purposes of protection, conservation and management of listed migratory, marine species. The *Wildlife Conservation Plan for Migratory Shorebirds* (Commonwealth of Australia 2014) provides a framework to guide conservation of 37 migratory shorebird species and their habitats in Australia, and in recognition of their migratory habits, outlines national activities to support their appreciation and conservation throughout the East Asian-Australasian Flyway (EAAF). The Draft Plan is available at https://www.environment.gov.au/biodiversity/publications/draft-wildlife-conservation-plan-migratory-shorebirds

The complete list of migratory species protected under the EPBC Act are at https://www.environment.gov.au/cgi-bin/sprat/public/publicshowmigratory.pl and Table 2 lists the migratory shorebirds protected under the EPBC Act 1999.

Table 2. Migratory shorebirds listed under the EPBC Act and international treaties.

Current Scientific Name or Listed Scientific Name	Common Name	Bonn	CAMBA	JAMBA	ROKAMBA
Actitis hypoleucos	Common Sandpiper	A2H	X	X	
Actitis hypoleucos/ Tringa hypoleucos	Common Sandpiper				X

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Current Scientific Name or Listed Scientific Name	Common Name	Bonn	CAMBA	JAMBA	ROKAMBA
Arenaria interpres	Ruddy Turnstone	A2H	X	X	X
Calidris acuminata	Sharp-tailed Sandpiper	A2H	X	X	X
Calidris alba	Sanderling	A2H	X	X	
Calidris alba/ Crocethia alba	Sanderling				X
Calidris alpina	Dunlin				X
Calidris bairdii	Baird's Sandpiper			X	
Calidris canutus	Red Knot, Knot	A2H	X	X	X
Calidris ferruginea	Curlew Sandpiper	A2H	X	X	X
Calidris mauri	Western Sandpiper			X	
Calidris melanotos	Pectoral Sandpiper	A2H		X	X
Calidris minuta	Little Stint				X
Calidris ruficollis	Red-necked Stint	A2H	X	X	X
Calidris subminuta	Long-toed Stint	A2H	X	X	X
Calidris tenuirostris	Great Knot	A2H	X	X	X
Charadrius bicinctus	Double-banded Plover	A2H			
Charadrius dubius	Little Ringed Plover		X		X
Charadrius hiaticula	Ringed Plover			X	X
Charadrius leschenaultii	Greater Sand Plover, Large Sand Plover	A2H	X	X	X
Charadrius mongolus	Lesser Sand Plover, Mongolian Plover	A2H	X	X	X
Charadrius veredus	Oriental Plover, Oriental Dotterel	A2H	X	X	X
Gallinago hardwickii	Latham's Snipe, Japanese Snipe	A2H		X	X
Gallinago megala	Swinhoe's Snipe	A2H	X	X	X
Gallinago stenura	Pin-tailed Snipe	A2H	X	X	X
Glareola maldivarum	Oriental Pratincole		X	X	X
Limicola falcinellus	Broad-billed Sandpiper	A2H	X	X	X
Limnodromus semipalmatus	Asian Dowitcher	A2H	X	X	X
Limosa lapponica	Bar-tailed Godwit	A2H	X	X	X
Limosa limosa	Black-tailed Godwit	A2H	X	X	X
Numenius madagascariensis	Eastern Curlew	A1	X	X	X
Numenius minutus	Little Curlew, Little Whimbrel	A2H	X	X	X
Numenius phaeopus	Whimbrel	A2H	X	X	X
Phalaropus fulicaria/ Phalaropus fulicarius	Grey Phalarope			X	
Phalaropus lobatus	Red-necked Phalarope	A2H	X	X	X
Pluvialis fulva	Pacific Golden Plover	A2H	X	X	X
Pluvialis squatarola	Grey Plover	A2H	X	X	X
Tringa brevipes/ Heteroscelus brevipes	Grey-tailed Tattler			X	
Tringa brevipes	Grey-tailed Tattler	A2H	X		X
Tringa glareola	Wood Sandpiper	A2H	X	X	X
Tringa incana/ Heteroscelus incanus	Wandering Tattler			X	
Tringa incana	Wandering Tattler	A2H			
Tringa nebularia	Common Greenshank,	A2H	X	X	X

Current Scientific Name or Listed Scientific Name	Common Name	Bonn	CAMBA	JAMBA	ROKAMBA
	Greenshank				
Tringa stagnatilis	Marsh Sandpiper, Little Greenshank	A2H	X	X	X
Tringa totanus	Common Redshank, Redshank	A2H	X		X
Tryngites subruficollis	Buff-breasted Sandpiper			X	X
Xenus cinereus	Terek Sandpiper	A2H	X	X	X

Table 2 notes: The Bonn Convention appendices identify migratory taxa at and below the species level, as well as some whole families in Appendix II. The convention definition of migratory species is 'the entire population or any geographically separate part of the population of any species or lower taxon of wild animals, a significant proportion of whose members cyclically and predictably cross one or more national jurisdictional boundaries'. This definition has been adopted in the EPBC Act.

The following codes are used in the Bonn Convention appendices: A1: species listed explicitly in Appendix 1, and A2H: species is member of a family listed in Appendix 2.

The annexes to JAMBA, CAMBA and ROKAMBA identify species known to be regular and predictable migrants between the agreement countries. An 'X' in the column indicates the species is protected under the bilateral agreement.

Source: Department of the Environment (2015). SPRAT EPBC Migratory Lists in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed 2015-10-06T08:56:25

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VERTEBRATES INGEST PLASTICS, INCLUDING ADSORBED CHEMICALS AND METALS

Microplastics have been found in planktivorous fish (ie fish that feed on zooplankton), including in families of fish consumed by humans (Collignon et al. 2012). Tanaka et al. (2013) examined Short-tailed Shearwaters (*Ardenna tenuirostris*) collected in the North Pacific Ocean and discovered POPs in the birds' tissues that were not present in their fish prey, but were present in the plastic pieces present in the stomachs of the birds, suggesting the transfer of the POPs from the ingested plastic to the birds' tissues. Lavers and Bond (2013) reported similar findings in Short-tailed Shearwaters.

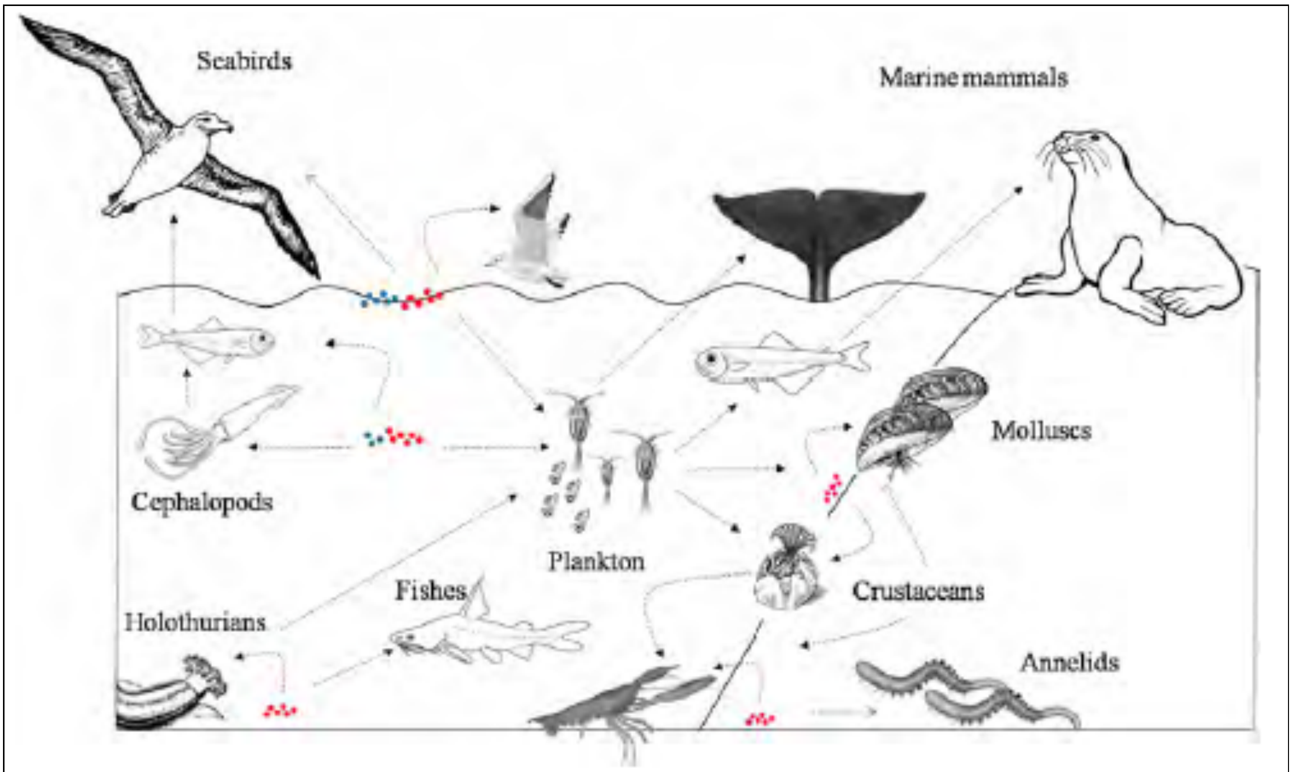
Recent studies have identified microplastic ingestion in several vertebrate species such as fish, fur-seals and seals. In larger marine species such as the Great Shearwater (*Puffinus gravis*), the amounts of ingested contaminated plastics and polychlorinated biphenyls (PCBs), DDE, DDT, and dieldrin) in adult fat tissue were positively correlated (eg Ryan et al., 1988). Kühn et al. (2015) detail the marine species globally that have been reported to have ingested plastics.

Verlis et al. (2013), Lavers and Bond (2013), Lavers et al. (2014) and Hardesty et al. (2014) reported the presence of microplastics in the stomachs of seabirds from around Australia, and Hardesty et al. (2014) correlated the tissue concentrations of three chemicals used in the manufacture of plastics with the numbers of particles in their stomachs.

Very few data are available on the transfer coefficients across marine trophic levels for POPs introduced via ingested microplastics. Seals in the North Atlantic Ocean were estimated to have concentrated plastic particles between 22 and 160 times by their ingestion of a particular fish species that feeds on surface invertebrates of similar size to microplastic particles (Wright et al. 2013)

Limited evidence – critically, from a limited number of studies – has shown bioaccumulation of microplastics in vertebrate marine predators (seals) from their marine prey (fish) that had eaten marine invertebrates (copepods). Whether the copepods had ingested microplastics or the fish had eaten microplastics mistaking them for prey is unknown.

Trophic transfer (ie prey to predator) of marine microplastics has been demonstrated and the end predator can easily have been seabirds or shorebirds, feeding on invertebrates directly. Browne et al. (2015) provide a framework for investigating ecological impacts associated with microplastics in the environment.



Conceptual model illustrating potential trophic routes within the marine environment from do Sul and Costa (2014).

There are well documented examples of trophic transfer for many POPs within marine food webs, for example dioxins, PCBs and polybrominated diphenylethers, many of which have been reported to associate with oceanic plastics (Ogata et al., 2009) and some of which can biomagnify (Hu et al., 2005).

do Sul and Costa (2014) provide perhaps the most complete review of trophic transfers of microplastics through the marine environment. Their conceptual model illustrating potential trophic routes within the marine environment is reproduced below.

The model does not include shorebirds as they are often overlooked as components of the "marine" ecosystem despite being largely- or totally-reliant (shorebird species-specific) on the marine ecosystem for their food year-round (see context for this submission, above). A similar conceptual model was presented by Lusher (2015).

SHOREBIRDS AS COASTLINE FORAGERS

Foreshores accumulate plastic ranging in size from metres (eg discarded and lost fishing nets) to particles millimetres or smaller (microplastics), Browne et al. (2011, 2015). This accumulation of plastic debris also occurs in estuarine environments, and is not confined to oceanic foreshores (eg Yonkos et al. 2014, Klein et al. 2015). Invertebrates can ingest these microplastic particles close to shore, or potentially on shore during normal feeding behaviour.

Shorebirds forage on coastlines around the world, both rocky and sandy foreshores. Many species are visual foragers, ie they visually locate their prey on or in the sediments and beach-cast seaweeds and grasses before ingestion. Shorebirds forage from above the high-water line to well into the water, depending on the lengths of their legs and bills.

At the high-water line on the beach, beach-cast marine grasses, sea-weeds and kelps accumulate in association with marine litter. This accumulation is known as wrack. Microplastics are present over the entire breadth of beaches, and are not confined to the wrack.

Shorebirds feed on inter-tidal invertebrates that live in and/or on the wet sand, and also on the invertebrates that live in the beach-washed kelps and marine grasses and seaweeds; these invertebrates are involved in the breakdown of marine vegetation on foreshores.

Microplastics are mistaken for food by a wide variety of animals including birds, fish, turtles, mammals and invertebrates (Lusher 2015). Despite concerns raised regarding microplastic ingestion, few studies have examined the occurrence of microplastic in natural *in situ* populations as it is methodologically challenging to assess microplastic ingestion in the field (Lusher 2015) – often this involves the death of the animal(s) under investigation.

Many of these marine and coastal invertebrate species have been shown to ingest microplastics (eg Cole et al. 2013, Ugolini et al. 2013, Remy et al. 2015) so provide an indirect route to shorebirds for the adsorbed chemicals and metals that are present on the microplastic particles.

Shorebirds may thus face threats from marine microplastics from (a) the ingestion of the particles themselves that can remain in their stomachs and potentially accumulate over time, and (b) the ingested microplastics are likely to have adsorbed POPs and metals that can be transferred to the shorebirds' body tissues.

Of particular concern is that the shorebirds may potentially act as bio-magnifiers/bio-accumulators of the adsorbed chemicals in the same manner that Peregrine Falcons and Brown Pelicans accumulated DDT in the 1960s (coastal shades of Rachel Carson's *Silent Spring*). As top predators, the birds accumulated the chemicals from their food and ultimately their physiology was adversely affected, reducing their capacity to breed successfully and their populations crashed to the points of near-extinction.

Birds are universally recognised as powerful indicators on the state of the health of their environments. With almost 15% of the world's bird species now listed as Threatened, there is a strong signal on the state of the deteriorating health of the world's natural ecosystems.

Several species of resident and migratory shorebirds are listed as threatened species under the EPBC Act, and BirdLife Australia believes marine microplastics pose a serious risk to potentially all species of shorebirds in Australia, exacerbating existing threats and potentially increasing the likelihood of species' extinctions.

This submission has identified a remarkable gap in our knowledge of coastal birds and their interaction with their environments. Given the similarities in feeding ecologies of closely-related species and those present in Australia, and coastal processes around the world, there is a strong case for predicting Australia's resident and migratory shorebirds are ingesting microplastics and the associated adsorbed POPs and metals. Clearly, this is a research priority that will serve to address the current gap in our knowledge.

Recommendation 4 BirdLife Australia requests the Commonwealth Government to support directed scientific research into the interactions between shorebirds and microplastics in Australia.

Based on this submission, we have identified the following initial foci:

- determine the chemical natures of the POPs and metals, and their concentrations, present on microplastics in coastal waters, in coastal sediments and on beach-washed kelps, grasses,
- determine if microplastics are present in zooplankton around Australia, and if so, are these species preyed upon by shorebirds, and do their concentrations in zooplankton increase in proximity to urban centres and manufacturing facilities (eg Wright et al. 2013),
- determine if microplastics are present in the stomachs and faeces of resident and migratory shorebirds, and if so are there differences between resident and migratory species?,
- determine the key risks to shorebirds from microplastics, and the ecological pathways involved,
- examine the relationship between microplastics levels in birds and their body POP/metals levels, with the expectation that the relationship between their levels will be correlated,
- investigate the potential for inference studies to serve as proxies for microplastics and chemical levels in shorebirds, by examining known prey species of Australian resident and migratory shorebirds; such studies would serve to minimise the need to sacrifice/collect living birds for sampling,
- investigate the potential for non-destructive methods to assess exposure and/or ingestion by shorebird (eg Hardesty et al. 2014), and
- Investigate the potential for opportunistic studies to assess the presence of microplastics in shorebirds that die from other causes (predator kills, vehicle strikes etc).

CONCLUSIONS

1. BirdLife Australia believes that based on our current understanding of coastal processes and the foraging ecologies of the shorebird species involved, the results obtained elsewhere are applicable to Australian resident and migratory shorebirds.

2. BirdLife Australia believes the threats to shorebirds (waders) in Australia from microplastics is presently unrecognised and undocumented.

3. The threats arise from both the ingestion of the marine microplastic articles, and from the adsorbed associated POPs and metals.

4. Shorebirds potentially face a long-term risk from the bio-magnification/bio-accumulation of the adsorbed chemicals associated with marine microplastics.

5. The complete absence of original, primary scientific research on the interaction and ingestion of marine microplastics and shorebirds globally prevents any assessment of the threats to shorebirds, many of which are listed as threatened species due to substantial population decreases.

6. The complete absence of original, primary scientific research on the interaction and ingestion of marine microplastics and shorebirds globally provides an opportunity for Australian researchers to undertake such research for the first time anywhere in the world.

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Appendix 1. Inquiry Terms of Reference

The threat of marine plastic pollution in Australia and Australian waters, with particular reference to:

- the review of current research and scientific understanding of plastic pollution in the marine environment;
- sources of marine plastic pollution;
- the impacts of marine plastic pollution, including impacts on species and ecosystems, fisheries, small business, and human health;
- measures and resourcing for mitigation; and
- any other relevant matters.