MESSAGE IN A BOTTLE

The shocking impact of plastic pollution on whales and dolphins and how we can reverse it

By Sonja Eisfeld-Pierantonio and Chris Vick, 2022

BRITA

WHALE AND DOLPHIN CONSERVATION

WDC

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WDC, Whale and Dolphin Conservation is the leading global charity dedicated to the conservation and protection of whales and dolphins. We defend these remarkable creatures against the many threats they face through campaigns, lobbying, advising governments, conservation projects, field research and rescue.

Our vision is a world where every whale and dolphin is safe and free.

WDC is registered as a charity in England and Wales (No. 1014705), and Scotland (SC040231). In the United States we are a registered 501c3 nonprofit.

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Foreword from BRITA UK

When we started partnering with Whale and Dolphin Conservation, we wanted to draw attention to the enormous volume of plastic that leaks into the ocean every year due to litter from single-use water bottles and other sources. In the period since, it's clear that public awareness of the impact of plastic pollution on marine species has grown – but unfortunately, as this report shows, so has the scale of the problem.

That's why we at BRITA UK are delighted to sponsor this ground-breaking report, supporting Whale and Dolphin Conservation in raising the alarm to help inspire change and mobilise the nation to secure a safe future for our planet. The report outlines the true scale of the plastic pollution crisis, showing that single-use plastics are having a devastating impact on our ocean, with severe repercussions for whales and dolphins. Importantly, they are also setting back the climate crisis at a time when action on climate change is vital.

This report highlights the important steps we can all take to help protect these beautiful marine species, whilst ensuring the ocean can continue to fulfil its vital role in the fight against climate change. And it makes clear that collaboration is key.

Huge progress to tackle plastic pollution was made by many businesses prior to the pandemic, but since then, competing priorities and a worldwide increase in the production of single-use plastic have reaffirmed an urgent need for action. As we look to build back better, businesses have an opportunity to restart and again make progress to stem the tide of plastic pollution.

At BRITA we are committed to making changes throughout our business, as well as engaging with customers and employees on the role they can play. We are proud to be making responsible choices that reflect our values and help people lead more sustainable lives. In 2025, BRITA will replace over 6.5 billion water bottles and prevent 1 million tons of CO_2 through our products. But we know we need to do more to protect our planet - and we are: by pursuing clear ambitions in four sustainability focus areas including our materials, packaging, reuse and recycling, and emissions.

This is not someone else's problem – we can all make small changes, like reducing and reusing, to protect whales, dolphins and other marine species and help fight climate change. We hope the findings of the report act as a wake-up call to us all about the ocean's vital role in the survival of the planet, underlining the crucial link between plastic waste and climate change.

BRITA is proud to be a long-term, dedicated partner of Whale and Dolphin Conservation, and proud of the work we have done to raise the profile of the impact of single-use plastic pollution on our natural environment and help industry and consumers to make more sustainable choices every day. With the publication of this report, we are committing to continuing to support Whale and Dolphin Conservation in raising awareness for their research, helping drive positive behaviour change and putting a stop to plastic pollution once and for all.

PART 1 – SUMMARY

The tide of plastic

Many people believe 'the whale is saved'.

The slow but steady recovery of species such as the blue whale, cleaner rivers flowing into the ocean in many parts of the world, and a growing awareness and willingness among the public and governments to act on conservation and environmental concerns, means there is cause for hope; reason to believe we can address the problems we have created.

The ocean can and should be a place where these intelligent, beautiful animals live safe and free from harpoons, from deadly nets and from pollution.

But whales - and their smaller cousins, dolphins and porpoises - are far from safe. A wave of dangers is threatening to do what centuries of whaling failed to complete. Together with global warming and bycatch, the 'tide' of plastic filling our seas threatens all whales and dolphins, the ocean itself, and ultimately our own health.

Furthermore, this 'tide' has rolled in upon us before scientists have been able to fully quantify the harm to whales and dolphins, let alone raise the alarm.

This is why WDC, Whale and Dolphin Conservation, has produced this report; to assess the evidence; to see what is happening in the deep ocean and make clear what must happen to avert catastrophe.

What we have found is both disturbing and alarming. But we are telling this story of whales, dolphins, and the effect of plastics, because we believe governments, corporations and the public acting together, and acting quickly, can save whales and dolphins from the worst impacts of plastic pollution.

We have all caused this problem, we can, together, all solve it.

The problem

1. Scale

We have looked at hundreds of studies, and individual cases, many of which are detailed and referenced in the body of this report.

The evidence builds a picture of an ocean awash with plastic; from whole fishing nets, discarded boats, crates, and food containers, down to bottles and packages, to trillions of tiny pieces; plastic that has broken into smaller fragments but not vanished; the ubiquitous, infamous 'microplastics.' These plastics affect whales' and dolphins' ability to feed, digest, navigate, breathe, breed and migrate.

The changes wrought even within two decades, are insidious and exponential. Worst of all, they appear to have increased more rapidly in the time that COVID-19 has crossed the world. Whilst whales and dolphins may have had some brief respite from hunting, expanding noise pollution, risk of boat collisions or being caught in fishing nets, the threat of plastics is greater now than ever before.

2. The amount of plastic in our ocean

It is estimated that in 2016 alone, between 19 and 23 million metric tonnes of plastic entered the marine environment. On average this amounts to 10 times the weight of all mature blue whales thought to be left on Earth (15,000 max). Because of its durability, low-recycling rates, poor waste management and maritime use, a significant portion of the plastic we produce and use enters and persists in marine ecosystems. Plastics account for 60 - 80% of marine litter, and are ubiquitous across the entire ocean, even in remote areas. A single litre plastic bottle can break down into enough small fragments to put one tiny piece of plastic on every mile of beach in the world.

It is estimated that in 2016 alone, between 19 and 23 million metric tonnes of plastic entered the marine environment. Plastics account for 60 - 80% of marine litter.

3. Toxicity

It is not only a problem of volume; plastic debris meeting other pollutants absorbs some harmful chemicals from the surrounding seawater acting like pollution sponges. One study found that virgin plastic pellets (small plastic pieces that form the base material for conversion into other plastic products) ‘suck up’ persistent organic pollutants (POPs) and other toxins with a concentration factor that is almost one million times greater compared to the overall concentration of the chemicals in seawater.

Smaller particles of plastic, in particular microplastics, can be ingested (or breathed in) by organisms from plankton to humans. One Mediterranean fin whale can ingest some 3,000 pieces of microplastics each day. Humpback whales from British Columbia reportedly ingest more microplastic particles than fin whales, with an estimated intake from trophic transfer of more than 300,000 items per day. With an average lifespan of ~85 years, a humpback whale potentially consumes 9.3 billion microplastic particles in their lifetime which is 1,266 times higher compared to what a human in the UK will consume (on average ~90,500 particles per year) in their lifetime of ~81.2 years.

4. The effect

Different kinds and sizes of plastics appear to affect species in different ways. For example, many of the large filter-feeding baleen whales are particularly prone to microplastic ingestion and contamination because of the volumes of water they ingest during feeding, (though it should be noted that microplastics have also been found in toothed whales in many parts of the world).

Members of the *Balaenopteridae* family (Rorqual whales) seem to be most affected by microplastics whilst members of the *Delphinidae* (dolphin family) seem to be particularly affected by medium and large macroplastic pollution.

Deep-diving offshore species such as True's and Cuvier's beaked whales ingest significantly more plastics than those species inhabiting coastal or shallower areas. Some scientists suggest deep-diving cetaceans such as sperm and beaked whales could be more vulnerable than other species to the ingestion of marine plastic.

Yet other species may ingest more debris due to how they hunt and feed, which means they can be strongly affected, even if they are not migrating through, or living in, areas already thick with plastic.

In short, plastic – of every type and size – is affecting whales and dolphins – of every type and size – in every part of the ocean. This is not surprising given the ocean's currents. A piece of plastic discarded in one country now, could be ingested by a whale or dolphin halfway around the world, some years or more than a decade from now.

5. An increasing problem

Discarded single use face masks. The Covid-19 pandemic triggered an estimated global use of 129 billion face masks every month.

Most worryingly of all, the production of plastic waste has increased worldwide during the pandemic, either through an increase of plastic packaging or use of PPE. COVID-19 triggered an estimated global use of 129 billion face masks and 65 billion gloves every month. The UK alone throws away 53 million disposable face masks every day.

Given this increase in the overall amount of plastics in the ocean and the amount entering the marine ecosystem, it is not surprising that there has been an increase in the number of cetacean species recorded to have ingested marine plastic. In 1997, 28 out of 75 whale and dolphin species had been described as having been affected by marine litter. Today this figure has risen to 62 of the 92 cetacean species recognised today.

Added to which, plastics both contribute to global warming and impact the ocean's ability to absorb carbon: plastic industries have become the most rapidly growing source of industrial greenhouse gas emissions. Marine microplastics can affect phytoplankton photosynthesis and growth and have toxic effects on zooplankton, severely affecting the ocean's ability to absorb and store CO_2. Plastics are hampering and counteracting efforts to prevent climate catastrophe, as well as impacting whales and dolphins, which are themselves, sinks for carbon. Fewer whales and dolphins means more carbon in the atmosphere.

6. The stories of individual whales and dolphins

With such statistics, it is easy to lose sight of the fact that each whale or dolphin is an individual, and each stranded body tells a story. The following are just some examples. The body of this report provides more.

Risso's dolphin trailing plastic marine debris.

Thirty sperm whales stranded along the coasts of the UK, France, The Netherlands and Germany between January and February 2016. The gastro-intestinal tracts of 22 carcasses were investigated. Marine debris was found in nine of the whales.

In January 2017, a Cuvier's beaked whale repeatedly swam into a shallow cove on the Island of Sotra in Norway. Inhabitants pushed him out three times, before the decision was taken to euthanise, because he was emaciated and lethargic. Thirty large pieces of plastic were recovered from his stomach.

In the summer of 2018, a sperm whale stranded in Spain with 29 kg of plastic bags in his stomach, another sperm whale stranded in Santorini with 30 kg of plastic in his stomach and a pilot whale was found in Thailand with more than 80 plastic bags in his stomach.

In January 2019, a sei whale calf (a baby probably still dependent on Mum's milk) stranded on a beach in North Carolina, USA. He was emaciated and euthanised. A necropsy revealed a plastic bag stuck in the baby's throat and no food in the stomach.

In March 2019, the carcass of a pregnant sperm whale washed up in Sardinia, Italy, with 22 kg of plastic in her stomach.

Perhaps most common of all: many whales ingest large numbers of plastic bags, which appear to be too easy to ingest, and which convince the whales' stomachs that they are 'full' or block the stomach so nothing can go in or out.

The range of objects found in these whales is staggering: transparent plastic, plastic mulch and burlap, hosepipe, ropes, flower pots, parts of a mattress, an ice cream tub, netting, ropes, foils, packaging material, part of a car engine cover, garbage bags, fishing nets, lines, tubes, the bag of a washing machine liquid, the outer wrapper from a six-pack of crisps, plastic sheeting, fragments of monofilament line, net, plastic cups, bags, gloves, packing straps and tubing.

Entanglement is a significant problem for cetaceans, however, the identification of entanglement by marine debris is difficult to attribute. While the majority of entanglement records are in fact bycatch events (unwanted capture during fishing operations), rather than entanglement in marine debris, abandoned, lost or otherwise discarded fishing gear (ALDFGs) certainly appears to pose a serious entanglement risk.

In Australian waters alone there have been at least 104 accounts of cetaceans impacted by plastic debris through entanglement or ingestion since 1998; of these, the vast majority (92.2%) relate to entanglement.

In December 2018, a Franciscana dolphin died as accidental bycatch in artisanal gillnets in Sao Paulo, Brazil, with a plastic bottle cap ring caught on his beak. He was very thin and would have starved to death, as he couldn't open his mouth to feed.

In January of 2019, a female common dolphin was found with twine-like plastic that tightly bound her snout closed on one of the Channel Islands. She had starved to death.

In October 2019, a pregnant minke whale drowned in the surfline on Orkney with a piece of fishing net entangled in her baleen.

The flow of plastic into the oceans needs to stop.

The solution cannot be reduced to single products or types of plastic, nor is the situation urgent only for whales and dolphins. Sea birds, turtles, other marine mammals, and fish are all impacted. And so are humans.

The opportunity

Without comprehensive action, in a few years, all whales and dolphins will be affected, and ever larger numbers will die. Furthermore, plastic exacerbates and compounds the impacts of existing threats such as chemical and noise pollution, hunting and bycatch in active fishing gear.

But there is hope. Many countries have banned plastic bags altogether; alternatives to plastic packaging exist and yet more are being developed. Supermarkets in some parts of the world are beginning to reduce the amount of plastic they use, and there is a huge amount of public willingness to do more, and pollute less.

Nobody wants a world without whales and dolphins (they are our allies in combating the climate crisis), no-one wants an ocean brimming with plastics of all kinds; where the volume of plastic and the speed it enters the ecosystem far, far outstrips nature's ability to absorb and break it down.

Plastic is, and has been an incredibly useful tool for making and building things, and has become almost ubiquitous in packaging. But the by-product and impact is too large to ignore.

Humanity can and does address its worst excesses. For many of us, we are wealthier, healthier, better educated and more peaceful than at any time in history. Huge problems still exist and new ones appear, but humanity is both resilient and resourceful and can act, especially where our own interests are at stake. The solutions exist and with will they can be implemented. To illustrate: If there is any silver lining to the COVID-19 situation, it has shown that if the will exists, huge problems can be overcome. Many 'experts' believed a vaccine could not be produced short of ten years. Yet many have been developed in under one year.

People can make choices and take actions, companies can lead the way with existing and new, innovative alternatives. Governments can pass legislation that creates big change and opportunities.

With the population of the world predicted to rise from 7.7 billion to 9.7 billion by 2050[1], without action, the ocean will simply fill with more plastic. Action is in the interest of us all, not only for whales and dolphins or the ocean itself, but for ourselves and generations to come.

The solution: what we must do and how we will do it

So what must we do across all of society, all countries and all peoples?

The UK and other governments:

- Industry needs to be held responsible via an extended producer responsibility scheme.
- An 'all-in' deposit return scheme needs to be introduced.
- A legislative framework that brings in a progressive certainty of direction in the elimination of single use plastics.

Corporations:

- Plastic production measurably reduced, especially of non-essential single-use items, enforced by legislation and policies.
- Consumers need to be given a choice to buy plastic-free.
- A widespread system of reusable and refillable containers and packaging needs to be introduced, for example with takeaways. And where this already exists, emulated and rolled out, possibly with grant support.
- Truly biodegradable products should be developed. Biopolymers occur in nature. Though research still needs to be done, there is an opportunity to create 'plastics' that truly biodegrade.

The public:

- Reuse and reduce are better than recycle.
- Choose alternatives, such as loose fruit and veg in non-plastic bags.
- Use reusable shopping bags, ideally made from recycled plastic.
- Request alternatives of shops, supermarkets, corporations and governments.
- Go litter picking in your towns and cities to prevent litter from making its way into the sea.

In one year, the UK population of 68.3 million people could prevent 177,580 tonnes of plastic from entering the oceans, if everyone prevented five 10g plastic items (e.g. five 0.5L plastic water bottles) from going into the ocean (due to not being bought, being recycled or litter picked) every week. These 177,580 tonnes are 0.85 % of the 21 million tonnes that on average enter the ocean each year.

1 https://www.un.org/en/sections/issues-depth/population/

How will we know we are making a difference?

Actions from government and corporations can be measured, and indeed are. Many of these are tracked by NGOs, as well as researchers and governments. The actions and legislation that will lead to reduction in plastics and their impact, can be measured, as can the impacts themselves.

We strongly encourage governments to invest in studies as action begins to reap rewards.

Perhaps the simplest and strongest measures will be reduction in overall plastic in the ocean, and far fewer incidents of whales and dolphins found with plastics in their bodies.

A plastic free ocean

An ocean free of plastics existed, not many decades long ago. Yet with the tide of plastics filling the ocean, and reports of the effects in our newsfeeds and on our TVs every week, that ocean is becoming harder to remember, or perhaps, even to imagine.

The sea is filling, the beaches are covered. Every beach goer, surfer, diver, sailor and fisher, sees this with their own eyes.

With effort, action, imagination and will, there is every reason that ocean health can be restored. It may be very difficult, if not impossible to return to a pristine oceanic environment, but we can at least live as responsible consumers and societies that will preserve and appreciate a healthy ocean that can benefit ourselves, for generations to come, as well as the whales and dolphins with which we share our planet.

PART 2 – DETAIL AND BACKGROUND

Introduction

Plastics pose a serious threat to marine wildlife - and also indirectly to human health (Thompson *et al*. 2009; Rochman 2015; Vethaak and Leslie 2016) - with an ever-increasing list of species linked to negative effects from debris (Laist 1987; Gall and Thompson 2015). In 2020, 914 marine species were documented either as entangled in human trash or with it lodged in their digestive tracts (Kühn and van Franeker 2020).

Between 19 and 23 million metric tonnes[2] of plastic are estimated to have entered the marine environment in 2016 (Borrelle *et al*. 2020) making marine litter, (or marine debris) a global environmental problem. Because of its durability, low-recycling rates, poor waste management and maritime use, a significant portion of the plastic produced worldwide enters and persists in marine ecosystems (Barnes *et al*. 2009). Plastics account for 60 - 80% of marine litter (Galgani *et al*. 2000; Barnes *et al*. 2009; Law *et al*. 2010; Thiel *et al*. 2013; Law 2017) and are ubiquitous across the entire ocean, even in remote areas (Waller *et al*. 2017). Smaller particles of plastic have been detected in all marine environments (Barnes *et al*. 2009), within the human food chain (Mathalon and Hill 2014) and lately, even in human placenta (Ragusa *et al*. 2021).The accumulated number of microplastic particles (see Info Box 1) in the ocean in 2014 is estimated to range from 15 to 51 trillion particles, weighing between 93 and 236 thousand metric tons, which is only approximately 1% of global plastic waste, estimated to have entered the ocean in the year 2010 (van Sebille *et al*. 2015). The average amount of plastic trash estimated to enter the

2 This figure was estimated as between 4.8 and 12.7 million metric tonnes for 2010 by (Jambeck *et al*. 2015)

oceans each year (~ 21 million tonnes) is 10 times the weight of all mature blue whales thought to be left on Earth (15,000 max, Cooke 2018)

Because of its durability, low-recycling rates, poor waste management and maritime use, a significant portion of the plastic produced worldwide enters and persists in marine ecosystems.

What happens to macroplastics once they are in the ocean primarily depends on the density of the specific plastic which influences its buoyancy. This, in turn, affects its position in the water column and its consequent risk to impact marine species (Wright *et al*. 2013). Moreover, biofouling (the growth of organisms on the surfaces of the plastic items) and the leaching of additives from the plastics, can change the weight and density of particles, affecting their position in the water column and whether they float (Ye and Andrady 1991; Kooi *et al*. 2016; Andrady 2017; Avio *et al*. 2017).

Info Box 1: Plastic size classification (GESAMP 2019):

Plastic debris is classified based on size into megaplastic (>1m), macroplastics (size 25 - 1000mm), mesoplastics (between 5 - 25mm), microplastics (< 5mm) and nanoplastics (size < 1µm).

Bigger items of plastic can break down into smaller size items due to weathering (Barnes *et al*. 2009) and generate the so called ‘secondary microplastics’ (and smaller particles). Microplastic pieces are also produced by industry directly and used in personal care products and in other industrial applications; these are called ‘primary microplastics’.

Plastic debris not only leach chemicals into the environment, but can also absorb harmful chemicals from the water they float in, acting like pollution sponges. Virgin plastic pellets in fact have been reported to ‘suck up’ persistent organic pollutants (POPs) and other toxins with a concentration factor that is almost 1 million times greater compared to the overall concentration of the chemicals in seawater (Mato *et al*. 2001).

Whilst larger pieces of plastics can entangle wildlife or be ingested (Derraik 2002), smaller items can have serious toxicological and pathological, rather than physical, effects also in higher vertebrates (Talsness *et al*. 2009; Teuten *et al*. 2009; Whitacre 2012; Rochman *et al*. 2013; Rochman 2015; Avio *et al*. 2017).

Filter-feeding marine megafauna (like baleen whales for example) are particularly prone to microplastic ingestion and contamination by plastic-associated toxins because of the large volumes of water they process during feeding, but microplastic particles have also been found in several non-suspension feeding species. As an instance, amongst odontocetes (toothed whales) species from UK waters (Nelms *et al*. 2019), Chinese waters (Xiong *et al*. 2018; Zhu *et al*. 2019), Mediterranean waters (Novillo *et al*. 2020), Galician waters (Hernandez-Gonzalez *et al*. 2018) and also Canadian waters (Moore *et al*. 2020) have been reported to have interacted with microplastics.

Just like entanglement in active fishing gear, entanglement in macroplastics can restrict the movement of marine mammals and other marine vertebrates and, in the worst cases, lead to their deaths, sometimes via a prolonged process of increasing debilitation (Moore and van der Hoop 2012; Baulch and Perry 2014; van der Hoop *et al*. 2016). Similarly, ingestion can cause blockages and serious damage to the gastro-intestinal tract which can also lead to death (Denuncio *et al*. 2011; Brandão *et al*. 2011; Di Beneditto and Ramos 2014).

Floating marine macroplastic is only a fraction of the plastic in the world's seas (Cózar *et al*. 2015) and it is currently difficult to estimate the full magnitude of oceanic plastic pollution (Worm 2015). Nonetheless, marine litter is now recognised as a critical threat to marine fauna (Thompson *et al*. 2014) and, accordingly, it is included in several national and international regulations[3] (Thompson *et al*. 2009b; Löhr *et al*. 2017).

Floating marine macroplastic is only a fraction of the plastic in the world's seas and it is currently difficult to estimate the full magnitude of oceanic plastic pollution.

3 These include the EU Marine Strategy Framework Directive (MSFD 2008/56/EC), with Descriptor 10 specifically focussing on marine litter (Galgani *et al*. 2013), amongst other legal measures e.g. Marine Litter Legislation: A Toolkit for Policymakers (https://goo.gl/Zc588N); Marine plastic debris and microplastics – Global lessons and research to inspire action and guide policy change (https://goo.gl/nSMzxw); International Law and Marine Plastic Pollution - Holding Offenders Accountable (https://goo.gl/484U2w)

At the end of 2019, single-use plastic reduction and the creation of sustainable packaging were high on the agenda around the globe. As of July 2018, 127 out of 192 countries reviewed had adopted some form of legislation to regulate plastic bags, either through a ban, levy (tax) or extended producer responsibility (United Nations Environment Programme 2018). Since the beginning of the ongoing COVID-19 pandemic, several elements of environmental concern have risen, alongside its more direct devastating impacts on communities across the world. In fact, since the first COVID-19 cases were reported, plastic has gained substantial media attention. Its importance for hospital devices and personal protective equipment (PPE) is unquestionable, but the same material that protects, becomes a polluter when inadequately disposed of (de Sousa 2020). COVID-19 triggered an estimated global use of 129 billion face masks and 65 billion gloves every month (Prata *et al*. 2020). The UK alone throws away 53 million disposable face masks every day[4]. Furthermore, more subtle consumption changes like switching to single-use products for hygiene and convenience, using disposable wipes for disinfecting surfaces or carrying small bottles of hand sanitiser have happened worldwide (Kalina and Tilley 2020). Where countries had started to make changes, the coronavirus spread reverted these with some places choosing to ban reusable shopping bags in an attempt to protect both customers and supermarket employees from spreading the virus[5]. In the UK, a much-heralded charge on plastic bags has been suspended, while many retailers, such as coffee shops, stopped accepting reusable products during the COVID-19 pandemic to protect against the spread of the disease.

The production of plastic waste has increased worldwide during the pandemic, either through an increase of plastic packaging or use of PPE with a concomitant raise in the presence of masks and gloves in oceans, seas, and rivers (CPRE 2020; Kalina and Tilley 2020; Okuku *et al*. 2020). Over the past 12 months, littering has occurred in new ways and different places – littering levels have fallen in town centres, but rocketed in parks and the countryside (CPRE 2020). A litter survey carried out in Essex, UK, found PPE litter in the 38% of sites inspected– with face masks being the most commonly found items (68%) followed by wipes (18%) and gloves (14%) (CPRE 2020). Similar figures were also reported during the Great British Beach Clean in September 2020[6].

Plastic not only poses an immense pollution problem, it also exacerbates climate change. With the focus on a global pandemic and environmental impact studies on toxicity, behaviour and fate of plastic, limited attention has been paid on the link between plastic and climate change. With the rapid expansion of global plastic production, plastic industrials have become the most important and rapidly growing source of industrial greenhouse gas emissions (Shen *et al*. 2020a). Greenhouse gas emissions come from the production and manufacturing process, but also from the extraction and transportation of raw materials for plastics, as well as plastic waste management and plastics entering the environment (Hamilton *et al*. 2019). The amount of emissions during manufacture depends on efficiency, configuration and the service life of equipment. When plastics are discarded, the impact of plastics on the climate does not stop; in fact most of its impacts on the climate occur after the end of its life span, because of emissions from plastic packaging waste incineration and greenhouse gases release during the degradation of plastic in the environment (Royer *et al*. 2018). The impact of marine plastics on ecosystems responsible for the gas exchange and circulation of marine CO2 may cause more greenhouse gas emissions (Shen *et al*. 2020b). Marine microplastics can 1) affect phytoplankton photosynthesis and growth and, 2) have toxic effects on zooplankton and affect their development and reproduction. Changes to this segment of the food chain (phytoplankton and zooplankton) may thus, 3) affect the ocean's ability to absorb and store CO_2[7].

4 This equated to 371 million per week or 1.6 billion per month which will weigh 20,000 tonnes in total. In one year, the UK alone will use 19.2 billion face masks which weight as much as 5.5 Eiffel towers. https://www.tradewaste.co.uk/20000-tonnes-of-single-use-face-masks-will-be-dumped-in-landfill-by-march/

5 https://www.independent.co.uk/life-style/coronavirus-reusable-shopping-bags-safe-plastic-supermarket-online-delivery-a9449836.html

6 https://www.mcsuk.org/news/gbbc_2020_results

7 For a comprehensive summary of the connections between plastic and the climate, please see the report (Hamilton *et al*. 2019) https://www.ciel.org/plasticandclimate/

Scientific research on the impact of marine plastic on marine life in general and specifically on cetaceans has been growing during the last decades. Evidence suggests a more than sevenfold rise in the number of cases of cetaceans interacting with marine debris during the last 50 years (Baulch and Perry 2014) with a concurrent increase in the number of cetacean species reported to have ingested marine debris (Denuncio *et al*. 2011).

This report reviews the available information on the number of cetacean species in which impacts of plastic debris have been documented in terms of both ingestion and entanglement. The most relevant types of debris affecting cetaceans are discussed in an effort to provide a comprehensive overview on the issue and inform appropriate mitigation and conservation decisions.

Methodology

Through a content review of available original scientific and other grey literature, and existing reviews on the subject, we gathered information on the cetacean species interacting with marine debris, the type of interaction (ingestion and/or entanglement) and size of litter (micro-, meso-, macro- and mega litter). We also included worldwide news articles to account for a number of stranding events that would have otherwise been missed, because they were not yet included in available literature. Some of these events are specifically referred to in the Findings section below. We used the most up to date list of cetacean species by the Society of Marine Mammalogy (SMM, last update June 2021).This list now includes the recently proposed Rice's whale, *Balaenoptera ricei* sp. Nov. (Rosel *et al*., 2021) and accounts for the recent taxonomic revision of the South Asian River dolphin (*Platanista gangetica gangetica*) by Braulik *et al*., (2021) that led to two separate species, the Indus River dolphin (*Platanista minor*) and Ganges River dolphin (*Platanista gangetica*). In this report we refer to the Ganges river dolphin.

Findings

Overall 62 (67.4%) of the 92 cetacean species officially recognised today have been reported to be affected by marine plastic pollution – either by ingestion or entanglement (Table 1, Figure 1a). While 58 species have been reported to have ingested plastic (63%, Figure 1b), 31 species may have been impacted by entanglement, as the source of debris was not available in all cases (33.7%, Figure 1c), with macroplastics being the main issue for all. Members of the *Balaenopteridae* family (Rorqual whales) seem to be most affected by microplastics (Figure 2a) whilst members of the *Delphinidae* (dolphin family) seem to be particularly affected by meso- and macroplastic (Figures 2b, c).

This can probably best be explained by the different feeding behaviours. To date, the only two cetacean families not reported to be affected by plastics are the *Lipotidae* (only member is the functionally extinct Baiji, *Lipotes vexillifer*) and the *Platanistidae*. The Ganges river dolphin is listed as endangered on the International Union for Conservation of Nature (IUCN) red list and suffers from threats like habitat fragmentation, pollution, dam/ irrigation canal construction, and accidental entanglement in fishing gear (Wakid 2009); (Bashir *et al*. 2010). The dolphin's optimal habitat overlaps with heavily-used fishing areas as both, dolphins and humans seek to exploit the same hotspots of bioproductivity, resulting in dolphin entanglement (Bashir *et al*. 2010). Because of demands for dolphin meat and oil for human consumption, claimed medicinal use, and catfish bait, dolphins are often killed once entangled, and it is not uncommon for fishers to deliberately set nets in areas where dolphins are likely to encounter them (Sinha 2002; Bashir *et al*. 2010; Kolipakam *et al*. 2020). These are the probable reasons that this species of river dolphin has not been reported as affected by plastic when it is highly likely that they are.

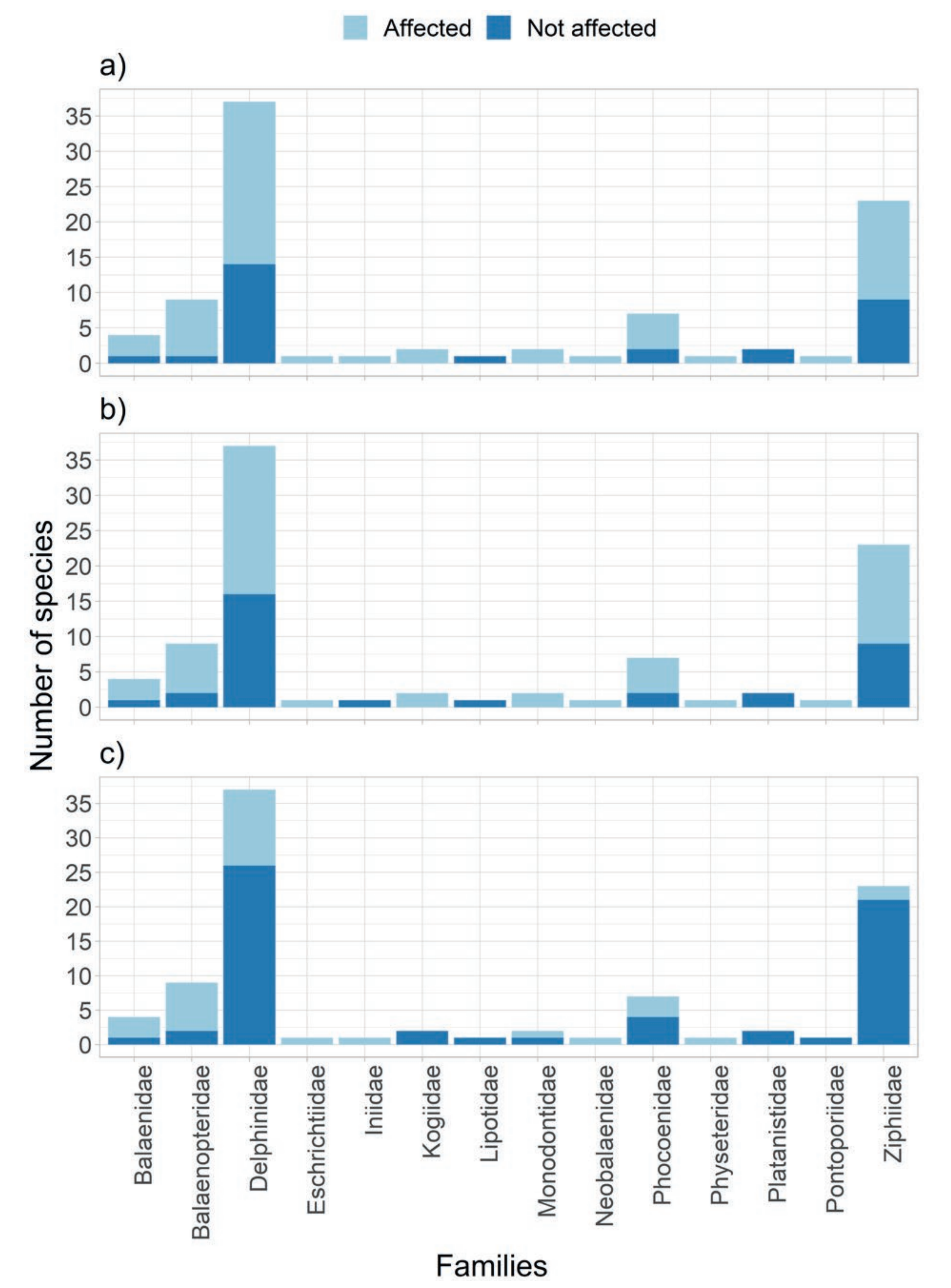

Figure 1: Showing the number of cetacean species per family affected and not affected by a) marine debris (either by entanglement or ingestion); b) by plastic ingestion; c) by entanglement.

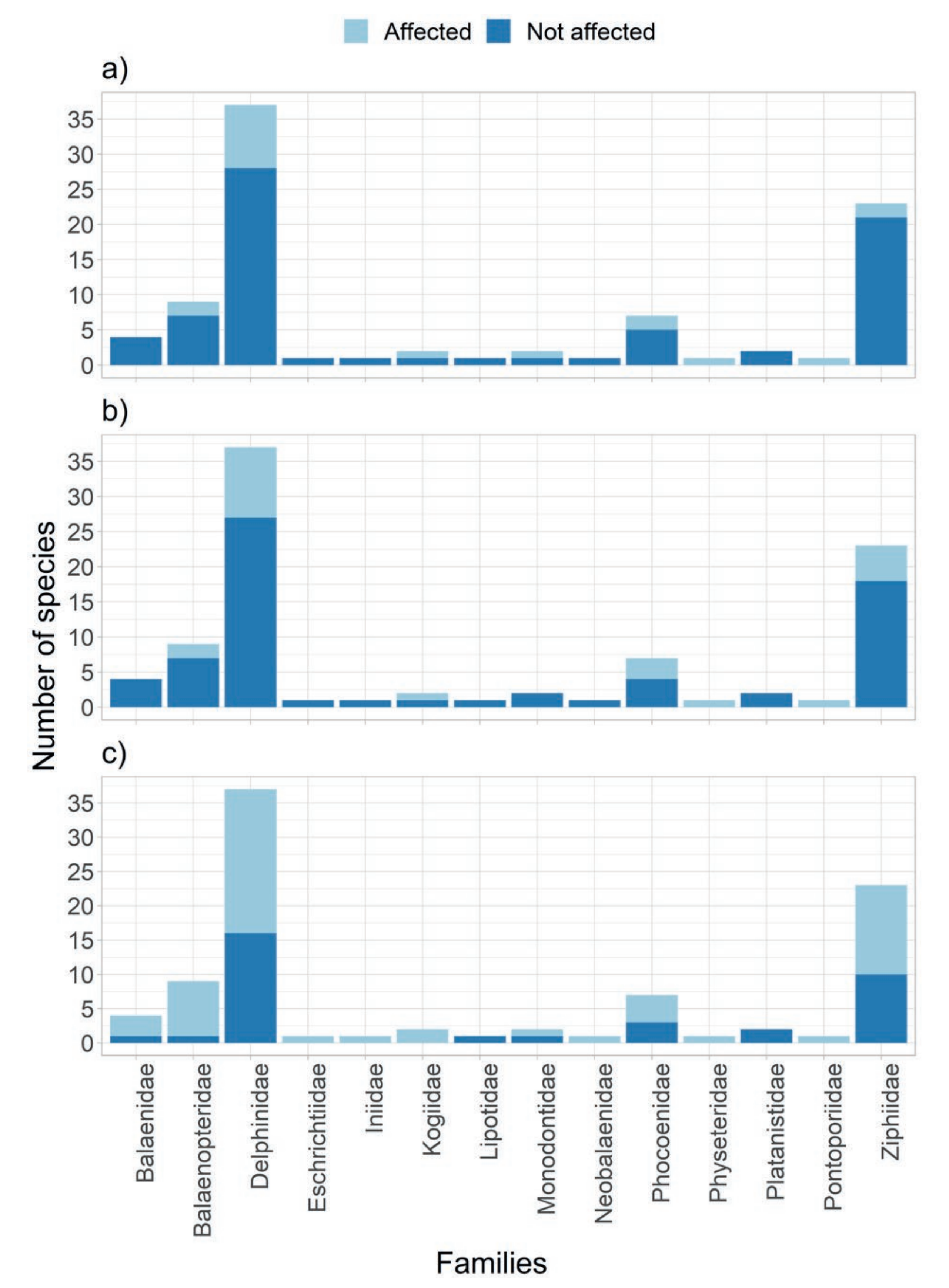

Figure 2: Showing the number of cetacean species by family affected by a) microplastic (< 5mm); b) mesoplastic (5 – 25mm); c) macro- and megaplastic (25 – >1000mm).

A summary of the collated information presented per Family is shown in Table 1 while the complete list of species along with the source of information used in the review process is presented in Annex I.

Table1: Summary of the number of cetacean families and the number of species per family impacted by marine debris. Ing. = Ingestion, Ent. = Entanglement, Micro. = Microplastic, Meso. = Mesoplastic, Macro. = Macro- and Megaplastic.

Family (Species per Family)	Affected (%)	Ing. (%)	Ent. (%)	Micro. (%)	Meso. (%)	Macro. (%)
Balaenidae (4)	3 (75)	3 (75)	3 (75)	0 (0)	0 (0)	3 (75)
Balaenopteridae (9)	8 (88.9)	7 (77.8)	7 (77.8)	2 (22.2)	2 (22.2)	8 (88.9)
Delphinidae (37)	23 (62.2)	21 (56.8)	11 (29.7)	9 (24.3)	10 (27)	21 (56.8)
Eschrichtiidae (1)	1 (100)	1 (100)	1 (100)	0 (0)	0 (0)	1 (100)
Iniidae (1)	1 (100)	0 (0)	1 (100)	0 (0)	0 (0)	1 (100)
Kogiidae (2)	2 (100)	2 (100)	0 (0)	1 (50)	1 (50)	2 (100)
Lipotidae (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Monodontidae (2)	2 (100)	2 (100)	1 (50)	1 (50)	0 (0)	1 (50)
Neobalaenidae (1)	1 (100)	1 (100)	1 (100)	0 (0)	0 (0)	1 (100)
Phocoenidae (7)	5 (71.4)	5 (71.4)	3 (42.9)	2 (28.6)	3 (42.9)	4 (57.1)
Physeteridae (1)	1 (100)	1 (100)	1 (100)	1 (100)	1 (100)	1 (100)
Platanistidae (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Pontoporiidae (1)	1 (100)	1 (100)	0 (0)	1 (100)	1 (100)	1 (100)
Ziphiidae (23)	14 (60.9)	14 (60.9)	2 (8.7)	2 (8.7)	5 (21.7)	13 (56.5)
Grand Total (92)	**62 (67.4)**	**58 (63)**	**31 (33.7)**	**19 (20.7)**	**23 (25)**	**57 (62)**

There has been an increase in the number of cases reported, as well as an increase in the number of cetacean species recorded to have ingested marine plastic. In one of the earliest reviews on this subject, (Laist 1997) reported 28 species of cetacean (37%, n = 75) as affected by either ingestion or entanglement or both. Since then the proportion of affected species has almost doubled and the absolute number of affected species is more than two times higher.

1. Ingestion

Whilst ingestion of plastics is mostly considered a contributing cause of death, lethal cases, where plastic bags fully occluded gastrointestinal passages or filled up stomach cavities, are reported worldwide (Secchi and Zarzur 1999; de Stephanis *et al*. 2013; Alexiadou *et al*. 2019). In 2008, two male sperm whales stranded along the northern California coast with large amounts of fishing net scraps, rope and other plastic debris in their stomachs. There were 134 different types of nets in these two whales, all made of floating material, varying in size from 10cm² to about 16m². One whale had a ruptured stomach, the other was emaciated, and gastric impaction was suspected as the cause of death for both (Jacobsen *et al*. 2010).

Another sperm whale stranded in March 2012 in the southeast of Spain. He had 59 different items in his stomach, most of them coming from greenhouse agriculture including two dozen pieces of transparent plastic, plastic mulch and burlap, two stretches of hosepipe, nine metres of ropes and two small flower pots amongst parts of a mattress, some plastic bags, an ice cream tub and other things, amounting to almost 18 kg of plastic waste in the stomach (de Stephanis *et al*. 2013). Cause of death was presumed to be gastric rupture following impaction with debris, which added to a previous problem of starvation.

In March 2019, a juvenile Cuvier's beaked whale died of "gastric shock" in the Philippines after swallowing 40 kg of plastic bags. The trash included 16 rice sacks, four banana plantation style bags and many disposable plastic shopping bags[8].

Ten days later, the carcass of a pregnant sperm whale washed up in Sardinia, Italy. She had 22 kg of plastic in her stomach, including garbage bags, fishing nets, lines, tubes, the bag of a washing machine liquid still identifiable with brand and barcode and other objects no longer identifiable[9].

Plastics, especially plastic bags, wrappers, plastic sheets, fragments of large plastic containers and, to a lesser extent, plastic bottles, represent the type of plastic item most frequently ingested by cetaceans (Simmonds 2012; Baulch and Perry 2014; Poeta *et al.* 2017). In the summer of 2018, a sperm whale stranded in Spain with 29 kg of plastic bags in his stomach[10], another sperm whale stranded in Santorini with 30 kg of plastic in his stomach[11] and a pilot whale was found in Thailand with more than 80 plastic bags in his stomach[12].

Left: Stomach contents found in the Cuvier's beaked whale stranded in January 2017 on Sotra, Norway.
Right: The outer wrapper from a Walkers crisps six-pack, the UK copyright and recycling symbol still visible, found in the stomach of the Cuvier's beaked whale stranded on Sotra, Norway, in 2017.

In January 2017, a Cuvier's beaked whale repeatedly swam into a shallow cove on the Island of Sotra in Norway. Inhabitants pushed him out three times, before the decision was taken to euthanise him because he was emaciated and lethargic. Thirty large pieces of plastic were recovered from the whale's stomach. One piece was a sheet of plastic more than two metres long, but most were plastic bags, some still with writing which gave away their origins – Ukraine and Denmark. There was also the outer wrapper from a six-pack of Walkers crisps, the UK copyright and recycling symbol still visible[13].

8 https://www.theguardian.com/environment/2019/mar/18/dead-whale-washed-up-in-philippines-had-40kg-of-plastic-bags-in-its-stomach?CMP=twt_gu

9 https://edition.cnn.com/2019/04/01/europe/sperm-whale-plastic-stomach-italy-scli-intl/index.html

10 https://www.telegraph.co.uk/news/2018/04/06/sperm-whale-killed-plastic-pollution-washes-spanish-coast/?utm_source=dlvr.it&utm_medium=twitter

11 https://greece.greekreporter.com/2018/04/17/30-kilos-of-plastic-found-in-stomach-of-beached-whale-in-santorini-photos/

12 https://www.theguardian.com/environment/2018/jun/03/whale-dies-from-eating-more-than-80-plastic-bags?utm_source=esp&utm_medium=Email&utm_campaign=GU+Today+main+NEW+H+categories&utm_term=276927&subid=16960118&CMP=EM-CNEWEML6619I2

13 https://news.sky.com/feature/sky-ocean-rescue-a-plastic-whale-10917187

At the beginning of January 2019, a 5m long sei whale calf (a baby probably still dependent on Mum's milk) stranded on a beach in North Carolina, USA. He was emaciated and the decision taken to euthanise him. A necropsy revealed a plastic bag stuck in the baby's throat and no food in the stomach[14].

Items linked to fishing activities, such as portions of ropes, nets, lines and hooks also constitute a large portion of ingested material (Simmonds 2012, 2017; Baulch and Perry 2014; Poeta *et al*. 2017; Lusher *et al*. 2018).

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Sperm whale strandings 2016

© TIHO/ITAW

The stomach contents of one of the sperm whales stranded in Germany in early 2016 included parts of a blue plastic bucket and part of a plastic car engine cover.

14 https://allthatsinteresting.com/sei-whale-euthanized

Thirty sperm whales stranded along the coasts of the UK, France, The Netherlands and Germany between January and February 2016. The gastro-intestinal tracts of 22 of the carcasses were investigated. Marine debris including netting, ropes, foils, packaging material and a part of a car were found in nine of the 22 individuals. While none of the ingested items led to their deaths, it can be assumed, that over time, especially the larger swallowed items, might have caused health issues for them, as seen in the cases of the two sperm whales in northern California in 2008 (see above) (Jacobsen *et al*. 2010).

In November and December 2019, two sperm whales stranded on the UK coast, one in Wales, the other one in Scotland. The whale in Wales had a large piece of blue plastic sheeting and a relatively large mass of ropes, fragments of monofilament line and other plastic fragments within the base of the main stomach[15]. The UK's Cetacean Strandings Investigation Program (CSIP) said: "It's not possible to accurately assess whether the ingestion of debris was a consequence of the whale's presence in the abnormal habitat of shallow waters around the UK; or indeed if other underlying issues may have played a role in their ingestion. Nonetheless, although the ingested debris can be considered to be an incidental finding and not necessarily the most significant factor in the whale's death, it may have had some impact on the animal's ability to digest any ingested prey". The whale in Scotland had a whole range of plastic including sections of net, bundles of rope, plastic cups, bags, gloves, packing straps and tubing in his stomach amounting to 100 kg of litter[16]. Whilst it is certainly plausible that this amount of debris was a factor in the live stranding, evidence couldn't be found that this had impacted or obstructed the intestines.

The ingestion of plastic is reported to have a variety of detrimental health effects (info box 2). Sharp, ingested plastic pieces can puncture the lining of the digestive system and cause ulceration, persistent lesions, secondary infections, parasitism and inflammation of the surrounding tissues (Gregory 1991), leading to reduced fitness and disease. Gastrointestinal blockages due to ingesting non-food items are common (Laist 1997; Derraik 2002), with such blockages causing malnutrition, starvation, and gastric rupture (Stamper *et al*. 2006; Jacobsen *et al*. 2010; de Stephanis *et al*. 2013; Alexiadou *et al*. 2019). In general, regardless of the species, debris in the digestive tract, particularly the stomach, may lead to a false sense of satiation, reducing the urge to feed properly (Secchi and Zarzur 1999).

Info Box 2: Reported health effects of plastic ingestion

- laceration or ulceration of the gastrointestinal tract, leading to infection and internal bleeding
- direct blockage of the digestive tract, reducing or preventing nutrient uptake
- satiation (i.e. reducing the urge to feed)
- failure of digestive tract compartmentalization, allowing highly acidic gastric secretions into areas not adequately shielded
- retention leading to an increasing amount of debris in the digestive system of the organism

Recent studies (Lusher *et al*. 2015, 2018) on the current and historical incidence of marine debris in cetaceans stranded and bycaught in Irish waters, show that deep-diving offshore species such as True's and Cuvier's beaked whales ingest significantly more plastics than those species inhabiting coastal or shallower areas. Simmonds (2012) and Baulch & Perry (2014) also suggested that deep-diving cetaceans such as sperm and beaked whales could be more vulnerable than other species to the ingestion of marine plastic. Variations in the amount, type and rate of ingestion of debris between estuarine and oceanic dolphins have also been reported (Denuncio *et al*. 2011). Strong evidence suggests that some species ingest debris more often than others due to their prey-

15 https://www.facebook.com/UKCSIP/posts/3192058730836408
16 https://www.bbc.co.uk/news/uk-scotland-highlands-islands-50621304

capture strategy rather than the presence of higher amounts of debris in the water column or the species' habitat preferences and diving behaviour (e.g. (Di Beneditto and Oliveira 2019).

Filter feeding species are reported to be mostly affected by the unintentional ingestion of microplastics, most likely through ingestion associated with lunge feeding or possibly as a result of trophic transfer through their prey. Fin whales in the Mediterranean Sea seem to be particularly vulnerable to microplastics because of direct ingestion and consumption of contaminated prey, with the potential impact of microplastics in this region being far greater than other areas, like the Sea of Cortez for example (Fossi *et al*. 2012, 2014, 2016, 2017). According to calculations by Fossi *et al* (2014), a Mediterranean fin whale ingests some 3,000 pieces of microplastics each day whilst feeding due to the high ratio of plastic to plankton in the Med. Humpback whales from British Columbia reportedly ingest more microplastic particles than fin whales, with an estimated intake from trophic transfer of more than 300,000 items per day (Desforges *et al*. 2015). With an average lifespan of ~85 years[17], a humpback whale potentially consumes 9.3 billion microplastic particles in their lifetime which is 1,266 times higher compared to what a human in the UK will consume (on average ~90,500 particles per year, Cox *et al*. 2020) in their lifetime of ~81.2 years[18]. Other species of mysticete that seem to be affected by microplastics include minke and sei whales (Baulch and Perry 2014). Humpback whales seem to be the most impacted species in Australian waters (Ceccarelli 2009). There, deaths and injuries of 14 species of cetaceans could be attributed directly to interactions with plastic debris between 1998 and 2008, with humpback whales dominating the available records. In terms of ingestion, Ceccarelli (2009), despite reporting only nine cases between 1998 and 2008, suggests that this value does not necessarily reflect the rarity of the phenomenon but the fact that necropsy results may not report on ingested plastic if this was not considered the primary cause of death.

From Chinese waters comes the first description of ingested microplastic in a stranded Indo-Pacific humpback dolphin, *Sousa chinensis*, (Zhu *et al*. 2019) and the presence of microplastic in the intestinal tracts of East Asian finless porpoises (*Neophocaena asiaeorientalis sunameri*)(Xiong *et al*. 2018) indicating that coastal delphinids might suffer from microplastic pollution, including young calves. Recent studies from stranded dolphins around Galicia, Spain, the British coast and the Canary Islands provide strong evidence that microplastic is ubiquitous not only amongst large filter feeding cetaceans but also in smaller odontocete species (Puig-Lozano *et al*. 2018, p.; Hernandez-Gonzalez *et al*. 2018; Nelms *et al*. 2019). For small-sized cetaceans, Lusher *et al*. (2018) suggest that the ingestion of high levels of microplastics might facilitate pollutant availability and therefore pollutants may bioaccumulate in organisms producing sub-lethal toxicological effects in addition to the more immediate consequences of macroplastic ingestion. In this context, Nelms *et al*. (2019) indicate that marine mammals that died due to infectious diseases had a slightly higher number of particles than those that died of trauma and other reasons for mortality, showing a possible relationship between the cause of death and the abundance of microplastics.

2. Entanglement

Entanglement in fishing gear is a global concern that is known to affect a large number of marine species (Macfadyen *et al*. 2009), however, the ability to differentiate between entanglements in actively fished gear and abandoned or lost gear remains difficult. In an effort to quantify the frequency of whale entanglements in "ghost gear", Lyman (2014) found that abandoned gear accounted for a small percentage of entanglements.

Regardless of the source, entanglement can cause decreased swimming ability, disruption in feeding, life-threatening injuries, and death (info box 3).

17 https://www.fisheries.noaa.gov/species/humpback-whale

18 https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/lifeexpectancies/bulletins/nationallifetablesunitedkingdom/2017to2019

Info Box 3: Reported effects of entanglement

- loops of material can be embedded into the skin and flesh leading to:
  - abscess formation and infection
  - amputation
  - compromised or restricted movement
  - disrupted feeding

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Divers removing ghost nets from the ocean to prevent entanglement of wildlife, including cetaceans.

While the majority of entanglement records are in fact bycatch events during active fishing activity, rather than entanglement in marine debris (Laist 1997; Butterworth *et al.* 2012; Baulch and Perry 2014), abandoned, lost or otherwise discarded fishing gear (ALDFGs) can pose a serious entanglement risk. However, the rate and number of entanglements in marine debris are generally difficult to decipher. Very high numbers of reports do not differentiate between ALDFGs, active fishing gear, or any other marine debris, and usually describe the cause of the entanglement as "Unknown" when clearly not attributable to a specific fishery (Johnson 1989; Johnson *et al.* 2005; Neilson *et al.* 2009).

Despite these difficulties, entanglement of cetaceans in marine debris can injure and/or kill individual whales and dolphins. Filter-feeders may be especially vulnerable to large sheets of plastic debris that can become entangled in their baleen (Lambertsen *et al.* 2005), which may partially limit food intake. In October 2019, a pregnant minke whale drowned in the surfline on Orkney with a piece of fishing net entangled in her baleen[19]. Later that same month, a female sei whale came ashore in Bridport, Tasmania. She died of starvation after rope became entangled around her upper jaw and restricted her ability to feed. Based on the level of emaciation and scarring, the whale had carried this entanglement for a significant length of time[20]. Southern right whales are also considered at high risk of entanglement due to their tendency to aggregate inshore, but available records are scant (Ceccarelli 2009).

19 https://www.facebook.com/Strandings/posts/2420197094737730
20 https://www.facebook.com/whalestas/

Odontocete species where marine debris entanglement has been shown are sperm whale, bottlenose dolphin, harbour porpoise, and Dall's porpoise, with most entanglements involving monofilament line, net fragments, or ropes attached to the animals' appendages (National Oceanic and Atmospheric Administration Marine Debris Program 2014).

In January of 2019, a female common dolphin was found with twine-like plastic that tightly bound her snout closed on one of the Channel Islands. She starved to death[21].

In December 2018, a Franciscana dolphin died as accidental bycatch in artisanal gillnets in Sao Paulo, Brazil, with a plastic bottle cap ring caught on his beak. He was very thin and would have starved to death, as he couldn't open his mouth to feed[22].

In October 2019, a Sowerby's beaked whale live stranded with chronic entanglement near Edinburgh in Scotland[23]. According to the Scottish Marine Animal Strandings Scheme (SMASS), the female was in thin body condition and showed severe trauma to the right pectoral fin, large areas of skin loss from the flank, and a loop of thin, green cord embedded around her neck. She had been entangled for long enough that the cord had worked its way right through the skin and blubber layer into the underlying muscle layer. In some places the skin had actually grown over the top of the rope; in others it had set up a deep tissue infection and abscessation. There were goose barnacles attached to the rope, an indication that the entanglement had considerably compromised her swimming capabilities[24]. While it is not clear if the line was from actively fished or discarded gear, it provides an example of the severity of impacts that entanglements cause.

© SMASS

Chronic entanglement on a female Sowerby's beaked whale live stranded in Edinburgh, Scotland in October 2019 with the cord having worked its way through the skin and blubber layer into the underlying muscle layer. In some places the skin had grown over the top of the rope around her neck. There were goose barnacles attached to the rope, an indication that the entanglement had considerably compromised her swimming capabilities.

21 https://www.dailymail.co.uk/sciencetech/article-6619057/Shocking-images-capture-emaciated-dolphin-plastic-waste-wrapped-it.html
22 Biopesca personal communication
23 https://www.bbc.co.uk/news/uk-scotland-edinburgh-east-fife-50081836?fbclid=IwAR0jQpiXPljrN9YbpKHKwi6Rkei2CUB2hvzvbC0cvZupRpSN5v08mVkdmWM
24 https://www.facebook.com/Strandings/posts/2439450696145703

Welfare concerns

The individual-level effects of interactions with marine debris include drowning, starvation, gastrointestinal tract damage, malnutrition, physical injury, reduced mobility, and physiological stress, resulting in reduced energy acquisition and assimilation, compromised health, reproductive impairment and mortality. Evidence strongly suggests that cetaceans are in the highest category of animals on a scale of sensibility to pain and suffering (Porter 1992) and in cases like entanglement, the pain and stress has been described as presumably extreme (Cassoff *et al*. 2011; Moore and van der Hoop 2012). The embedded loops of material that affect a whale or dolphin who is entangled with fishing gear can compromise or restrict movement and eventually lead to severe wounding, infection, amputations and death, a process that can take months if not years, involving a lot of discomfort and pain. Therefore, from a welfare perspective, lethal entanglements of baleen whales are, arguably, one of the worst forms of human-caused mortality in any wild creature (Cassoff *et al*. 2011).

It is widely accepted that wild creatures can experience and suffer pain and stress, although there are difficulties in measuring the intensities of these states (Kirkwood *et al*. 1994). A Welfare Assessment tool for Wild Cetaceans (WATWC) including a pilot study on three hypothetical demonstration scenarios concerning the ingestion of marine debris by Cuvier's beaked whales (Ziphius cavirostris) and its results were presented at the plenary session of the IWC Scientific Committee meeting in Bled, Slovenia in April 2018 (Nicol *et al*. 2020). However, while it is understood that the tool, once the protocols have been fully developed, might be applied to the evaluation of a range of issues including comparing different welfare responses, the Scientific Committee Report SC67B (IWC 2018) and the associated ANNEX N do not present any details on the above mentioned pilot study. Therefore there is only anecdotal evidence that cetaceans suffer after ingesting plastic. Studies from other taxa, however show that ingestion of foreign objects likely causes discomfort, deep pain and can manifest in behavioural changes (e.g. Omidi *et al*. 2012; Priyanka and Dey 2018; Harne 2019; Eriksen *et al*. 2021). Recently Alexiadou *et al*. (2019) noted that sperm whales who stranded with copious amounts of plastic in their stomachs had changed their swimming and diving behaviour in the days prior to the stranding, highlighting how such changes could increase the risk of ship strikes to the species. Plastic bezoars, indigestible objects introduced in the gastro-intestinal tract, are considered a serious and painful threat also to humans (Verma 2013; Yaka *et al*. 2015; Tharayil *et al*. 2020).

Cetaceans are sentient, sapient individuals, many of whom form complex social bonds with their conspecifics (Marino 2013; Jones 2013). As a result, interaction with plastic may deeply undermine their wellbeing and their ability to cope with normal life, including feeding, socialising and mating.

On a wider scale, the death of key individuals may cause breakdowns in social structure, leading to loss of social knowledge (lost wisdom) and fragmentation of social units (e.g. allomaternal care). As a result, this might have an impact on a whole group or even populations.

Clearly, marine debris is a pollution concern, but also an economic and social issue and all these aspects are currently taken into consideration when dealing with the plastic crisis worldwide. However, species' welfare and wellbeing at the individual and population level are crucial and should not be overlooked.

What needs to change and what is being done?

It is the plastics *we* have created and discarded that impact whales, dolphins and porpoises around the world. If waste management is not improved by 2025, plastic inputs into the ocean will increase by an order of magnitude (Jambeck *et al*. 2015), regardless of an increased plastic production rate. Irrespective of improvements to waste management, the problem of greenhouse gas emissions from the plastic lifecycle cannot be solved downstream. A recent study looked at the recyclability of four types of plastic after being exposed to UV radiation in the ocean. All plastic types in this study showed damage to their thermal and mechanical properties, making mechanical recycling unfeasible (Iñiguez *et al*. 2018).

Beach clean-ups and direct removal of ocean plastics are quick-fix solutions with strongly limited outcomes. The only way to reduce plastic pollution in the sea is to stop it from entering the marine environment. Reducing sources of plastic entering the oceans and waterways must be an urgent area of focus. Rivers are one entry point for ocean plastic (Schmidt *et al*. 2017), and studies looking at how, where, and what type of plastic pollution is entering these rivers are needed, but this area is largely understudied and lacks monitoring.

Unless the growth of plastic production and disposal is reversed, such end-of-life efforts to manage plastic will be confronted with ever greater flows of pollution to be managed. The most effective way to stem this rising tide of plastic in the environment is to dramatically reduce the amount of plastic being produced and discarded. Manufacturers need to improve product design and packaging so that they are truly recyclable, supermarkets must reduce plastic packaging and authorities should develop better ways of collecting and processing plastic waste.

Shifting to a circular economy from the current linear economy can introduce potential solutions to the plastic pollution problem in the oceanic and terrestrial environments. Where circularity isn't possible, replacement with natural-based products for plastic can be an option. However, bioplastic is not necessarily biodegradable, more sustainable or more environmentally friendly than conventional plastic. Some products are only biodegradable in industrial systems and not in natural environments.

We as consumers also need to rethink our use of single-use plastic, and redouble our efforts to reduce, reuse and recycle and more. Individual pledges to cut back on plastic may seem futile, but if everybody changed their behaviour, those small actions would add up and help to protect our oceans and the animals that live within them. Plastic reduction and reuse, part of zero-waste living, is a growing trend worldwide and, in some cases, is helping remove ocean plastic pollution. For example, lost or discarded fishing gear is being upcycled into sunglasses, skateboards or carpets.

Stopping the flow of plastic into our oceans is not something that one person, one organisation or one country can achieve by themselves; this needs the effort, energy and input from everyone, all over the world.

The solution also cannot be reduced to single products or types of plastic, nor is the situation urgent only for whales, dolphins and porpoises, but concerns sea birds, turtles, other marine mammals, fish and ultimately humans.

Without comprehensive action, in a short time, all whales and dolphins will be affected, and both large and larger numbers will die.

Actions that the UK and other governments need to enact, *inter-alia*:

- Industry needs to be held responsible, legally and financially, for their product's environmental impacts via an extended producer responsibility scheme
- An 'all-in' deposit return scheme needs to be introduced
- A legislative framework that brings in a progressive certainty of direction in the elimination of single use plastics

Actions that corporations need to enact:

- Plastic production needs to be reduced, especially of non-essential single-use plastic items. This must be enforced by appropriate legislation and policies
- Consumers need to be given a choice to buy plastic-free
- A widespread system of reusable and refillable containers and packaging needs to be introduced, for example with takeaways. And where this already exists, emulated and rolled out, possibly with grant support
- Truly biodegradable products should be developed. Biopolymers occur in nature

Actions that the public needs to enact:

- Reuse and reduce are better than recycle
- Choose alternatives, such as loose fruit and veg in non-plastic bags
- Use reusable shopping bags, ideally made from recycled plastic
- Request alternatives of shops, supermarkets, corporations and governments
- Go litter picking in your towns and cities to prevent litter from making its way into the sea
- Replace items for non-plastic only after it has served its life

In one year, the UK population of 68.3 million people[25] could prevent 177,580 tonnes of plastic from entering the oceans, if everyone prevented five 10g plastic items (e.g. five 0.5L plastic water bottles) from going into the ocean (due to not being bought, being recycled or litter picked) every week. These 177,580 tonnes are 0.85 % of the 21 million tonnes that on average enter the ocean each year.

Reusable to-go dishware systems are already being used in various countries. This movement is mostly using mobile apps to change the status quo systems of disposable takeaway/food4delivery to new delivery systems using returnable-reusable containers. The movement is spreading but needs more support and incentives. CupClub UK received monetary support from the Ellen MacArthur Foundation and got the ball rolling in the UK. Many of the apps for these systems are fabulous innovations. In Belgium, you can buy a leak proof stainless steel container that will last a lifetime for your takeaway and then get a discount at participating members. Here is a list of what is available in European countries and the USA at the time of drafting this report:

25 https://www.worldometers.info/world-population/uk-population/

			Type of service		
Country	**Name**	**Website**	**Food & Drink Delivery/ Takeaway**	**Drinks Only**	**Event containers & services**
Belgium	Deliverhood	https://recyclingnetwerk.org/deliveround/	x		
	Billiecup	https://billiecup.be		x	
	Tiffin	tiffin.be			x
France, Paris (only)	Milubo	milubo.com	x		
	Ecoverre	https://www.ecoverre.com			x
Germany	Vytal	https://www.vytal.org	x		
	Rebowl	https://rebowl.de	x		
	Recup	https://recup.de/der-recup		x	
Ireland	2gocup	https://www.2gocup.ie		x	
Italy	Ecoverre	https://www.ecoverre.com			x
Luxemburg	Ecobox	https://ecobox.lu/en/	x		
Netherlands (Amsterdam)	Ozarka	https://ozarka.nl	x		
Portugal	Ecoverre	https://www.ecoverre.com			x
Spain	Youbumerang	https://www.youbumerang.com	x		
Switzerland	reCircle	https://www.recircle.ch/en/	x		
	Ecoverre	https://www.ecoverre.com			x
UK	CupClub	https://youtu.be/E80K-Nqvp50 https://www.newplasticseconomy.org/innovation-prize/winners/cupclub		x	
USA	Dispatch Goods	https://aboutdispatchgoods.com/home	x		
	Vessel Works	https://vesselworks.org	x		

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Annex 1

List of all cetacean species showing ingestion of, or entanglement in, different litter types, along with the source of information used in the review process

Index	Family	Scientific Name	Common Name	Ingestion	Entanglement	Microlitter	Mesolitter	Macrolitter	Source
1	*Balaenidae*	*Balaena mysticetus*	bowhead whale	1	1	0	0	1	(Laist, 1997; Lowry, 1993; Philo *et al.*, 1992)
2	*Balaenidae*	*Eubalaena australis*	southern right whale	1	1	0	0	1	(Alzugaray *et al.*, 2020; Cawthorn, 1984; Ceccarelli, 2009; Kemper *et al.*, 2008; Laist, 1997)
3	*Balaenidae*	*Eubalaena glacialis*	North Atlantic right whale	1	1	0	0	1	(Cassoff *et al.*, 2011; Cole *et al.*, 2006; T. Good *et al.*, 2007; Henry *et al.*, 2012; Johnson *et al.*, 2005; Knowlton and Kraus, 2001; Knowlton *et al.*, 2012; Kraus *et al.*, 2016; Laist, 1997)
4	*Balaenidae*	*Eubalaena japonica*	North Pacific right whale	0	0	0	0	0	
5	*Balaenopteridae*	*Balaenoptera acutorostrata*	Common minke whale	1	1	0	1	1	(Baulch and Perry, 2014; Cassoff *et al.*, 2011; Cawthorn, 1984; Ceccarelli, 2009; Cole *et al.*, 2006; De Pierrepont *et al.*, 2005; Gill *et al.*, 2000; T. P. Good *et al.*, 2007; Hare and Mead, 1987; Henry *et al.*, 2012; Mate, 1984; Mauger *et al.*, 2002; Tarpley and Marwitz, 1993)
6	*Balaenopteridae*	*Balaenoptera bonaerensis*	Antarctic minke whale	0	1	0	0	1	(Thiel *et al.*, 2018)
7	*Balaenopteridae*	*Balaenoptera borealis*	sei whale	1	1	0	0	1	(Baulch and Perry, 2014; Lyman, 2012)
8	*Balaenopteridae*	*Balaenoptera edeni*	Bryde's whale	1	1	0	0	1	(Cassoff *et al.*, 2011; Ceccarelli, 2009; Cole *et al.*, 2006; Haines and Limpus, 2000)

9	*Balaenopteridae*	*Balaenoptera musculus*	blue whale	1	1	0	0	1	(Baxter, 2009; Cole *et al.*, 2006)
10	*Balaenopteridae*	*Balaenoptera omurai*	Omura's whale	0	0	0	0	0	
11	*Balaenopteridae*	*Balaenoptera physalus*	fin whale	1	1	1	0	1	(Baulch and Perry, 2014; Cole *et al.*, 2006; Fossi *et al.*, 2014, 2012; Henry *et al.*, 2012; Lusher *et al.*, 2018; Sadove and Morreale, 1989)
12	*Balaenopteridae*	*Balaenoptera ricei*	Rice's whale	1	0	0	0	1	(Rosel et al., 2021)
13	*Balaenopteridae*	*Megaptera novaeangliae*	humpback whale	1	1	1	1	1	(Baulch and Perry, 2014; Besseling *et al.*, 2015; Cassoff *et al.*, 2011; Ceccarelli, 2009; Cole *et al.*, 2006; T. Good *et al.*, 2007; Henry *et al.*, 2012; Johnson *et al.*, 2005; Laist, 1997; Lusher *et al.*, 2018; Lyman, 2012; Mate, 1984; Mattila and Lyman, 2006; Moore *et al.*, 2009; National Marine Fisheries Service, 1991; Thiel *et al.*, 2011; Volgenau *et al.*, 1995)
14	*Delphinidae*	*Cephalorhynchus commersonii*	Commerson's dolphin	0	0	0	0	0	
15	*Delphinidae*	*Cephalorhynchus eutropia*	Chilean dolphin	0	0	0	0	0	
16	*Delphinidae*	*Cephalorhynchus heavisidii*	Heaviside's dolphin	0	0	0	0	0	
17	*Delphinidae*	*Cephalorhynchus hectori*	Hector's dolphin	0	0	0	0	0	
18	*Delphinidae*	*Delphinus delphis*	common dolphin	1	1	1	1	1	(Baulch and Perry, 2014; Ceccarelli, 2009; Deaville and Jepson, 2011; Hernandez-Gonzalez *et al.*, 2018; Lusher *et al.*, 2018; Simmonds, 2012; Walker and Coe, 1990)
19	*Delphinidae*	*Feresa attenuata*	pygmy killer whale	0	0	0	0	0	

20	*Delphinidae*	*Globicephala macrorhynchus*	short-finned pilot whale	1	1	0	0	1	(Barros *et al.*, 1997; Baulch and Perry, 2014; Byrd *et al.*, 2014; Ceccarelli, 2009; Simmonds, 2012; Walker and Coe, 1990)
21	*Delphinidae*	*Globicephala melas*	long-finned pilot whale	1	1	0	1	1	(Ceccarelli, 2009; Donoghue, 1994; Laist, 1997; Sadove and Morreale, 1989; Thiel *et al.*, 2011)
22	*Delphinidae*	*Grampus griseus*	Risso's dolphin	1	1	1	0	1	(Baulch and Perry, 2014; Bermúdez Villapol *et al.*, 2008; de Stephanis *et al.*, 2013; Jacobsen *et al.*, 2010; Li *et al.*, 2021; Nelms *et al.*, 2019; Puig-Lozano *et al.*, 2018; Shoham-Frider *et al.*, 2002; Simmonds, 2012; Walker and Coe, 1990)
23	*Delphinidae*	*Lagenodelphis hosei*	Fraser's dolphin	1	0	0	1	1	(Baulch and Perry, 2014; Fernandez *et al.*, 2009; Li *et al.*, 2021)
24	*Delphinidae*	*Lagenorhynchus acutus*	Atlantic white-sided dolphin	1	0	1	0	0	(Nelms *et al.*, 2019)
25	*Delphinidae*	*Lagenorhynchus albirostris*	white-beaked dolphin	1	0	1	0	1	(Baird and Hooker, 2000; Baulch and Perry, 2014; Nelms *et al.*, 2019)
26	*Delphinidae*	*Lagenorhynchus australis*	Peale's dolphin	0	0	0	0	0	
27	*Delphinidae*	*Lagenorhynchus cruciger*	hourglass dolphin	0	0	0	0	0	
28	*Delphinidae*	*Lagenorhynchus obliquidens*	Pacific white-sided dolphin	1	1	0	1	1	(Caldwell *et al.*, 1965; Cowan *et al.*, 1986; Simmonds, 2012; Walker and Coe, 1990)
29	*Delphinidae*	*Lagenorhynchus obscurus*	dusky dolphin	0	0	0	0	0	
30	*Delphinidae*	*Lissodelphis borealis*	northern right whale dolphin	1	0	0	1	1	(Simmonds, 2012; Walker and Coe, 1990)
31	*Delphinidae*	*Lissodelphis peronii*	southern right whale dolphin	0	0	0	0	0	

32	*Delphinidae*	*Orcaella brevirostris*	Irrawaddy dolphin	1	0	0	0	1	(Baulch and Perry, 2014)
33	*Delphinidae*	*Orcaella heinsohni*	Australian snubfin dolphin	0	1	0	0	1	(Ceccarelli, 2009)
34	*Delphinidae*	*Orcinus orca*	killer whale	1	1	1	0	1	(Baird and Hooker, 2000; Baulch and Perry, 2014; Cawthorn, 1984; Lusher *et al.*, 2018; Thiel *et al.*, 2011)
35	*Delphinidae*	*Peponocephala electra*	melon-headed whale	1	0	0	0	1	(Abreo *et al.*, 2019; dos Santos Costa *et al.*, 2012; Li *et al.*, 2021)
36	*Delphinidae*	*Pseudorca crassidens*	false killer whale	1	0	0	1	1	(Barros *et al.*, 1990; Puig-Lozano *et al.*, 2018)
37	*Delphinidae*	*Sotalia fluviatilis*	tucuxi	1	0	0	1	1	(Geise and Gomes, 1992; Laist, 1997)
38	*Delphinidae*	*Sotalia guianensis*	Guiana dolphin	1	1	1	1	1	(Azevedo *et al.*, 2009; Baulch and Perry, 2014; da Rocha and Andriolo, 2005; Di Beneditto and Awabdi, 2014; Di Beneditto and Oliveira, 2019; Di Beneditto and Ramos, 2014; Geise and Gomes, 1992)
39	*Delphinidae*	*Sousa chinensis*	Indo-Pacific humpbacked dolphin	1	1	1	0	0	(Ceccarelli, 2009; Zhu *et al.*, 2019)
40	*Delphinidae*	*Sousa plumbea*	Indian Ocean humpback dolphin	0	0	0	0	0	
41	*Delphinidae*	*Sousa sahulensis*	Australian humpback dolphin	0	0	0	0	0	
42	*Delphinidae*	*Sousa teuszii*	Atlantic humpback dolphin	0	0	0	0	0	

43	*Delphinidae*	*Stenella attenuata*	pantropical spotted dolphin	1	0	0	0	1	(Baird and Hooker, 2000; Li *et al.*, 2021)
44	*Delphinidae*	*Stenella clymene*	clymene dolphin	0	0	0	0	0	
45	*Delphinidae*	*Stenella coeruleoalba*	striped dolphin	1	0	1	0	1	(Barros *et al.*, 1997; Baulch and Perry, 2014; Fernandez *et al.*, 2009; Lusher *et al.*, 2018; Nelms *et al.*, 2019; Novillo *et al.*, 2020; Pribanic *et al.*, 1999; Simmonds, 2012; Walker and Coe, 1990)
46	*Delphinidae*	*Stenella frontalis*	Atlantic spotted dolphin	1	0	0	0	1	(Baulch and Perry, 2014)
47	*Delphinidae*	*Stenella longirostris*	spinner dolphin	0	0	0	0	0	
48	*Delphinidae*	*Steno bredanensis*	rough-toothed dolphin	1	0	0	1	1	(Baulch and Perry, 2014; Oliveira de Meirelles and Duarte do Rego Barros, 2007; Simmonds, 2012; Walker and Coe, 1990)
49	*Delphinidae*	*Tursiops aduncus*	Indo-Pacific bottlenose dolphin	0	1	0	0	1	(Bossley *et al.*, 2005; Ceccarelli, 2009; Chatto and Warneke, 2000)
50	*Delphinidae*	*Tursiops truncatus*	Common bottlenose dolphin	1	1	1	1	1	(Barros *et al.*, 1990; Baulch and Perry, 2014; Byrd *et al.*, 2014; Ceccarelli, 2009; da Rocha and Andriolo, 2005; Deaville and Jepson, 2011; Đuras Gomer i *et al.*, 2009; Gorzelany, 1998; Levy *et al.*, 2009; Li *et al.*, 2021; Mann *et al.*, 1995; McFee *et al.*, 2006; McFee and Hopkins-Murphy, 2002; Nelms *et al.*, 2019; NMFS, 2009a; Schwartz *et al.*, 1991; Simmonds, 2012; Stolen *et al.*, 2013; Walker and Coe, 1990)

51	*Eschrichtiidae*	*Eschrichtius robustus*	gray whale	1	1	0	0	1	(Cascadia Research Collective, 2010; Hare and Mead, 1987; Laist, 1997; Mate, 1984)
52	*Iniidae*	*Inia geoffrensis*	boto	0	1	0	0	1	(da Rocha and Andriolo, 2005; Iriarte and Marmontel, 2013)
53	*Kogiidae*	*Kogia breviceps*	pygmy sperm whale	1	0	1	1	1	(Barros *et al.*, 1990; Baulch and Perry, 2014; Brentano and Petry, 2020; Fernandez *et al.*, 2009; Jacobsen *et al.*, 2010; Laist *et al.*, 1999; Li *et al.*, 2021; Nelms *et al.*, 2019; Sadove and Morreale, 1989; Simmonds, 2012; Stamper *et al.*, 2006; Tarpley and Marwitz, 1993; Walker and Coe, 1990)
54	*Kogiidae*	*Kogia sima*	dwarf sperm whale	1	0	0	0	1	(Barros *et al.*, 1990; Baulch and Perry, 2014; Simmonds, 2012; Walker and Coe, 1990)
55	*Lipotidae*	*Lipotes vexillifer*	baiji	0	0	0	0	0	
56	*Monodontidae*	*Delphinapterus leucas*	white whale	1	1	1	0	0	(Helker *et al.*, 2015; Moore *et al.*, 2020)
57	*Monodontidae*	*Monodon monoceros*	narwhal	1	0	0	0	1	(Haelters *et al.*, 2018)
58	*Neobalaenidae*	*Caperea marginata*	pygmy right whale	1	1	0	0	1	(Baulch and Perry, 2014; Ceccarelli, 2009)
59	*Phocoenidae*	*Neophocaena asiaeorientalis*	Narrow-ridged finless porpoise	1	0	1	0	0	(Xiong *et al.*, 2018)
60	*Phocoenidae*	*Neophocaena phocaenoides*	finless porpoise	1	1	0	1	1	(Baird and Hooker, 2000; Hong *et al.*, 2013)
61	*Phocoenidae*	*Phocoena dioptrica*	spectacled porpoise	0	0	0	0	0	

62	*Phocoenidae*	*Phocoena phocoena*	harbour porpoise	1	1	1	1	1	(Baird and Hooker, 2000; Baulch and Perry, 2014; Bogomolni *et al.*, 2010; Deaville and Jepson, 2011; Good *et al.*, 2010; Hare and Mead, 1987; Kastelein and Lavaleije, 1992; Lusher *et al.*, 2018; Nelms *et al.*, 2019; Philipp *et al.*, 2021; Simmonds, 2012; Tonay *et al.*, 2007; Walker and Coe, 1990)
63	*Phocoenidae*	*Phocoena sinus*	vaquita	0	0	0	0	0	
64	*Phocoenidae*	*Phocoena spinipinnis*	Burmeister's porpoise	1	0	0	0	1	(Baulch and Perry, 2014)
65	*Phocoenidae*	*Phocoenoides dalli*	Dall's porpoise	1	1	0	1	1	(Jones and Ferrero, 1985; Simmonds, 2012; Walker and Coe, 1990)
66	*Physeteridae*	*Physeter macrocephalus*	sperm whale	1	1	1	1	1	(Alexiadou *et al.*, 2019; Baulch and Perry, 2014; Byrd *et al.*, 2014; de Stephanis *et al.*, 2013; Fernandez *et al.*, 2009; Jacobsen *et al.*, 2010; Katsanevakis, 2008; Laist, 1997; Lambertsen, 1990; Lambertsen and Kohn, 1987; Lyman, 2012; Martin and Clarke, 1986; Mate, 1984, 1984; Mazzariol *et al.*, 2011; Moore *et al.*, 2009; NMFS, 2009b; Roberts, 2003; Sadove and Morreale, 1989; Simmonds, 2012; Spence, 1995; Unger *et al.*, 2016; Viale *et al.*, 1992; Walker and Coe, 1990)
67	*Platanistidae*	*Platanista gangetica*	Ganges river dolphin	0	0	0	0	0	
68	*Platanistidae*	*Platanista minor*	Indus river dolphin	0	0	0	0	0	
69	*Pontoporiidae*	*Pontoporia blainvillei*	franciscana	1	0	1	1	1	(Bassoi, 1997; Bastida *et al.*, 2000; Denuncio *et al.*, 2011; Di Beneditto and Awabdi, 2014; Di Beneditto and Oliveira, 2019; Di Beneditto and Ramos, 2014; Pinedo, 1982)

70	*Ziphiidae*	*Berardius arnuxii*	Arnoux's beaked whale	0	0	0	0	0	
71	*Ziphiidae*	*Berardius bairdii*	Baird's beaked whale	1	0	0	1	1	(Baulch and Perry, 2014; Walker and Coe, 1990)
72	*Ziphiidae*	*Berardius minimus Yamada*	Satos beaked whale	0	0	0	0	0	
73	*Ziphiidae*	*Hyperoodon ampullatus*	northern bottlenose whale	1	1	0	1	1	(Baird and Hooker, 2000; Baulch and Perry, 2014; Deaville and Jepson, 2011; Gowans *et al.*, 2000)
74	*Ziphiidae*	*Hyperoodon planifrons*	southern bottlenose whale	0	0	0	0	0	
75	*Ziphiidae*	*Indopacetus pacificus*	Longman's beaked whale	1	0	0	0	1	(Baulch and Perry, 2014; Yamada *et al.*, 2012b)
76	*Ziphiidae*	*Mesoplodon bidens*	Sowerby's beaked whale	1	0	0	1	1	(Baulch and Perry, 2014; Deaville and Jepson, 2011; Lusher *et al.*, 2018)
77	*Ziphiidae*	*Mesoplodon bowdoini*	Andrews' beaked whale	0	0	0	0	0	
78	*Ziphiidae*	*Mesoplodon carlhubbsi*	Hubbs' beaked whale	1	0	0	0	1	(Baulch and Perry, 2014; Yamada *et al.*, 2012a)
79	*Ziphiidae*	*Mesoplodon densirostris*	Blainville's beaked whale	1	0	0	1	1	(Baulch and Perry, 2014; Byrd *et al.*, 2014; Secchi and Zarzur, 1999; Simmonds, 2012; Walker and Coe, 1990)
80	*Ziphiidae*	*Mesoplodon europaeus*	Gervais' beaked whale	1	0	0	0	1	(Baulch and Perry, 2014; Byrd *et al.*, 2014; Fernandez *et al.*, 2009; Simmonds, 2012; Walker and Coe, 1990)
81	*Ziphiidae*	*Mesoplodon ginkgodens*	ginkgo-toothed beaked whale	1	0	0	0	0	(Baulch and Perry, 2014)

82	*Ziphiidae*	*Mesoplodon grayi*	Gray's beaked whale	1	0	0	0	1	(Baulch and Perry, 2014)
83	*Ziphiidae*	*Mesoplodon hectori*	Hector's beaked whale	0	0	0	0	0	
84	*Ziphiidae*	*Mesoplodon hotaula Deraniyagala*	Deraniyagala's beaked whale	1	0	0	0	1	(Abreo *et al.*, 2016)
85	*Ziphiidae*	*Mesoplodon layardii*	strap-toothed whale	0	0	0	0	0	
86	*Ziphiidae*	*Mesoplodon mirus*	True's beaked whale	1	0	1	0	1	(Baulch and Perry, 2014; Lusher *et al.*, 2018, 2015)
87	*Ziphiidae*	*Mesoplodon perrini*	Perrin's beaked whale	0	0	0	0	0	
88	*Ziphiidae*	*Mesoplodon peruvianus*	pygmy beaked whale	0	0	0	0	0	
89	*Ziphiidae*	*Mesoplodon stejnegeri*	Stejneger's beaked whale	1	0	0	1	1	(Walker and Hanson, 1999; Yamada *et al.*, 2012b)
90	*Ziphiidae*	*Mesoplodon traversii*	spade-toothed whale	0	0	0	0	0	
91	*Ziphiidae*	*Tasmacetus shepherdi*	Shepherd's beaked whale	1	0	0	0	1	(Goodall *et al.*, 2008)
92	*Ziphiidae*	*Ziphius cavirostris*	Cuvier's beaked whale	1	1	1	0	1	(Baulch and Perry, 2014; Bortolotto *et al.*, 2016; Foster and Hare, 1990; Gomer i *et al.*, 2006; Lusher *et al.*, 2018; Poeta *et al.*, 2017; Poncelet *et al.*, 2000; Santos *et al.*, 2007, 2001; Simmonds, 2012; Walker and Coe, 1990)

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