# PLASTICS AND SHALLOW WATER CORAL REEFS

Synthesis of the science for policy-makers

UN environment

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# About

The overall purpose of this brief is to provide policy and management recommendations for addressing and reducing the impacts of plastics on shallow water coral reefs, based on current scientific knowledge. In doing so, the brief will contribute to achieving the related global, national and regional goals and targets, including the Sustainable Development Goals (SDGs).
The brief promotes integrated planning and management, awareness-raising, and other efforts to improve and standardise the monitoring of plastics on reefs.

It is primarily aimed at national and state policy-makers. The supporting scientific evidence provides rationale for recommendations and more detailed information for government officials with technical roles, as well as regional environmental organisations and conservation organizations.

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# EXECUTIVE SUMMARY


Hundreds of millions of people and industries worth billions of dollars depend on healthy shallow water reef ecosystems (UN Environment, 2018). Yet, anthropogenic stressors, including climate change and pollution, are threatening these fragile ecosystems. As a result, we are now seeing unprecedented levels of decline in reef health and coral cover across the globe.

Plastic, which makes up a sizable proportion of marine pollution, can now be found in all the world's oceans, but it is thought to be in highest concentration in coastal areas and reef environments where the vast majority of this litter originates from land-based sources.

Marine plastic litter pollution is already affecting more than 800 marine and coastal species through ingestion, entanglement and habitat change. With the additional impacts of climate change on coral reef ecosystems, the threat of plastics must be taken seriously.

However, there remains a significant lack of knowledge on the true impacts of plastics on the reef environment. This research identifies a number of knowledge gaps that are necessary to address in order to strengthen the scientific evidence base for action on marine plastics that impact coral reefs, and towards achievement of targets set by the global community.

### WHAT WE KNOW

The issue of plastics in the marine environment has been recognised by scientists, governmental organisations, non-governmental organisations, private institutions and charities alike. It is recognized as a global priority, including in the 2030 Sustainable Development Agenda, under Sustainability Development Goal (SDG) 14 on conserving and using the oceans, seas and marine resources for sustainable development. Specifically, Target 14.1 is to prevent and significantly reduce marine pollution of all kinds by 2025, with indicator 14.1.1 including an index on floating plastic debris density.

### THE SCALE

A landmark study by Jambeck et al. (2015a) calculated that approximately 275 million metric tonnes (MT) of plastic waste was generated by coastal countries, with 4.8 to 12.7 million MT entering the ocean. In the Asia-Pacific region alone, approximately 11.1 billion items of plastic are thought to be present in the shallow water reef environments and this is predicted to rise to more than 15.7 billion by 2025. In addition to the influx of plastics found around coastal areas, five major gyres (or aggregations of floating plastics) have now been identified across the world's oceans. However, a significant proportion of marine litter is unaccountable as estimates on the total amount of litter entering the marine ecosystem are one to three times the magnitude of that reported (Jambeck et al., 2015b).

### THE SOURCE

Marine litter, due to its transboundary nature, is found in all the world's oceans and seas, threatening ecosystem health and causing substantial economic costs through its impacts on public health, tourism, shipping, fishing and aquaculture. The majority of marine litter is plastics (60-80%), predominantly from land-based sources through rivers and run-off. Tourism can be among the most significant sources of marine litter and unsurprisingly the most commonly encountered macroplastics in many reef environments are food and drink packages (Lamb et al., 2018). Other sources include direct dumping of solid waste into the ocean; abandoned, lost or discarded fishing gear, referred to as 'ghost gear'; and micro- or nano-plastics, which can include tyre dust, industrial pellets, paint chips, textile particles and cosmetic microbeads.

## THE IMPACT

More than 800 species have had some form of encounter with marine litter, of which the majority is plastic. For example, every species of sea turtle has been documented to have been impacted, as well as 66% of marine mammals and 50% of seabirds. Trends over the past two decades have shown that instances of ingestion and entanglement of plastic debris has increased by 49% (Gall & Thompson, 2015). Recently, Lamb et al. (2018) demonstrated a link between macroplastic pollution and increased likelihood of coral disease, with the likelihood of disease rising from 4% to 89% when corals were in contact with plastics. However, across the current breadth of research globally, there remains major knowledge gaps as to the true scale and impact of plastic on reef organisms and the ecosystem as a whole.

## WHAT WE NEED TO KNOW

Summary of knowledge gaps associated with reef ecosystems:

1. Understanding of the scale of mismanaged waste in relation to coral reef environments.
2. Understanding of the patterns of plastic pollution in and around coral reef environments.
3. Understanding of the impacts of leaching chemicals from plastics in coral reef environments.
4. Understanding of how, on a wider, more ecologically relevant scale plastics impact coral reef environments.
5. Understanding how macroplastics interact with and affect benthic invertebrates such as sponges and corals.
6. Quantification of the impact of ghost gear and its impact on coral reef communities.
7. Exploring the role of macro- and micro-plastics in transporting invasive epibionts and possible pathogenic agents on a global scale.
8. Measuring concentrations of microplastics across coral reef ecoregions to understand the scale of the issue in a standardised manner.
9. Exploring the level of risk microplastics have on reef organisms.
10. Exploring issues with the detection of microplastics in organisms and the surrounding environment
11. Assessing the quality of current assays used to assess microplastics and validate models for assessing the chance of false negatives and positives in plastic counts.

## WHAT WE NEED TO DO

Closing the knowledge gaps highlighted above will allow us to understand the impacts of plastics on reef organisms and the ecosystem as a whole. However, even without this knowledge it remains clear that plastics are a major concern but one which can be addressed. Namely the restriction or elimination of single use plastics on a global scale would have a considerable and measurable impact on the amount of plastics which reach reefs.

This report identifies detrimental impacts of marine plastic litter on shallow water coral reef ecosystems and organisms. In response to these threats, the following recommendations are made in order to advance action on marine litter and SDG Target 14.1, especially in relation to the sustainable management of coral reef ecosystems:

1. ***Strengthen partnerships to eliminate marine litter and plastic pollution***
   Governments, civil society and private sector actors are encouraged to join the Global Partnership on Marine Litter and engage with the partnership to develop plans and targets for reduction of waste that may enter coral reef areas.

2. ***Strengthen national planning to address land-based sources of plastic litter on coral reefs***
   Countries with coral reefs should develop or revise national action plans and local mitigation measures, based on strategic assessments that identify key sources, pathways and impacts of plastics on reefs; identify and manage major local sources of plastic pollution; apply bans on harmful single-use plastics on beaches close to coral reefs; work with key plastic-producing industries to implement liability and compensation schemes based on polluter-pays mechanisms; and address consumer demand to ensure lasting impact.

3. ***Reduce the impact of marine litter from aquaculture, lost and abandoned fishing gear on coral reefs***
   Develop and apply regional regulations and guidelines on eliminating or reducing lost and abandoned fishing gear from entering the ocean on or around coral reefs, through relevant regional organizations such as Regional Fisheries Management Organizations and Regional Seas Conventions and Action Plans, in close consultation with fishing industries and communities.

4. ***Invest in monitoring and research***
   Financial investment by governments and other entities, and efforts by academic and research institutions is required, in particular, to:
   i. Understand the status and magnitude of marine litter on coral reef ecosystems;
   ii. Understand the impact of plastics on coral reef species and ecosystems;
   iii. Understand the potential societal and economic impacts of plastics on coral reefs;
   iv. And improve data collection and information to address these knowledge gaps.

# موجز تنفيذي

يعتمد مئات الملايين من الناس وصناعات تقدر ببلايين الدولارات على سلامة النظم الإيكولوجية في الشعاب المرجانية بالمياه الضحلة (برنامج الأمم المتحدة للبيئة، ٢٠١٨). ومع ذلك فإن عوامل الإجهاد البشرية المنشأ، بما في ذلك تغير المناخ والتلوث، تهدد هذه النظم الإيكولوجية الهشة. ونتيجة لذلك، نشهد الآن مستويات تدهور غير مسبوقة في صحة الشعاب المرجانية والغطاء المرجاني في جميع أنحاء العالم.

ويمكن الآن أن نجد البلاستيك، الذي يشكل نسبة كبيرة من التلوث البحري، في جميع محيطات العالم، ولكن يعتقد أن أعلى تركيزاته توجد في المناطق الساحلية وبيئات الشعاب المرجانية حيث تأتي الغالبية العظمى من هذه النفايات من مصادر برية.

ويؤثر التلوث بالنفايات البلاستيكية البحرية بالفعل على أكثر من ٨٠٠ نوع من الأنواع البحرية والساحلية من خلال الابتلاع والتشبك وتغيير الموئل. وفي ظل وجود آثار إضافية لتغير المناخ على النظم الإيكولوجية للشعاب المرجانية فإن خطر المواد البلاستيكية يجب أن يؤخذ على محمل الجد.

بيد أنه لا يزال هناك نقص كبير في المعارف بشأن الآثار الحقيقية للمواد البلاستيكية على بيئة الشعاب المرجانية. ويحدد هذا البحث عددا من الفجوات المعرفية التي يتعين معالجتها من أجل تعزيز قاعدة الأدلة العلمية للعمل بشأن المواد البلاستيكية البحرية التي تؤثر على الشعاب المرجانية، وصوب تحقيق الأهداف التي حددها المجتمع العالمي.

### ما نعرفه

أقر العلماء والمنظمات الحكومية والمنظمات غير الحكومية والمؤسسات الخاصة والمؤسسات الخيرية على السواء بمسألة المواد البلاستيكية في البيئة البحرية. وجرى الاعتراف بهذه المسألة بوصفها إحدى الأولويات العالمية، بما في ذلك في خطة التنمية المستدامة لعام ٢٠٣٠، في إطار الهدف ١٤ من أهداف التنمية المستدامة بشأن حفظ واستخدام المحيطات والبحار والموارد البحرية من أجل التنمية المستدامة. وعلى وجه التحديد، تنص الغاية ١٤-١ على منع التلوث البحري بجميع أنواعه وخفضه بشكل كبير بحلول عام ٢٠٢٥، بينما يتضمن المؤشر ١٤-١-١ على معيار بشأن كثافة النفايات البلاستيكية الطافية.

### حجم النفايات

وجدت دراسة مرجعية أجراها جامبيك وآخرون (٢٠١٥أ) أن زهاء ٢٧٥ مليون طن مرتي من النفايات البلاستيكية تتولد في بلداً من البلدان الساحلية، بينما تدخل إلى المحيطات ٤٫٨ إلى ١٢٫٧ مليون طن متري. وفي منطقة آسيا والمحيط الهادئ وحدها يعتقد أن زهاء ١١٫١ بليون قطعة من البلاستيك موجودة في بيئات الشعاب المرجانية في المياه الضحلة، ويتوقع أن تزداد الكمية إلى أكثر من ١٥٫٧ بليون بحلول عام ٢٠٢٥. وإضافةً إلى تدفق المواد البلاستيكية الموجودة حول المناطق الساحلية جرى الآن تحديد خمس دوامات رئيسية (أو تجمعات مواد بلاستيكية طافية) في محيطات العالم. بيد أن هناك نسبة كبيرة من القمامة البحرية لا يمكن تحديدها نظراً لأن التقديرات الكمية الكلية من القمامة التي تدخل إلى النظام الإيكولوجي البحري تعادل من واحد إلى ثلاثة أضعاف كمية القمامة المبلغ عنها (Jambeck et al., ٢٠١٥b).

### مصدر النفايات

توجد القمامة البحرية، بالنظر إلى طابعها العابر للحدود، في جميع محيطات العالم وبحاره، مما يهدد صحة النظام الإيكولوجي ويتسبب في تكبد تكاليف اقتصادية كبيرة من خلال تأثيرها على الصحة العامة، والسياحة، والنقل البحري، وصيد الأسماك، وتربية الأحياء المائية. إن غالبية القمامة البحرية هي مواد بلاستيكية (٦٠-٨٠ في المائة)، يأتي معظمها من مصادر برية عبر الأنهار والجريان السطحي. ويمكن أن تكون السياحة من بين أهم مصادر القمامة البحرية، وليس بمستغرب أن الجسيمات البلاستيكية البحرية الكبيرة الأكثر شيوعاً في العديد من بيئات الشعاب المرجانية هي عبوات الأغذية والمشروبات (Lamb et al., ٢٠١٨). وتشمل المصادر الأخرى إلقاء النفايات الصلبة بشكل مباشر في المحيطات؛ ومعدات الصيد المتروكة أو المفقودة أو المهملة المشار إليها "بمعدات الصيد الشبحية"؛ والمواد البلاستيكية الدقيقة أو النانوية التي يمكن أن تشمل غبار الإطارات والكريات الصناعية ورقاقات الطلاء وجسيمات المنسوجات وحبيبات مواد التجميل الدقيقة.

### تأثير النفايات

يمر أكثر من ٨٠٠ نوع بشكل من أشكال المواجهة مع القمامة البحرية، التي يكون معظمها مواد بلاستيكية. فعلى سبيل المثال، جرى توثيق تأثر كل نوع من أنواع السلاحف البحرية، وكذلك ٦٦ في المائة من الثدييات البحرية و٥٠ في المائة من الطيور البحرية. وأظهرت الاتجاهات السائدة على مدى العقدين الماضيين أن حالات الابتلاع والتشبك في النفايات البلاستيكية زادت بنسبة ٤٩ في المائة (Gall & Thompson, ٢٠١٥). وفي الآونة الأخيرة بين لامب وآخرون (٢٠١٨) وجود صلة بين التلوث بالجسيمات البلاستيكية البحرية الدقيقة وزيادة احتمال اعتلال المرجان، حيث زاد احتمال حدوث الاعتلال من ٤ في المائة إلى ٨٩ في المائة عندما يحدث تلامس بين الشعاب المرجانية والمواد البلاستيكية. بيد أنه لا تزال توجد في كامل البحوث الحالية على الصعيد العالمي فجوات معرفية رئيسية بشأن حجم وتأثير المواد البلاستيكية الحقيقيين على الكائنات الدقيقة بالشعاب المرجانية ونظامها الإيكولوجي ككل.

### ما نحتاج إلى معرفته

موجز للفجوات المعرفية المرتبطة بالنظم الإيكولوجية في الشعاب المرجانية:

١. فهم حجم النفايات التي تدار بطريقة سيئة فيما يتعلق ببيئات الشعاب المرجانية.
٢. فهم أنماط التلوث البلاستيكي في بيئات الشعاب المرجانية وحولها.
٣. فهم آثار المواد الكيميائية التي تنضح من المواد البلاستيكية في بيئات الشعاب المرجانية.
٤. فهم كيفية تأثير المواد البلاستيكية على بيئات الشعاب المرجانية على نطاق أوسع وأكثر أهميةً من الناحية الإيكولوجية.
٥. فهم كيفية تفاعل الجسيمات البلاستيكية البحرية الكبيرة مع اللافقاريات القاعية مثل الإسفنجيات والمرجان وكيفية تأثيرها عليها.
٦. القياس الكمي لتأثير معدات الصيد الشبحية وتأثيرها على تجمعات الشعاب المرجانية.
٧. استكشاف دور الجسيمات البلاستيكية البحرية الدقيقة والكبيرة في نقل الكائنات الحية الغازية التي تعيش على سطح الماء والعوامل الممرضة المحتملة على الصعيد العالمي.
٨. قياس تركيزات الجسيمات البلاستيكية البحرية الدقيقة في المناطق الإيكولوجية للشعاب المرجانية لفهم نطاق المسألة بطريقة موحدة.
٩. استكشاف مستوى مخاطر الجسيمات البلاستيكية البحرية الدقيقة على الكائنات الحية بالشعاب المرجانية.
١٠. استكشاف مسائل تتعلق بالكشف عن الجسيمات البلاستيكية البحرية الدقيقة في الكائنات الحية والبيئة المحيطة بها.
١١. تقييم جودة الاختبارات الحالية المستخدمة في تقييم الجسيمات البلاستيكية البحرية الدقيقة واعتماد نماذج لتقييم احتمالات النتائج السلبية والإيجابية الزائفة في الحسابات الكمية للمواد البلاستيكية.

### ما نحتاج إلى فعله

إن سد الفجوات المعرفية المبينة أعلاه سيمكننا من فهم آثار المواد البلاستيكية على الكائنات الحية في الشعاب المرجانية والنظام الإيكولوجي ككل. بيد أنه حتى بدون توفر هذه المعرفة يظل من الواضح أن المواد البلاستيكية تمثل أحد الشواغل الرئيسية، ولكنه شاغل يمكن معالجته. إن تقييد أو وقف استخدام المواد البلاستيكية الأحادية الاستخدام على الصعيد العالمي سيكون له، على وجه التحديد، تأثير كبير يمكن قياسه على كمية المواد البلاستيكية التي تصل إلى الشعاب المرجانية.

ويحدد هذا التقرير الآثار الضارة للنفايات البلاستيكية البحرية على النظم الإيكولوجية والكائنات الحية في الشعاب المرجانية بالمياه الضحلة. ولمواجهة هذه التهديدات تُقدم التوصيات التالية من أجل تعزيز العمل على صعيد القمامة البحرية والغاية ١٤-١ من أهداف التنمية المستدامة، لا سيما فيما يتعلق بالإدارة المستدامة للنظم الإيكولوجية بالشعاب المرجانية:

**١. تعزيز الشراكات من أجل القضاء على النفايات البحرية والتلوث البلاستيكي**

تشـجع الحكومـات والمجتمـع المـدني والجهـات الفاعلـة في القطـاع الخـاص عـلى الانضمـام إلى الشراكـة العالميـة لمعالجـة مشكلة القمامـة البحريـة والانخـراط مـع الشراكـة في وضـع خطـط وأهـداف للحـد مـن النفايـات الـتي يمكـن أن تدخـل مناطـق الشـعاب المرجانيـة.

**٢. تعزيز التخطيط الوطني لمعالجة المصادر البرية للنفايات البلاستيكية في الشعاب المرجانية**

يتعـين عـلى البلـدان الـتي لديهـا شـعاب مرجانيـة أن تضـع أو تنقـح خطـط العمـل الوطنيـة وتدابـير التخفيـف المحليـة، اسـتناداً إلى تقييمـات اسـتراتيجية تحـدد المصـادر الرئيسـية والمسـارات وآثـار المـواد البلاسـتيكية عـلى الشـعاب المرجانيـة؛ وأن تحـدد وتديـر المصـادر المحليـة الرئيسـية للتلـوث بالمـواد البلاسـتيكية؛ وأن تطبـق الحظـر المفـروض عـلى المـواد البلاسـتيكية الأحاديـة الاسـتخدام الضـارة عـلى الشـواطئ القريبـة مـن الشـعاب المرجانيـة؛ وأن تعمـل مـع الصناعـات الرئيسـية المنتجـة للمـواد البلاسـتيكية لتنفيـذ نظـم المسـؤولية والتعويـض القائمـة عـلى آليـات "الملـوث يدفـع"؛ وأن تعالـج طلـب المسـتهلك لضمـان تحقيـق أثـر دائـم.

**٣. الحـد مـن تأثـير القمامـة البحريـة الناتجـة عـن تربيـة الأحيـاء المائيـة، ومعـدات الصيـد المفقـودة أو المتروكـة عـلى الشـعاب المرجانيـة**

وضـع وتطبيـق قواعـد ومبـادئ توجيهيـة إقليميـة بشـأن وقـف أو خفـض دخـول معـدات الصيـد المفقـودة أو المتروكـة إلى المحيطـات في منطقـة الشـعاب المرجانيـة أو حولهـا، مـن خـلال منظمـات إقليميـة ذات صلـة مثـل المنظمـات الإقليميـة لإدارة مصائـد الأسـماك واتفاقيـات وخطـط عمـل البحـار الإقليميـة، بالتشـاور الوثيـق مـع صناعـات ومجتمعـات صيـد الأسـماك.

### ٤. الاستثمار في الرصد والبحوث

إن الاستثمارات المالية من الحكومات والكيانات الأخرى والجهود التي تبذلها المؤسسات الأكاديمية والبحثية ضرورية، وبخاصة من أجل القيام بما يلي:

أولاً- فهم حالة وحجم القمامة البحرية على النظم الإيكولوجية في الشعاب المرجانية؛

ثانياً- فهم تأثير المواد البلاستيكية على أنواع الشعاب المرجانية والنظم الإيكولوجية فيها؛

ثالثاً- فهم الآثار الاقتصادية والاجتماعية المحتملة للمواد البلاستيكية على الشعاب المرجانية؛

رابعاً- تحسين جمع البيانات والمعلومات من أجل التصدي لهذه الفجوات المعرفية.

# 执行摘要

数亿人以及价值数十亿美元的工业依赖于健康的浅水珊瑚礁生态系统（联合国环境署，2018年）。然而，包括气候变化和污染在内的人为压力源，正威胁着这些脆弱的生态系统。因此，全球范围内珊瑚礁健康状况和珊瑚覆盖率正在空前下降。

塑料在全球所有海洋中可见，在海洋污染中占相当大的比例。然而塑料最集中的区域是沿海海域和珊瑚礁生态，这里绝大多数垃圾是陆源垃圾。

由于吞食、缠绕和栖息地环境改变，海洋塑料垃圾污染已经影响了800多种海洋生物和滨海物种。考虑到气候变化对珊瑚礁生态系统产生的额外影响，我们必须重视塑料带来的威胁。然而，关于塑料对珊瑚礁环境的真正影响仍严重缺少相关认识。这项研究识别了一些必须填补的知识缺口，将为我们针对影响珊瑚礁的海洋塑料所开展的行动提供科学依据，并有助于实现国际社会所设定的目标。

### 我们已知

海洋塑料问题已经得到了科学家、政府组织、非政府组织、私人机构和慈善机构的重视。塑料污染被视为全球优先事项， 在2030年可持续发展议程的可持续发展目标（SDG）14：关于保护和可持续利用海洋和海洋资源以促进可持续发展也是如此。具体来说，目标14.1中指出，截止至2025年，我们需要预防和显著减少各种海洋污染，指标14.1.1中包括了一项漂浮塑料废弃物密度指数。

### 规模

Jambeck等人的里程碑式研究（2015a）计算出沿海国家约产生共计2.75亿公吨的塑料废物，其中480万至1270万公吨进入海洋。仅在亚太地区，浅水珊瑚礁环境中就有大约111亿件塑料垃圾，预计到2025年将增加到157亿件以上。除了近岸海域发现的塑料流入外，全球海洋中还发现了五个主要的垃圾带（或漂浮塑料的聚集体）。然而，由于进入海洋生态系统的垃圾总量估计是已报告数量的1至3倍，因此有很大比例的海洋垃圾仍未被计算在内 (Jambeck 等人., 2015b)。

### 来源

海洋垃圾，由于其跨境性质，可以在全球各地的海洋中发现。由于对公共卫生、旅游、航运、渔业和水产养殖等领域的影响，正在威胁生态系统健康并造成巨大的经济损失。大部分海洋垃圾是塑料（60-80%），主要来自陆源，并通过河流和径流汇入海洋。旅游业是海洋垃圾最突出的来源之一，因而食品和饮料包装毫不意外地是许多珊瑚礁环境中最常见的塑料制品(Lamb 等人., 2018) 。其他来源包括直接向海洋倾倒固体废物；废弃、丢失或丢弃的渔具，被称为“幽灵渔具”；以及微型或纳米塑料，如轮胎粉尘、工业颗粒、油漆碎片、纺织颗粒和化妆品微珠等。

### 影响

800多个物种曾以某种形式接触海洋垃圾，其中大多数是塑料垃圾。例如，所有种类的海龟，以及66%的海洋哺乳动物和50%的海鸟皆被塑料垃圾影响。过去20年的趋势表明，吞食和被塑料废弃物缠绕的情况增加了49% (Gall & Thompson, 2015)。最近，Lamb等人（2018）证明了大塑料污染与珊瑚患病可能性上升之

间的联系：当珊瑚与塑料接触时，其患病率将从4%上升到89%。然而，纵观当下全球的研究，在塑料对珊瑚礁生物和整个生态系统的真实影响规模和结果方面，仍然存在重大的认识缺口。

## 我们需要了解什么

珊瑚礁生态系统知识缺口总结：

1. 了解珊瑚礁环境中未被正确处置的废弃物规模。
2. 了解珊瑚礁环境中和周围的塑料污染模式。
3. 了解塑料垃圾中分解出的化学物质对珊瑚礁环境的影响。
4. 了解塑料如何在更广泛、更与生态相关的层面上影响珊瑚礁环境。
5. 了解大塑料与海绵和珊瑚等底栖无脊椎动物之间的相互作用和影响。
6. 量化幽灵渔网的数量及其对珊瑚礁群落的影响。
7. 了解大和微塑料在全球范围内运输入侵性表生生物和可能致病因子中的作用。
8. 测量珊瑚礁生态区的微塑料浓度，以便用标准化方式了解塑料污染程度。
9. 探索微塑料对礁生物的危害程度。
10. 探索生物体内和周围环境中微塑料的检测方法。
11. 评估当前微型塑料估算的检测和用以评估塑料计量中出现假阴性和假阳性概率模型的质量。

## 我们需要做什么

缩小上述认知缺口将使我们了解塑料对珊瑚礁生物和整个生态系统的影响。然而，即使没有这方面的知识，我们仍明确知道塑料垃圾是一个重大但可解决的问题。比如全球范围内限制或减少一次性塑料的使用，就可大幅度影响触及珊瑚礁环境的塑料数量。

本报告指出了海洋塑料垃圾对浅水珊瑚礁生态系统和生物的危害。为应对这些威胁，我们提出了以下建议，以推进减少海洋垃圾的行动，实现可持续发展目标14.1，特别是与珊瑚礁生态系统的可持续管理相关的行动：

1. **强化合作关系，消灭海洋垃圾和塑料污染**
   鼓励各国政府、公民社会和私营企业行动者加入全球海洋垃圾合作关系，并与伙伴合作一同制定计划和目标，以减少可能进入珊瑚礁地区的废弃物。
2. **完善国家规划，解决珊瑚礁陆源塑料垃圾**
   拥有珊瑚礁生态的国家应制定或修订国家行动计划和地方减缓措施，基于战略评估识别珊瑚礁中塑料垃圾的关键来源、途径和影响；辨别并管理主要塑料污染源；在靠近珊瑚礁地区实施一次性塑料禁令；与主要塑料生产企业实施基于污染者生态赔付机制的责任和补偿方案；满足消费者需求，确保持久影响。
3. **降低水产养殖垃圾、丢失和废弃渔具对珊瑚礁的影响**
   通过区域渔业管理机构、区域海洋公约和行动计划等相关区域组织，并与捕鱼业和社区密切协商，制定和使用区域法规和指导方针，以消灭或减少进入珊瑚礁周围海洋的丢失和废弃渔具。

4．投资监测和研究

政府与其他机构应当进行资金投入，学术和研究机构具体也应：

i. 了解珊瑚礁生态系统中海洋垃圾的状况和规模；

ii. 了解塑料垃圾对珊瑚礁物种和生态系统的影响；

iii. 了解塑料垃圾对珊瑚礁的潜在社会和经济影响；

iv. 完善数据和信息收集，以弥补这些认知缺口。

# RÉSUMÉ ANALYTIQUE

Des centaines de millions de personnes et des secteurs d'activité qui représentent des milliards de dollars dépendent de la bonne santé des écosystèmes de récifs coralliens des eaux peu profondes (PNUE 2018). Or les facteurs de stress anthropiques, y compris les changements climatiques et la pollution, mettent en péril ces écosystèmes fragiles. C'est ainsi que nous observons actuellement à travers le monde un taux de déclin sans précédent de l'état de santé des récifs et de la couverture corallienne.

Les plastiques, qui constituent une part importante de la pollution marine, sont désormais présents dans tous les océans de la planète, mais on estime que les niveaux de concentration sont les plus élevés dans les zones côtières et les ensembles coralliens où la vaste majorité des déchets proviennent de sources terrestres.

La pollution des mers par des déchets plastiques a déjà une incidence sur plus de 800 espèces marines et côtières du fait de l'ingestion de débris ou l'enchevêtrement dans ces derniers et de la modification de leur habitat. Compte tenu également des effets des changements climatiques sur les écosystèmes de récifs coralliens, la menace que représentent les plastiques doit être prise au sérieux.

Cependant, l'on connaît encore très mal l'impact réel des plastiques sur les ensembles coralliens. La présente étude recense un certain nombre de lacunes dans les connaissances qu'il faudra acquérir afin de renforcer les mesures qui sont basées sur le corpus de données scientifiques et permettront tant de lutter contre les plastiques présents dans le milieu marin qui ont un impact sur les récifs coralliens que d'atteindre les objectifs qui ont été fixés par la communauté internationale.

## CE QUE NOUS SAVONS

Les problèmes associés à la présence de matières plastiques dans le milieu marin ont été reconnus par la communauté scientifique, les organisations gouvernementales, les organisations non-gouvernementales, mais aussi les institutions du secteur privé et les organisations caritatives. Ils représentent une priorité à l'échelle de la planète, notamment dans le cadre du Programme de développement durable à l'horizon 2030, en vertu de l'objectif de développement durable 14 intitulé « Conserver et exploiter de manière durable les océans, les mers et les ressources marines aux fins du développement durable ». Plus précisément, la cible 14.1 a pour objectif, d'ici à 2025, de prévenir et de réduire nettement la pollution marine de tous types, l'indicateur 14.1.1 fournissant notamment un indice de densité des débris de plastiques flottant en surface des océans.

## L'AMPLEUR DU PROBLÈME

Une étude de Jambeck et al. (2015a), qui fait date, a montré que selon les calculs, environ 275 millions de tonnes métriques de déchets plastiques ont été produites par pays côtiers, dont 4,8 à 12,7 millions de tonnes métriques ont été déversées dans le milieu marin. Dans la seule région de l'Asie et du Pacifique, environ 11,1 milliards d'objets en matière plastique seraient présents dans les eaux peu profondes des ensembles coralliens, et on prévoit que d'ici à 2025, le nombre d'objets devrait augmenter, dépassant 15,7 milliards. Mis à part l'afflux de matières plastiques que l'on trouve à proximité des zones côtières, cinq énormes « tourbillons » (ou amas de matière plastiques flottantes) ont maintenant été recensés à travers tous les océans de la planète. Cependant, une part significative des déchets en mer n'a pas été comptabilisée, étant donné que le volume total de déchets qui entrent dans l'écosystème marin est trois fois supérieur à celui qui est effectivement recensé (Jambeck et al., 2015b).

## LA SOURCE

Les déchets en mer, compte tenu de leur nature transfrontière, se retrouvent dans toutes les mers et tous les océans de la planète. Ils menacent la bonne santé de l'écosystème et engendrent des coûts économiques importants en raison de leurs incidences sur la santé publique, le tourisme, les transports maritimes, la pêche et l'aquaculture. La majorité des déchets en mer est constituée de matières plastiques (60-80 %), provenant principalement de sources terrestres, qui sont acheminées vers les océans par les rivières ou par ruissèlement. Le tourisme figure parmi les sources de déchets en mer les plus notables et il n'est dès lors pas surprenant de noter que les emballages de produits alimentaires et de boissons représentent un des types de microplastiques les plus répandus dans de nombreux ensembles coralliens (Lamb et al., 2018). Parmi les autres sources de pollution, l'on peut citer le déversement direct de déchets solides dans les océans ; les équipements de pêche abandonnés, perdus ou rejetés, que l'on appelle également des engins de pêche « fantômes » ; ainsi que les microplastiques et nanoplastiques, tels que les poussières issues de l'usure des pneus, les granulés industriels, les éclats de peinture, les particules textiles et les microbilles provenant de produits cosmétiques.

## L'IMPACT

Plus de 800 espèces animales ont été confrontées d'une manière ou d'une autre à des déchets en milieu marin, dont la majorité est composée de matières plastiques. Par exemple, il a été attesté que toutes les espèces de tortues marines ont été affectées, tout comme 66 % des mammifères marins et 50 % des oiseaux de mer. Au cours des deux dernières décennies, il a été constaté que les cas d'ingestion de débris plastiques ou d'enchevêtrement dans ces derniers ont augmenté de 49 % (Gall & Thompson, 2015). Récemment, l'étude réalisée par Lamb et al. (2018) a établi un lien entre la pollution par les microplastiques et la probabilité accrue de maladie des coraux, dont l'incidence passe de 4 à 89 % lorsque les coraux entrent en contact avec des matières plastiques. Cependant, il existe encore d'énormes lacunes de connaissances dans le corpus mondial des études qui ont été menées, s'agissant de l'ampleur et des effets réels des matières plastiques sur les organismes vivant dans les ensembles coralliens et sur l'écosystème en général.

### CE QUE NOUS DEVONS SAVOIR

Synthèse des lacunes dans les connaissances concernant les écosystèmes coralliens :

1. Connaissance de l'ampleur de la mauvaise gestion des déchets associés aux ensembles de récifs coralliens.
2. Connaissance des modes de pollution par les matières plastiques au sein des ensembles coralliens et à leur proximité.
3. Connaissance des incidences sur les ensembles coralliens de la lixiviation de produits chimiques issus des déchets plastiques.
4. Connaissance de la manière dont les déchets plastiques ont un impact sur les ensembles coralliens, dans une perspective plus large et plus axée sur les aspects écologiques.
5. Connaissance de la manière dont les macroplastiques entrent en interaction avec des invertébrés benthiques tels que les éponges et les coraux et de leur impact sur ces êtres vivants.
6. Évaluation quantitative de l'impact des engins de pêche fantômes sur les ensembles coralliens.
7. Évaluation du rôle des macroplastiques et des microplastiques dans le transport d'épibiontes envahissants et d'agents potentiellement pathogènes, sur le plan mondial.
8. Mesure des concentrations de microplastiques sur toutes les écorégions de récifs coralliens afin de bien cerner l'ampleur du problème de manière standardisée.
9. Étude du niveau de risque que présentent les microplastiques sur les organismes des récifs coralliens.
10. Examen des problèmes relatifs à la détection des microplastiques dans les organismes et les milieux environnants.
11. Évaluation de la qualité des tests actuels utilisés pour mesurer les microplastiques et valider les modèles, afin de déterminer les risques de faux positifs et de faux négatifs dans le comptage des plastiques.

### CE QUE NOUS DEVONS FAIRE

En comblant les lacunes de connaissances recensées ci-dessus, il sera possible de comprendre l'impact des matières plastiques sur les organismes des récifs coralliens et l'écosystème dans son ensemble. Néanmoins, même sans disposer de ces connaissances, il convient déjà d'affirmer que les plastiques représentent une cause de préoccupation majeure, mais que l'on peut résoudre. Par exemple, la restriction ou l'élimination de l'utilisation de plastiques à usage unique à l'échelle de la planète aurait des effets considérables et mesurables sur la quantité de matières plastiques qui échouent dans les récifs coralliens.

Le présent rapport fait état des incidences néfastes des déchets plastiques présents en mer sur les écosystèmes de récifs coralliens des eaux peu profondes et les organismes qui y vivent. Face à ces menaces, les recommandations suivantes ont été formulées afin de faire progresser les mesures de lutte contre les déchets en mer et la réalisation de la cible 14.1 des objectifs de développement durable, notamment en ce qui concerne la gestion durable des écosystèmes de récifs coralliens :

1. ***Renforcement des partenariats dans le but d'éliminer les déchets en mer et la pollution par les plastiques***
   Les gouvernements, la société civile et les acteurs du secteur privé sont encouragés à rejoindre le Partenariat mondial sur les déchets marins et à s'investir dans cette initiative afin d'élaborer des plans et de déterminer des objectifs de réduction des déchets susceptibles de se retrouver dans des ensembles de récifs coralliens.

2. ***Renforcement de la planification au niveau national afin de lutter contre les déchets plastiques d'origine terrestre qui se retrouvent dans les récifs coralliens***
   Les pays dotés de récifs coralliens devraient élaborer ou réviser leurs plans d'action nationaux et leurs mesures locales d'atténuation, en se fondant sur les évaluations stratégiques qui recensent les principales sources, modes de propagation et incidences des déchets et leurs conséquences sur les récifs coralliens ; recenser et gérer les principales sources de pollution par les plastiques au niveau local ; interdire l'utilisation de plastiques à usage unique nocifs sur les plages qui se trouvent à proximité des récifs coralliens ; collaborer avec les principaux secteurs d'activités qui produisent des matières plastiques afin de mettre en place des systèmes de responsabilité et de compensation fonctionnant selon le principe pollueur-payeur ; et tenir compte de la demande des consommateurs afin de veiller à ce que les mesures continuent à avoir des effets positifs sur la durée.

3. ***Réduction de l'impact sur les récifs coralliens des déchets en mer provenant de l'aquaculture et des équipements de pêche abandonnés, perdus ou rejetés***
   Élaborer et appliquer des réglementations et des lignes directrices régionales visant à éviter que les équipements de pêche abandonnés, perdus ou rejetés n'atteignent ou ne pénètrent des zones maritimes qui se trouvent à proximité ou en présence de récifs coralliens, dans le cadre d'organisations régionales concernées, telles que les organisations régionales de gestion des pêches et les conventions et plans d'action concernant les mers régionales, en étroite consultation avec les communautés de pêcheurs et les industries de la pêche.

4. ***Investissement en matière de surveillance et de recherche***
   Des investissements financiers des gouvernements et d'autres entités, et des efforts de la part des établissements d'enseignement et de recherche seront nécessaires, notamment afin d'atteindre les objectifs suivants :
   i. Connaissance de la situation et de l'ampleur du problème posé par les déchets marins dans les écosystèmes de récifs coralliens ;
   ii. Connaissance de l'incidence des matières plastiques sur les espèces et les écosystèmes des récifs coralliens ;
   iii. Connaissance des incidences sociétales et économiques potentielles de la présence de matières plastiques dans les récifs coralliens ;
   iv. Et amélioration de la collecte de données et de renseignements dans le but de combler les lacunes dans les connaissances.

# РЕЗЮМЕ

Сотни миллионов людей и отрасли промышленности, чья стоимость исчисляется миллиардами долларов, зависят от здоровых мелководных рифовых экосистем (Программа Организации Объединенных Наций по окружающей среде, 2018 год). Однако антропогенные факторы стресса, включая изменение климата и загрязнение окружающей среды, угрожают этим хрупким экосистемам. В результате этого в настоящее время наблюдается беспрецедентный уровень ухудшения состояния рифов и сокращения площади кораллов во всем мире.

Пластмассу, на которую приходится значительная часть загрязнения морской среды, в настоящее время можно обнаружить во всех океанах мира, но считается, что в наибольшей концентрации она присутствует в прибрежных районах и рифовой среде, куда подавляющее большинство этого мусора поступает из наземных источников.

Загрязнение морской среды пластмассовым мусором уже затрагивает более 800 видов морских и прибрежных организмов в результате его проглатывания, запутывания в нем и изменения среды обитания. Учитывая дополнительное воздействие изменения климата на экосистемы коралловых рифов, следует серьезно отнестись к представляемой пластмассами угрозе.

Однако по-прежнему ощущается значительная нехватка знаний о реальном воздействии пластмасс на рифовую среду. В ходе данного исследования был выявлен ряд пробелов в знаниях, которые необходимо устранить в целях укрепления базы научных данных для осуществления деятельности в отношении загрязнения морской среды пластмассами, которые воздействуют на коралловые рифы, а также для достижения целей, поставленных мировым сообществом.

### ЧТО НАМ ИЗВЕСТНО

Проблема наличия пластмасс в морской среде была признана учеными, правительственными организациями, неправительственными организациями, частными учреждениями и благотворительными организациями. Она признана в качестве одного из глобальных приоритетов, в том числе в Повестке дня в области устойчивого развития на период до 2030 года в рамках цели 14 в области устойчивого развития (ЦУР), касающейся сохранения и использования океанов, морей и морских ресурсов в интересах устойчивого развития. В частности, задача 14.1 заключается в предотвращении и существенном сокращении любого загрязнения морской среды к 2025 году, а показатель 14.1.1 включает индекс плотности плавающего пластмассового мусора.

### МАСШТАБ ПРОБЛЕМЫ

В ходе знакового исследования, проведенного Jambeck et al. (2015a), было подсчитано, что в странах, имеющих выход к морю, образовалось примерно 275 млн. тонн пластмассовых отходов, при этом от 4,8 до 12,7 млн. тонн попало в океан. Только в Азиатско-Тихоокеанском регионе в мелководной рифовой среде предположительно находится около 11,1 миллиарда единиц пластмасс и к 2025 году этот показатель, по прогнозам, превысит 15,7 миллиарда. В дополнение к притоку пластмасс, обнаруженному в прибрежных районах, в настоящее время в океанах мира выявлено пять крупных «островов» (или скоплений плавающих пластмасс). Однако значительная доля морского мусора не поддается учету, поскольку оценки общего количества мусора, поступающего в морскую экосистему, в один-три раза превышают показатель, о котором сообщается (Jambeck et al., 2015b).

### ИСТОЧНИК

Морской мусор в силу своего трансграничного характера встречается во всех океанах и морях мира, угрожая здоровью экосистем и сопровождаясь значительными экономическими издержками в результате его воздействия на здоровье населения, туризм, судоходство, рыболовство и аквакультуру. Основную часть морского мусора составляет пластмасса (60-80 процентов), поступающая преимущественно из наземных источников через реки и сточные воды. Туризм может быть одним из наиболее значительных источников морского мусора, и неудивительно, что наиболее часто встречающимися видами макрочастиц пластмасс во многих рифовых средах является упаковка продуктов питания и напитков (Lamb et al., 2018). К другим источникам относятся непосредственный сброс твердых отходов в океан; оставленные, утерянные или брошенные орудия лова, называемые «орудиями фантомного лова»; и микро- или наночастицы пластмасс, которые могут включать шинную пыль, промышленные гранулы, частицы отслоившейся краски, частицы текстиля и микрогранулы косметики.

### ВОЗДЕЙСТВИЕ

Более 800 видов в той или иной форме сталкивались с морским мусором, основная часть которого представляет собой пластмассу. Например, было документально подтверждено, что пострадали все виды морских черепах, а также 66 процентов морских млекопитающих и 50 процентов морских птиц. Тенденции последних двух десятилетий показали, что количество случаев проглатывания пластмассового мусора и запутывания в нем увеличилось на 49 процентов (Gall & Thompson, 2015). Недавно Lamb et al. (2018) продемонстрировали связь между загрязнением макрочастицами пластмасс и повышенной вероятностью заболевания кораллов: в случае контакта кораллов с пластмассами вероятность заболевания увеличилась с 4 процентов до 89 процентов. Тем не менее, по всему спектру проводимых в настоящее время во всем мире исследований сохраняются серьезные пробелы в знаниях относительно истинных масштабов и воздействия пластмассы на рифовые организмы и экосистему в целом.

### ЧТО НАМ НЕОБХОДИМО ЗНАТЬ

Резюме пробелов в знаниях, связанных с рифовыми экосистемами:

1. понимание масштабов ненадлежащего регулирования отходов в том, что касается среды коралловых рифов;
2. понимание закономерностей загрязнения пластмассой окружающей среды в коралловых рифах и вокруг них;
3. понимание воздействия выщелачивания химических веществ из пластмасс в среде коралловых рифов;
4. понимание того, как в более широком и экологически значимом масштабе пластмассы воздействуют на окружающую среду коралловых рифов;
5. понимание того, как макрочастицы пластмасс взаимодействуют с бентическими беспозвоночными, такими как губки и кораллы, и влияют на них;
6. количественная оценка воздействия орудий фантомного лова и их влияния на сообщества коралловых рифов;
7. изучение роли макро- и микрочастиц пластмасс в переносе инвазивных эпибионтов и вероятных патогенных агентов в глобальном масштабе;
8. измерение концентраций микрочастиц пластмасс в экорегионах коралловых рифов для понимания масштабов данной проблемы стандартизированным образом;
9. изучение уровня риска для рифовых организмов, связанного с микрочастицами пластмасс;
10. изучение проблем с обнаружением микрочастиц пластмасс в организмах и окружающей среде;
11. оценка качества проводимых в настоящее время исследований, используемых для оценки микрочастиц пластмасс и проверки моделей для оценки вероятности ложных отрицательных и положительных результатов при подсчете количества пластмасс.

### ЧТО НАМ НЕОБХОДИМО ДЕЛАТЬ

Устранение отмеченных выше пробелов в знаниях позволит нам понять воздействие пластмасс на рифовые организмы и экосистему в целом. Однако даже без этих знаний очевидно, что пластмассы представляют собой серьезную проблему, которая, тем не менее, может быть решена. В частности, ограничение или прекращение использования пластмассовых изделий одноразового применения в глобальном масштабе окажет значительное и измеримое воздействие на объем пластмасс, достигающих рифов.

В настоящем докладе выявляется пагубное воздействие морского пластмассового мусора на экосистемы и организмы мелководных коралловых рифов. В ответ на эти угрозы выносятся следующие рекомендации в целях активизации действий в отношении морского мусора и задачи 14.1 ЦУР, особенно в том, что касается рационального использования экосистем коралловых рифов:

1. ***Укрепление партнерских связей в целях ликвидации загрязнения морским мусором и пластмассами***
   Правительствам, гражданскому обществу и субъектам частного сектора рекомендуется присоединиться к Глобальному партнерству по морскому мусору и сотрудничать с данным партнерством в разработке планов и целевых показателей по сокращению объема отходов, которые могут попасть в районы коралловых рифов.

2. ***Укрепление национального планирования для решения проблемы загрязнения коралловых рифов пластмассовым мусором из наземных источников***
   Страны, имеющие коралловые рифы, должны разработать или пересмотреть национальные планы действий и местные меры по смягчению последствий на основе стратегических оценок, в которых определяются основные источники, пути распространения и воздействие пластмасс на рифы; выявить основные местные источники загрязнения пластмассой и регулировать их; ввести запрет на использование наносящих вред пластмассовых изделий одноразового применения на пляжах вблизи коралловых рифов; сотрудничать с ключевыми отраслями промышленности, производящими пластмассы, в деле внедрения систем ответственности и компенсации на основе механизмов «платит тот, кто загрязняет»; и удовлетворить потребительский спрос, чтобы обеспечить долгосрочное воздействие.

3. ***Сокращение воздействия морского мусора, образовавшегося в результате аквакультуры, утерянных и оставленных орудий лова на коралловые рифы***
   Разработать и применять региональные положения и руководяшие принципы по ликвидации или сокрашению попадания утерянных и оставленных орудий лова в океан на коралловых рифах или вокруг них через соответствуюшие региональные организации, такие как региональные рыбохозяйственные организации и конвенции и планы действий по региональным морям, в тесной консультации с рыбопромысловыми отраслями и обшинами.

4. ***Инвестиции в мониторинг и научные исследования***
   Необходимы финансовые инвестиции со стороны правительств и других структур и усилия академических и научно-исследовательских учреждений, преследуюшие, в частности, следуюшие цели:
   i) понимание состояния и масштабов загрязнения экосистем коралловых рифов морским мусором;
   ii) понимание воздействия пластмасс на виды и экосистемы коралловых рифов;
   iii) понимание потенциального социального и экономического воздействия пластмасс на коралловые рифы;
   iv) и совершенствование сбора данных и информации для устранения этих пробелов в знаниях.

# RESUMEN


Cientos de millones de personas e industrias por valor de miles de millones de dólares dependen de la buena salud de los ecosistemas de arrecifes en aguas poco profundas (PNUMA, 2018). Pese a ello, varios factores de perturbación de origen humano, entre ellos el cambio climático y la contaminación, suponen una amenaza para esos frágiles ecosistemas. Como resultado de ello, estamos presenciando niveles sin precedentes de declive en la salud de los arrecifes y en la cubierta de coral en todo el mundo.

El plástico, que representa una proporción considerable de la contaminación del mar, está ya presente en todos los océanos del mundo, pero se cree que las mayores concentraciones se producen en las zonas costeras y los entornos de los arrecifes, aun cuando la gran mayoría de esta basura procede de fuentes terrestres.

La contaminación de los mares por basura plástica ya afecta a más de 800 especies marinas y costeras, bien porque la ingieren o porque quedan enganchados en ella, o por los cambios que provoca en los hábitats. Si tenemos en cuenta las repercusiones adicionales del cambio climático sobre los ecosistemas de los arrecifes de coral, es necesario tomarse muy en serio la amenaza de los plásticos.

Sin embargo, persiste una considerable falta de conocimientos sobre las verdaderas repercusiones que los plásticos tienen sobre el entorno de los arrecifes. La presente investigación ha identificado una serie de lagunas en los conocimientos que es preciso abordar a fin de fortalecer la base de datos científicos para la adopción de medidas sobre los plásticos marinos que afectan a los arrecifes de coral, por una parte, y para lograr los objetivos fijados por la comunidad mundial, por otra.

**LO QUE SABEMOS**

Científicos, organizaciones gubernamentales, organizaciones no gubernamentales, instituciones privadas y organizaciones benéficas por igual han identificado el problema que suponen los plásticos en el medio marino. Ha sido reconocido como una prioridad mundial, entre otros en la Agenda 2030 para el Desarrollo Sostenible, específicamente en el Objetivo de Desarrollo Sostenibilidad 14, sobre la conservación y el uso de los océanos, los mares y los recursos marinos para el desarrollo sostenible. Concretamente, la meta 14.1 se cifra en prevenir y reducir significativamente la contaminación marina de todo tipo de aquí a 2025, mientras que en el indicador 14.1.1 se incluye un índice sobre la densidad de desechos plásticos flotantes.

**LA ESCALA**

Un estudio de referencia realizado por Jambeck y otros (2015a) calculó que países ribereños generan aproximadamente 275 millones de toneladas métricas de desechos plásticos , de las que entre 4,8 millones y 12,7 millones de toneladas llegan a los océanos. Se cree que solo en la región de Asia y el Pacífico hay unos 11.100 millones de piezas de plástico presentes en los entornos de los arrecifes de aguas poco profundas, y que esa cifra aumentará a más de 15.700 millones para 2025. Además de la afluencia de plásticos constatada en las zonas costeras, se han identificado también cinco grandes de plásticos en los alrededores de las zonas costeras, determinó cinco grandes "giros" (o concentraciones de plásticos flotantes) en los océanos del mundo. Sin embargo, una proporción importante de la basura marina no puede cuantificarse, ya que las estimaciones sobre la cantidad total de basura que entra en los ecosistemas marinos superan entre una y tres veces la magnitud de las cantidades comunicadas (Jambeck y otros, 2015b).

**LA FUENTE**

Debido a su naturaleza transfronteriza, la basura marina está presente en todos los océanos y mares del mundo, donde pone en peligro la salud de los ecosistemas y causa importantes pérdidas económicas como consecuencia de sus efectos sobre la salud pública, el turismo, la navegación, la pesca y la acuicultura. La mayor parte de la basura marina consiste en plásticos (del 60 % al 80 %), que llegan principalmente de fuentes terrestres a través de ríos y escorrentías. El turismo puede ser una de las fuentes de basura marina más importantes, y no es sorprendente que los macroplásticos más comúnmente encontrados en muchos entornos de arrecifes sean envoltorios de alimentos y bebidas (Lamb y otros, 2018) Otras fuentes incluyen vertidos directos de desechos sólidos en los océanos; aparejos de pesca abandonados, perdidos o desechados; y microplásticos y nanoplásticos, que incluyen polvo de neumáticos, gránulos industriales, partículas de pintura , partículas textiles y micropartículas cosméticas.

**LOS EFECTOS**

Más de 800 especies han tenido encuentros de algún tipo con la basura marina, en la mayoría de los casos con plásticos. Por ejemplo, hay casos documentados de efectos sobre todas las especies de tortuga marina, así como sobre el 66 % de los mamíferos marinos y el 50 % de las aves marinas. Las tendencias en los últimos dos decenios revelan que los casos de animales que ingieren basuras plásticas y se enredan en ellas han aumentado en un 49 % (Gall y Thompson, 2015). Recientemente, Lamb y

otros (2018) demostraron la existencia de un vínculo entre la contaminación por plásticos y una mayor probabilidad de enfermedades en los corales, según el cual la probabilidad de que los corales enfermasen aumentaba del 4 % al 89 % cuando estos entraban en contacto con los plásticos. Sin embargo, a lo largo y ancho de las investigaciones en marcha actualmente en todo el mundo persisten importantes lagunas en los conocimientos relativos a la verdadera escala de los plásticos y a sus efectos sobre los organismos de los arrecifes y el ecosistema en su conjunto.

## LO QUE HAY QUE SABER

Resumen de los conocimientos de los que carecemos en relación con los ecosistemas de los arrecifes:

1. Comprensión de la magnitud de los desechos incorrectamente gestionados en lo que respecta a los entornos de arrecifes de coral.
2. Comprensión de los patrones de contaminación por plástico en los entornos de arrecifes de coral y sus alrededores.
3. Comprensión de los efectos que tienen las sustancias químicas lixiviadoras de los plásticos sobre los entornos de arrecifes de coral.
4. Comprensión de la forma en la que los plásticos afectan a los entornos de arrecifes de coral en una escala más amplia y ecológicamente pertinente.
5. Comprensión de la forma en que los macroplásticos interactúan con los invertebrados bentónicos, como esponjas y corales, y en qué modo los afectan.
6. Cuantificación de los efectos de los aparejos de pesca abandonados y su repercusión sobre las comunidades de los arrecifes de coral.
7. Exploración del papel de los macroplásticos y los microplásticos en el transporte de epibiontes invasores y posibles agentes patógenos a escala mundial.
8. Medición de las concentraciones de microplásticos en las ecorregiones de los arrecifes de coral a fin de comprender la magnitud del problema de forma normalizada.
9. Exploración del nivel de riesgo que suponen los microplásticos para los organismos de los arrecifes.
10. Estudio de las cuestiones relacionadas con la detección de microplásticos en los organismos y su entorno.
11. Evaluación de la calidad de los ensayos utilizados actualmente para evaluar los microplásticos y validar los modelos con los que se evalúan las posibilidades de falsos negativos y positivos en el conteo de plásticos.

## QUÉ TENEMOS QUE HACER

Paliar la falta de conocimientos descrita en párrafos anteriores nos permitirá comprender las repercusiones de la presencia de plásticos en los organismos y ecosistemas de arrecifes en su conjunto. No obstante, aun sin esos conocimientos es evidente que los plásticos constituyen un motivo de gran preocupación, pero que es un problema al que podemos enfrentarnos. Específicamente, la restricción o la eliminación de productos de plástico desechables a escala mundial tendría un efecto considerable y mensurable sobre la cantidad de plásticos que llegan hasta los arrecifes.

En el informe se señalan los efectos perjudiciales de la basura plástica marina sobre los ecosistemas y los organismos de los arrecifes de coral en aguas poco profundas. En respuesta a esas amenazas, se formulan las siguientes recomendaciones a fin de impulsar iniciativas sobre la basura marina y la meta 14.1 de los Objetivos de Desarrollo Sostenible, especialmente en relación con la gestión sostenible de los ecosistemas de arrecifes de coral:

1. ***Fortalecer las asociaciones para eliminar la basura marina y la contaminación por plástico***
   Se anima a los Gobiernos, la sociedad civil y los agentes del sector privado a que se sumen a la Alianza Mundial sobre la Basura Marina y colaboren con la Alianza en la elaboración de planes y metas para la reducción de los desechos que puedan llegar hasta las zonas de arrecifes de coral.

2. ***Reforzar la planificación nacional para hacer frente a las fuentes terrestres de la basura plástica en los arrecifes de coral***
   Los países que cuenten con arrecifes de coral deben elaborar o revisar los planes de acción nacionales y las medidas de mitigación a escala local, sobre la base de evaluaciones estratégicas que determinen las fuentes, vías y consecuencias principales de la presencia de plásticos en los arrecifes; determinen y gestionen las principales fuentes locales de contaminación por plásticos; establezcan prohibiciones de productos de plástico desechables en las playas cercanas a los arrecifes de coral; colaboren con las principales industrias productoras de plástico para aplicar planes de responsabilidad e indemnizaciones a través de mecanismos basados en la idea de que quien contamina paga; y hagan frente a la demanda de los consumidores a fin de lograr efectos duraderos.

3. ***Reducir los efectos de la basura marina procedente de la acuicultura y los aparejos de pesca perdidos y abandonados sobre los arrecifes de coral***
   Elaborar y aplicar normas y directrices regionales sobre la eliminación o reducción del riesgo de que los aparejos de pesca perdidos o abandonados entren en el océano en los arrecifes de coral o en zonas cercanas a estos, por conducto de las organizaciones regionales pertinentes, como las organizaciones regionales de ordenación pesquera y los convenios y planes de acción sobre mares regionales, en estrecha consulta con las industrias y las comunidades pesqueras.

4. ***Inversión en seguimiento e investigación***
   Se necesita inversión financiera por parte de Gobiernos y otras entidades, y esfuerzos de las instituciones académicas y de investigación, en particular, para:
   i. Comprender la situación y la magnitud de la basura marina en los ecosistemas de arrecifes de coral;
   ii. Comprender las repercusiones de la presencia de plásticos en las especies y los ecosistemas de los arrecifes de coral;
   iii. Comprender las posibles repercusiones sociales y económicas negativas de la presencia de plásticos en los arrecifes de coral;
   iv. Y mejorar la recopilación de datos e información para hacer frente a esa falta de conocimientos.

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**Mismanaged plastic dump site on the coast**

## A GLOBAL PRIORITY

It has been estimated that over 500 million people, as well as industries worth billions of dollars (including tourism and fisheries) depend on healthy reef ecosystems (Cesar, 2000, Figure 1 A). As such, the continued decline in coral cover and shifts in community composition on a global scale are an extremely worrying trend from economic, social and ecological perspectives (Sweet and Brown, 2016; Hughes *et al.*, 2018). The overarching impacts of anthropogenic stresses, including those related to climate change and pollution, are unarguably responsible for the recent unprecedented declines. However, understanding how these may interact with natural stresses (with regard to their impact on coral reef organisms) remains a challenge, which in turn means management and mitigation of these threats are difficult.

Marine litter is a major anthropogenic stressor and one which is faced by all ecosystems in the marine biome. For this report, litter is defined as any persistent, manufactured or processed solid material discarded, disposed of, or abandoned in the marine and coastal environment (Coe and Rogers, 1997; GPA, 2006). Marine litter is, due to its transboundary nature, found in all the world's oceans and seas, even in remote areas far from human contact and obvious sources of the problem. It thereby constitutes an increasing risk to ecosystem health and biodiversity, while entailing substantial economic costs through its impacts on public health, tourism, shipping, fishing and aquaculture. Coming from both land-based as well as sea-based sources (abandoned, lost or discarded fishing gear, ship-based waste etc.), the majority of marine litter is plastics (60-80%). With regard to reefs, such litter can cause mechanical damage from fishing gear for example, direct uptake of micro- or nano-plastics via feeding, as well as smothering of reefs by certain types of macroplastics. This report aims to discuss these potential impacts and outline current state of knowledge as well as gaps therein with a specific focus on shallow water coral reefs.

Ghost fishing gear dislodging corals

## SOURCES OF PLASTICS IN REEF ENVIRONMENTS

Plastics have become increasingly dominant in the consumer marketplace since their commercial development in the 1930s and 40s (Jambeck *et al.*, 2015). This has subsequently led to an increase in influx to the marine environment. The vast majority of plastics entering the marine ecosystem are from land-based sources (Table 1).

**Table 1. Sources of plastic pollution reaching the marine ecosystem.**

| Source | Tonnage of plastics estimated to be entering the marine ecosystem (thousand metric tonnes per annum) |
|---|---|
| Rivers/land run off – land based | 9000 |
| Direct dumping | 1500 |
| Fishing gear | 640 |
| Lost cargo | 600 |
| Vehicle tire dust | 270 |
| Industrial pellet spills | 230 |
| Road and building paint | 210 |
| Textiles | 190 |
| Cosmetics | 35 |
| Marine paint | 16 |

In 2010 approximately 275 million metric tonnes of plastic waste was generated by 192 countries, with 4.8 to 12.7 million metric tonnes entering the ocean.

A landmark study by Jambeck *et al.* (2015) calculated that approximately 275 million metric tonnes (MT) of plastic waste was generated by 192 coastal countries, with 4.8 to 12.7 million MT entering the ocean. An abridged version of the Table – whereby mismanaged waste is mapped against countries with highest reef area is indicated below (Table 2). Here, Indonesia is ranked as having the highest percentage of the world's reefs and second highest levels of estimated mismanaged plastic waste.

Coastal areas (where the majority of shallow water reefs are found) are generally considered to be amongst the most highly impacted areas by

**Table 2. Top 25 countries (from where data is available) in descending order (from highest to lowest) of area percentage of world total of reef within their jurisdiction. Data from World Atlas of Coral Reefs http://coral.unep.ch/atlaspr.htm. Along with the countries' percentage of total mismanaged plastic waste and therefore the plastic marine debris present – taken from (Jambeck *et al.*, 2015).**

| Country | Reef Area (km$^2$) | Percentage of World Total (%) – estimated total coverage of reefs = 284,300 km$^2$ | % of total mismanaged plastic waste (as of 2010) | Plastic marine debris [million MT/year] as of 2010 |
|---|---|---|---|---|
| Republic of Indonesia | 51,020 | 17.95 | 10.10 | 0.48-1.29 |
| Australia | 48,960 | 17.22 | 0.01-0.25 | |
| Republic of the Philippines | 25,060 | 8.81 | 5.90 | 0.28-0.75 |
| France | 14,280 | 5.02 | 0.01-0.25 | |
| Papua New Guinea | 13,840 | 4.87 | 1-5 | |
| Republic of Fiji | 10,020 | 3.52 | 0.01-0.25 | |
| Republic of Maldives | 8,920 | 3.14 | 1-5 | |
| Kingdom of Saudi Arabia | 6,660 | 2.34 | 0.01-0.25 | |
| Republic of the Marshall Islands | 6,110 | 2.15 | 0.01-0.25 | |
| Republic of India | 5,790 | 2.04 | 1.90 | 0.09-0.24 |
| Solomon Islands | 5,750 | 2,02 | 0.01-0.25 | |
| United Kingdom | 5,500 | 2 | 0.01-0.25 | |
| Federated States of Micronesia | 4,340 | 1.53 | 0.01-0.25 | |
| Republic of Vanuatu | 4,110 | 1.45 | 0.01-0.25 | |
| Arab Republic of Egypt | 3,800 | 1.34 | 3 | 0.15-0.39 |
| United States of America | 3,770 | 1.33 | 0.90 | 0.04-0.11 |
| Malaysia | 3,600 | 1.27 | 2.90 | 0.14-0.37 |
| United Republic of Tanzania | 3,580 | 1.26 | 0.01-0.25 | |
| Eritrea | 3,260 | 1.15 | 0.01-0.25 | |
| Commonwealth of the Bahamas | 3,150 | 1.11 | 0.01-0.25 | |
| Republic of Cuba | 3,020 | 1.06 | 0.01-0.25 | |
| Kiribati | 2,940 | 1.03 | 0.01-0.25 | |
| Japan | 2,900 | 1.02 | 0.01-0.25 | |
| Republic of the Sudan | 2,720 | 0.96 | 0.01-0.25 | |
| Republic of Madagascar | 2,230 | 0.78 | 0.01-0.25 | |

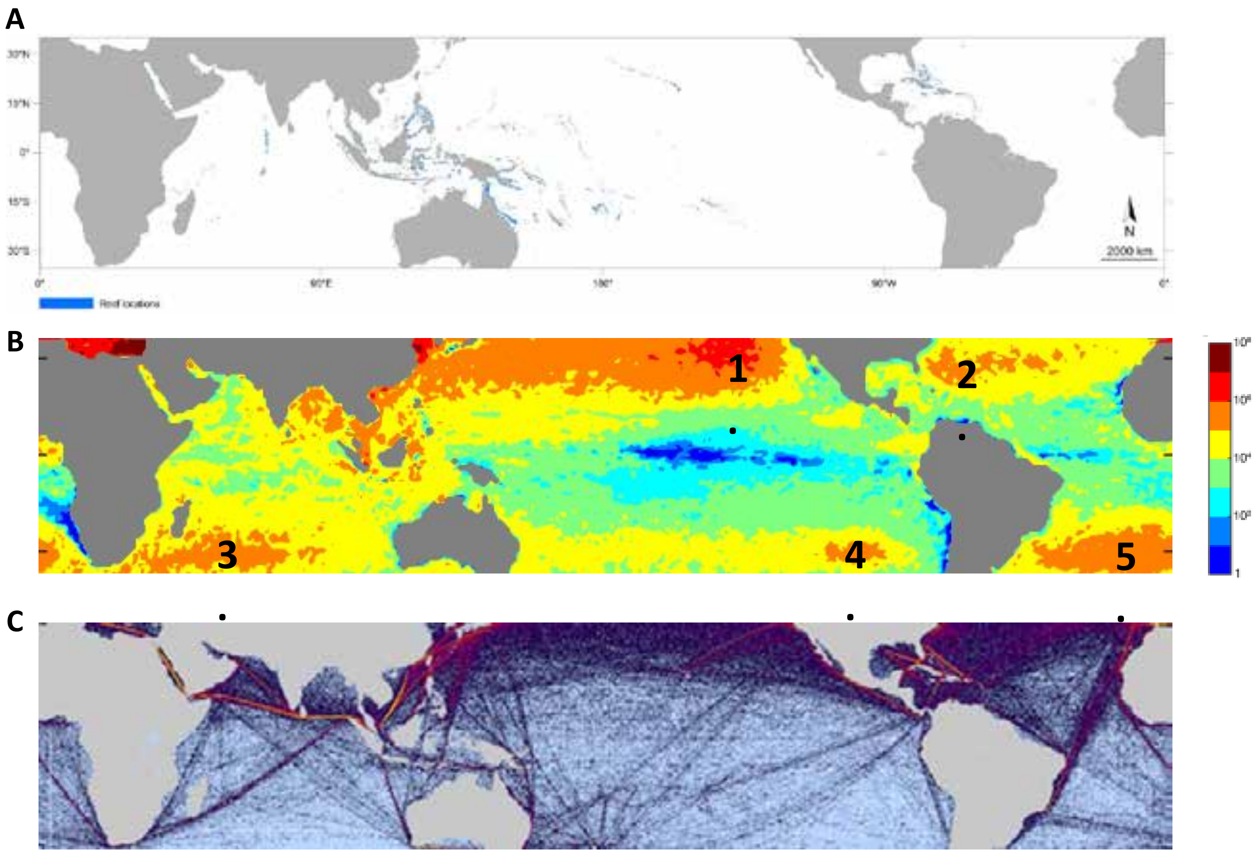


Figure 1 Highlighting reef location (A) against density of surface microplastics present # per km$^2$ (B) adapted from (Van Sebille *et al.*, 2015). (C) Shipping routes within the tropics. Numbers on B relate to major gyres 1. North Pacific Gyre, 2. North Atlantic Gyre, 3. Indian Ocean Gyre, 4. South Pacific Gyre and 5. South Atlantic Gyre.

plastic pollution. Indeed, recent research indicates that tourism can be among the most significant sources of marine litter such as in the southern Great Barrier Reef (Wilson and Verlis, 2017) and unsurprisingly, the most commonly encountered macroplastics in many reef environments are food and drink packages (Lamb *et al.*, 2018). In addition to the influx of plastics found around coastal areas, five major gyres (or aggregations of floating plastics) have now been identified across the world's oceans (Fig 1 B). However, estimates around the total amount of litter entering the marine ecosystem are in an order of one to three times the magnitude of that reported in any of the floating garbage patches or those found in coastal environments (Jambeck *et al.*, 2015). This suggests that a significant proportion of this litter is unaccountable.

The third major source of marine plastics has been linked to abandoned, lost or discarded fishing gear, also referred to as 'ghost gear', although this 'type' of plastic receives considerably less attention in main stream media than other macroplastics, like straws for example (Stelfox *et al.* 2015). A final 'type' of plastics includes the micro- or nano-plastics, which encompass; tyre dust, industrial pellets, paint chips, textile particles and cosmetic microbeads for example (Table 1).

**Marine litter on the beach**

For these 'types', entry of plastics into the environment can occur at all stages of the life cycle of the product. For example, microplastics can be categorised as either primary or secondary (Thompson, 2015). A source of microplastics is considered primary when it enters the environment as a microplastic - such as synthetic textile fibres from washing machines, microbeads from personal care products or spillage of industrial pellets (Rochman *et al.*, 2016) (Table 1). A secondary, and likely more significant source results when a larger piece of plastic debris (i.e. macroplastics) break into micro-sized or nano-sized pieces via chemical, biological or physical degradation processes (Rochman *et al.*, 2016).

This makes understanding the scale of the issue difficult to quantify. If we look at the quantity of microplastics produced (i.e. the primary source) for only resins and fibres for example, production is thought to be in excess of 380 million MT a year (data for 2015) (Geyer *et al.*, 2017). However, as these microplastics are unlikely to decompose in their entirety, it is worth looking at the total tonnage of these plastics from their initial design in the 1950s. In this context, the amount of plastic fibres alone is predicted to be within the region of 700 million MT (Geyer *et al.*, 2017). Fibres have been documented to be the largest contributing microplastic in the effluent of wastewater-treatment plants. A single garment can produce more than 1900 individual fibres per wash (Browne *et al.*, 2011). Although, removal of a significant amount of this small anthropogenic litter (SAL) can occur in well-managed wastewater treatment (Michielssen *et al.*, 2016). This does vary with the type of treatment utilised. For example, many plants use either, secondary treatment (activated sludge), tertiary treatment (granular sand filtration), both as a final step, or a pilot membrane bioreactor system that finishes treatment with microfiltration. When secondary treatment is utilised, 95.6% of SAL are removed. This increases to 97.2% when tertiary treatment is applied and 99.4% with the membrane bioreactor treatment (Michielssen *et al.*, 2016). However, whilst plants that utilise one of these three methods are clearly reducing the impact of SAL downstream, out of the percentage which escapes, fibres make up the largest proportion. This equates to 79 and 83%, for plants using sand filtration or bioreactors respectively and 44% with the plants utilising activated sludge.

Over 700 million metric tonnes of plastic fibres have been produced and washing a single garment releases more than 1900 individual fibres into our rivers and oceans

Another major contributor to plastics in the marine environment is that of microbeads. In 2009 alone, 263 tonnes of polyethylene microbeads were utilised in liquid soap products in the US (Gouin *et al.*, 2011). In the EU, 714 tonnes of microbeads were reported to be used in rinse-off personal care products per year, with a further 540-1120 tonnes associated with leave-on products (Scudo *et al.*, 2017). The raw plastic pellets associated with this industry have been shown to comprise approximately 11% by abundance and 7% of weight of the total measurable small plastic debris recorded in Hawaiian beaches (McDermid and McMullen, 2004). This brings us to our first Knowledge Gap.

### 1: Understanding of the scale of mismanaged waste in relation to coral reef environments

The few studies which have attempted to quantify the amount of plastics associated with reef environments show significant variation, with as little as 0.04 X $10^{-3}$ items per $m^2$ found on Hawaiian beaches, up to 6 items per $m^2$ in Jordan - the Gulf of Aqaba, Red Sea (Abu-Hilal and Al-Najjar, 2009; Donohue *et al.*, 2001).

**Plastic litter on the beach in Myanmar**

## MACROPLASTICS

There is a huge disparity between global estimates of plastic waste entering the oceans and the amount observed or recorded in any given marine biome. The levels of macroplastics observed on coral reefs (at least in the Asia-Pacific region - Figure 2) do appear to correspond to the estimated levels of plastic litter entering the ocean from the nearest coast (Lamb *et al.*, 2018). Throughout the Asia-Pacific region it was estimated that approximately 0.9 to 26.6 items of macroplastics were present in coastal areas per 100 $m^2$ in 2010. That equates to around 11.1 billion items in this region. Although staggering, this number is actually likely to be an underestimation, as China and Singapore fell outside of the studies model range and China in particular is a major source of mismanaged waste entering the oceans. Extrapolating the data, the researchers were able to illustrate that by as early as 2025, reefs and their organisms (in the same region) will have been exposed to 15.7 billion macroplastic items under 'business as usual' scenarios – a 40% rise from 2010 levels (Lamb *et al.*, 2018 - Figure 2). This value is not surprising as the same region encompasses 73% of the global population residing within 50 km of the coast (Jambeck *et al.*, 2015).

As of 2010 an estimated 11.1 billion items of plastic are thought to be in the Asia-Pacific region alone and this is expected to increase to 15.7 billion by 2025.

Accordingly, we utilized the same modeling parameters from Lamb *et al.* (2018) and the global levels of mismanaged plastic waste entering the ocean from Jambeck *et al.* (2015) to extrapolate levels of macroplastic debris on coral reefs to other global regions (Figure 2). Only relatively small changes are predicted to occur (from 2010 levels to 2025) outside of the Asia-Pacific region – with the exception of marked increases in macroplastic debris in Brazil and Egypt. Within the Asia-Pacific region, India by far shows the most worrying predicted changes, suggesting this country will be joining the ranks of Indonesia and China in the next 7 years or less.

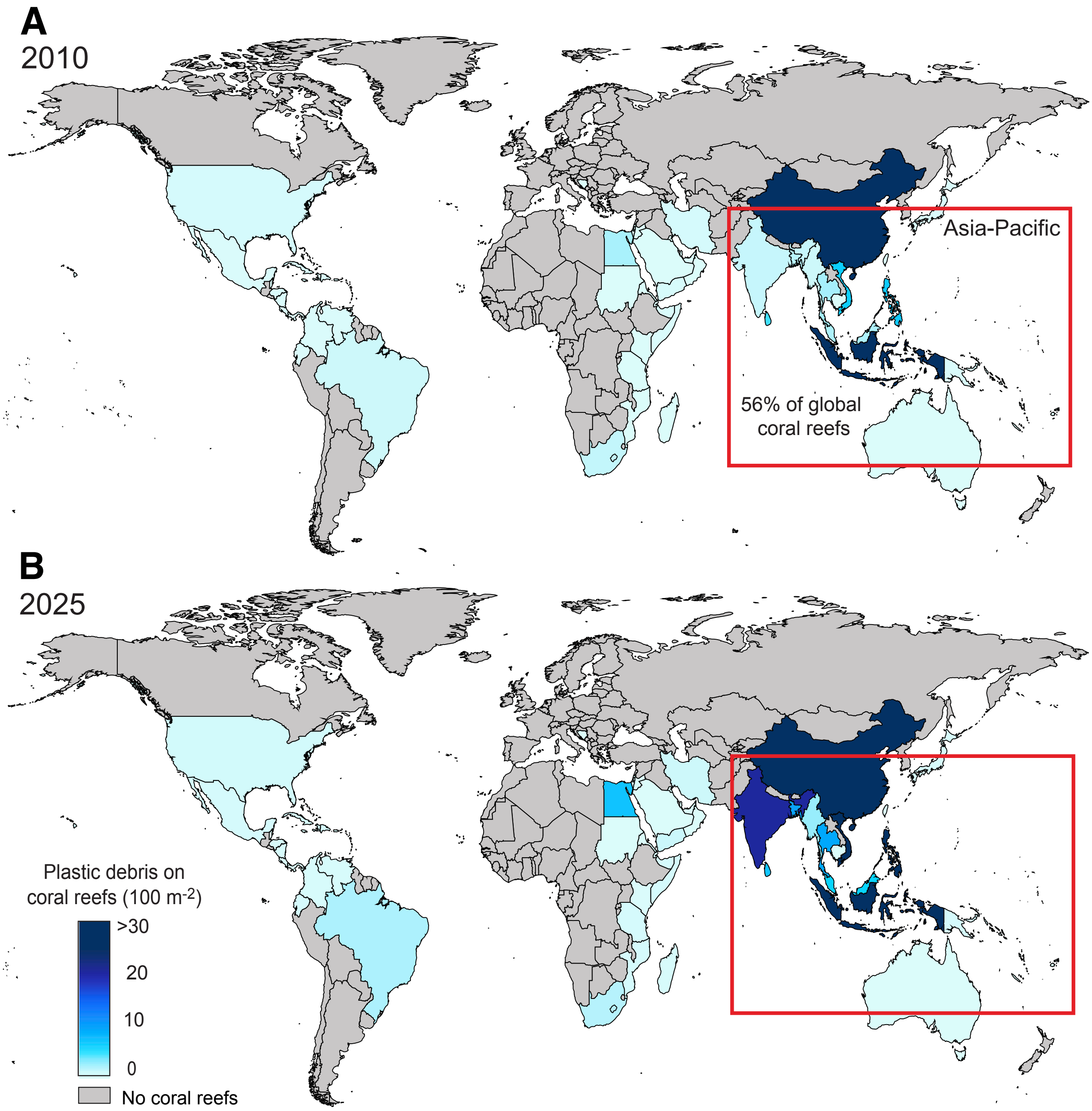


Figure 2. Estimated plastic debris levels estimated on coral reefs in 2010 and projected to 2025. Global dataset extrapolated from Lamb *et al.* 2018 (red square) and Jambeck *et al.* 2015 (global). Jambeck *et al.* (2015) assessed the mass of waste generated per capita annually, the percentage of waste that is plastic; and the percentage of plastic waste that is mismanaged and, therefore, has the potential to enter the ocean as marine debris. A range of conversion rates from mismanaged waste to marine debris was then applied, in order to estimate the mass of plastic waste entering the ocean from each country in 2010. Population growth data was then utilised to further predict growth in the percentage of waste that is plastic up to 2025. The colour scale represents the minima and maxima model estimates of mismanaged plastic waste on coral reefs from 2010. Areas without coral reefs are shown in grey.

Although plastic abundance on coral reefs is associated with the levels of mismanaged plastic in regions less than 50 km from the coast, the issue is certainly global. Levels of macroplastics found associated with an unpopulated island in the Maldives archipelago for example, were recorded at 35.8 particles per $m^2$ – compared to beaches in Mumbai, India (10-180 particles per $m^2$) and South Korea (976 particles per $m^2$) (Imhof *et al.*, 2017). Another study, which focused on one of the world's most remote and pristine islands, Henderson Island (in the South Pacific), estimated the level of macroplastics to be in excess of 37.7 million pieces - weighing 17.6 tonnes (Lavers and Bond, 2017). The authors went on to state that if historic records of plastic pollution were correct in this region, this is a 6.6-79.9% increase since the last time it was surveyed in 1991. Such large numbers in this instance are likely due to this particular study including naturally buried materials in their counts. Buried material is thought to encompass upwards of 68% of the total of plastics in

Buried material is thought to encompass upwards of 68% of the total plastics in a reef environment any given region, so this certainly needs to be taken into account in future studies (Lavers and Bond, 2017). It is therefore important to understand (or differentiate) that plastic loads recorded 'on' coral reefs (i.e. benthic plastic counts) is not necessarily the same as plastic that could 'end up' or 'floating above' a reef – and this is certainly not going to be a linear relationship (Lamb *et al.*, 2018). Indeed, the predicted increase of macroplastic debris on coral reefs is set to happen much faster in developing countries than industrialised ones. For example, between 2010 and 2025 the amount of macroplastic debris on U.S. coral reefs will increase by only about 1%, whereas for Myanmar it will almost double (Figure 2). This leads us to Knowledge Gap 2.

## 2: Understanding of the patterns of plastic pollution in and around coral reef environments

*Impacts of macroplastics on reef organisms*

More than 800 species are impacted directly by marine litter and plastics constitute 92% of the type of litter recorded (CBD technical report no. 83). For example, all sea turtles species have now been documented to have been impacted, 66% of marine mammals and 50% of seabirds and these figures appear to be increasing yearly (Kühn *et al.*, 2015). Trends over the last 2 decades have shown that instances of ingestion and entanglement (of plastic debris) has increased by 49% (Gall and Thompson, 2015).

Ingestion of macroplastics has been implicated in the mortality of a wide range of organisms Including seabirds and cetaceans, sirenians and sea turtles (Jacobsen *et al.*, 2010; Provencher *et al.*, 2014; Santos *et al.*, 2015). The impact of macroplastics on sea turtles in particular has been identified as a major concern as their visual feeding strategies select for structures analogous to jellyfish and soft floating plastics. Furthermore, their backward facing oesophageal papillae inhibit regurgitation and facilitate particle accumulation in the gut (Schuyler *et al.*, 2014; Vegter *et al.*, 2014). Indeed plastic bottle fragments, fishing lines and paint chips are commonly encountered in the guts of sea turtles (Clukey *et al.*, 2017; Wedemeyer-Strombel *et al.*, 2015). In Brazil for example, 70% of juvenile turtles analysed showed plastic ingestion with a mean of 47.5 items per turtle (Santos *et al.*, 2015). In the North-Pacific Ocean, 83% of turtles where shown to have ingested some form of debris (Wedemeyer-Strombel *et al.*, 2015).

Furthermore, in addition to causing blockages of the digestive tracts, many studies have highlighted the possibility of plastics acting as vectors for toxic chemicals and pathogenic agents (Moore, 2008; Von Moos *et al.*, 2012; Besseling *et al.*, 2013). Toxicity can occur via leaching plasticisers and UV stabilisers into the organisms' post ingestion, and/or adsorption of polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), metals and pesticides. Furthermore, accumulation of these toxins can also likely occur as further up the food chain (Caron *et al.*, 2018). However, a critical analysis of the available literature by Koelmans *et al.* (2016) suggested that this particular aspect of plastic pollution posed little concern and lacked any real tangible evidence. This highlights the need for further studies in this area to understand the impacts in more detail – Knowledge Gap 3.

At the time of writing over 700 different species have been documented to have had some form of negative interaction with marine litter (namely plastics).

### 3: Understanding of the impacts of leaching chemicals from plastics in coral reef environments

The majority of documented impacts that plastics have on any given organism are at the sub-organismal or organism level of biological organization and focus is usually on microplastics rather than macroplastics. This is not surprising as many of these studies have focused on laboratory exposure experiments – where the smaller size of microplastics allow for more manageable scaled experiments (Rochman *et al.*, 2016). Such studies have shown evidence of changes in gene expression (Rochman *et al.*, 2014), possible inflammation of tissues (Von Moos *et al.*, 2012) and changes in behaviour and mortality (Browne *et al.*, 2013) in various organisms under a diversity of exposure scenarios.

There are, however, only relatively few studies which demonstrate how macroplastics may cause wider scale ecological impact in reef ecosystems – Knowledge Gap 4.

### 4: Understanding of how, on a wider, more ecologically relevant scale plastics impact coral reef environments

More field studies are urgently needed as they can highlight the impacts macroplastics have on a whole ecosystem level. For example, Lewis *et al.* (2009) highlighted the direct physical damage lost or abandoned lobster pots could have on the benthic reef communities and Lamb *et al.* (2018) demonstrated a link between macroplastic pollution and increased likelihood of coral disease. The likelihood of disease on corals rose from 4% to 89% when corals were in contact with plastics. However, why this is the case remains to be addressed – Knowledge Gap 5.

### 5: Understaing how macroplastics interact with and affect benthic invertebrates such as sponges and corals

Macroplastics impact reefs by:

1. Direct physical, mechanical damage
2. The introduction of pathogenic agents 'hitch-hiking' on the plastics
3. 'Overtopping' phototrophic animals preventing light from reaching tissue and creating low oxygen levels
4. Direct ingestion and gut blockage
5. Entanglement and entrapment

Although the mechanisms are not yet clear, the influence of macroplastic debris on disease development may differ from organism to organism and from disease to disease. For example, macroplastic debris can likely cause direct damage to the tissue of coral, offering an opening to pathogenic agents like ciliates (Sweet and Bythell, 2015; Sweet and Séré, 2016). Plastic debris could also introduce pathogens directly. Polyvinyl chloride (PVC) (a very common plastic used in children's toys, building materials like pipes, and many other products) has been found carrying a family of bacteria called Rhodobacterales (Dang *et al.*, 2008). Rhodobacterales have been proposed as causal agents of some coral diseases (Soffer *et al.*, 2015). Similarly, polypropylene (used to make bottle caps and toothbrushes for example) can be colonised by members from the genus *Vibrio*, pathogenic bacteria which have been linked to a globally devastating group of coral diseases known as white syndromes and a multitude of other marine diseases that affect invertebrates, fishes and humans (Séré *et al.*, 2015; Sweet *et al.*, 2016; Lamb *et al.*, 2017). Yet, the virulence and disease dynamics of these pathogens 'hitching a ride' on plastics remains unknown (Bidegain and Paul-Pont, 2018). Finally, macroplastic debris overtopping corals can block out light and create low-oxygen conditions that favour the growth of microorganisms, for example those associated with another coral disease known as black band disease (Glas *et al.*, 2012). Furthermore, Lamb *et al.* (2018) highlighted that structurally complex corals (i.e. those accredited for the rugosity of reefs important to support the diversity of life) were eight times more likely to be affected by macroplastics. Such a result may have implications for the microhabitats of reef dwelling organisms. An economic impact of this finding can be linked to a reduction in the fishery productivity in these areas by a factor of 3 (Rogers *et al.*, 2014).


Plastic packaging litter floating next to a canoe

## ABANDONED, LOST OR DISCARDED FISHING GEAR

The vast majority of fishing gear in use today is made from plastics including nylon, polyethylene and polypropylene (Stelfox *et al.*, 2016). Fishing gear can be lost during storms but it can also be abandoned deliberately. The problem surrounding abandoned, lost or discarded fishing gear (more commonly referred to as 'ghost gear') has been well documented in recent years (Phillips, 2017; Richardson *et al.*, 2018; Stelfox *et al.*, 2016; Wilcox *et al.*, 2016). Out of 30,896 individual animals, counted entangled in ghost gear by one study, 79% of cases led to serious injury or death. Of the 13,110 reported to have ingested debris, 4% of cases led to injury and mortality (Gall and Thompson, 2015). For all cases, 92% of the time the marine debris was composed of plastics (Gall and Thompson, 2015; CBD technical report no. 83). Furthermore, the Coordinating Body on the Seas of East Asia (COBSEA) Regional Group on Marine Litter acknowledges significant marine litter generated from aquaculture e.g. loss of packaging, is released in the near shore environment and therefore in the immediate vicinity of coral reefs. A diverse range of materials are used to build and maintain the culture systems, and with the expansion of the aquaculture industry has also come an expansion in the use of synthetic polymers over the last 50 years (Lusher *et al.*, 2017).

Historically, it was estimated that less than 10% of the global marine debris could be attributed to ghost gear (Macfadyen *et al.*, 2009). However, more recent studies have shown contrasting results in this regard (Loulad *et al.*, 2017; Melli *et al.*, 2017; Pham *et al.*, 2014). For example, a study by Lebreton *et al.* (2017) highlighted 46% of the plastics associated with the Great Pacific Garbage Patch or gyre (Fig 1 B No. 1 and 4) were fishing nets, whilst in contrast only 8% were shown to be microplastics. There are however, still very few studies which attempt to quantify the impact on ghost gear globally and even fewer that focus on its impact on coral reefs – Knowledge Gap 6.

Ghost gear is likely to be one of the most significant threats in marine ecosystems and over 46% of plastics found in the 'floating garbage patches' (or gyres) are made up of this plastic type.

### 6: Quantification of the impact of ghost gear and its impact on coral reef communities

Evidence suggests that ghost gear can smother, entangle, occupy space and increase disease prevalence in coral reef environments (Angiolillo and Canese, 2018; Donohue *et al.*, 2001; Ferrigno *et al.*, 2017). For example, derelict monofilament fishing line has been shown to have a negative impact on the health of corals in Hawaii through entanglement and smothering (Asoh *et al.*, 2004). Moreover, derelict traps and pots can become wind driven during stormy, monsoonal or winter cold fronts and may travel a significant distance from where they were originally deployed. One study in the Florida Keys found this movement to cause significant damage to sponges, octocoral and stony coral in the area (Lewis *et al.*, 2009). Indeed remnant fishing traps and lost hook and line fishing gear accounted for 87% of all debris encountered in a 2001 survey on the Florida Keys and the authors accredited this gear to 84% of the recorded damage found on the adjacent reefs where the debris was located (Chiappone *et al.*, 2005). Such mechanical damage has also been linked with increased levels of disease associated with reef organisms, such as coral (Lamb *et al.*, 2015; 2016).

Damage from ghost gear may also have various indirect impacts on reef environments. For example, ghost nets that become snagged on a coral structure may have the capacity to entangle reef associated animals long after it is lost due to the structure of the mesh remaining intact. The efficiency of ghost gear to trap and kill marine organisms is partly dependent on environmental factors and habitat type (Kaiser *et al.*, 1996) and ghost nets that end up as a pile on the deep ocean floor loose efficiency because of loss in net structure (Stelfox *et al.*, 2016).
Further, ghost gear smothers reefs and block sunlight in a similar manner to that of macroplastics. Although this issue would be difficult to measure, it is reasonable to assume that ghost gear can disrupt productivity on sensitive habitats which may have a negative impact on heterotrophic levels. Disruption may also occur when fouling and encrusting epibionts are transported between regions by ocean currents – Knowledge Gap 7.

### 7: Exploring the role of macro- and microplastics in transporting invasive epibionts and possible pathogenic agents on a global scale

Invasive 'hitchhikers' clinging to, - or associated with, floating ghost gear could potentially 'jump ship' and invade sensitive reef habitats that may cause the spread of disease or the introduction of invasive species (Carlton *et al.*, 2017). For example, after the 2011 East Japanese earthquake and tsunami, nearly 300 (mainly invertebrate) species reached the shores of the US Pacific Northwest. Most of these 'hitchhikers' arrived attached to manmade structures (Carlton *et al.*, 2017).

**Synthetic rope entangling branching coral**

**Plastic fibre smothering  corals and causing death**

## MICROPLASTICS AND NANOPLASTICS

Microplastics and nanoplastics began accumulating in the oceans more than four decades ago (Allen *et al.*, 2017). In general it is often assumed that coastal ecosystems, such as inshore coral reefs will be particularly heavily impacted by microplastics as these contaminants often enter the marine environment through fragmentation of larger plastic items from terrestrial sources (Table 1, Hall *et al.*, 2015). Studies have indeed shown that a large percentage of the plastics coming from coastal areas remain in the vicinity of the source for a long time, while fragmenting into microplastics (Reisser *et al.*, 2013). Coral reefs are also popular sites for short and long term visits by tourists, as well as trawlers and recreational vessels (Fig 1 C), many of which carry components that are composed of various forms of plastics (Claessens *et al.*, 2011). Routine boating, fishing and other recreational activities can potentially introduce plastic debris into the marine environment through minor damage to boat hulls (releasing paint chips into the ocean) and/or inadvertent loss of ropes and rigging lines, fishing floats and marker buoys (Table 1). Indeed the most commonly encountered microplastics on the Great Barrier Reef have been shown to be made from polyurethane, polystyrene and polyester, - plastics which are commonly found in marine paints and fishing floats (Hall *et al.*, 2015).

## 8: Measuring concentrations of microplastics across coral reef ecoregions to understand the scale of the issue in a standardised manner

Of the few studies which have explored the concentrations of microplastics in reef environments, only relatively few particles are commonly reported within any given sample. For example in the waters off Mo'orea, microplastics are found at a concentration of 0.74 pieces per $m^2$ (Connors, 2017) and off the Great Barrier Reef levels are as low as 2 particles per 11,000 litres of seawater (Hall *et al.*, 2015). Closer to the coast however, particle levels do increase and in Australia 4.3 pieces per $m^2$ have been reported in certain areas (Reisser *et al.*, 2014).

Furthermore, in other (non-reef) environments, microplastic concentrations can be significantly higher. For example, in the North Atlantic, 14 particles per 100 litres of water have been reported (Wieczorek *et al.*, 2018) and record levels have been shown to occur in the sea ice off the Arctic (up to 12,000 microplastic particles per litre) (Obbard *et al.*, 2014). These levels are likely to illustrate a major historic global sink of particles, accumulated over many years. In a similar manner, where currents converge, concentrations in the ocean gyres are also reportedly high (Fig 1 B). For example, 334 pieces of microplastics have been found per $m^2$ in the North East Pacific (Moore *et al.*, 2001 - Fig 1 B), 324 pieces per $m^2$ in the Mediterranean (van der Hal *et al.*, 2017 – Fig 1 B) and 396 pieces per $m^2$ in the South Pacific gyres (Eriksen *et al.*, 2013 - Fig 1 B) or 26,898 particles per $km^2$ (Eriksen *et al.*, 2014).

Accumulation is also probable in reef sediments (Cheang *et al.*, 2018; Cordova *et al.*, 2018). Yet, from the few studies which have assessed this, concentrations range substantially, from 35 ± 13.98 items/kg to 221 ± 45 items/kg - (Indonesia and Hong Kong, China respectively) (Cheang *et al.*, 2018; Cordova *et al.*, 2018). The proportion of microplastics made from PE and PET in sediments is reportedly higher than that observed in local beach sediments (Cheang *et al.*, 2018).

It should be noted that concentration of microplastics recorded is directly influenced by the sampling approach used, this can and does vary significantly between studies, and makes comparison between studies difficult and almost impossible – hence the need for a standardised approach to measuring microplastic concentrations highlighted in knowledge gap 8 - above.

Consumption of microplastics by organisms at the base of food webs such as mussels (Farrell and Nelson, 2013) and plankton (Cole *et al.*, 2013) have raised concerns about the potential for transfer of plastics and their associated toxins throughout marine food webs (Thompson *et al.*, 2009). Ingestion of plastics has indeed been shown by some studies to result in gut blockage, false saturation and reduced energy reserves in various organisms stemming from laboratory based trials (Allen *et al.*, 2017). Fibres for example, have been shown to form tangled balls in the guts of reef dwelling organisms such as crabs (Watts *et al.*, 2015).

Athough microplastics (and potentially nanoplastics) are commonly found within organisms – there is a substantial contrasting body of evidence which highlights little to no significant impact of plastic exposure (and ingestion) on growth, body condition or behaviour for a number of organisms including reef fish and urchins for example (Kaposi *et al.*, 2014; Critchell and Hoogenboom, 2018).

In fact many organisms have been shown to be able to detect and actively avoid ingestion of the microplastics when the plastics in question were of similar size to their food items (i.e. 2mm in the fish study mentioned here) (Critchell and Hoogenboom, 2018). However, it was also highlighted that when the size of the microplastics available were reduced, the amount of plastic ingestion increased and after 1 week of exposure, upwards of 2102 microplastics (<300μm diameter) were found within the guts of the test subjects (Critchell and Hoogenboom, 2018). As plastics continue to break down (and will therefore naturally get smaller and smaller within the ocean environment), this study highlights that ingestion will undoubtedly be occurring at large scales, though the level of risk still remains undetermined – Knowledge Gap 9.

### 9: Exploring the level of risk microplastics have on reef organisms

Critchell and Hoogenboom (2018), went on to further conclude that given the additive impacts of climate change on plankton diversity and concentrations, ingestion of microplastics may well increase in the absence of normal fish prey items. Furthermore, the species of fish and the life stage have also been suggested to be factors worthy of consideration when exploring the impact of microplastics on fish assemblages. In a recent study, Garnier *et al*. (2019) assessed the presence of microplastics across four common reef fish genera; *Myripristis, Siganus, Epinephelus* and *Cheilopogon* – representing four different trophic guilds. Only 21% of the fish surveyed showed particles within the digestive tract of the fish (28/133) and this was independent of the trophic guild. Furthermore, many reef fish exhibit ontogenetic changes in diet as they grow, with smaller fish generally eating smaller prey. For instance, some (like damselfish) increase their reliance on consumption of benthic algae as they mature, meaning that juvenile fish may be at more risk of harm from microplastic consumption than adults (Critchell and Hoogenboom, 2018). The colour of the microplastics also appears to be important with regard to likelihood of ingestion by many coastal dwelling fish species, with white often being preferred (Carpenter *et al.*, 1972). As reefs are well known nurseries of many fish species (including larger commercially important pelagic species) further work should be undertaken in this regard to ascertain the level of threat. That said, the majority of studies which have explored microplastic ingestion, illustrate that excretion occurs after relative short time periods (2-3 hours for copepods/plankton, 2-3 days for mussels and oysters and 2-3 weeks for top predators such as turtles (Duis and Coors, 2016) and so some argue ingestion of microplastics may not be a major threat to reef organisms.

'The additive effects of climate change and other stressors (like plastic pollution) are unknown'.

Direct ingestion, however is not the only way higher trophic level organisms can be exposed to microplastics – and the impact of movement of plastics through the food chain is gaining increasing attention. Indeed, organisms at the lower end of many food chains such as zooplankton and phytoplankton have been shown to uptake microplastics in experimental trials (Cole *et al.*, 2013; Besseling *et al.*, 2014; Sun *et al.*, 2017). Furthermore, when exposed to microplastics, such organisms express reduced levels of feeding rates (in the case of copepods) growth and photosynthesis (for algae) (Cole *et al.*, 2013; Besseling *et al.*, 2014). Further, Duncan *et al.* (2019) indicated the presence of microplastics in seven turtle species occupying different trophic levels, indicating that multiple ingestion pathways are likely. These may include, for example - exposure from polluted seawater and sediments (direct ingestion) and/or additional trophic transfer from contaminated prey or forage items.

Corals have also been shown to directly uptake microplastics. For example, 21% of coral polyps analysed in an ex situ exposure trial of microplastics were shown to have ingested at least one particle (Hall *et al.*, 2015). Corals appeared to be able to ingest fragments from a wide variety of shapes and sizes (ranging from 100μm to 2mm) and they are able to trap the particles in their mucus


**Debris lining the beach in Sulawesi, Indonesia**

(Hall *et al.*, 2015; Allen *et al.*, 2017; Hankins *et al.*, 2018; Reichert *et al.*, 2018) - the coral mucus is used to clear the surface from settling debris as well as for feeding. Feeding rates of microplastics by the corals have been shown to be variable between individual colonies and species but they can still ingest upwards of 660 μg cm-2 per day (Hall *et al.*, 2015). However, the majority of ingested particles are again highlighted as being expelled relatively quickly i.e. within 48 hrs in this instance (Hankins *et al.*, 2018). When expulsion does not occur, corals have been shown to be able to overgrow the microplastic particles (Reichert *et al.*, 2018), again providing further evidence that microplastics may not be a major threat. Overgrowth particularly occurs in areas where cleaning mechanisms were ineffective and where tissue or skeletal morphology, colony orientation and water movement hindered passive removal of the particles.

It is now clear that reef organisms can and do ingest plastics from their environment, however, there is limited documented evidence to illustrate the impact this ingestion has on the health of the individual - Knowledge Gap 9.

The few studies, which have explored this issue, highlight that the impacts of microplastic ingestion are likely to be species specific. For example, the coral species *Pocillopora verrucosa* and *P. damicornis* were reported to show varying levels of tissue necrosis when exposed to microplastics. *Acropora humilis, A. millepora* and *Porites cylindrica* bleached under the same conditions, whilst Porites lutea showed no adverse effects (Reichert *et al.*, 2018). Hankins *et al.* (2018) used calcification rates as a proxy for the impact of microplastics in their study and focused on two Caribbean coral species, *Montastrea cavernosa* and *Orbicella faveolata*, however they were unable to show any impact of the presence of plastics. Although polyethylene (a common polymer found in marine sediment and surface waters) was utilised in both studies, the sizes and densities (per litre of sea water) varied and could possibly explain the differences in host response. Hankins *et al.* (2018) for example, reported that an undetermined number of microplastics in the range of 90-106 μm per $L^{-1}$ were used in their experiments, 215 particles per $L^{-1}$ for the 425-500 μm size class and 24 particles per $L^{-1}$ for the 850-100 μm size class. In contrast, Reichert *et al.* (2018) used only one size class (37 to 163 μm) and reported 4000 particles per $L^{-1}$.

Unlike that of macroplastics, the levels of microplastics in higher organisms like sea turtles, sirenians, cetaceans and sea birds is less well understood. Caron *et al.* (2018) attempted to tackle this issue and designed a novel method to explore levels of microplastics in these higher organisms and used green sea turtles (Chelonia mydas) as an example. From a combined approach (visual inspection, nitric acid digestion, emulsification of residual fat, density separation and chemical identification by Fourier transform infrared spectrometry), microplastics were indeed located in the turtles and were identified as paint chips and synthetic fibres. As mentioned earlier, Duncan *et al.* (2019) has now highlighted that microplastic ingestion is ubiquitous in marine turtles and found in all seven species sampled, across three ocean basins (the Mediterranean, Pacific and Atlantic). These results hint the levels of plastics found in these organisms may well be underreported at the current time – leading us to Knowledge Gap 10 and issues with the detection of plastics.

## 10: Exploring issues with the detection of microplastics in organisms and the surrounding environment

Finally, it should be noted that caution needs to be taken in all microplastic experiments and surveys due to the high possibility of contamination occurring from other sources including natural fibres (Hermsen *et al.*, 2017, GESAMP 2016). Indeed, one study which used particularly strict quality assurance criteria, illustrated substantially low numbers of microplastics in fish surveyed from wild habitats, compared to studies which may not have been so stringent (Hermsen *et al.*, 2017). This particular study focused on the North Sea.

### Challenges with detecting plastics

As with all sciences, the interpretation of the findings is limited by the quality of the data utilised. Identifying larger pieces of plastics is not difficult and should result in little error. Microplastics and nanoplastics in contrast are often much harder to count reliably and need a little more attention. Further, the methods utilised to record the abundance of plastics vary from publication to publication and can make compiling meta-analysis difficult or impossible.

There is an urgent need to agree upon a standardised method for surveying plastics in a reef environment in order to allow for direct comparisons between studies and different regions and facilitate effective management and mitigation solutions.

For example, assessing the number of plastic items collected by an observer (along a certain stretch of beach), then comparing these numbers across space and time, rests on the assumption that a constant proportion of plastic pieces are detected and recorded. Below, we suggest that standardisation of surveying for plastics is one way to help with this issue. Although we acknowledge that there are some (quite significant) hurdles which need to be overcome (or at least understood) before reliable interpretation of any data can be undertaken.

As with any count data, the importance of detection probability is paramount. For plastics this has been shown to range from 60-100% and varies considerably by observer, observer experience and biological material present on the beach which can be confused with plastics (Lavers *et al.*, 2016). Blue microplastics have been shown to have the highest detection probability, while white microplastics had the lowest. Such information could be adapted into survey design for long term monitoring or utilisation of statistical models in order to reliably predict the level of missed plastics in any given environment. Imperfect detection of plastic debris can potentially be accounted for using repeat surveys and modelling the data. For this to occur at least 3-10 independent repeat counts need to be conducted from at least 25-50 distinct sites (Lavers *et al.*, 2016). Whilst it is acknowledged that such effort is expensive and time consuming, the use of citizen scientists could overcome certain costs associated with more detailed surveying. Alternatively, corrections in counts could be utilised to adjust for the missed plastic items. For example, in the surface sediments on beaches it has been suggested that multiplying the actual count of white microplastic particles by 1.3-9.5 will give a more realistic account (Lavers *et al.*, 2016).

One could argue, however, that we have enough knowledge to understand the issue and so as long as a standardised protocol can be decided and is consistent, any underestimates are not going to be vastly important as long as the underestimate is consistent between repeat surveys. Therefore focusing on one 'type' or candidate of microplastic (as an indicator) could be a way round this. Before such application is undertaken in wide spread survey methods, a study needs to be undertaken that estimates the correlation between the abundance of white or blue plastics for example and other plastic debris. A more pressing issue however, is the quality of assays used for detection of microplastics and the detection of false positives. Indeed, false positives are often routine in any count data and attempts should always be undertaken to minimise this issue where possible. In the case of microplastics again, false positives have been shown to be highly likely and often confused with natural debris for example clam shell fragments, charcoal or coral (Imhof *et al.*, 2017). When strict quality assurance criteria are put in place, much lower numbers of microplastics are usually reported, compared to other studies, which may not pay attention to as much detail (Hermsen *et al.*, 2017). Whilst the use of certain statistical models (binomial mixed) can account for 'undetected' microplastics, they cannot deal with false positives as well. Further research is needed in this area – Knowledge Gap 11.

### 11: Assessing the quality of current assays used to assess microplastics and validate models for assessing the chance of false negatives and positives in plastic counts

Only 61% of particles identified as microplastics were indeed plastic.

One method aimed at tackling false positives is the use of 'polymer identification techniques' such as Fourier Transform Infrared Spectroscopy (FTIR). For example, in a study exploring the levels of microplastics in the Maldives archipelago, FTIR highlighted that only 61% of the particles visually identified as microplastics were indeed plastic (Imhof *et al.*, 2017).

The final two knowledge gaps (10 and 11) are designed in order to address the issues around measuring and monitoring plastics in reef ecosystems. There are many methods employed in assessing the levels of plastics (both macro and micro) and there appears to be no clear consensus over which can, or should be utilised over others. Before any mitigation strategy is undertaken there is an urgent need to develop a standardised approach to measuring environmental levels of plastic contaminants in reef ecosystems. This will enable before-after-control-impact designs to be implemented to measure the impact of any management activity.

**Discarded fishing gear on a rocky shore**

# POLICY AND MANAGEMENT RECOMMENDATIONS

The issue of plastics in the marine environment has been recognised by scientists, governmental organisations, non-governmental organisations, private institutions and charities alike. It is recognized as a global priority, including in the 2030 Sustainable Development Agenda, under Sustainability Development Goal (SDG) 14 on conserving and using the oceans, seas and marine resources for sustainable development. Specifically, Target 14.1 is to prevent and significantly reduce marine pollution of all kinds by 2025, with indicator 14.1.1 including an index on floating plastic debris density.

This report identifies detrimental impacts of marine plastic litter on shallow water coral reef ecosystems and organisms. In response to these threats, the following recommendations are made in order to advance action on marine litter and SDG Target 14.1, especially in relation to the sustainable management of coral reef ecosystems.

### 1. Strengthen partnerships to eliminate marine litter and plastic pollution at source

Governments, civil society and private sector actors are encouraged to join the Global Partnership on Marine Litter, and engage with the partnership to develop plans and targets for reduction of waste that may enter coral reef areas.

The Global Partnership on Marine Litter, hosted by UN Environment, is a multistakeholder partnership that gathers international agencies, governments, non-governmental organizations, academia, private sector, civil society and individuals with the common goal of protecting human health and the global environment through the reduction and management of marine litter. The Global Partnership on Marine Litter has several specific objectives including:

- to reduce the impacts of marine litter worldwide on economies, ecosystems, animal welfare and human health;

- to enhance international cooperation and coordination through the promotion and implementation of the Honolulu Strategy - a global framework for the prevention and management of marine litter, as well as the Honolulu Commitment – a multi-stakeholder pledge;

- to promote knowledge management, information sharing and monitoring of progress on the implementation of the Honolulu Strategy;

- to promote resource efficiency and economic development through waste prevention e.g. 4Rs (reduce, re-use, recycle and re-design) and by recovering valuable material and/or energy from waste;

- to increase awareness on sources of marine litter, its fate and impacts, and

- to assess emerging issues related to the fate and potential influence of marine litter, including (micro) plastics uptake in the food web and associated transfer of pollutants as well as impacts on the conservation and welfare of marine fauna.

### 2. Strengthen national planning to address land-based sources of plastic litter on coral reefs

1. Countries with coral reefs should develop or revise national action plans and local mitigation measures, based on strategic assessments that identify key sources, pathways and impacts of plastics on reefs. It is important to engage the full range of stakeholders in the development of plans and implementation of mitigation measures.

2. Identify and manage major local sources of plastic pollution to coral reefs, for example through appropriate and low-cost technology such as litter traps in river mouths close to coral reefs, or through improved waste management in nearshore dumpsites and waste management facilities close to coral reefs.

3. Apply bans on harmful single-use plastics on beaches close to coral reefs, for example banning smoking on public beaches to reduce littering of cigarette butts, and banning the use of plastic straws, bottles and bags.

4. Work with key plastic-producing industries to implement liability and compensation schemes based on polluter-pays mechanisms.

5. Consumer demand should also be addressed in tandem in order to ensure lasting impact.

### 3. Reduce the impact of aquaculture, lost and abandoned fishing gear on coral reefs

Develop and apply regional regulations and guidelines on eliminating or reducing lost and abandoned fishing gear from entering the ocean on or around coral reefs, through relevant regional organizations such as Regional Fisheries Management Organizations and Regional Seas Conventions and Action Plans, in close consultation with fishing industries and communities.

1. Invest in education of fishers to implement preventative measures or interventions before the fishing gear reaches sensitive coral reef habitats.

2. Develop incentives for the retrieval or safe deposit of used gear, including innovative financial mechanisms to incentivize gear retrieval such as https://www.aquafil.com/ or http://net-works.com/.

3. Implement programmes to mark fishing gear, so that lost and abandoned fishing gear can be traced back to owners. The Food and Agriculture Organization Committee on Fisheries has developed voluntary guidelines on marking fishing gear, which should be implemented globally.

4. Reduce or eliminate harmful fishing subsidies which exacerbate overfishing, with special attention to industrialized fishing.

5. Reduce fishing demand from wild stocks by investing in closed system, environmentally-sustainable, aquaculture practices, which do not allow macro-plastics to enter the marine environment.

6. Enforce the reporting of accidental or discharge of fishing gear as specified in regulation 10.6 of the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex V (MEPC, 2017).

## 4. Invest in monitoring and research

This report identifies a number of knowledge gaps that are necessary to address in order to strengthen the scientific evidence base for action on marine plastics that impact coral reefs, and towards achievement of targets set by the global community. Addressing these knowledge gaps requires financial investment by governments and other entities, and efforts by academic and research institutions. The knowledge gaps include:

1. The status and magnitude of marine litter on coral reef ecosystems:
- Understand the scale of mismanaged waste entering coral reef environments.
- Understand the patterns of plastic pollution in and around coral reef environments, e.g. identify hot spots of plastic pollution accumulation on coral reefs.
- Ascertain concentrations of microplastics across coral reef ecoregions to understand the scale of the issue in a standardised manner.
- Assess the quality of current assays used to assess microplastics and validate models for assessing the chance of false negatives and positives in plastic counts.

2. The impact of plastics on coral reef species and ecosystems:
- Understand the impacts of leaching chemicals from plastics in coral reef environments.
- Understand how, on a wider, ecologically relevant scale plastics impact coral reef environments.
- Explore how macroplastics interact with and affect benthic invertebrates such as sponges and corals.
- Quantify the amount of ghost gear and its impact on coral reef communities.
- Explore the level of risk microplastics have on reef organisms, e.g. by cross mapping microplastic quantities and the distribution of sensitive reef organisms.
- Explore issues with the detection of microplastics in organisms and the surrounding environments.
- Explore the role of macro- and micro-plastics in transporting invasive epibionts and possible pathogenic agents on a global scale.

3. The potential societal and economic impacts of plastics on coral reefs:
- Understand reef mediated human exposure to microplastics, chemicals leeched by plastics as well as entanglement of or injuries to swimmers.
- Understand the health impacts on humans of consuming microplastics in coral reef organisms.
- Understand current and projected economic impacts of marine plastic litter and microplastics on reef dependent industries and communities.

4. Improving data collection and information to address these knowledge gaps:
- Include coral reef environments in marine litter monitoring programmes.
- Incorporate marine plastic litter indicators in regular national coral reef monitoring programmes, for example occurrence of macro-plastics on coral reefs as well as its effects on coral reef organisms (e.g. mortality, injury or competitive interactions with other biota). This may be advanced through the Global Coral Reef Monitoring Network.
- Engage citizen scientists to collect data on macro-plastics and ghost gear on coral reefs, for example through the marinelitternetwork.org.

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