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UN Sustainable Development Goals 14 and 15 – Life below water, Life on land

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Since the 1960s, when Rachel Carson's *Silent Spring* was published and the World Wildlife Fund (WWF) was launched, it has been clear that anthropogenic activities from agricultural to industrial have enormous impacts on the animals and plants that we share our planet with. However, many chemists would feel reluctant to connect their research to SDGs 14 and 15 and would be inclined to think that these goals are more aligned with the work of ecologists, conservation biologists and ocean scientists. In this editorial, I will attempt to highlight sustainable chemistry research that impacts these SDGs.

As can be seen from the targets listed in Table 1, solutions to and tools for prevention of marine pollution, including ocean acidification, eutrophication and plastic pollution, are needed.[1] These problems not only endanger life below water but also impact the livelihoods of many people living in coastal regions of the world. Small island developing states could benefit enormously from new technologies that address SDG 14 such as sustainable management of fisheries and aquaculture. For example, in addition to ocean pollution with single-use plastics, plastics are extensively used in fishing and aquaculture (*e.g.* ropes, nets, enclosures and bags of feed), and these could be better designed for re-use or repurposing at the end of their lives. In terms of aquaculture, farming in sea pens can lead to ocean pollution (*e.g.* eutrophication due to overfeeding or faecal matter from fish, antibiotics and other veterinary treatments) and spread of disease to wild fish populations. Therefore, research on sensing technologies is essential for monitoring fish health and preventing excessive feeding. Also, cultivation of seafood in tanks on land and integrated multi-trophic aquaculture on land (or in the sea) can prevent pollution whilst at the same time sustainably providing food. Increased food and protein production is essential due to increasing global population, and aquaculture has been highlighted by the UN as one of the sustainable methods to achieve this. In my own research group, we have been investigating methods for processing waste produced in the seafood industry, which will increase sustainability in this sector. In addition to such technologies potentially preventing waste disposal into the sea, they offer additional income streams to fishers, aquaculturists and processors. Dumping of waste in the sea is widely practiced in many regions of the world and leads to eutrophication of coastal waters and adverse impacts on important marine ecosystems.

There is some overlap between SDGs 14 and 15. For example, the need to reduce, control and eradicate invasive species. According to the UN, nearly all countries have adopted legislation to prevent or control invasive alien species, although there is wide variation in the coverage of this legislation across the world. In America, Asia and Australia, one such invasive species is the European Green Crab that has become abundant in coastal waters after its introduction *via* the bilge waters of ships originating in Europe. This invasive crab species competes with native animals including economically important fishery species such as the American lobster in the USA and Canada. Furthermore, green crabs are known to damage eelgrass, which are important nursery habitats for young fish. The Moores group has developed a sustainable method for isolating chitin from this invasive species based on mechanochemical treatment of green crab shells with an organic acid, *e.g.* salicylic acid, citric acid or acetic acid.[2] Finding a use for invasive species like this prevents the need to dispose of them *via* landfills or incineration. However, care must be taken not to incentivize the presence of alien species, especially in regions with poorer economic opportunities.

Ocean acidification is caused by oceans taking up atmospheric CO_2. This causes ocean pH to decrease and negatively impacts marine organisms especially calcifying organisms such as

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Table 1 Sections of targets related to SDGs 14 and 15 of relevance to *RSC Sustainability* authors and readers

Target 14.1	"…reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution"
Target 14.3	"Minimize and address the impacts of ocean acidification…"
Target 14.7	"…increase the economic benefits to Small Island Developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture…"
Target 14.a	"Increase scientific knowledge, develop research capacity and transfer marine technology… in order to improve ocean health…"
Target 15.1	"…ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands…"
Target 15.5	"Take urgent and significant action to reduce the degradation of natural habitats…" also Targets 15.2 and 15.3, sustainable forest management and combat desertification
Target 15.8	"…introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species"

molluscs and corals. The UN reports that data collected in 2022 from 308 monitoring stations across 35 countries shows a continued decline in ocean pH in the global ocean.[3] The most effective way to address this is to reduce reliance on fossil fuels and thereby reduce CO_2 emissions. Therefore, SDG 14 is inherently connected with SDG 7 Affordable and Clean Energy, and SDG 13 Climate Action.

Sustainable resource management is key in achieving both SDGs 14 and 15. Deforestation and land degradation are particular concerns in terms of realizing SDG 15, and ignoring these highly visible problems will lead to significant biodiversity loss and poses major risks to human survival and sustainable development. In this regard, technologies that address climate change play critical roles in preventing further land degradation and desertification. As land degrades and turns to desert, this can in turn lead to more deforestation and habitat destruction as humans move into (live, farm and industrialize) previously pristine environments. Therefore, sustainable forest and natural resource management are needed to balance biodiversity and maintain or improve living standards for people worldwide. Therefore, chemists interested in sustainable development should give greater consideration to chemical lifecycles including the use of renewable feedstocks and industry by-products (*e.g.* lignin from the paper industry, biochar produced from forestry waste) where possible. Despite a strong desire to pursue renewable chemicals and materials in our research goals, it is important that we do consider the full cost and impact of obtaining these feedstocks. For example, palm oil plantations have led to deforestation in tropical regions of the world including some of the most sensitive, biodiverse habitats. Palm oil is used in many food and consumer products (cosmetics, detergents, snack foods and other processed foods), and in most cases cannot be considered a truly sustainable feedstock.

Although, the tone of this editorial may be pessimistic at times, it does highlight the broad ranges of activities needed to achieve SDGs 14 and 15. With regards to some targets of SDG 15, there is scope for optimism as the world's proportion of forest area only decreased by 0.7% of total land area between 2000 and 2020, which suggests a path towards sustainable forest management is being pursued around the world.[4] *RSC Sustainability* would welcome your papers providing potential solutions to targets within the scopes of SDGs 14 and 15.

SDGs: although this editorial largely addresses SDGs 14 and 15, it also impacts on many of the other ones. These include SDG 2, as the carbon footprint of farmed seafood especially molluscs is significantly lower than many other forms of protein (including beef and chicken). SDG 5, the seafood processing sector is dominated by women and research addressing SDG 14 can improve opportunities for these employees. SDG 8, 9 and 10, sustainable use of marine resources is of critical importance to many small island developing states and new technologies addressing SDG 14 could lead to improved economic growth and reduced inequalities. SDG 12, responsible consumption and production can be addressed by considering the lifecycle of materials we use and produce on land and in the oceans. SDG 13, climate action can be impacted by reductions in CO_2 emissions (*e.g.* carbon capture, storage and utilization) and this should lead to reductions in ocean acidification. As with all sustainability related research, SDG 17 partnerships for the goals are essential as scientists including social scientists and engineers must work together from around the world to achieve the goals.

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