Non-indigenous species and invasive aquatic species

Oceans are home to a wide variety of species such as plants, algae, fish and micro-organisms, which have evolved in their habitats, separated by natural barriers. Species have always moved around the planet through the oceans. Whether swimming or hitching a ride on a log, leaf or other debris, organisms have found new worlds in which to thrive. Until recently, this process has been moderated, limited by currents and winds, but some species have moved, intentionally or unintentionally, as a result of human activity.

When the habitat of adoption has similar characteristics to the habitat of origin, non-indigenous species have a good chance to adapt and thrive. In addition, due to some competitive advantages such as the absence of natural predators, some non-indigenous species have become dominant and have disrupted the biodiversity of their new habitat. These species are generally referred to as Invasive Aquatic Species (IAS).

In the marine environment, IAS are capable of altering adoptive habitats, competing with native organisms for limited resources and reducing biodiversity by causing the extinction of native plants and animals. This can lead to considerable economic impacts and fundamental disruption of coastal and lake ecosystems.

The introduction and establishment of invasive aquatic species is considered one of the greatest threats to the world's freshwater, coastal and marine ecosystems. Economic impacts of IAS include disruption of fisheries, biofouling of coastal infrastructure and disruption of coastal services for tourism and recreation. Globally, the value of the economic impact has been estimated at several hundred million dollars per year. The main vectors responsible for the unintentional transfer of non-indigenous species are ballast water from ships, biofouling of mobile marine structures and aquaculture.

Biofouling

The term biofouling is used to describe the gradual accumulation of water-borne organisms on the surfaces of submerged structures that contributes to their corrosion, increased weight and drag, or decreased efficiency of moving parts. The process typically begins with organisms such as bacteria and protozoa, but then expands to include larger species such as algae, plants, molluscs, tubeworms or barnacles.

Biofouling therefore presents an opportunity for invasive aquatic species to move outside of mobile marine structures, such as ships, to new habitats outside what would be considered their natural range. Today, there are many opportunities for hitchhiking species. There are hundreds of thousands of boats, yachts, sailboats, oil rigs and other floating structures in our oceans. Worse, the continued rise in sea temperature caused by climate change is allowing invasive species to colonise ocean habitats that were once too cold to be hospitable.

Controlling fouling organisms has long been a formidable challenge, leading to the development and application of a wide variety of toxic paints and greases, or the use of metals that emit toxic ions when they corrode. However, none of the existing methods provide permanent control. In addition, recognition of the potential environmental hazards associated with the use of materials that leach toxins into the marine environment has led to the banning of some of the most widely used materials.

Biofouling and ballast water

In the past, it was commonly believed that ships' ballast water was the main vector responsible for the introduction of non-indigenous species. In the last ten years, significant progress has been made in managing this pathway through the GloBallast Project (2004-2017), promoted by the GEF, UNDP and IMO, and the entry into force on 8 September 2017 of the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention). However, despite new measures to manage the transfer of invasive species through ballast water, recent research suggests that biofouling has been underestimated as a potential vector and may in fact represent the most common mechanism for the introduction of non-indigenous species. For example, some research estimates that up to 69% of introductions may have occurred via biofouling.

In addition, it has been observed that domestic spread of non-indigenous species from the area of introduction to other parts of the same region is often via biofouling, especially on recreational boats. In many cases, port regions serve as central "nodes" for the invasion of wider coastal ecosystems.

Root causes and obstacles that need to be addressed

It should be noted that biofouling is a natural process. The problem exists when it acts as a vector for invasions or when it affects industry and its structures.

One of the root causes of the difficulty in fully and effectively curbing the spread of invasive species through biofouling is the complex and multi-sectoral nature of structures subject to biofouling, which makes it essential to address the issue across the full range of anthropogenic structures in the marine environment. In addition to the problem of biofouling on ships, which has led to the introduction of IAS, there is an increasing number and variety of fixed surfaces in marine waters (e.g. oil and gas platforms, aquaculture networks, tidal energy equipment, etc.), which can provide the substrate for potentially invasive species to settle and grow in the vicinity of ships. These anthropogenic structures can serve as a source of biofouling organisms that can attach to a previously "clean" ship, with the biofouling organisms transported to a location where they can become invasive.

In addition, these structures can also be moved between regions, with structures such as Mobile Offshore Drilling Units (MODUs) regularly moving across ocean basins and large marine ecosystems, and new aquaculture structures regularly moving nationally and regionally, giving rise to the potential for IAS to be introduced transboundary.

Environmental threats and socio-economic impacts

Due to the technical, scientific, environmental and economic implications, the issue of biofouling is more complex than most other marine pollution threats facing countries and the global marine ecosystem. The environmental threats and socio-economic impacts that could result from the transfer of invasive aquatic species detailed above can be summarised in the table below. This is a useful starting point for identifying and discussing the general causes of these threats and impacts.

- **Ecological impacts,** including loss of native biodiversity due to predation on or competition with native species; decreased habitat availability for native species; smothering and overgrowth; parasites and disease; as well as hybridisation, leading to genetic dilution.

- **Environmental impacts,** including changes in nutrient cycles and declining water quality, which in turn can have negative impacts on shipping, fisheries and drinking water availability, to name a few.
- **Impacts on human health and well-being,** including reduced recreational opportunities, overgrowth of aquifers and smothering of beaches, as well as increased parasites and diseases that can enter the food chain.
- **Cultural impacts,** resulting from the disappearance of populations of native species used for subsistence harvesting or degradation of culturally important habitats.