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ICES VIEWPOINT: Biofouling on vessels – what is the risk, and what might be done about it?

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Summary

Vessel biofouling is the growth of organisms on the wetted surfaces of vessels. When the vessels move, organisms can be introduced to new regions where they may have adverse effects. Biofouling affects not only the economics of vessel management but also the environment.

Biofouled vessels support ecological communities characterized by a great abundance of opportunistic and non-native species. These vessel-transported species can, if they become established in new regions, affect the native species, community structure, and ultimately ecosystem function.

Biofouling compromises the vessels' operations, their effective range and manoeuvrability, and in some cases their safety. Biofouling can accelerate corrosion as well as increase hull roughness and frictional resistance. This in turn increases power demands, fuel consumption, emissions, and costs.

ICES recommends the following actions to evaluate and mitigate biofouling introductions:

- Urgent implementation of the International Maritime Organization (IMO) generic guidelines for the control and management of biofouling on vessels, with new and more detailed guidelines be developed for different vessel types.
- Ship designs should aim to reduce the potential for biofouling.
- All vessels, whether recreational, domestic, decommissioned, derelict, or abandoned, should adhere to the same standard for the control and management of biofouling.
- Performance measures should be implemented to assess management practice, in order to evaluate efficacy and guide adaptive management.

Recommendations

This document aims to help those that wish to manage biofouling. It is recognized that a lot of work is already being carried out in the context of the International Maritime Organization (IMO). ICES recommends the following:

- The development of biofouling management guidelines suitable for different vessel types and operation profiles. These guidelines should consider vessel design, maintenance regimen, shipping route, port residence time, and other factors. These factors can result in different vessels having very different fouling communities, so a more detailed approach to management would be an improvement.
- The adoption of hull form optimization to reduce biofouling (e.g. the reduction of niche areas) in environmentally friendly ship ("Green ship") designs. The transport and delivery of non-native species or their propagules will be limited by a reduction of niche areas, which typically harbour more organisms than the main hull surface.
- Taking measures to reduce introductions from decommissioned vessels, or drafting and implementing relevant guidelines.
- The implementation of performance measures to assess management practices, to evaluate efficacy, and to guide adaptive management.
- In the siting, layout, design, and engineering of seaports and small craft harbours, the aim should be to reduce the presence of biofouling organisms that can contaminate vessels while in port. This can be achieved by modifying sheltered, shaded, vertical, and floating surfaces, as well as by using specific textures/materials for surface covers.

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What is biofouling?

Biofouling has been defined as the accumulation of aquatic organisms such as microorganisms, plants, and animals on surfaces and structures immersed in or exposed to the aquatic environment.

Biofouled vessels create mobile and novel habitats. The wetted surfaces of vessels support very different biotic assemblage from those found in any other marine habitats. They are characterized by greater abundances of specialized opportunistic and non-native species.

Biofouling does not necessarily translate to the introduction of aquatic organisms, though transportation is an initial step in the process. The introduction of a translocated organism requires a number of further conditions to be present, such as dislodgement or spawning, as well as appropriate environmental conditions.

How many vessels may be affected by biofouling?

All vessels have some degree of biofouling. Sea-going vessels are generally classified as merchant fleet, fishing, naval, and recreational vessels, and platforms such as oil rigs. The number of merchant vessels (>100 deadweight tonnes) in the North Atlantic ecoregions at the start of 2017 was over 93 000. Of these between 9000 and 10 000 are naval vessels, and around 500 offshore rigs. In 2014, 64 000 fishing vessels of 24 m or longer were in operation.

Recreational craft can also spread species to environment that they are not native to. In 2016 there were more than 11 million mechanically propelled recreational vessels registered in the USA; approximately half of these measured at least 7.9 m. Over 6 million boats are kept in European waters, where 4500 marinas provide 1.75 million berths. In 2009, 800 000 recreational vessels were registered in Australia. The construction of marinas in the Indian Ocean and in southeast Asia highlights the growth of long-distance recreational travel.

Derelict, slow moving, and intermittently moving vessels are considered to be high biofouling biosecurity risks.

The global commercial shipping fleet's wetted surface area (WSA) is estimated to be as high as 570 km^2. A quarter of a ship's WSA is typically occupied by biofouling. Most fouling is concentrated in niche areas such as rudders, propellers, thruster tunnels, and sea chests. Many fouling species can settle on surfaces treated with antifouling coatings.

What are the consequences and impacts of vessel biofouling on the environment?

Biofouled vessels can transport organisms beyond the limits of natural dispersal, leading to the introduction of species to new environments. These introductions can negatively impact recipient communities through competition, predation, parasitism, and habitat change. Biofouled vessels have been responsible for a large proportion of marine invasive species globally: >30% of the non-native species in the North Sea, 69% in New Zealand, and 70% in the continental USA. Some of the most widespread invasive species, with dire ecological, economic, and human health impacts are considered to have been transported by fouled commercial and recreational vessels.

Examples of the consequences of invasions caused by biofouling

The economic costs of vessel biofouling can be illustrated in a case study of the colonial tunicate *Didemnum vexillum* (the carpet sea squirt), which is one of the most aggressive and rapidly spreading fouling-mediated species. It was the focus of a recent ICES Alien Species Alert. This invasive organism can encrust a wide range of substrates, fouling artificial submerged structures and overgrowing natural habitats, thereby greatly altering those structures and their accompanying biota. As a recent invader in many parts of the world, the extent of its impacts have only begun to be studied. It spread with fouled shellfish and vessels to Europe, North America, and New Zealand. Eradication attempts in Shakespeare Bay (~1 km²) in New Zealand, costing 650 000 NZ dollars, failed. Due to concerns regarding impacts to nearby shellfish farms, an intensive surveillance and eradication programme was initiated in July 2006 in Shakespeare Bay and the wider Marlborough Sounds (~750 km²). It continued for two years, until eradication was no longer considered feasible, and the cessation of control efforts resulted in rapid re-infestation. An eradication effort in Holyhead Harbour in Wales, UK, where the species was confined to a small marina and unrecorded elsewhere, was undertaken at an estimated cost of £350 000. The eradication process was initially successful, but the marina was rapidly recolonized and *D. vexillum* ultimately spread with biofouled vessels throughout the UK.

What are the consequences and impacts of biofouling on vessel operation?

Slime fouling can increase vessel surface friction up to 70%, with increased power demand estimated to be between 1.5% and 10.1% (to maintain pre-fouling speeds). Moderate biofouling needs a power increase of 11–21%, while heavy calcareous biofouling requires a 35–86% power increase to maintain the same speed as a clean hull. Although the modelling is complex, the primary cost associated with biofouling is the increased fuel consumption attributed to increased frictional drag. Biofouling of internal systems on vessels using seawater (e.g. for cooling) also reduces efficiency and increases fuel consumption. Increased fossil fuel consumption results in the increased emission of greenhouse gases.

How is the risk of biofouling expected to change in the next 20 years?

Of the many factors that influence the risk of introduction of invasive species via vessel fouling, two are especially notable and intertwined: (a) changes in the number of vessels and routes, and (b) climate change.

The global vessel fleet is expected to grow in both tonnage and number for all major vessel types. Global demand for ship-carrying capacity has increased by almost 75% in the first 15 years of this century, and this trend is expected to continue. Recreational boating is also increasing in the number of boats and of marinas. The Asia–Pacific region is expected to experience the highest growth over the forecast period.

Changes in shipping routes alter direct and indirect connectivity between the potential sources and destinations of fouling organisms. Shipping routes in the 21st century have changed from direct port-to-port services along the major East–West routes, which linked Europe, the United States, and East Asia, to "hub and spoke" networks that link the major East–West maritime motorway with secondary North–South services. Future changes depend on economic, demographic, and political drivers, as well as on security risks such as the piracy crisis near Somalia.

Changes to routes may also occur due to climate change, with the most dramatic and direct changes occurring in the subpolar regions. Sea ice coverage across the Arctic has declined since the 1980s, and the trans-Arctic shipping routes between Asia and ports in Europe or eastern North America that were once thought impossible may become economically feasible by the 2050s. Increasing maritime traffic in the waters around Antarctica may increase the risk of introduction to the subpolar region, though to a lesser degree than in the high Arctic. Climate change not only opens new routes, but the resultant environmental changes as polar and subpolar regions warm may lead to more introductions through better survival and spread. Climate change may also indirectly alter shipping and boating patterns and routes, through its impact on worldwide economic, demographic, and political drivers.

What has been done to prevent/minimize biofouling on vessels?

The International Maritime Organization (IMO) adopted their "*Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species*" in 2011, followed by approval of the "*Guidance for minimizing the transfer of invasive aquatic species as biofouling (hull fouling) for recreational craft*" in 2012. A "*European code of conduct on recreational boating and invasive alien species"* was recently presented to the Council of Europe. Several jurisdictions have already established mandatory policies (e.g. California and New Zealand). It is too early to assess their effectiveness on rates of introduction, but the implementation of these guidelines will require investment, institutional reforms, and capacity building. International bodies such as the United Nations Development Programme (UNDP) and the Global Environmental Facility (GEF) have started working with the IMO to build capacity in developing countries through the GloFouling Programme. It is likely that the voluntary management of biofouling will not deliver the necessary level of control.

Source

Galil, B.S., McKenzie, C., Bailey, S., Campbell M., Davidson, I., Drake, L., Hewitt, C., Occhipinti-Ambrogi, A., and Piola, R. 2019. ICES Viewpoint background document: Evaluating and mitigating introduction of marine non-native species via vessel biofouling. ICES Ad Hoc Report 2019. 17 pp. https://doi.org/10.17895/ices.pub.4680