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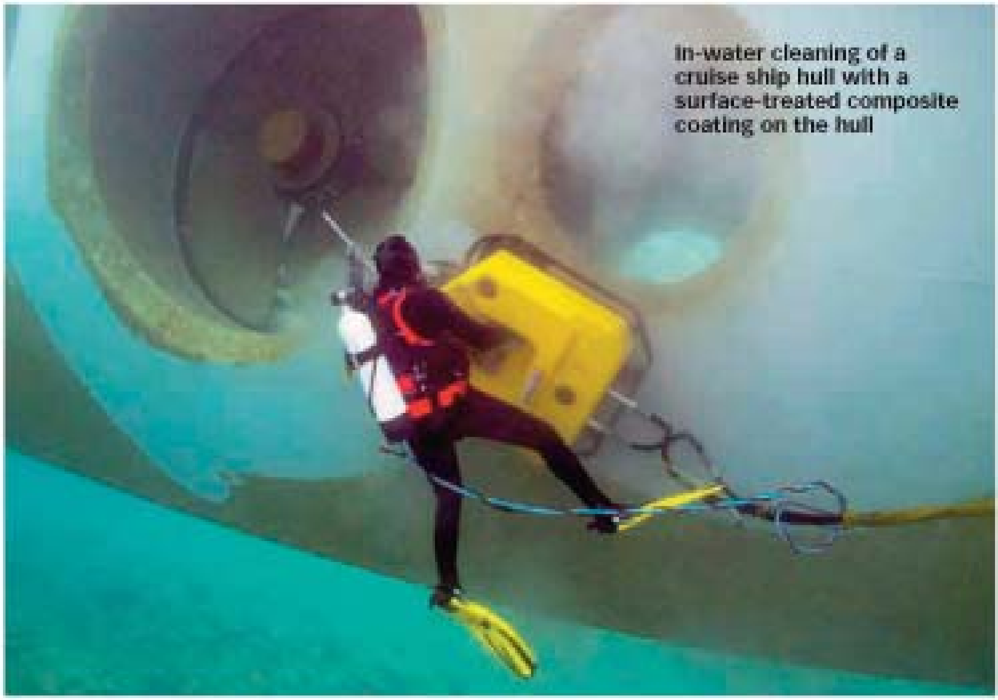
Eliminating hull-borne aquatic invasive species

BIOFOULING CONTROL

The spread of aquatic invasive species (AIS), also known as non-indigenous species (NIS) translocated by shipping, is not only concentrated on ballast water. In the last few years, ship hull fouling has increasingly been recognised as a problem as well. David Phillips, editor of the Journal of Ship Hull Performance, describes current and innovative approaches to biofouling control meant to deal with hull-borne NIS.



In-water cleaning of a cruise ship hull with a surface-treated composite coating on the hull

Marine ecosystems are local. When non-native species are introduced, deliberately or accidentally, they can cause serious environmental and economic problems in their new environment. They do this in a number of ways, including the destruction of local species that are important to the environment. There is no question among scientists that NIS are a serious, expensive, global problem, nor that ship hull fouling is one of the major vectors for the transfer of aquatic NIS.

NIS are an economic as well as an environmental problem. It is more efficient and far less expensive to prevent the translocation of NIS in the first place than to try to repair the damage they cause and eliminate the now-established species and prevent their further spread. Thus it is the responsibility of all those who sail ships between environmental zones to make sure that they are not translocating NIS via fouling on their ship's hull.

Regulatory framework

The NIS threat is growing due to more shipping traffic and also perhaps because the antifouling systems in use since the ban of TBT (tributyltin hydride) have been generally much less effective in eliminating hull fouling.

The pressure, mostly regulatory, on shipowners and operators to prevent the spread of NIS via ship hull fouling is also increasing, with some rigorous measures on the horizon.

The major international initiative regarding hull-borne NIS has come from the IMO in the form of "2011 Guidelines for the control and management of ships' biofouling to minimise the transfer of invasive aquatic species", adopted on July 15th 2011. These voluntary guidelines, still under review, recommend various hull husbandry measures and record-keeping designed to, as the title suggests, minimise the transfer of NIS.

Australia and New Zealand have been at the forefront of recognising and addressing the issue of NIS. They have been working on revising the ANZECC (Australian and New Zealand Environment and Conservation Council) code with a view to preventing bioinvasions into Australia and New Zealand via international shipping. They have commissioned extensive and in-depth studies of current technology for biofouling control, including types of coating and in-water cleaning methods, and have published their findings. They have issued draft guidelines and are evaluating public response before finalising.

Recognising the increasingly serious problem of invasive alien species in Europe, the European Commission is currently working on a dedicated legislative instrument on invasive alien species that is due to be adopted this year.

The California State Lands Commission has drafted legislation designed to prevent the introduction of NIS into California, which is making its way through the legislative machine. California is working with other US and Canadian Pacific Coast states and provinces: Oregon, Washington, Alaska, British Columbia and Hawaii.

The Polar Code is expected to include measures to prevent the import of NIS into sensitive polar waters.

Implementing an effective system can be much less expensive and stressful if one looks well ahead, plans newbuilds accordingly now, chooses hull coating systems with impending regulation in mind and applies them at the next scheduled drydocking.

The current approach

All hull coatings foul in varying degree. How much they foul depends on the coating itself, the operational pattern of the vessel, the climate and therefore the temperature of the water in which the ship operates. Perhaps 90% of the world fleet is using biocidal antifouling coatings. In most cases the coating is applied at newbuild stage and patched, renewed or replaced during each class-required dry-docking. The vessel operator may schedule in-water cleaning in between dry-docking, but in-water cleaning of hulls and particularly of niche areas is fairly infrequent.

The two major barriers to effective handling of the global NIS problem are:

▶ The hull coatings in general use are not suitable for in-water cleaning, but in-water cleaning is an essential part of the solution to NIS;

▶ In order for the NIS spread to be curtailed, ships must leave their port of origin with a clean hull, and concentration needs to be on the beginning of the voyage just as much or more than on the state of the hull at the port of destination. Current efforts by ports and states to limit the spread of NIS concentrate on incoming ships and neglect those that are outward bound.

Biocidal coatings have four main issues:

▶ They are toxic and by their nature pollute the marine environment and pose a hazard to non-target organisms, to marine life in general and potentially to human health, as numerous studies have found.

▶ They are not suitable for in-water cleaning. The cleaning depletes and damages the coating and produces a pulse discharge of biocides.

▶ A number of copper-tolerant and other biocide-tolerant aquatic species have been found (for example the fouling alga Ectocarpus siliculosus and the invasive bryozoan Schizoporella subtorquata) that thrive on these toxicants and are not deterred by the copper-based AF coatings. The biocide-tolerant species become tougher and more resistant than the non-biocide tolerant species in the environment they invade, posing a worse problem than normal invasive species. Thus biocidal antifouling creates "gladiator species" of invaders that dominate the invaded area.

▶ Biocidal AF coatings require a water flow for the biocides to be replenished and continue to leach. The lack of flow in niche areas makes this type of coating ineffective or less effective. While they can be effective in preventing much of the macrofouling on the main hull, at least for a year or two, there are many niche areas of the ship that they do not protect: Sea chests, gratings, the stern area, bilge keels, thruster tunnels and similar nooks and crannies tend not to be kept clear of macrofouling by biocidal antifouling coatings.

Some ships have switched to fouling-release coatings with or without cleaning. This system is only effective on the main hull of fast ships that do not stay long in port or at anchor.

Fouling-release coatings have the following issues:

▶ They tend to be fragile and easily damaged. Thus they cannot be cleaned with abrasive brushes and only microfouling can be gently removed without ruining the coating.

▶ They require a water flow past them to work. Thus in niche areas they are ineffective.

▶ If a vessel is laid up for any length of time it tends to foul.

▶ There is a question about the toxicity of these coatings. For example, studies have shown that silicone fouling-release coatings interfere with the enzymes in barnacle glue. This is a biochemical reaction, not simply a surface energy manifestation. Research has also shown that silicone oils can smother benthic organisms. At the very least, more research is required. The precautionary principle applies. Frequent dry-docking to clean the hull would be ideal. This is, however, impractical and not feasible for economic reasons.

The IMO guidelines, the draft ANZECC code revision, EU guidelines and the California State Lands Commission-proposed regulations all acknowledge the need for in-water cleaning between dry-docking in order to remove macrofouling that has accumulated on the hull and in the niche areas – regardless of coating type – and therefore poses a threat of spreading NIS. ▶

However, in most ports and states, in-water cleaning of biocidal antifouling coatings is forbidden.

And even where it is permitted, underwater cleaning of a biocidal antifouling and fouling-release coatings often damage the coating and are hazardous to the environment. In-water cleaning of a fouling-release coating with any degree of macrofouling is at least damaging to the coating and possibly to the environment as well. The environmental effects of fouling-release coatings are largely unresearched, although there is evidence of toxicity.

It is generally agreed that in-water cleaning must be part of any handling, yet the antifouling and fouling-release coatings in general use impose severe restrictions on in-water cleaning.

The time is right for a fully workable solution that is acceptable to governments, port authorities, environmental groups and the shipping industry. The ideal solution would also bring with it fuel savings, reduction of GHG (greenhouse gases) and other emissions, and elimination of the contamination of ports and oceans caused by heavy metals and other toxicants contained in traditional biocidal antifouling paints.

Comprehensive approach

It can be a big mistake to adopt a one-track approach to solving the NIS issue without taking other related factors into consideration.

NIS are an environmental and economic problem. Any solution to the problem has to take into account all related environmental and economic factors. Otherwise the solution simply becomes a new problem.

The main factors that need to be taken into account are:

- preventing the spread of NIS,
- avoiding toxic pollution of water column and sediment contamination,
- improving fuel efficiency, thus reducing noxious air emissions,
- doing all of the above in a way that is economical and cost-effective to the shipping industry so as to reduce the overall cost of shipping.

Macrofouling in a niche area of a ship coated with antifouling paint

Any solution, in order to be workable, popular and enforceable, has to balance up all these factors. The test of any approach is how little one has to compromise with any of these points.

Alternative, non-toxic approach

The challenge is to find an alternative approach to the NIS problem that is novel, different and aligns with the recommendations of the above-quoted study.

There are a number of non-toxic coatings and systems. The one described here is a commercially available glassflake STC (surface treated composite). This system combines a hard, inert glassflake-reinforced coating with routine in-water cleaning.

The hard coating is properly applied over the entire underwater hull including niche areas (but not the propeller): inside sea chests, on the rudder, in the thruster tunnels, etc. If applied properly on correctly prepared steel, aluminum or GRP, it can last the life of the hull with minimal touch-ups during routine dry-docking. The coating is homogenous and relatively thick (usually 1,000 microns). No primer or other type of coating is required. It is easily applied directly to the prepared hull, usually in two coats, with an overcoat time of about three hours minimum and no maximum.

The hull is then cleaned regularly in the water using mechanical brushes, high-pressure water jet and a variety of other tools. Ideally from a fuel consumption and NIS point of view, the fouling is kept at no more than a light slime layer. The frequency of cleaning will depend on the operating pattern of the vessel and the climate in which it is sailing.

Cleaning of the main hull is done by large, diver-operated multiple brush machines. Niche areas are cleaned with smaller brushes and with high-pressure water jet equipment. If the ship is cleaned regularly, there need be no concern about bioinvasions on the part of the fouling removed since it will be local species. Using this system, a 400m-long VLCC can be cleaned at anchor by two teams of divers in less than 12 hours.

In order for the niche areas to be cleaned thoroughly, a third team concentrates only on them and the overall time of cleaning remains the same. The cost of the cleaning is far outweighed by the resulting fuel savings. Even a slime layer can produce a fuel penalty of as much as 18%. With today's fuel prices, the cost of cleaning can be more than recouped on the very next voyage. One major cruise line using this system has announced fuel savings of 10% compared with its previous biocidal antifouling system.

The fouled ship is cleaned before leaving port. Thus any fouling picked up locally will be removed and not translocated. Very little fouling accumulates en route. Therefore, the ship arrives at its next port of call with a clean hull. If it remains in port for any length of time and accumulates any macrofouling, it is again cleaned before leaving port so that the potential NIS are cleaned off before the ship sails.

This system has the added benefit of making a dry-dock interval of seven and a half to ten years possible, at least from the underwater hull protection and maintenance and fouling control point of view. The coating is expected to last the entire service life of the ship with only minor touch-ups of any mechanical damage, which can easily be carried out during routine, class-required dry-docking without interfering with other activities.

Some changes would be required to operations and infrastructure, so the system could not be expected to be applied universally overnight. But implementation for any vessel could begin at its next scheduled dry-docking. It is a matter of blasting the hull, replacing the coating and beginning a cleaning routine. And it can be performed immediately on all newbuilds. Many shipping companies have already implemented the system successfully.

It is a novel, simple, workable approach that has been tested and validated commercially. It eliminates active, toxic ingredients in bottom paint and substitutes elbow-grease cleaning. The fouling organisms are easily removed without harm to the coating or hazard to the environment.

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