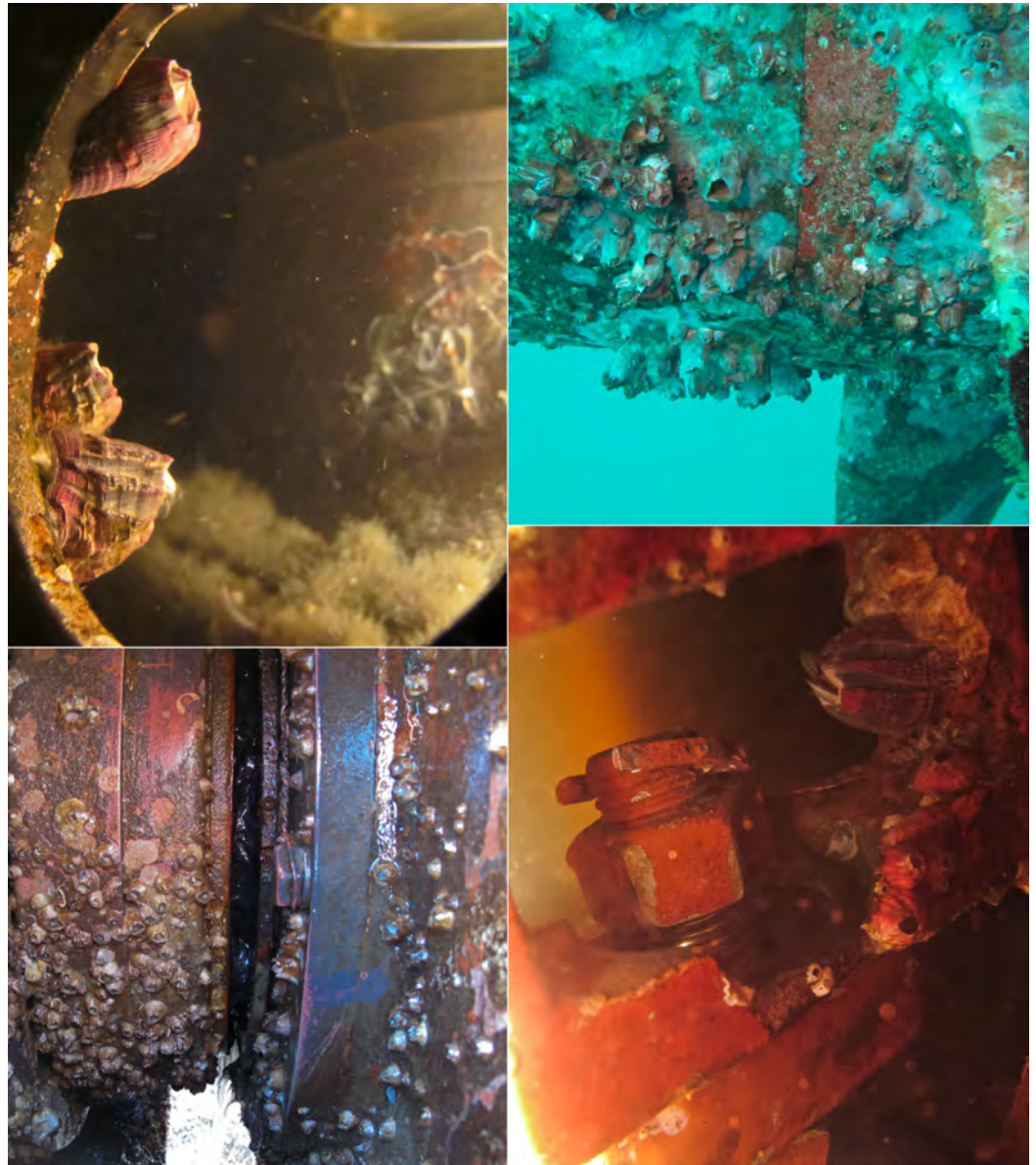


WHITE PAPER

# Invasive Aquatic Species



**A proposed alternative solution**

The Hydrex  
Group  
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## I. Introduction

One hears and reads a great deal these days about aquatic invasive species (AIS), also referred to as non-indigenous marine species (NIMS), non-indigenous species (NIS), aquatic nuisance species, alien species and a number of other names. We shall refer to them here as NIS, perhaps the most prevalent term in non-scientific circles.

NIS are an economical as well as an environmental problem.

For some time the concentration on the shipping industry's role in the spread of NIS centered on ballast water. More recently the focus has extended to include ship hull fouling as a vector of NIS translocation just as important as ballast water if not more so.<sup>1 2</sup>

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

It is more efficient and far less expensive to prevent the translocation of NIS in the first place than to try to clean up the damage they cause and eliminate the now-established species and prevent their further spread.<sup>3 4</sup>

Legislation and regulation to prevent the spread of NIS via ship hull fouling is increasing in severity with some quite rigorous measures looming.

Efforts to deal with the problem to date have not been effective. It is generally agreed that in-water cleaning must be part of any handling, yet the antifouling and foul release coatings in general use impose severe restrictions on in-water cleaning.<sup>5</sup> Frequent dry-docking is not economically or logistically feasible.<sup>6</sup>

The time is right for a thoroughly workable solution which 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 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.

So far the efforts of states and ports have been in the direction of preventing ships arriving in their waters with fouled hulls and NIS. For example, the ANZECC code (currently under review) forbids in-water cleaning of vessels in Australian waters for fear that incoming vessels will bring NIS into Australia which will then establish themselves there. But forbidding in-water cleaning means that vessels leaving Australian ports, especially

**Legislation and regulation to prevent the spread of NIS via ship hull fouling is increasing in severity with some quite rigorous measures looming.**

<sup>1</sup> Jason Savarese, National Sea Grant Law Center, "Preventing and Managing Hull Fouling: International, Federal, and State Laws and Policies," Proceedings of the 14th Biennial Coastal Zone Conference, New Orleans, Louisiana, July 17 to 21, 2005.

<sup>2</sup> Dr. Naomi Parker, MAF Biosecurity New Zealand, "Managing Biofouling at the International Level" (presentation).

<sup>3</sup> Oliver Floerl et al., "A Risk-Based Predictive Tool to Prevent Accidental Introductions of Nonindigenous Marine Species," National Centre for Aquatic Biodiversity and Biosecurity, National Institute of Water and Atmospheric Research, Christchurch, New Zealand, *Environmental Management*, Vol. 35, No. 6, pp. 765 - 778, (2005).

<sup>4</sup> Adrianna A. Muir, "Managing Coastal Aquatic Invasive Species in California: Existing Policies and Policy Gaps," California Senate Natural Resources and Water Committee report, (January 2011), pp: 12-13.

<sup>5</sup> MEPC Annex 26, Resolution MEPC.207(62) "2011 Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species," p. 10 (15 July 2011).

<sup>6</sup> BIMCO article, "Doing without drydocks," (August 2010).

those that have been laid up for some time, will sail with a fouled hull and carry invasive species picked up in Australia to other parts of the world. This may appear to help with the local problem but in fact magnifies the international situation. And NIS is by its very nature an international problem.

A novel approach would be for ports and states to at least place equal emphasis on ships sailing from their port of departure with a clean hull. This would require international cooperation but the IMO is there to make sure that such international cooperation on important shipping related matters is obtained. And if such a solution also carried with it great financial benefits to shipowners/operators the world over, then it is quite likely to be accepted and adopted.

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

- 1) 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;
- 2) 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. Ships do not foul while steaming. They foul when they are stationary.

This White Paper has been inspired by IMO MEPC Annex 26, *2011 Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species*, section 12, Future Work <sup>7</sup> which states:

#### Research needs

12.1 States and other interested parties should encourage and support research into, and development of technologies for:

- .1 minimizing and/or managing both macrofouling and microfouling particularly in niche areas (e.g., new or different anti-fouling systems and different designs for niche areas to minimize biofouling);
- .2 in-water cleaning that ensures effective management of the anti-fouling system, biofouling and other contaminants, including effective capture of biological material;
- .3 comprehensive methods for assessing the risks associated with in-water cleaning;
- .4 shipboard monitoring and detection of biofouling;
- .5 reducing the macrofouling risk posed by the dry-docking support strips, (e.g., alternative keel block designs that leave less uncoated hull area);
- .6 the geographic distribution of biofouling invasive aquatic species; and
- .7 the rapid response to invasive aquatic species incursions, including diagnostic tools and eradication methods.

12.2 Potential operational benefits of such technologies should also be highlighted and relevant information provided to the Organization.

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<sup>7</sup> MEPC Annex 26, Resolution MEPC.207(62) "2011 Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species," p. 15 (15 July 2011).

### **Independent information needs**

**12.3 Summaries are needed of the different types of anti-fouling systems and other biofouling management measures currently available, how they work and their performance under different operating conditions and situations. This information could assist shipowners and operators when making decisions about the most appropriate coatings and coating systems for their ship type and activity.**

A great deal of work has been done on the subject of NIS by the IMO Marine Environmental Protection Committee's Correspondence Group on the development of measures to minimize the transfer of invasive aquatic species through biofouling, under the coordination of New Zealand. This White Paper is a response to section 12 quoted above and will outline an existing, workable, environmentally and economically beneficial method of eliminating the threat of further spread of NIS via the ship and boat hull fouling vector using only currently extant, proven technology and methods.

## II. What exactly is the NIS problem?

Marine ecosystems are local. The collection of marine animal and plant life native to waterways in Cambridgeshire, England, or the Great Lakes in the USA, may be very different from that found in the Black Sea. Species of marine animals or plants which are native to, for example, the Black Sea, when introduced intentionally or accidentally to waterways of, for example, Cambridgeshire or the Great Lakes where they are not native, can cause serious environmental and economic problems in their new environment. They do this in a number of ways which can include the destruction of local species which are important to the environment they are invading, damage to infrastructure in their new locale and obliteration of local industry. These are non-indigenous invasive aquatic species.<sup>8</sup>

**NIS are not just an environmental problem. They are also an economic problem**

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A fairly well known example is the Zebra mussel, native to parts of southeast Russia. When the zebra mussel was accidentally introduced into foreign waters, it rapidly colonized in many parts of the world to which it was not indigenous, including, among a long list of places, the east of England, and the Great Lakes in the USA;. Anglian Water, a water company in the east of England, has estimated that it spends £500,000 a year clearing these non-indigenous mussels out of water treatment plants.<sup>9</sup> According to the Center for Invasive Species Research at the University of California, the cost of managing the Zebra mussel invasion in the Great Lakes alone exceeds \$500 million annually.<sup>10</sup> And the Great Lakes are certainly not the only US waterways affected. This is a substantial amount of money that would not have to be spent had the Zebra mussel not been inadvertently introduced into the USA to begin with. It is reckoned that the introduction to the Great Lakes occurred via ships' ballast water.<sup>11</sup>



*Zebra mussel infestation Ormond Lock.*

<sup>8</sup> Elizabeth Barton and Jessica Heard, "Alien, Non-Native and Invasive Marine Species," The Marine Biological Association of the United Kingdom, *MarLIN* (September 2005).

<sup>9</sup> ["British waterways fight invasion by Russian zebra mussels"](#). BBC News. 2011-08-04.

<sup>10</sup> Mark S. Hoddle, Center for Invasive Species Research, University of California, Riverside, "Quagga and Zebra Mussels," [http://civr.ucr.edu/quagga\\_zebra\\_mussels.html](http://civr.ucr.edu/quagga_zebra_mussels.html), accessed 19 December 2011.

<sup>11</sup> *Ibid.*

The Zebra mussel is also considered to be the source of avian botulism poisoning which has killed tens of thousands of birds in the Great Lakes.<sup>12</sup>

Once introduced from foreign parts by ship hull fouling or ballast water or some other source, the invasive species continue to be spread within the new zone by pleasure craft and local ship and boat traffic. Already the Zebra mussel has spread to many locations throughout the USA, as far afield as California.<sup>13</sup>

But it's not just Zebra mussels. The North American comb jelly, a voracious, plankton-eating, comb jelly common to the Atlantic Coast of North America was introduced into the Black Sea and Sea of Azov in the early 1980s. The comb jelly population expanded rapidly, causing severe economic and social impacts. The cost to Black Sea fisheries is estimated at \$250 million, and anchovy fisheries in the Sea of Azov are nearly extinct.<sup>14</sup>

The Chinese mitten crab has caused the equivalent of millions of dollars in damage in European waterways. Migrating crabs clog water delivery facilities and disrupt fish salvage operations. The mitten crab is a potential human health hazard as it can be a host for the Oriental lung fluke, a parasite that causes tuberculosis-like symptoms in humans.<sup>15</sup>

In 2000, New Zealand spent \$3.5 million to remove a species of invasive seaweed, *Undaria pinnatifida*, from the fouled hull of a single vessel that sank offshore.<sup>16</sup>

There are many examples of the severe harmful effects of the introduction of aquatic NIS on the health of marine organisms and even humans through the food web, and on local industry and commerce.

### *Hull fouling as a vector for NIS*

For some time now the subject of NIS has been a hot topic in the context of ships and shipping, boats and small craft. Until a few years ago it was considered that ballast water taken in by ships in one environmental zone and discharged in another was the main vector by which aquatic NIS were being translocated from zone to zone. Many regulations sprung from this, and new industries and arms of government agencies came into being or expanded to cope with this problem. Much research, ballast water treatment equipment, an IMO task force, coast guard activity, meetings, conferences and literature came into existence all on the subject of ballast water as a vector for NIS and how to deal with it.

Then a few years ago another vector came to the fore: hull fouling was observed to be a key vector in the translocation of NIS. This was not new. Ships have been sailing with fouled hulls from one part of the world to another for thousands of years, transporting all sorts of nuisance weeds and creatures in amongst the fouling to the four corners of the world with impunity— at least with impunity to the ships. What was new was the awareness of hull fouling as an NIS vector and the concern about it. Perhaps a factor that

**What was new was the awareness of hull fouling as an NIS vector and the concern about it**

<sup>12</sup> Janega, James (2008-01-15). "[Botulism takes fatal toll on thousands of Great Lakes birds](#)". [Chicago Tribune](#). Archived from [the original](#) on 2011-04-05. Retrieved 2011-04-05.

<sup>13</sup> Amy J. Benson, "The Exotic Zebra Mussel," U. S. Fish & Wildlife Services <http://www.fws.gov/midwest/angered/clams/zebra.html> (accessed December 2012).

<sup>14</sup> Aquatic Invasive Species, Marine Pollution Adviser, Secretariat of the Pacific Regional Environment Programme (SPREP) Factsheet (2008).

<sup>15</sup> Ibid.

<sup>16</sup> Ibid.

raised its importance was the ban on TBT. TBT was fairly effective in killing all fauna and flora which sought to attach itself to the ship's bottom, and ships bearing TBT (almost the entire world fleet) sailed with relatively unfouled hulls. The various coatings which followed in the wake of the TBT ban have not been so effective in preventing fouling. A quick inspection of a sea chest or some other protected or recessed area of the ship hull coated with any of the antifouling or foul release coatings currently in use will usually reveal a veritable menagerie of living creatures hitching a ride on the ship, among them some of the more obnoxious and harmful invasive species.

### *Regulation and legislation*

The wheels of regulation and legislation are turning even at time of writing. California is in the process of developing regulations which will require that ships entering California waters operate with no more than specified, limited amounts of macrofouling with thresholds based on underwater surfaces (i.e. niche areas vs. the rest of the hull). If inspection reveals macrofouling beyond the specified amount in niche areas or the rest of the hull, this macrofouling will have to be removed on a regular, defined basis. The regulations are not finalized and may change but this is where the process stands at time of writing.<sup>17 18</sup> Other US states may well follow California's lead.

In June 2011 the IMO adopted MPEC Annex 26, 2011 *Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species*. Although the guidelines are still voluntary, they will undoubtedly move forward into compulsory regulations for the prevention of the spread of NIS via hull fouling. For some time now the ANZECC code has prohibited almost all in-water cleaning of hulls in Australian and New Zealand waters on the basis that NIS may be dislodged as part of this cleaning, resulting in new invasions. This code is currently under review.<sup>19</sup>

### *Is it a real problem?*

To some shipowners and operators, the concerns about NIS and the resulting and impending legislation and regulation may well appear to be just interference and restrictions imposed by environmentalists and government agencies which in the end complicate the normal business of shipping and make it more difficult, for no good reason, for them to make a profit.

The various examples listed above of damage done by NIS, along with many other similar cases explain the concern of local government and of the IMO and the need to prevent further translocation and spread of NIS.

The evidence clearly supports the fact that the shipping industry must cooperate in these efforts to eliminate the spread of NIS via ships.

So far the attention has mainly been on ballast water and a handling for this NIS vector is well under way. Now hull fouling is coming to the fore and a full and effective handling is needed for that. While ballast water and hull fouling have something in common with each other in that they are both connected with ships, as NIS vectors they are quite different and each needs its own entirely separate handling.

This White Paper deals only with the ship hull vector and does not address the ballast water issue at all. That issue has been well covered elsewhere.

**The evidence clearly supports the fact that the shipping industry must cooperate in these efforts to eliminate the spread of NIS via ships.**

<sup>17</sup> Proposed changes to Article 4.8. of Title 2, Division 3, Chapter 1 of the California Code of Regulations (2011).

<sup>18</sup> Email correspondence with Chris Scianni, Staff Environmental Scientist, Marine Invasive Species Program, California State Lands Commission, December 2011.

<sup>19</sup> <http://www.environment.gov.au/coasts/pollution/antifouling/code> accessed December 2011.

### III. The current approach

The current basic recommended approach to preventing the spread of NIS through hull fouling consists of an effort to employ an appropriate hull coating coupled with various methods of cleaning the hull to remove fouling without spreading NIS in the process. In theory, the approach is sound. In practice, the hull coatings in widespread use and the existing hull cleaning methods present great challenges to the workability of this approach.

It is a complex problem with many contributing factors and variables which have to be taken into account.

#### The hull coating

The vast majority of ships afloat today use some sort of biocidal antifouling on their hull. Cuprous oxide is the most common biocide in use. Zinc is also used. Most antifouling paints also contain a number of co-biocides (pesticides, herbicides) in the formula, designed to cope with different types of fouling organisms.

The second most prevalent type of hull coating is the fouling release family of coatings which use silicone or fluoropolymer to render the surface more difficult for fouling to adhere to and easier for fouling to be released from, hence the name.

Less seen but growing in importance are surface treated coating systems which consist of a hard, inert, non-toxic coating combined with routine in-water cleaning.

None of these coatings prevent microfouling from adhering to the hull.<sup>20 21</sup> However, microfouling is not considered to represent any major NIS risk.<sup>22 23</sup>

**None of these coating systems prevent the accumulation of macrofouling organisms in what are commonly referred to as the “niche areas” of the underwater hull.**

None of these coating systems prevent the accumulation of macrofouling organisms in what are commonly referred to as the “niche areas” of the underwater hull. The “niche areas” are the nooks and crannies in the hull, of which there are a great many: sea chests, bilge keels, the areas around the propeller and the rudder, bow thruster tunnels, stabilizer fin recesses and many, many other parts of the ship hull, being protected from the main flow of water along the hull, are prime hideaways for NIS looking for a free ride to a foreign port.<sup>24</sup> The evidence is very plain: examine these areas on a ship hull painted with any of these hull coatings and, unless the area has been specially cleaned, there will be a large accumulation of macrofouling organisms and very likely among them will be invasive species which are definitely not wanted at the destination port.

In the case of biocidal antifouling and fouling release coatings, the flow of water as the ship travels is an essential part of their action. These niche areas are protected from this flow. Thus these coatings are not effective in preventing or in releasing macrofouling which accumulates in the niche areas.

<sup>20</sup> Sergey Dobretsov, “Marine Biofilms,” Chapter 9 of *Biofouling*, Edited by S. Dürr, J. C. Thomason, Wiley-Blackwell, (2010).

<sup>21</sup> Woods Hole Oceanographic Institution, *Marine Fouling and Its Prevention*, United States Naval Institute, Annapolis, Maryland, 1952: pp 29-30.

<sup>22</sup> E-mail correspondence with Dr. Naomi Parker, 2 Nov 2011.

<sup>23</sup> Oliver Floerl et al., “Review of biosecurity and contaminant risks associated with in-water cleaning,” report commissioned by The Department of Agriculture, Fisheries and Forestry (Australia) and prepared by The National Institute of Water and Atmospheric Research Ltd., (September 2010), pp: 5, 81-108.

<sup>24</sup> Ian Davidson, Gail Ashton, Greg Ruiz, Christopher Scianni, “Biofouling as a vector of marine organisms on the US West Coast: a preliminary evaluation of barges and cruise ships,” report to The California State Lands Commission, (2010), pp: 14-16.



These niche areas are also the hardest parts of the hull to clean in the water. The large, multi-brush underwater cleaning machines cannot be used to clean these niche areas. They require smaller power tools or hand tools or, a more efficient solution, high pressure water jet equipment.

However, it is not only the niche areas that accumulate fouling. Even coated with biocidal hull paint or fouling release coatings, the hull of a ship will accumulate macrofouling. It is astonishing how many living organisms populate the marine environment and how ready they are to attach themselves tenaciously to any surface immersed in the water in their vicinity for any length of time, regardless of the coating on that surface. Again, the evidence is plain for any diver or ROV camera to see.

### *“Gladiator species” and biocide tolerance*

There is a further liability involved in an attempt to deal with NIS using biocidal paint coatings. The organisms that do survive and are successfully translocated from one environmental zone to another have been found to become “copper tolerant” or “biocide tolerant” and especially tough, tenacious and resilient and thus more able to establish themselves and to survive in their new environment. In fact, they prove to be tougher than the local species which have not become tolerant to the various biocides in use and it is easier for the invading species to overwhelm the local species and take over.<sup>25 26 27</sup>

**Therefore, the idea that one can simply put the “right coating” on the hull and the NIS problem will disappear is an illusion. There is no “right coating” that will, all on its own, prevent the spread of NIS.**

Therefore, the idea that one can simply put the “right coating” on the hull and the NIS problem will disappear is an illusion. There is no “right coating” that will, all on its own, prevent the spread of NIS. The closest there was to that concept was TBT, described by Dr. Edward D. Goldberg of the Scripps Institution of Oceanography as, “perhaps the most toxic substance deliberately introduced to the marine environment.” TBT has been widely and quite correctly banned. In fact, some types of coating will worsen the situation by helping to breed tougher and more viable invasive species.

### **Hull cleaning**

If a ship is to have a hull which is free from macrofouling, the fouling must be actively removed.

An option is to take the vessel out of the water and remove the macrofouling using high pressure water jet equipment, scrapers or other methods. This has the advantage of easier recovery of waste water and any viable macrofouling organisms.

Another option is to clean the hull while the vessel is still in the water. This is done by divers or remotely operated vehicles (ROVs) using rotating brushes, high pressure water jet equipment or hand tools.

There are some other technologies for in-water cleaning in various stages of development and experimentation but none that could be considered commercially mature at this time.

<sup>25</sup> Michelle Lande, Leigh Johnson, Carolyn Culver, “Hull Fouling and Copper Tolerance – 2011 Scientific Review,” UCCE-SD/UC-SGEP Fact Sheet 2011-5 (August 2011).

<sup>26</sup> Jamie Gonzalez, Leigh Johnson, “Copper-Tolerant Hull-Borne Invasive Species: Further Analysis,” UCCE-Sea Grant Extension (April 2008).

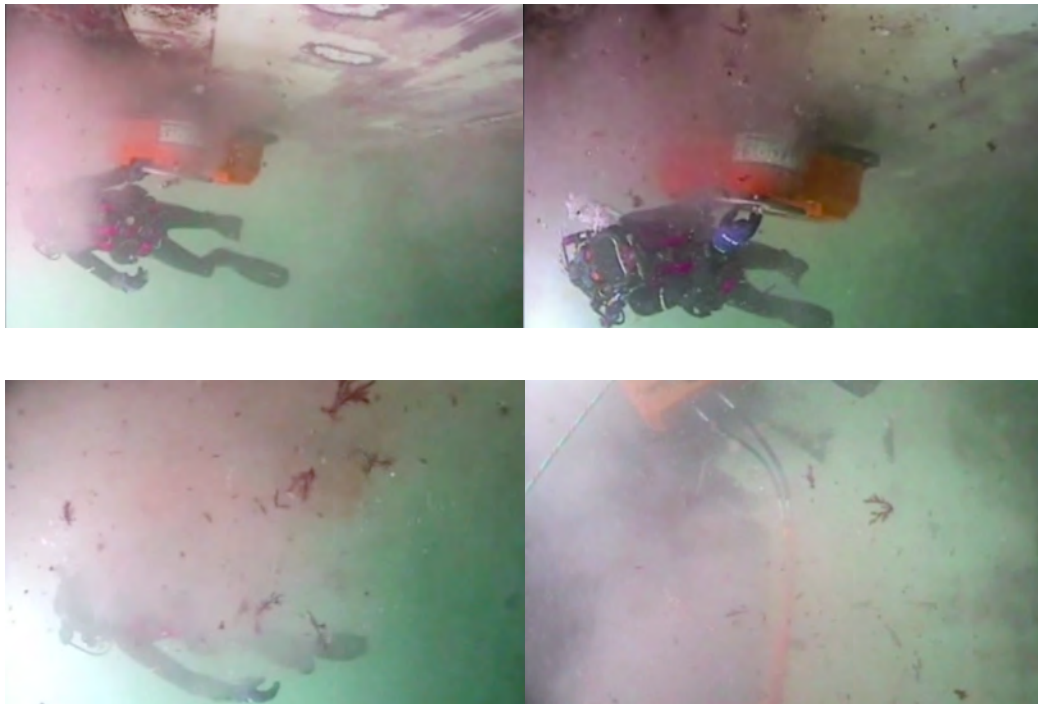
<sup>27</sup> Richard F. Piola, Emma L. Johnston, “Differential resistance to extended copper exposure in four introduced bryozoans,” Marine Ecology Progress Series, Vol. 311: 103-114, (2006).

There is an inextricable relationship between the type of coating and the method of cleaning. It is a waste of time to consider a particular approach to cleaning without taking into account the type of coating being cleaned.<sup>28</sup>

Again, this is a complex problem with many variables. Examining these variables will help to simplify the problem.

### *Cleaning biocidal antifouling paints*

A biocidal antifouling paint is not designed to be cleaned and does not lend itself to cleaning. By its nature, a biocidal antifouling paint is a “soft” coating designed to release part of its substance into the water as its *modus operandi*. It wears away. It is designed to prevent fouling through this release of chemicals. Cleaning a biocidal antifouling coating by any method will speed up this process of chemical release into the water and will deplete and damage the coating. If cleaned in the water, the pulse discharge of biocides into the water column and thus the ocean bed poses an even greater hazard to the marine environment than does the normal use of such a coating. If cleaned in drydock, precautions must be taken to ensure that the waste does not make its way back into the water. It is virtually impossible to prevent some of the chemicals from entering the water column. Cleaning this type of ship coating contributes to paint deterioration which in turn results in a greater fuel penalty. This effect multiplies with each attempt to clean a hull so coated.



*Four frames from a short video clip showing the effects on the water of in-water cleaning on a hull coating with a conventional copper-based antifouling paint.*

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<sup>28</sup> Oliver Floerl et al., “Review of biosecurity and contaminant risks associated with in-water cleaning,” report commissioned by The Department of Agriculture, Fisheries and Forestry (Australia) and prepared by The National Institute of Water and Atmospheric Research Ltd., (September 2010).

### *Cleaning silicone and other fouling release systems*

Fouling release coatings can be cleaned as long as the fouling does not comprise more than a microfilm (slime layer) and as long as the cleaning is very gentle and careful as these coatings are fragile and easily damaged. There is evidence that some of them at least are toxic. Studies show that silicone in fouling release coatings alters the enzymes in barnacle glue; it does not simply provide a slippery surface which is harder for the barnacles to adhere to and easier to remove them from. It produces a physical change in the organisms.<sup>29</sup> Other studies have shown that silicone oils released from fouling release coatings tend to smother aquatic organisms.<sup>30</sup> Further research is needed into the toxicological effects of fouling release coatings and any environmental hazard they pose. If macrofouling is permitted to attach to fouling release coatings (for example, during a lay-up in port), it cannot be removed, in or out of the water, without damage to the coating. Again, this will contribute to paint deterioration and a rapidly mounting fuel penalty. The integrity of the fouling release coating will be compromised by such damage and more fouling will build up on the damaged areas.

### *Cleaning hard, inert surface treated coatings*

Surface treated coatings do not prevent fouling from accumulating. However, they can be cleaned in or out of the water as often as needed without any toxic effect on the environment and without damage to the coating. In fact, if cleaned in the water with multi-brush cleaning equipment, the hydrodynamic properties of a surface treated coating are enhanced, dramatically improving fuel efficiency. The ease of cleaning STCs without destructive effect to environment or coating represents a huge advantage over other coating systems.<sup>31</sup>

### *Removing macrofouling vs. microfouling – NIS risk*

When a ship has arrived from a different environmental zone with a fouled hull, the act of cleaning that ship's hull, regardless of coating, presents a risk of dislodging viable invasive species which can then establish themselves in the new zone. These can of course separate themselves from the hull without any cleaning activity, but studies have shown that dislodging the macrofouling through cleaning increases the risk of NIS establishment, even though the cleaning itself can destroy many of the organisms removed.<sup>32 33</sup>

*Microfouling not a risk:* If the fouling has only reached microfouling stage, the NIS risk is considered minimal.

*Locally acquired macrofouling not a risk:* If the macrofouling on a hull has been acquired at the location where it is to be removed, this is not considered to be a risk of NIS spread, since the organisms are not introduced from an external environmental zone.

**If the fouling has only reached microfouling stage, the NIS risk is considered minimal.**

<sup>29</sup> Daniel Rittschof et al., "Compounds from Silicones Alter Enzyme Activity in Curing Barnacle Glue and Model Enzymes," PLoS ONE, 2011.

<sup>30</sup> Monika Nendza, "Hazard assessment of silicone oils (polydimethylsiloxanes, PDMS) used in antifouling-/foul-release-products in the marine environment," Marine Pollution Bulletin 54, no. 8 (August 2007): 1190-1196.

<sup>31</sup> Hydrex White Paper No. 5, "Underwater ship hull cleaning: cost-effective, non-toxic fouling control," (2011).

<sup>32</sup> Oliver Florerl et al., "Review of biosecurity and contaminant risks associated with in-water cleaning," prepared by The National Institute of Water and Atmospheric Research Limited, commissioned by The Department of Agriculture, Fisheries and Forestry (Australia), (September 2010), pp. 42-48.

<sup>33</sup> Grant A. Hopkins, Barrie M. Forrest, "Management options for vessel hull fouling: an overview of risks posed by in-water cleaning," Oxford Journals, (2008).

*Recovery systems not workable:* Various attempts to recapture the dislodged material by suction or other recovery means have been attempted. Due to the nature of working underwater, the shape of a ship's hull and the type of equipment needed to clean rapidly and effectively, none of these systems achieve full recovery. Experiments show that a system which would effect complete recovery, even were this possible, would make the in-water cleaning so slow and expensive that it would be cheaper and quicker to drydock the vessel and clean the hull out of the water. Certainly no recovery system is capable of preventing the biocide release into the nearby water column and thence to the seabed. But none has been developed so far that even captures all of the fouling removed from the hull. Even a few viable NIS surviving the cleaning can establish themselves in the new environment and present all the hazards of an invasion. If the NIS problem is to be fully handled, then this is not the answer.

### *Cleaning in drydock*

Cleaning a ship's hull in drydock is the easiest way to collect the fouling cleaned off so that it can be safely disposed of. Studies show, however, that drydocking a ship or raising a boat out of the water for cleaning can also dislodge viable NIS from the hull and thus be the cause of spreading NIS.<sup>34</sup>

Drydocking a ship is very expensive both in terms of drydocking fees and loss of income while the ship is out of service. It is a last resort. The current trend is to extend the drydocking interval to save money.<sup>35</sup> Frequent drydocking is not a solution to keeping the hull free of macrofouling because it won't work economically. Any solution to the NIS problem, no matter how promising in theory, must work in practice and be economically sound if it is to be adopted and enforced. The idea is to put the NIS out of business, not the shipowners/operators.

If a ship has to go to drydock to meet classification society requirements or for repairs, then the hull can be cleaned during that drydocking. But drydocking for the sole purpose of removing fouling is not economically feasible. Fortunately, it is not necessary.

### *Relationship between a smooth, clean hull and fuel efficiency*

Covered exhaustively elsewhere, a ship operating with a smooth, clean hull can save 25% or more in fuel costs compared to that same ship operating with a rough, fouled hull and deteriorated hull coating. With fuel costs at their current levels, the amount saved by sailing with a smooth, clean hull pays back many times over the costs involved in maintaining the hull in that condition through correctly applied suitable hull coating and routine maintenance and cleaning. The savings involved are considerable.<sup>36</sup>

From a fuel savings point of view, hull fouling should be kept down to a light slime at most.<sup>37</sup> This coincides with the optimum cleaning for eliminating the danger of

**From a fuel savings point of view, hull fouling should be kept down to a light slime at most. This coincides with the optimum cleaning for eliminating the danger of spreading NIS since microfouling can be disregarded as a risk.**

<sup>34</sup> D. M. Coutts et al., "Removing vessels from the water for biofouling treatment has the potential to introduce mobile non-indigenous marine species," *Marine Pollution Bulletin* 60 (2010) pp. 1533 - 1540.

<sup>35</sup> BIMCO, "Doing without drydocks," [https://www.bimco.org/Education/Seascapes/Sea\\_View/Doing\\_without\\_drydocks.aspx](https://www.bimco.org/Education/Seascapes/Sea_View/Doing_without_drydocks.aspx) (2010) accessed 19 December 2011.

<sup>36</sup> Hydrex White Paper No. 2, "The Slime Factor – Shipowners/operators can gain enormous savings through advanced underwater hull maintenance technology," (2010).

<sup>37</sup> *Ibid.*

spreading NIS since microfouling can be disregarded as a risk.<sup>38 39</sup> In many circumstances this requires frequent cleaning (perhaps as often as every six weeks or two months depending on sailing pattern and location). Efficient in-water cleaning can be carried out with minimal interruption to a ship's schedule. As demand for in-water cleaning increases, so will the infrastructure to provide this service expand and evolve.

### *Summary*

Because this may seem quite complicated, here is a short summary of the various factors covered:

1. NIS spread via hull fouling is a serious situation which is becoming subject to increasing regulation and legislation. The issue is not simply going to go away.
2. No hull coating currently available is capable, all on its own, of eliminating the NIS risk.
3. Routine hull cleaning including "niche areas" is key to eliminating the spread of NIS.
4. Frequent drydocking for the purposes of cleaning the hull may be desirable but is not economically feasible. It is not the handling.
5. In-water cleaning of biocidal antifouling coatings can damage the coating and poses an environmental hazard. In many areas it is forbidden.
6. Cleaning of fouling release coatings should be limited to microfouling. Trying to remove macrofouling will damage the coating.
7. Microfouling and macrofouling can be removed from surface treated coatings as often as needed in the water without damage to the coating or the environment and with favorable results.
8. Removing microfouling in the water, no matter where acquired, poses minimal risk of spreading NIS.
9. Removing macrofouling acquired in another environmental zone poses a risk of spreading viable NIS locally, even if recovery is attempted.<sup>40</sup>
10. Removing macrofouling acquired locally poses no NIS risk.<sup>41</sup>
11. The expense involved in proper hull protection and maintenance, including routine in-water cleaning of the hull and niche areas to keep the fouling to a light slime at most is compensated for many times by the saving in fuel alone.<sup>42</sup>
12. The real answer to preventing the spread of NIS lies in the direction of ensuring that ships sail with a clean hull from their point of departure, just as much as in attempting to prevent ships from entering ports or waters with a fouled hull.

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<sup>38</sup> Email correspondence with Dr. Naomi Parker, 2 Nov 2011.

<sup>39</sup> Oliver Floerl et al., "Review of biosecurity and contaminant risks associated with in-water cleaning," report commissioned by The Department of Agriculture, Fisheries and Forestry (Australia) and prepared by The National Institute of Water and Atmospheric Research Ltd., (September 2010), pp: 5, 81-108.

<sup>40</sup> Ibid.

<sup>41</sup> Ibid.

<sup>42</sup> Hydrex White Paper No. 2, "The Slime Factor – Shipowners/operators can gain enormous savings through advanced underwater hull maintenance technology," (2010).

## IV. A better alternative

This begins to remove some of the variables, simplify the problem and point the way to a resolution.

**Ideally any vessel would leave its port of departure with a clean hull, no macrofouling at all, even in niche areas.**

Ideally any vessel would leave its port of departure with a clean hull, no macrofouling at all, even in niche areas. This is the only way to guarantee that a ship will not carry invasive species on its hull. It also happens to be by far the most fuel-efficient approach and therefore the most economically favorable.

If the ship is laid up long enough to accumulate any macrofouling at any port along the way, it should again be cleaned before departing that port. Again, not only will this avoid translocation of NIS from that port, removal of any slime layer and hard fouling accumulated will also be hugely beneficial from a fuel savings standpoint.

It is the only real answer.

To bring this about, the following requirements apply:

1. The coating used should be a hard, inert, non-toxic coating, preferably, a surface treated coating (STC).
2. The hull must be cleaned routinely in the water as well as at scheduled drydockings. In no case should the hull of a ship in active service be allowed to foul beyond a biofilm or slime layer or light weed or grass. It must be cleaned frequently enough to prevent macrofouling. (An exception would be a ship which has to be laid up for long periods, in which case the hull should be clean when the ship is laid up and all the fouling should be cleaned off *in situ* before the ship sails. But even in this case, the stationery ship should be cleaned from time to time so that the fouling does not become too thick as it then is much harder, more time consuming and expensive to clean off.)
3. This cleaning must include the niche areas of the vessel. They can be cleaned rapidly using high pressure water jet equipment, as long as the right coating has been applied.
4. A ship should be thoroughly cleaned *before* departing a port or zone. Then it will arrive at its next port of call free of NIS.
5. The cost of such cleaning, no matter how frequent, will be paid back many times by the cost of fuel saved on the very next passage. Payback is almost immediate.
6. If, through negligence, a ship has not been cleaned before sailing and therefore arrives at its destination with macrofouling, it should be drydocked and cleaned with due attention to containing and destroying any NIS removed. In-water cleaning of a heavily fouled hull poses a greater threat of NIS establishment.

High quality cleaning services are available now and these will increase in availability.

Hard coatings and surface treated coatings are available now for immediate application.<sup>43</sup>

The benefits of this approach can easily be seen:

1. It is a non-toxic solution, far better from the marine pollution viewpoint than using harmful biocides to try to kill the fouling, even if these biocides were capable of preventing NIS from accumulating on ship hulls.
2. It will save the shipowner/operator a great deal of money in fuel.

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<sup>43</sup> Hydrex White Paper No. 4, "Coating comparison," (2011).

3. It is the only real guarantee that NIS will not be spread via ship hull fouling. If ships leave their port of departure free of fouling organisms, they will arrive at their next destination with a clean hull and thus pose no threat of spreading NIS via hull fouling.
4. On a practical level for the shipowner/operator, this approach will avoid complications, wasted time and fines that will result from having a badly fouled hull and trying to enter waters where regulations or legislation forbid this.
5. Enlightened ports will offer benefits such as discounted port fees for ships arriving with a clean hull and a non-toxic hull coating. They will recognize the value of keeping their port free from contamination and pollution and NIS.
6. Drydock intervals will be lengthened. In the case of a high quality surface treated coating, no repainting is required. The hull is blasted and fully prepped and the coating is applied once only and lasts for the service life of the vessel with only very minor touch-ups required during regularly scheduled drydocking. This obviates the need to drydock solely for painting resulting in fewer and shorter drydockings.
7. Reduced fuel consumption means lowered atmospheric emissions.
8. This alternative approach tends to substitute manpower and work for the chemicals which have been relied on but which have been shown not to work. This will mean an economic improvement as more jobs are generated.

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## V. Implementation

What will it take to implement this alternative approach to resolving the NIS problem worldwide?

As with all workable solutions, there are barriers and obstacles to surmount. However, the end result makes overcoming these obstacles very worthwhile and even essential. The added benefit of greatly reduced fuel costs throughout the world fleet makes it doubly so.

What is needed is a willingness to face the problem and realize that simply continuing in old patterns will not resolve it, since the problem has in fact worsened to the point of now necessitating regulatory intervention worldwide. There is no need to wait for regulation and legislation that will inevitably come.

Shipowners and operators must work together to implement an alternative method such as that proposed in this White Paper. This may require a new type of contract between owners and operators which results in a fair division of costs and benefits for both parties in a charter contract. Since the operator will save fuel costs and the owner will benefit from a better preserved investment with no need for further hull painting for the life of the vessel, there should be no conflict in working out how to pay to have the ship hull blasted and properly prepared, coated with a hard surface treated coating and then cleaned routinely to keep the hull free of fouling. An equitable arrangement will result in benefits to both parties. In the case of shipowners operating their own ships, cruise lines, navies and any other type of vessel, the saving will be both from lower fuel consumption and the greatly reduced maintenance costs over the useful life of the vessel.

States and ports wishing to keep the waters they are responsible for clean and to prevent the ingress of NIS, will see that an international approach as proposed here, rather than a strictly local one, is needed in order to solve the problem internationally and will be willing to participate in such an international solution which will need to be administered by the IMO.

The approach proposed here will substitute work for chemicals, create new jobs and thus aid local economies.

The alternative handling for NIS proposed in this paper consists of the following:

1. Recognition on the part of the shipping industry, IMO, states, ports, local government, NGOs and all those involved that a global approach to preventing the spread of NIS must be adopted. This should place equal emphasis on not permitting ships to leave a port or state with a fouled hull which will then create NIS problems for other ports or states, as on preventing such ships from entering their waters.
2. A plan to phase over from the existing unsuccessful practices to full adoption of the alternative approach proposed herein would need to be introduced at international level by shipping and boating associations, interested NGOs, as well as regulatory bodies such as the IMO.
3. Such a plan needs to include clear standards of levels of fouling which are acceptable and unacceptable from the NIS point of view as well as methods of inspection and enforcement.
4. Such a plan will also need to not only permit but encourage in-water cleaning of ships and boats as long as they have a non-toxic hull coating and as long as any macrofouling they bear was acquired locally and not brought in from another environmental zone.
5. Administrative measures, such as ship logs and records of maintenance, port records of inspection of departing as well as incoming vessels and other systems need to be

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introduced to ensure that the system is properly implemented. These can be standardized internationally under IMO supervision to ensure a fair and broadly beneficial implementation.

6. The plan will need to take into account small craft, pleasure boats, work boats and other local marine transport which is capable of spreading NIS in the local environment. The same approach and precautions should be taken as with international shipping but the implementation needs to be worked out on a local basis.
7. The plan would need to be executed over a reasonable period of time so as to allow all those involved to change over without any short term loss or sacrifice.
8. Shipowners and operators need to review their contractual arrangements and practices with regard to hull coating systems and underwater hull maintenance routines and make sure that the agreements are fair and beneficial to both parties so that all have an incentive to participate.
9. Naval architects will need to design the underwater ship hull with this alternative approach (hard coating and frequent in-water cleaning) in mind. Niche areas should be kept to a minimum and must have easy access so that they can be cleaned in the water with high pressure water jets. For example, a sea chest grid would be hinged and easily opened, rather than bolted in place and hard to access.

None of these measures are beyond the resources, ingenuity and skills of the shipping industry. As soon as the value of the alternative approach is grasped, the collective genius of those responsible for the smooth running of the shipping and boating industries internationally can be turned to creating a painless, rapid and effective implementation.

**One great advantage of this alternative approach is that all the parts needed to make it work are already in existence. Nothing has to be invented.**

One great advantage of this alternative approach is that all the parts needed to make it work are already in existence. Nothing has to be invented. No equipment or hull coating has to be developed. It is simply a matter of recognition, acceptance and then cooperation in implementation.

The other great advantage is that this alternative approach will also result in a tremendous saving in fuel costs throughout the industry, an accompanying reduction in atmospheric emissions and the elimination of the steady ongoing contamination of the marine environment by heavy metals and biocides.

## Hydrex and Ecospeed

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