Available online at www.sciencedirect.com

ScienceDirect

Marine Policy 32 (2008) 559–569

MARINE POLICY

www.elsevier.com/locate/marpol

International legal options for the control of biofouling on international vessels☆

Julian Roberts[a,b,*], Martin Tsamenyi[a]

[a]The Australian National Centre for Ocean Resources & Security (ANCORS), University of Wollongong, NSW 2522, Australia
[b]IUCN-World Conservation Union, Rue Mauverney 28, 1196 Gland, Switzerland

Received 27 August 2007; accepted 17 October 2007

Abstract

Shipping represents a threat as a vector for the transfer of non-indigenous marine species through the discharge of ballast water and biofouling of vessels' external structures and internal piping. While considerable attention has been given to the management of ballast water, there currently exists no international legal instrument with which to control biofouling.

A number of existing legal mechanisms may be applicable in the context of coastal States' rights under international law. However, existing mechanisms are insufficient to regulate all aspects of the biofouling problem to ensure comprehensive management of the issue. There is, therefore, a need for the development of a comprehensive international agreement to address this gap. The issue of biofouling on international vessels has now been included on the work programme of the International Maritime Organisation (IMO). As a contribution to discussions on how to address this particular issue at an international level, this article provides an analysis of the options available through the IMO to address this issue.

Having defined the specific "threat scenario" with regard to hull fouling, the article will consider: (i) the international legal framework that has been established to regulate the harmful impacts of international shipping; (ii) the range of practical measures that are available to manage biofouling on vessels; and (iii) international legal options available to States to address the threat of biofouling posed by international shipping.
© 2007 Elsevier Ltd. All rights reserved.

Keywords: International Maritime Organisation; Biofouling

1. Introduction

Shipping has been identified as the major vector for non-indigenous marine species (NIMS) on a global scale and the frequency by which NIMS are being spread around the world by shipping appears to be increasing. Shipping can disperse NIMS via a variety of mechanisms including ballast and bilge water discharges, biofouling and fouling of sea chests and internal piping [1]. The effects of such species can be significant, as they can compete with local species for space or nutrients, they can be toxic to both humans and marine life and they can significantly affect local fisheries (see e.g. GESAMP [2]). They can also cause economic damage to marine resources and amenities as a result of damage to infrastructure and the costs associated with control measures [3]. The reduction in biodiversity has the potential to be permanent, and is considered by some to represent one of the most critical threats to the marine environment at present [4].

While ballast water has been identified as the primary causal mechanism and has been the major focus of investigations concerned with marine invasion vectors [5], transport of NIMS on vessel hulls has been given less consideration [6]. However, a number of recent studies suggest that despite technological advances aimed at reducing vessel fouling, the attachment of organisms on the hulls of vessels remains a significant vector, possibly equal to ballast water [7,8]. For example, Hewitt et al. [9]

☆The views reflected in this paper are exclusively those of the authors and do not necessarily reflect the views or positions of the IUCN.

*Corresponding author. IUCN-World Conservation Union, Rue Mauverney 28, 1196 Gland, Switzerland. Tel.: +41 79 821 5846.

E-mail addresses: Julian.roberts@iucn.org (J. Roberts), martin_tsamenyi@uow.edu.au (M. Tsamenyi).

0308-597X/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.marpol.2007.10.002

estimated that about 77% of the exotics recorded in Port Phillip Bay (Australia) were introduced by biofouling. Most (60–69%) of the NIMS recorded in Australia and New Zealand are fouling organisms that are thought to have been introduced accidentally on the hulls of ships and other floating structures [10]. As such, biofouling on vessels is beginning to be acknowledged, particularly in the southern hemisphere, as one of the single most important vectors for the dispersal of NIMS [1]. However, to date, this particular issue remains unregulated in a global sense.

At the 56th session of the International Maritime Organisation (IMO) Marine Environment Protection Committee (MEPC) in July 2007, the committee considered a request from several member States and observers for the additional vessel biofouling to the agenda of the IMO workplan.[1] The paper noted that "*There are currently no international measures in place addressing the risks of the introduction of invasive aquatic species in biofouling of ships*."[2] The paper further noted that "*it is consistent with the IMO's objectives that new issues that might adversely affect the marine environment, such as biofouling, should be identified at the earliest feasible stage and action taken to avoid or mitigate such effects*."[3]

A number of existing legal mechanisms may be available to coastal States under international law to respond to this threat. Notable among these are restrictions on navigation and the promulgation of conditions of port entry for foreign flagged vessels. However, existing mechanisms are insufficient to regulate all aspects of the biofouling problem to ensure comprehensive management of the issue. Moreover, the lack of internationally accepted rules and standards may result in unilateral regulation by coastal States.

In the context of international merchant vessels, a number of options may be worth pursuing under the auspices of the IMO. Notable among these are: the development of a new mandatory instrument to address biofouling; amendments to the existing IMO instruments dealing with anti-fouling systems and ballast water management; and non-mandatory instruments such as codes, guidelines and recommendations adopted by IMO Assembly resolutions, pursuant to the IMO Convention.

[1]IMO paper MEPC 56/19/3, *Development of international measures for minimizing the translocation of invasive aquatic species through biofouling of ships*. Submitted by New Zealand, Australia, UK, Friends of the Erath International and the World Conservation Union (IUCN), 5 April 2007. The proposal was accepted by the Committee which approved the inclusion of a new high priority item in the Sub-committee on Bulk Liquids and Gases' work programme on "Development of international measures for minimizing the translocation of invasive aquatic species through bio-fouling of ships". MEPC 56/23, *Report of the Marine Environment Protection Committee on its fifty-sixth session*. 30 July 2007, para 19.11.

[2]MEPC 56/19/3 (see footnote 1), para 7.

[3]MEPC 56/19/3 (see footnote 1) para 16.

2. Biofouling as an environmental threat

2.1. Vectors for the transmission of NIMS

While certain categories of vessels may present a higher risk of transporting NIMS as fouling organisms, such organisms are transported between ports and harbours on all vessels types [11]. Although organotin anti-fouling paints have reduced settlement on hulls, fouling has not been eliminated. In particular, fouling organisms tend to concentrate in sheltered "anomaly" areas of the hull, such as sea chest intakes and the rudderpost [12,13] and develop in areas where anti-fouling coatings have been compromised. Coutts and Taylor [1] identified three main groups of hull locations, where biofouling presents a significant problem:

1. Areas lacking anti-fouling paint (e.g. propeller).
2. Areas that often had damaged paint (bulbous bow) or ineffective anti-fouling paint (bilge keel, rudder, rope guard, and sea-chest gratings).
3. Areas with inactive or old anti-fouling paint such as the area beneath a vessel that cannot be painted with fresh anti-fouling during a dry-docking because of the position of docking blocks. (For large ships, up to 15–20% of a hull's flat bottom could remain unprotected as a result of lack of anti-fouling where support blocks were positioned [14].)

Sea chest intakes in particular tend to harbour a diverse community that is sheltered from the turbulence created by movement through the water. Thus, even properly maintained vessels can transport fouling organisms when these factors exist.

2.2. Biosecurity risk

Simplistically, the greatest biosecurity risk is presented by those vessels with the greatest levels of biofouling. Slow moving vessels that have long residence times in port are more likely to develop fouling organisms than those that have short residence times and are transiting more often. However, their frequency of visits to foreign locations is typically less than the pattern of foreign voyages for faster moving merchant vessels. Towed vessels, such as overseas cargo barges, floating dry docks, vessels from decommission yards, or any floating platform, are examples of this type of vector [5]. As modern merchant vessels travel at relatively high speeds, it is unlikely that settlements occur in transit, except in areas of turbulence where there are hull projections and hollows. Settlement probably takes place in port regions when ship speeds are low or when ships are anchored or berthed. Vessels idle for long periods can accumulate a significant biomass, as may fast-moving vessels that are either awaiting missions or de-commissioned and subsequently transported to breakers yards awaiting demolition.

Coutts et al. [6] argue that the most serious biofouling vectors are therefore vessels that are poorly maintained or have been inactive for long periods, or vessels where areas of anti-fouling have been compromised. Alternatively, it is argued that faster moving vessels may present a greater risk than slower moving vessels since they spend less time travelling and thereby exposing fouling organisms to less stress induced by variability in environmental conditions [15].

It is notable that the majority of established exotic species occur in port regions. Ships converge on port regions, and may remain there for some days, and this may explain the preponderance of exotics there. Different ports have widely varying numbers of exotics but they would appear to be most frequent in shallow, partly enclosed harbours. The smaller numbers in coastal regions appearing between ports could be attributed to range expansions from port areas or due to other vector processes [15].

2.3. Biofouling control mechanisms

Fouling of a ships hull leads to increased friction between the hull and water, which combined with the increase weight of fouling organisms can lead to considerable increases in fuel consumption.[4] The application of anti-fouling compounds to ships' hulls is therefore the most widely used and most effective measure, to control biofouling and thereby reduce drag. These coatings inhibit the growth of unwanted organisms through the controlled release of biocides which are, by their nature, harmful to a range of marine organisms. The nature of the toxicity is chronic and can affect such functions as growth, morphology and reproduction of a range of marine species. If the coatings applied to the hulls of modern commercial vessels are maintained, they act as a deterrent to the settlement of marine organisms on vessel surfaces below the water line.

The most common and effective anti-fouling substance used to date is tributyltin (TBT). Although biofouling may be reduced considerably by using organotins, as noted above, vessels continue to be fouled, especially on worn, damaged or unpainted surfaces of the hull [15]. Since the discovery of environmental harm associated with TBT-based anti-fouling systems, the IMO has taken a number of steps, including supporting the ban on the application of TBT on vessels $<25\,m$[5] and the development of a new convention[6] aimed at limiting the application of harmful anti-fouling substances. As such the use of TBT anti-fouling paints will be phased out over time. However, this policy is hampered by the lack of equivalent substitutes for TBT [16,17].

Individual anti-fouling systems are designed to be most effective for a given vessel's optimal speed and the amount of time they propose to spend in port. For instance, fast-moving vessels that spend minimal time in port are likely to adopt harder, slow-polishing, anti-fouling paints, whereas slow vessels are likely to adopt softer, faster-polishing paints. The recommended operational lifetime of anti-fouling coatings is based on assessments designed to maintain or improve the vessel's performance, rather than to prevent establishment of particular taxa. It is unclear, therefore, how selective they are for a range of fouling taxa that may be considered NIMS in certain countries.

It is argued that effective anti-fouling systems that can provide a high level of protection against fouling organisms, are available for virtually all vessel types if they are selected, applied and maintained in accordance with recommended practices [14]. If operating conditions for a merchant vessel are optimal, anti-fouling systems are capable of maintaining a vessel free from macroscopic biofouling for up to 5 years [1]. However, despite the uniform areas of the hull being relatively clean, significant biofouling can still be present in those anomalous areas previously discussed, and/or in areas that lack anti-fouling paint.

The other major management technique used to control fouling of hulls is physical removal of fouling material, either during maintenance periods where the vessel is dry docked or, more frequently, through in water cleaning. Removal of biofouling material in dry dock would usually coincide with the removal of old anti-fouling coatings and the reapplication of new contains. However, manual in water cleaning, by scraping or scrubbing of the hull, has several important implications for the spread of NIMS. First, exotic organisms dislodged from the hull can potentially survive and establish within the local area. Mature adults injured by the physical abrasion may also be induced to release gametes and/or competent larvae into the surrounding environment [5]. It has also been shown that those areas where fouling is removed mechanically are more susceptible to re-colonisation of fouling organisms which may increase the risk posed by an individual vessel.

The final complimentary management measure that is worth considering is the treatment of internal pipe systems with biocides. Biofouling within a ship's heat exchangers and engine cooling system can restrict cooling flow in pipe runs and it reduces heat transfer across heat exchangers and condensers thereby reducing the efficiency of the system and increasing fuel consumption. The effects of

[4]Fouling of ships hull leads to increased friction between the hull and water, causing hull roughness. This, combined with the increase weight of fouling organisms can lead to considerable increases in fuel consumption. According to Evans et al. [16] a layer of algal slime 1 mm thick will increase hull friction by 80% and cause a 15% loss in ship speed, while a 5% increase in fouling for a tanker weighing 250,000 DWT will increase fuel usage by 17%.

[5]Resolution MEPC 46(30). *Measures to control potential adverse impacts associated with use of tributyl tin compounds in antifouling paints.* Adopted 16 November 1990.

[6]*International Convention on the Control of Harmful Anti-Fouling Systems*, 5 October 2001. Not yet in force. ⟨http://www.imo.org/InfoResource/mainframe.asp?topic_id=830&bcsi_scan_EC783A0C3C997A81=82DferRM6ClYBLyp+IbdXQIAAACKVhEA&bcsi_scan_filename=mainframe.asp⟩.

such fouling include over-heated engines, increased RPM, reduced air conditioning capacity and acceleration of corrosion caused by fouling. To address this, the piping systems are regularly dosed with biocides to inhibit the settlement and growth of such organisms. Since fouling of pipe systems has been identified as one possible vector for the introduction of NIMS, this management technique should also be considered in the context of any proposed regulatory approach.

3. International legal regime governing shipping

The 1982 United Nations Convention on the Law of the Sea[7] (LOSC) implicitly recognises that the IMO is the "competent international organisation" in respect of setting rules and standards for the protection of the marine environment from the impacts of vessel-sourced pollution and for maintaining safety of navigation [18,19]. To this end the IMO has developed a remarkably comprehensive body of law/regulations dealing with all aspects of maritime transportation. A major aim, in order to achieve its constitutive requirements, is to create uniform global standards for shipping safety and marine environmental protection. The IMO's role in the regulation of shipping is to enable Governments to cooperate in establishing the highest practicable standards for the regulation of shipping; to promote uniformity in the content and application of States measures; and to assist States which need assistance in developing and implementing the requisite measures. The IMO thus provides the forum for both harmonisation of existing standards and for creating new ones.

The IMO has three different roles under the LOSC: the first is as a forum for international co-operation; the second role relates to the review and approval of specific regulatory proposals of individual States; and the third role relates to the establishment of legal standards promulgated by or through the IMO or in IMO-related treaties, i.e. standard-setting [20]. It is the latter aspect of the IMO's work that is of relevance to this article.

3.1. Standard-setting

The balance of jurisdiction over vessel-sourced pollution laid down in the LOSC mainly centres around three distinct types of measures, namely: discharge standards; construction, design, equipment and manning (CDEM) standards and navigation standards. Each of these could be applied in the context of regulating to prevent the introduction of NIMS. However, in the context of a possible new legal instrument, only discharge and CDEM standards are likely to be applied.

IMO's work is predicated on the principle that it is the prerogative of States to regulate international shipping [21]. Accordingly, the measures required for the protection of the State and for safeguarding "common" amenities and facilities must ultimately depend on the willingness, readiness and ability of the States concerned to take the measures needed.

Over the past 45 years, the IMO has established a comprehensive set of treaty and non-treaty instruments aimed at enhancing safety of commercial navigation and the prevention and control of marine pollution from vessel sources, including:

- Over 40 conventions and protocols providing the technical basis for inclusion of LOSC requirements into the national laws of member States.
- In excess of 60 codes and recommendations focused on achieving the highest standards of seamanship, environmental protection, cargo handling and crew certification.
- An extensive programme of technical assistance aimed at helping nations meet their international convention obligations.

The international instruments adopted by the IMO fall into two classes:

1. Those establishing technical standards and procedures on construction and operation of ships; and
2. Those promoting uniform rules and procedures concerning legal issues, which can take the form of conventions, or other binding treaty instruments incorporating technical regulations, and non-binding instruments, regarded by the IMO as of equal importance for States to incorporate into their national legislation.

In the context of NIMS, two conventions adopted by the IMO are of relevance:

- International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2002 (Ballast Water Convention); and
- International Convention on the Control of Harmful Anti-fouling Systems on Ships, 2001 (AFS Convention).

3.2. Ballast Water Convention[8]

The Ballast Water Convention requires that all new and existing vessels with ballast tanks implement ballast water management procedures and meet specific standards when on voyages entering a nation's waters from beyond its

[7] *United Nations Convention on the Law of the Sea*, 10 December 1982. In force 16 November 1983. 1833 *U.N.T.S.* 397.

[8] *International Convention for the Control and Management of Ships' Ballast Water and Sediments*, 13 February 2004. Not yet in force. 〈http://www.imo.org/InfoResource/mainframe.asp?topic_id=830&bcsi_scan_EC783A0C3C997A81=82DferRM6ClYBLyp+IbdXQIAAACKVhEA&bcsi_scan_filename=mainframe.asp〉.

EEZ.[9] An important requirement under the Convention is that ships are required to have on board and implement a Ballast Water Management Plan approved by the Administration. The Ballast Water Management Plan is specific to each ship and includes a detailed description of the actions to be taken to implement ballast water management requirements. Ships must also have a Ballast Water Record Book to record when ballast water is taken on board; circulated or treated for ballast water management purposes; and discharged into the sea. It should also record when ballast water is discharged to a reception facility and accidental or other exceptional discharges of ballast water.

To assist in the uniform implementation of the Convention a series of 14 technical guidelines[10] have been developed to provide Flag Administrations and Port State Authorities with guidance on procedures and principles to minimise the risk of transferring harmful aquatic organisms in ships' ballast water and sediments and to be in compliance with the Convention.

3.3. *AFS Convention*[11]

The AFS Convention will prohibit the use of harmful organotins in anti-fouling paints used on ships and will establish a mechanism to prevent the potential future use of other harmful substances in anti-fouling systems.[12]

Under the terms of the new convention, Parties to the convention are required to prohibit and/or restrict the use of harmful anti-fouling systems on ships flying their flag, as well as ships not entitled to fly their flag but which operate under their authority and all ships that enter a port, shipyard or offshore terminal of a Party. This applies to all ships (excluding fixed and floating offshore oil installations). Ships of above 400 GRT and above engaged in international voyages will be required to undergo an initial survey before the ship is put into service or before the International Anti-fouling System Certificate is issued for the first time; and a survey when the anti-fouling systems are changed or replaced.

Ships of 24 m or more in length but less than 400 GRT engaged in international voyages will have to carry a Declaration on Anti-fouling Systems signed by the owner or authorised agent. The Declaration will have to be accompanied by appropriate documentation such as a paint receipt or contractor invoice.

The AFS Convention includes four technical Annexes which address respectively: controls on anti-fouling systems (Annex 1)—Annex I defines those substances that are included under the Convention as harmful anti-fouling systems; required elements for an initial proposal to define a substance as a harmful anti-fouling system for the purpose of the Convention (Annex 2); required elements for a comprehensive proposal to define a substance as a harmful anti-fouling system for the purpose of the Convention (Annex 3); and surveys and certificate requirements for anti-fouling substances (Annex 4).

The regulations of the technical Annexes address *inter alia*: Surveys; issuing and endorsement of International Anti-Fouling Certificates; validity of International Anti-Fouling Certificates; and declarations relating to anti-fouling systems.

As with the Ballast Water Convention, the IMO has developed a number of technical guidelines to assist in the unified implementation of the AFS Convention.[13]

4. International legal options for the control of biofouling

Measures taken to prevent the spread of invasive species are typically focussed on two objectives:

1. reducing the size and range of outbreak populations (control); and
2. preventing dispersal to new sites by vectors (containment through vector management).

In the context of international legal options for the control of biofouling, the focus must certainly be on approaches to vector management, which can take different forms. According to Fluerl et al. [22], there are four common approaches to vector management:

1. prevent exposure of vectors to the species;
2. enhance resistance of vectors to colonisation by the species;
3. control the movement of infested vectors; and
4. remove infestations from affected vectors.

[9]The convention will enter into force 12 months after ratification by 30 States, representing 35% of world merchant shipping tonnage. As of 15 August 2007 only 10 States, representing 3.42% world merchant shipping tonnage had become contracting States to the convention.

[10]Guidelines have been written for: sediment reception facilities; ballast water sampling; ballast water management equivalent compliance; ballast water management and development of ballast water management plans; ballast water reception facilities; ballast water exchange; risk assessment; approval of ballast water management systems; procedure for approval of ballast water management systems that make use of active substances; approval and oversight of prototype ballast water treatment technology programmes; ballast water exchange design and construction standards; sediment control on ships; additional measures including emergency situations; and, designation of areas for ballast water exchange.

[11]See footnote 6.

[12]The convention will enter into force 12 months after 25 States representing 25% of the world's merchant shipping tonnage have ratified it. As of 15 August 2007 only 24 States, representing 16.63% world merchant shipping tonnage had become contracting States to the convention. However, at MEPC 56, the delegation of Panama announced that Panama had submitted its instrument of ratification to the IMO (personal observation of the author). As such, once accepted, the entry into force conditions for this convention will have been satisfied.

[13]At this stage the following guidelines have been developed and adopted: survey and certification of anti-fouling systems on ships; brief sampling of anti-fouling systems on ships; and inspection of anti-fouling systems on ships.

The first two of these approaches could be considered measures intended to prevent infestation of new vectors, whilst the latter two are designed to prevent contagion to new sites. From a coastal State's perspective, it is the last three of these options that may be most applicable in the context of preventing the introduction of NIMS, since a coastal State has very little control over the environmental conditions that exist in the ports of another State. These different approaches all have varying legal implications which need to be understood in order to fully appreciate the regulatory options available to coastal States for the control of biofouling.

4.1. Prevent exposure of vectors to the species

Of the four approaches, this one may be the most problematic from an international regulatory perspective, since it relies largely on coastal States to implement appropriate measures in their own waters, to ensure that ships departing that State do not carry NIMS. While the onus must be on the ship to ensure that it does not carry such species, without the co-operation of the coastal State of origin this may be extremely difficult.

One option would be for a receiving port State to have, as a condition of port entry, a requirement that vessels leaving a port of origin, *en-route* to that State, undergo an inspection at the port of origin. Given that many States have identified those species considered as NIMS, such an approach could be limited to those ports where it is known, or there is a high likelihood, that such species have established. The application of a risk profiling approach is consistent with the manner in which many coastal States have implemented domestic ballast water regulations, and is a pragmatic solution focussing on those vessels that present the greatest risk.

The most obvious problem in implementing such an approach would appear to be the definition of a measurable performance standard for "hull cleanliness". Under the Ballast Water Convention, a performance standard has been proposed for the number of viable organisms within ballast water. A similar approach for determining the level of fouling on hulls and other structures would appear more complex. However, if there is a need to define whether a ship is free of biofouling then such a standard may be required in the future.

4.2. Enhance resistance of vectors to colonisation by the species

Approaches to reducing the colonisation of vectors by species will require a number of control mechanisms as listed above. The primary measure must be the effective application and maintenance of anti-fouling systems for the entire hull structure, including those anomalous areas previously identified.

A number of specific measures should be considered in combination including:

- Type approval to an IMO standard of anti-fouling systems to ensure their effectiveness.
- Warranting of anti-fouling systems to ensure they have an adequate lifecycle and also to identify any conditions that must be met for their correct application and action under the specific circumstances of the ship operation.
- International certification issued by the flag administration to confirm that an approved anti-fouling system has been applied and that the hull has been surveyed to ensure the integrity of the coating. This may require changes in shipyard management practices to ensure that those areas where a vessel is supported in dry-dock are not left untreated to ensure adequate protection. It may also require that different parts of the ships are treated with different types of anti-fouling systems reflecting their specific risk characteristics.
- The requirement for a "Hull Maintenance Record Book" similar to the Ballast Water Record Book which provides a record of scheduled and non-scheduled hull maintenance including damage repairs, re-application of anti-fouling and periodic removal of biofouling.
- Periodic survey and inspection to ensure the ongoing integrity of the anti-fouling system. This could be performed as part of Port State Control procedures, provided the specific survey requirements and performance criteria are either included in an internationally recognised instrument or notified as conditions of port entry.

In addition to focussing attention on anti-fouling systems, other requirements may include the need to remove fouling from ships where the fouling is extensive and the correct application of biocidal systems to internal piping and sea chest intakes. As such, the following additional measures may also be appropriate:

- A performance standard to determine when biofouling should be removed from the vessel.
- Type approval of biocide treatment systems used to treat internal piping systems.
- A Biocide Record Book, approved by the flag administration, to record dosing operations for internal treatment systems. In practice, this would be combined with the Hull Record Maintenance Book discussed above.

4.3. Control the movement of infested vectors

Coastal states have considerable authority to control the entry of vessels into their internal waters or ports [23,24]. Subject to accepted international rules and standards or the promulgation of clearly defined port entry conditions, a coastal State may restrict the entry of vessels or direct vessels to undertake specific actions in order to satisfy those conditions. As such there is no requirement for the development of an international legal instrument to allow a coastal State to protect itself from the risk of introduction of NIMS from specific ships, since it may currently adopt stringent port entry requirements and enforce these unilaterally. Furthermore, it is also possible that two or more port States may establish identical requirements in order to harmonise such policies.

However, an important aspect of this role is the relationship between Port State Authorities under the various Port State Control Memorandum of Understanding (MoUs).[14] The MoUs could be used as a mechanism to identify high-risk ships thereby allowing port States to identify such vessels in advance of their arrival, provided internationally accepted rules and standards exist which the MoU members can apply. In Europe, ships that have consistently been detained or been issued deficiencies for breaches of safety and environmental standards—pursuant to the International Convention on the Safety of Life at Sea, 1974 (SOLAS)[15] and the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78),[16] respectively, have been banned from entering European State ports. Thus, the development of international rules and standards through the IMO would add considerable strength to the ability of a port State to regulate ships entering its ports.

Regulatory options for the control of such vessels might include the designation of areas where removal of biofouling can be undertaken, in the same way as areas may be designated for ballast water exchange under the Ballast Water Convention. The designation of such areas would need to be strictly controlled through prescriptive criteria for their identification and designation, taking into account the rights of coastal States in the vicinity of such areas. However, given that the purpose of the control mechanism is to prevent the release of NIMS, it is unlikely that coastal States will actively promote the removal of fouling from vessels in open water.

Alternatively, a coastal State may wish to define certain areas where ships are not permitted to enter due to the high risk posed by NIMS. This can be achieved through the application of specific ships' routeing measures such as areas to be avoided or no anchor areas, which are currently provided for under SOLAS and the IMO's General Provisions on Ships' Routeing (GPSR) [25].

4.4. *Remove infestations from affected vectors*

The removal of infestations from affected vessels presents the greatest challenge for coastal States. Both MARPOL 73/78 and the Ballast Water Convention place obligations on coastal States to ensure the provision of adequate waste reception and treatment facilities. The provision of adequate treatment facilities for the removal of biofouling would need to be considered as a coastal State responsibility, taking into account the obligation not to unduly delay or detain vessels and to ensure that any material removed from a vessel was adequately treated and disposed off so as not to increase the risk of a NIMS release in the vicinity of the facility. Alternatively, a coastal State may seek to identify areas of open water, where removal of fouling could be undertaken *in situ*.

5. Options for an international legal instrument

Having considered the specific measures that might be employed to regulate fouling, specific attention must now be given to the form of legal instrument through which such measures could be given effect. A range of options should be considered, including *inter alia*:

- Development of a new mandatory IMO instrument specifically to address biofouling;
- Amendments to existing IMO instruments; and
- Non-binding IMO instruments such as guidelines and codes adopted by IMO Assembly resolution pursuant to the IMO Convention.

5.1. *New mandatory IMO instrument*

The development of a new mandatory instrument would logically follow the structure of the numerous existing conventions adopted by the IMO, namely the substantive provisions containing the Articles and the technical Annexes containing prescriptive regulations dealing with the range of technical issues the instrument addresses.[17]

---

[14] As at 2006 there are a total of eight regional PSC MoUs plus the United States Coastguard. These MOUs are in various stages of development with the Paris and Tokyo MOUs and the US Coast Guard being recognized as the leading agreements: 1982 Paris MOU; 1992 Acuerdo de Vina del Mar; 1993 Tokyo MOU; 1996 Caribbean MOU; 1997 Mediterranean MOU; 1998 Indian Ocean MOU; 1999 West and central African MOU; 2000 Black Sea MOU; 2004 Riyadh MOU.

[15] *The International Convention for the Safety of Life at Sea*, 1 November 1974. In force 25 May 1980. 1184 *U.N.T.S.* 2.

[16] *International Convention for the Prevention of Pollution from Ships 1973 as modified by the Protocol of 1978 relating thereto*, 1 June 1978. In force 2 October 1983. 1340 *U.N.T.S.* 61.

[17] While IMO environmental conventions are generally complex instruments, the complexity is easily broken down by considering the conventions as a collection of provisions of two basic kinds: the substantive and the technical. The substantive provisions of the Conventions are contained in the Articles of the main body of the texts. These provisions include *inter alia* the obligation on states to implement the convention's technical standards on board its ships; to penalise breaches and co-operate in enforcement; and to provide information on participation in the convention to other States party through the IMO. The Articles of the conventions also define a State's entitlement to exercise jurisdiction over visiting foreign ships. The technical provisions for each convention are specific to the nature of the issue being regulated. For example, the technical standards of MARPOL 73/78 are contained in a series of annexes, each dealing with a distinct category of harmful

As a minimum any draft instrument should address the following substantive provisions:

- General provisions including obligations, definitions and application.
- Requirements for the control and management of biofouling on hulls, sea chests, piping, etc.
- International approval and certification of anti-fouling systems.
- Controls of fouling waste including the provision of reception facilities.
- Scientific and technical research and monitoring.
- Technical cooperation and collaboration.
- Survey and certification requirements.
- Inspections of ships and detentions of violations.
- Delays to ships and disputes settlement.

To support the substantive provisions, a number of technical annexes would also be needed. Given the management approaches discussed above it is suggested that technical annexes addressing the following aspects should be included as a minimum.

5.1.1. International anti-fouling certification scheme

Any mandatory instrument should ensure that anti-fouling systems applied to ships flying the flag of a State party enable it to meet the obligations of the instrument. An international certification scheme could be developed to allow for type approval of individual anti-fouling systems, as well as endorsement of warranty provisions for individual substances and standards for application and certification of hull coatings. In particular, there appears to be a need to move away from the single substance application and to consider the application of different anti-fouling compounds to different areas of a vessels structure to account for differences in hydrodynamic flows.

Such a scheme would result in an *International Anti-fouling Certificate* issued to the vessel in the same way as certificates are issued under MARPOL 73/78. The certificate would confirm that the anti-fouling system was of a type approved by the IMO and would verify the integrity of the hull coating. As such a prescribed form of the certificate should also be drafted and included in the technical annex.

(*footnote continued*)
substance. These are oil (Annex I), noxious liquid substances carried in bulk (Annex II); harmful substances in packaged form (Annex III); sewage (Annex IV); and garbage (Annex V). Annex VI on air pollution, agreed in 1997, breaks the mould somewhat, being concerned principally with the terrestrial impact of air emissions. The technical regulations of MARPOL 73/78 in turn fall into two broad categories: the hardware of the maritime system, covering the design and construction of ships and the on board equipment; and operational and systems requirements, including permitted discharges, shipboard recording of operations involving harmful substances, and pollution emergency preparedness.

5.1.2. Management of biofouling

In the same way as the Ballast Water Convention addresses ballast water management, a biofouling instrument should address the management of biofouling. Management measures could include maintenance and periodic inspections of the hull and high risk areas; standards for removal of biofouling; measures to treat and monitor high risk fouling areas such as sea chests; biocide treatment of internal pipework; and the requirement for a Hull Maintenance Record Book.

5.1.3. Survey and certificate requirements for biofouling

Survey and certification periods for anti-fouling system integrity and biofouling should be prescribed in the instrument including any need for additional surveys and the penalties for failing to meet the survey requirements. A prescribed form of international certificate should also be drafted and included in the technical annex.

5.2. Amendments to existing IMO instruments

Given the timeframe required for the development, adoption and entry into force of a new mandatory instrument, an alternative to the adoption of a new instrument would be to seek amendments to existing instruments to give effect to some or all of the measures discussed above. Under the current circumstances, two options appear available for amending existing conventions to also address biofouling concerns: amendments to the AFS Convention and the development of a new annex to the Ballast Water Convention.

5.2.1. Amendments to AFS convention

The first option that may merit investigation is amendments to the AFS Convention, largely because it has a number of specific provisions which may be adapted and developed in the context of this discussion.

First, the AFS Convention already provides for the certification of a hull coating to verify the integrity of the anti-fouling system. As noted above, one of the primary measures for the regulation of biofouling should be periodic survey and inspection to ensure the ongoing integrity of the anti-fouling system. Given that the requirement to survey and certify the anti-fouling coating is currently addressed in the AFS Convention, this requirement could be enhanced to allow for certification of the hull coating, rather than the simple verification of the integrity of the coating against TBT coatings. Similarly, the AFS Convention currently provides for the designation of harmful anti-fouling substances in Annex 1 of the Convention.

This "black list" approach could be revised to incorporate a "reverse list" whereby the Annex lists those substances that are approved for use. This approach has been taken in the London Convention whereby the 1972 Convention included a 'black list' and 'grey list' of substances that may not be dumped, whereas the 1996

Protocol to the Convention simply lists those substances that may be considered for dumping. This would of course require the development of criteria against which anti-fouling substances could be assessed. In the past, there has been reluctance on the part of IMO members to develop performance or efficacy criteria for anti-fouling systems through IMO with preference shown instead for allowing market pressures to drive their selection. This approach may need to be revisited in the light of what is to be regulated under a prospective biofouling regime.

The AFS convention also has a requirement that any anti-fouling substance removed from the hull of a vessel must be disposed off in an appropriate manner.[18] This requirement could be amended to incorporate the requirement that any material removed from the hull of a vessel be disposed off in an appropriate manner.

A number of resolutions adopted at the Diplomatic Conference of the AFS Convention[19] are also relevant in the current context. Notably, Resolution 3 invites States to approve, register or license anti-fouling systems applied in their territories. It also urges States to continue the work, in appropriate international forum, for the harmonisation of test methods and performance standards for anti-fouling systems containing biocides.

However, notwithstanding the possible mechanisms discussed above, the overall structure of the AFS Convention probably precludes it from being amended sufficiently to address the entire range of issues that have been identified for regulation to manage the biofouling issue. The AFS is, after all, a convention dealing with reducing the harmful effects of anti-fouling systems, and not for controlling biofouling itself.

5.2.2. Amendment to the ballast water convention

An alternative, therefore, would be to consider amending the existing Ballast Water Convention, in order to develop a more inclusive instrument addressing NIMS generally. The purpose of the Ballast Water Convention is broadly to prevent the transfer of harmful aquatic organisms (including pathogens) from ballast water and sediment discharges. Therefore, the intent of the existing instrument does lend itself to a more complete treatment of the NIMS issue.

Unlike the AFS Convention, the Ballast Water Convention does not include specific technical provisions that could easily be amended to address biofouling, since the technical and operational issues relating to ballast water and biofouling are very different. Instead, a new technical annex would be required which addressed the range of technical issues identified above. Concurrently, there would be a need to amend the substantive provisions of the convention to address the broadened role. In effect, the development of a new annex should be seen as no different to the development of a new mandatory instrument. The difference being that the annex sits within the umbrella of an existing instrument.

Comparison can be drawn with the approach taken in the development of MARPOL 73/78. Over time, new annexes have been drafted and entered into force independently as States became party to those individual annexes. This is one of the advantages of the flexible approach taken with MARPOL 73/78. Thus, this option presents a significant advantage, that is, subject to agreement on amendments to the substantive provisions of the convention, the ballast water annex could enter into force independently of the biofouling annex, thereby minimising any disruption to progress on the implementation of the existing instrument.

5.3. IMO guidelines, codes and recommendations

In addition to conventions and other treaty instruments, IMO also adopts numerous non-treaty instruments such as guidelines, codes and recommendations, which are adopted by the IMO Assembly, the Maritime Safety Committee (MSC) or the MEPC.

5.3.1. Codes and recommendations

Although recommendations are not usually binding on governments, they provide guidance in framing domestic legislation and requirements. Many governments do in fact apply the provisions of IMO recommendations by incorporating them in domestic legislation. In appropriate cases, the recommendations may incorporate further requirements which have been found to be useful or necessary in the light of experience gained in the application of the previous provisions. In other cases, recommendations clarify various questions which arise in connection with specific measures and thereby ensure their uniform interpretation and application in all countries.

Examples of the principal recommendations, codes, etc., adopted for environmental protection purposes include: International Maritime Dangerous Goods Code (IMDG Code) (first adopted in 1965); Code of Safe Practice for Solid Bulk Cargoes (1965); Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (1971); Code of Safety for Nuclear Merchant Ships (1981); International Gas Carrier Code (1983); International Bulk Chemicals Code (IBC Code) (1983).

In some cases, important codes have become mandatory by including appropriate references in a convention. These recommendations are generally intended to supplement or assist the implementation of the relevant provisions of the conventions and, in some cases, the principal codes, guidelines, etc. In many cases, codes either form integral parts of conventions or have been made mandatory by incorporation into relevant conventions. For example, the IMDG Code and the IBC Code directly cross reference to Annexes II and III of MARPOL 73/78, respectively. Furthermore, the IMDG Code has recently been made mandatory pursuant to an amendment to SOLAS.

[18] AFS Convention (see footnote 6), Article 5.

[19] ⟨http://www.imo.org/Conventions/mainframe.asp?topic_id=258&doc_id=1494⟩.

Similarly, the International Safety Management Code (ISM Code) was made mandatory in 1994 after a new chapter was added to SOLAS to give effect to the ISM Code. Alternatively, some codes are mandatory by nature. For example, The International Ship and Port Facility Security Code (ISPS Code) was implemented from the outset through chapter XI-2 of SOLAS. The ISPS Code has two parts, one mandatory and one recommendatory.

IMO recommendations enable provisions or requirements to be suggested relatively quickly to governments for consideration and action. It is also easier for governments to act on such matters than would be possible in respect of provisions in formal treaty instruments, which involve international legal obligations.

One other benefit of recommendations is that they may be applied more widely to all classes of vessel. For example, in 1990 MEPC adopted resolution MEPC.46(30)[20] which recommended that member Governments:

- adopt measures to eliminate the use of anti-fouling paint containing TBT on non-aluminium hulled vessels <25 m; and
- eliminate the use of anti-fouling paints with a leaching rate of more than 4 μg of TBT per day.

These recommendations were intended to be interim measures until IMO could consider a possible total prohibition of TBT compounds in anti-fouling paints for ships. Nevertheless, on the basis of these recommendations, the sale and application of TBT-based paints was banned on may countries, resulting in a measurable decline in the concentrations of TBT in many State's coastal waters. Arguable therefore, it may be possible to seek the adoption of recommendations, in the form of an IMO Resolution, which applies more widely than to those classes of vessel normally regulated under an IMO instrument. Such recommendations could then form the basis to develop a harmonised system of national legislation with like-minded countries.

5.3.2. Guidelines

Guidelines may either be adopted on their own or as supporting documents to facilitate the unified implementation of a convention. An example of the former are the series of guidelines adopted by MEPC and the IMO Assembly concerning the introduction of unwanted organisms from ships ballast water and sediment discharges:

- Resolution MEPC.50(31): *Guidelines for preventing the introduction of unwanted organisms and pathogens from ships' ballast water and sediment discharges* (1991).
- Resolution A.774(18): *Guidelines for preventing the introduction of unwanted organisms and pathogens from ships' ballast water and sediment discharges* (1993)—the resolution requested the MEPC and the MSC to keep the Guidelines under review with a view to developing internationally applicable, legally binding provisions.
- Resolution A.868(20): *Guidelines for the control and management of ships' ballast water to minimise the transfer of harmful aquatic organisms and pathogens* (1997). The resolution superceded resolution A.774(18).

Each of these guidelines was recommended in nature, although it is acknowledged that resolution A.868(20) has contributed to the development of the current Ballast Water Convention. Furthermore, many countries developed domestic standards to regulate ballast water discharges based on the IMO Guidelines, and as a result, the tanker industry in particular took steps to implement the guidelines.

Such guidelines therefore facilitate a unified interpretation and implementation of the conventions requirements for all States and the industry.

5.3.3. Possible application of codes and guidelines for biofouling

An alternative option to a mandatory instrument could therefore be the adoption of one or a series of resolutions providing for codes, recommendations or guidelines addressing different aspects of the biofouling problem.

For example the following series of resolutions could be envisaged:

- International code for the approval and application of effective anti-fouling systems.
- Guidelines for surveying and certifying the effectiveness of anti-fouling systems on merchant vessels, MODUs and barges.
- Guidelines for the periodic survey and inspection of the anti-fouling systems on merchant vessels, MODUs and barges.
- Guidelines for the application of biocides to internal piping systems.
- Guidelines for risk targeting and control of vessels carrying fouling organisms.
- Guidelines for the removal of hull fouling from merchant vessels.
- Guidelines for the design and operation of hull cleaning facilities in ports.

Several of these could expand upon existing guidelines adopted under the AFS Convention although without an amendment to the parent convention to reflect a broader application, expanded guidelines would retain only recommended status.

6. Conclusion

Shipping represents a threat as a vector for the transfer of NIMS through the discharge of ballast water and biofouling of a vessel's external structure and internal piping. While considerable attention has been given to

[20]See footnote 5.

regulatory options for the control of ballast water, there exists no international legal instrument with which to control biofouling.

A number of existing legal mechanisms may be applicable in the context of a coastal State's rights under international law. However, existing mechanisms are insufficient to regulate all aspects of the biofouling problem to ensure comprehensive management of the issue. Moreover, the lack of internationally accepted rules and standards may result in unilateral regulation by coastal States which is inconsistent with the international nature of the shipping industry and ongoing efforts to ensure a unified international regulatory framework for shipping at a global level. There is, therefore, a need for the development of a comprehensive international agreement to address this gap.

The issue of biofouling on international vessels has now been included on the work programme of the IMO. As a contribution to discussions on how to address this particular issue at an international level, this paper has sought to provide a comprehensive analysis of the range of regulatory options available through the IMO to address this gap with respect to international vessels.

However, while the IMO provides a comprehensive mechanism for regulating those international vessels registered under a Flag, a significant gap that remains is the management of biofouling associated with the large fleet of vessels that fall outside of the IMO's mandate: this includes but is not limited to, the following categories of vessels:

- barges and associated support vessels;
- fishing vessels;
- recreational craft.

While no attempt has been made above to address this broader issue, this is an important area that warrants further consideration. There is a need to explore a range of alternative options to address the threat posed by this category of vessel given the un-flagged/unregistered nature of this class of vessel, national and regional regulatory mechanisms would appear to be the primary solution [26]. Indeed, many States are responding to this issue with the development of comprehensive domestic measures aimed at tackling such categories of vessel. However, the IMO or other international forum could be used to develop non-mandatory international standards in the form of recommendations and non-binding resolutions to provide a basis for harmonisation of such measures.

References

[1] Coutts ADM, Taylor MD. A preliminary investigation of biosecurity risks associated with biofouling on merchant vessels in New Zealand. New Zealand Journal of Marine and Freshwater Research 2004;38: 215–29.

[2] GESAMP. Opportunistic settlers and the problem of the ctenophore Mnemiopsis leidyi invasion in the Black Sea. GESAMP reports and studies, no. 58. London: IMO; 1997.

[3] White I, Molloy F. Ships and the marine environment. In: Proceedings of the Maritime Cyprus 2001 conference. Limassol, Cyprus, 23–26 September 2001.

[4] GESAMP. A sea of troubles. GESAMP reports and studies, no. 70. UNEP; 2001.

[5] Godwin LS. Hull fouling of maritime vessels as a pathway for marine species invasions to the Hawaiian Islands. Biofouling 2003; 19(Suppl.):123–31.

[6] Coutts ADM, Moore KM, Hewitt CL. Ships' sea-chests: an overlooked transfer mechanism for non-indigenous marine species? Marine Pollution Bulletin 2003;46:1504–15.

[7] Hewitt CL. The distribution and biodiversity of tropical Australian marine bioinvasions. Pacific Science 2002;56:213–22.

[8] Gollasch S. The importance of ship hull fouling as a vector of species introductions into the North Sea. Biofouling 2002;18:105–21.

[9] Hewitt CL, Campbell ML, Thresher RE, Martin JB. Marine biological invasions of Port Phillip Bay, Victoria. Centre for Research on introduced marine pests, Technical report no. 20. Australia: CSIRO; 1999.

[10] Floerl O, Inglis GJ, Hayden BJ. A risk-based predictive tool to prevent accidental introductions of nonindigenous marine species. Environmental Management 2005;35:765–78.

[11] AMOG Consulting. Hull fouling as a vector for the translocation of marine organisms. Phase 1 Study—Hull Fouling research. Australia: Department of Agriculture, Fisheries and Forestry; 2001.

[12] James P, Hayden B. The potential for the introduction of exotic species by vessel hull fouling: a preliminary study. NIWA technical report no. 16. Wellington, NZ: NIWA; 2000.

[13] Lewis PN, Hewitt CL, Riddle M, McMinn A. Marine introductions in the Southern Ocean: an unrecognised hazard to biodiversity. Marine Pollution Bulletin 2003;46:213–23.

[14] Taylor AH, Rigby G. The identification and management of vessel biofouling areas as pathways for the introduction of unwanted aquatic organisms. Australia: Department of Agriculture, Fisheries and Forestry; 2002.

[15] Minchin D, Gollasch S. Fouling and ships' hulls: how changing circumstances and spawning events may result in the spread of exotic species. Biofouling 2003;19(Suppl.):111–22.

[16] Evans SM, Birchenough AC, Brancato MS. The TBT ban: out of the frying pan into the fire? Marine Pollution Bulletin 2000;40:204–11.

[17] Omae I. Organotin antifouling paints and their alternatives. Applied Organometallic Chemistry 2003;17:81–105.

[18] Kindt JW. Marine pollution and the law of the sea. Buffalo, NY: William S. Hein & Co. Inc.; 1986.

[19] McRae DM. The new oceans regime: implementing the convention. Marine Policy 1984;8:83–94.

[20] Oxman BH. Environmental protection in archipelagic waters and international straits—the role of the International Maritime Organisation. The International Journal of Marine and coastal Law 1985;10:467–81.

[21] Mensah T. The international regulation of maritime traffic: IMO approaches. In: Proceedings of the 19th annual conference of the Law of the Sea Institute; 1985. p. 483–9.

[22] Floerl O, Inglis GJ, Marsh HM. Selectivity in vector management: an investigation of the effectiveness of measures used to prevent transport of non-indigenous species. Biological Invasions 2005;7:459–75.

[23] Johnson LS. Coastal state regulation of international shipping. Dobbs Ferry, NY: Oceana Publications; 2004.

[24] De La Fayette L. Access to ports in international law. International Journal of Marine and Coastal Law 1996;11:1–22.

[25] Roberts J. Protecting sensitive marine environments: the role and application of ships' routeing measures. International Journal of Marine and Coastal Law 2005;20:135–59.

[26] Meliane I, Hewitt C. Gaps and priorities in addressing marine invasive species. Gland, Switzerland: IUCN; 2005.