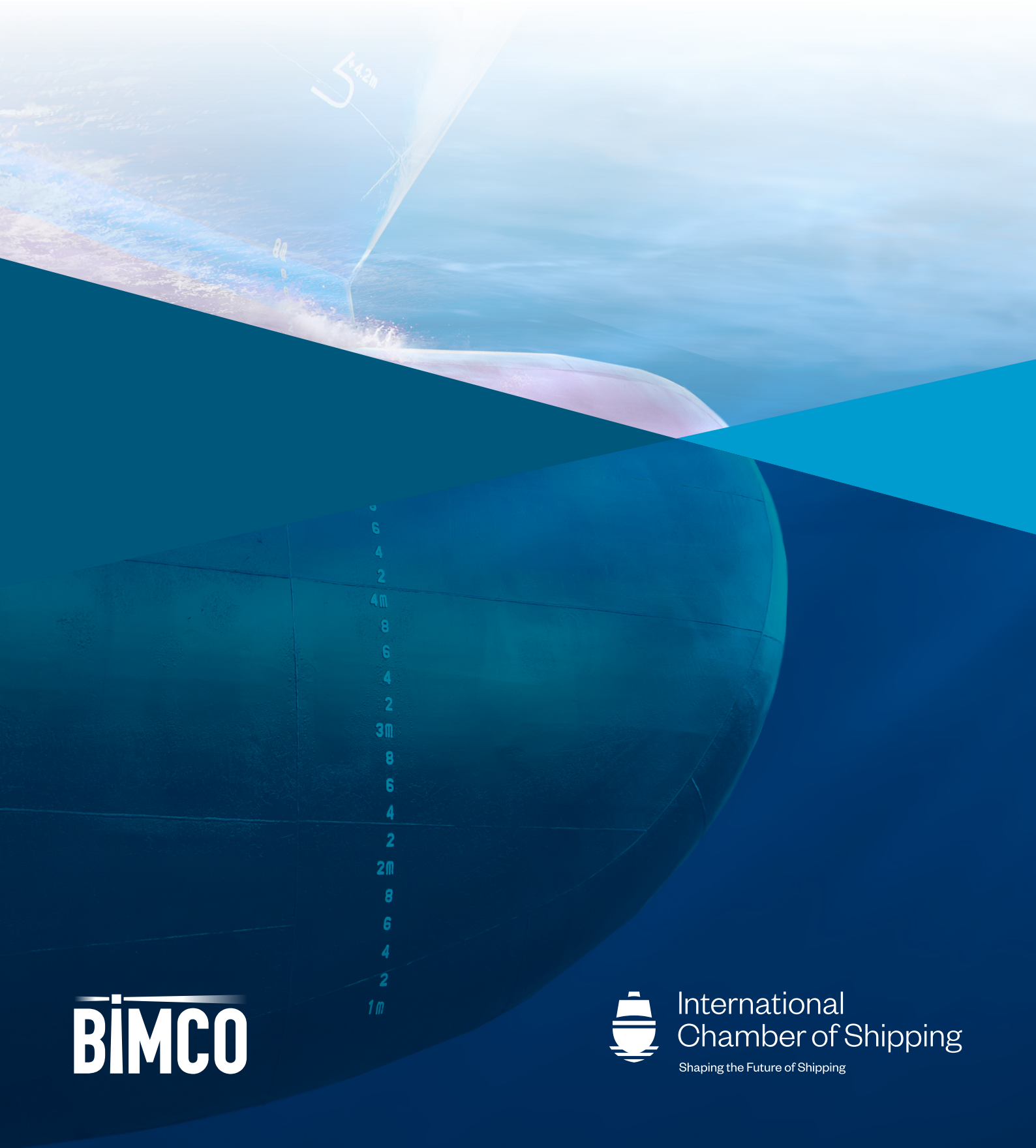
INDUSTRY STANDARD ON
IN-WATER CLEANING WITH CAPTURE

v1.01



BIMCO

International Chamber of Shipping

Shaping the Future of Shipping

Industry standard on in-water cleaning with capture

Version 1.01

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Introduction

The *Industry standard* is one of two separate documents that outline performance-based requirements for in-water cleaning of a ship's hull, propeller and niche areas with the capture of the materials that are removed during the process:

- *Approval procedure for in-water cleaning companies*
- *Industry standard on in-water cleaning with capture*.

In the documents, the stakeholders are ships, cleaning companies, independent approval bodies, anti-fouling system (AFS) manufacturers, ports and other local authorities. The set- up is as follows:

1. The cleaning system and working procedures are tested and approved by an independent approval body in accordance with the *Approval procedure for in-water cleaning companies*.
2. After approval, the quality systems of the cleaning company will be subject to periodic internal audits and external audits carried out by the approval body.
3. Ships, AFS manufacturers and cleaning companies will use the requirements outlined in the *Industry standard* on in-water cleaning for planning, conducting and reporting on the cleaning process.
4. For an approved cleaning company to operate in any given location, a local permit[1] must be issued by the port and other relevant authorities.

The *Industry standard* helps to ensure that the in-water cleaning of a ship's hull, and niche areas including the propeller, can be carried out safely, efficiently and in an environmentally sustainable way.

The *Industry standard* has been written by an industry working group consisting of AFS manufacturers, in-water cleaners, shipowners, ports, international organisations and authorities. The following were represented in the work: Akzo Nobel, BIMCO, C-Leanship, CMA Ships, DG Diving Group, Dutch Ministry of Infrastructure and Water Management, Fleet Cleaner, Hapag-Lloyd, Hempel, HullWiper, International Association of Classification Societies, International Chamber of Shipping, Minerva Shipping, Portland Port (UK), Port of Rotterdam and PPG Coatings.

A reference group was asked twice to comment on the *Industry standard* and several parts of the standard have been updated by correspondence. Members of the reference group represented the following AFS manufacturers, authorities, cleaning companies, international organisations representing shipowners, laboratories, research institutes, and shipowners:

Bernhard Schulte Shipmanagement, Chevron Shipping CO – Houston, ECOsubsea AS, International Association of Independent Tanker Owners (INTERTANKO), Kristian Gerhard Jebsen Skipsrederi AS, Laboratory for Aquatic Research and Comparative Pathology, NACE International, Plymouth Marine Laboratory, SeaTec, SRN Group, TecHullClean Pte. Ltd.

1 Note: local permits may require additional requirements to the ones in the *Industry Standard on in-water cleaning with capture* and the *Approval procedure for in-water cleaning companies*.

Contents

Foreword

The work started three years ago because more and more ports were prohibiting in-water cleaning activities in their areas. Further, there was a genuine desire among stakeholders to improve practices by establishing a minimum standard for the cleaning and capture of biofouling.

BIMCO would like to thank all members of the working group for their valuable time and constructive contributions. The reference group is also thanked for their comments and proposals to the text.

BIMCO, January 2021

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2 Scope

This *Industry standard* outlines the requirements for planning and carrying out in-water cleaning while the ship is alongside or at anchorage. It addresses a planned approach by all stakeholders connected to in-water cleaning: the shipowner, cleaning company, AFS manufacturer, the port and other relevant authorities.

This *Industry standard* applies to in-water cleaning methods with capture capabilities only and does not apply to cleaning systems that cannot capture material during cleaning.

The hull, propeller and niche areas of the ship can be cleaned either in-water or in dry dock. Since the scope of this standard is limited to in-water cleaning, the discussion about out of water cleaning is excluded.

The *Industry standard* addresses the in-water cleaning of ships carried out by cleaning companies that are approved in accordance with the *Approval procedure for in-water cleaning companies*. After the cleaning capability of the cleaning company has been tested, the approval certificate states the types of biofouling, the height of hard calcareous biofouling and the coverage that the system can clean and capture. Some niche areas located on the flat surfaces of the ship's hull (for example dock support strips) are more susceptible to biofouling than the rest of the hull. If such niche areas contain soft and hard macro biofouling beyond the tested capability of the approved cleaning system, the standard allows the cleaning of the identified niche areas to proceed providing the total area of the fouled niche areas and hull does not cover more than 5% of the submerged area of the hull. If this limit is exceeded, the cleaning shall be undertaken by a more capable cleaning company, out of water or after obtaining special permission from the authorities. The *Industry standard* does not specify a detailed description of the methods and/or techniques required for carrying out the cleaning. However, the AFS manufacturer is encouraged to provide detailed information on recommended cleaning methods including brush type and water pressure to the shipowner and the cleaning company.

The primary users of this *Industry standard* are shipowners, who are responsible for managing biofouling on the ship's hull, propeller and niche areas, and approved cleaning companies (ie in accordance with the standard's requirements for approval of in-water cleaning companies). The *Industry standard* can also be used by ports and other authorities for making decisions regarding permits etc. Finally, the *Industry standard* provides a possibility to improve the level of communication between shipowners and AFS manufacturers.

In this *Industry standard*, the management of biofouling is based on using responsive cleaning as part of a ship's normal maintenance system. Continual monitoring of changes in hull performance and biofouling condition will enable the shipowner to initiate in-water cleaning with due diligence before the biofouling growth becomes severe.

This *Industry standard* does not cover cleaning systems that do not capture materials during cleaning (grooming), although systems with capture capability used in a proactive way are covered by this standard.

Commercial aspects covered by a contract between the shipowner, AFS manufacturer and/or the cleaning company and others are outside the scope of this *Industry standard*.

3 Terms and definitions

Accredited laboratory	A laboratory verified to an appropriate level of expertise, and whose quality management system can perform specific test methods accredited to internationally accepted standards or recognized by the government where the laboratory is located.
Anti-fouling coating system (AFC)	The combination of all component coatings, surface treatments (including primer, sealer, anti-corrosive and anti-fouling coatings) or other surface treatments used on a ship to control or prevent attachment of unwanted aquatic organisms.
Anti-fouling system (AFS)	A coating, paint, surface treatment, surface, or device that is used on a ship to control or prevent attachment of unwanted organisms.
Approval body	An organization, which audits the cleaning company (including its subsidiaries and sub-contractors) in accordance with the requirements of the *Industry standard on in-water cleaning with capture* and the *Approval procedure for in-water cleaning companies* and issues a certificate of approval.
Biocide	A chemical substance incorporated into anti-fouling coatings to prevent settlement or survival of aquatic organisms.
Biofouling	The accumulation of aquatic organisms such as micro-organisms, algae, and animals on surfaces and structures immersed in or exposed to the aquatic environment. Biofouling types can include soft biofouling (slime and soft macrofouling), and hard calcareous biofouling (see below).
Biofouling management plan	A ship-specific document(s), that includes details of the ship and the biofouling management procedures consistent with the IMO's Biofouling guidelines to minimize the transfer of invasive aquatic species.
Biofouling record book	A record book that captures all the activities in relation to the biofouling of the ship as mentioned in the IMO's Biofouling Guidelines to minimize the transfer of invasive aquatic species.
Cables and hoses	These connect the cleaning unit to the unit ashore or on a barge. The hoses may carry water to transport the captured material from the cleaning unit to the separation and/or treatment unit. Cables are used to power the various units in the system.
Cleaning inspection	Refers to an inspection of the area to be cleaned prior to conducting the actual cleaning activity or of the area that has just been cleaned.
Cleaning unit	The cleaning device interacts with the ship's hull and other areas to remove and capture the material attached to the surface. This unit may be operated by a diver or by a remotely operated vehicle (ROV) pilot.
Control unit	This unit houses the controls such as the remote control of ROVs, communication devices with divers, camera monitors etc.

Diver	A person, who is qualified to dive underwater safely using self-contained breathing apparatus or other similar systems. He/she is trained in one of the diving standards recognized by relevant authorities and has working knowledge on the use of tools normally used in in-water cleaning/ visual inspection as well as emergency escape training.
Hard biofouling	Often referred to as hard calcareous biofouling, which consists of organisms visible to the human eye. It can include barnacles, mussels tube worms and bryozoans etc.
Invasive aquatic species	A species which may pose threats to human, animal and plant life, economic and cultural activities and the aquatic environment.
In-water cleaning	The physical removal of biofouling from a ship in water.
Marine growth prevention system (MGPS)	An AFS used for the prevention of biofouling accumulation in internal seawater cooling systems and sea chests and can include the use of anodes, injection systems, electrolysis, ultrasound or other methods.
Materials	The solid substances captured during the cleaning of a ship. This may include biofouling (macro and micro) growth, paint flakes and the matters contained within the AFC such as biocides, heavy metals, silicon substances etc.
Niche areas	Areas on a ship that may be more susceptible to biofouling due to different hydrodynamic forces, coating system wear or damage, or being inadequately painted, eg, sea chests, bow thrusters, propellers and propeller shafts, rope guards, inlet gratings, dry-dock support strips, rudder pintle areas etc.
Out of water cleaning	Refers to the cleaning of the hull areas when the ship is out of water, for example, in a dry-dock.
Reference area	A square or rectangle on the hull with an area of approximately 1 square metre, or a niche area that serves as a datum for inspections and/or cleanings.
Remotely operated vehicle (ROV)	A vehicle that may be used as part of a cleaning unit, which is navigated remotely from the surface to inspect and/or clean submerged hull and niche areas.
Responsive cleaning	Cleaning initiated by a marked reduction in the ship's performance or when an inspection shows that cleaning is necessary.
Sea water effluent	Refers to the water that has been filtered, and/or treated to specifications mentioned in this *industry standard* and is ready to be discharged back into the environment.
Sea water influent	Refers to the water that is captured into the cleaning system during the cleaning process. This water may still contain biofouling, paint flakes and other associated solids.
Separation performance	Refers to the effectiveness of separating solid materials from water during in water cleaning. The separation unit used in connection with in-water cleaning shall be able to remove particles of solid materials that are larger than a defined limit.

Separation unit	Consists of the equipment that uses physical processes to remove solid material (macrofouling, coating chips, etc) from the collected water, including but not limited to settling tanks, filtration, and centrifugation. Separation and treatment stages may be combined into one unit.
Ship	A watercraft of any type whatsoever operating in the aquatic environment including hydrofoil boats, air-cushion vehicles, submersibles, floating craft, fixed or floating platforms (excluding licensed aquaculture assets), floating storage units (FSUs) and floating production storage and off-loading units (FPSOs).
Soft macrofouling	Consists of organisms without calcareous shells or tubes, that develops and overgrows the microfouling slime. It consists of large, distinct multicellular organisms visible to the human eye such as soft corals, sponges, hydroids, anemones, algae and tunicates.
Storage unit	Captured material is pumped directly into tanks, a barge, etc. The collected material and seawater in a storage unit can either be appropriately disposed of or subsequently processed through a separation and/or treatment units.
Treatment unit	Treatment consists of a physical, chemical or biological addition(s) to alter or remove solid and/or dissolved material(s). The range of treatments can include but are not limited to flocculation, metals sorbent media, UV (ultraviolet) light and biocides. Treatment and separation stages may be combined into one unit.

4 Ship's documentation

Biofouling management measures shall be outlined in the ship's biofouling management plan, and records of biofouling management practices including all inspection and cleaning reports shall be documented in a biofouling record book.

For detailed information on what to put in the biofouling management plan and the biofouling record book, please refer to the IMO's Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species (IMO Biofouling Guidelines).

4.1 Biofouling management plan and record book

In-water cleaning is a tool to be considered as part of effective biofouling management and any actions and events, such as in-water inspections, cleaning operations, maintenance and incidents related to it should be reflected in the biofouling management plan and record book.

In addition to the IMO Biofouling Guidelines, the following information should be reflected in the biofouling management plan:

- reference areas to be used for inspections and reporting
- information on the chemicals, such as chlorine or sodium hypochlorite, used in MGPS, including the recommended amount of chemicals that should be used
- contingency planning for managing biofouling when the ship is inactive for an extended period.
- contingency planning for incidents such as grounding, contact with a tug etc that may cause damage to the AFS.

In conjunction with the biofouling management plan, the ship shall maintain a biofouling record book that itemises all inspections and biofouling management actions undertaken. The record book should include documentation or references to documentation about actions undertaken in connection with biofouling management such as service reports, incidents, video/photo recordings of inspection/ cleaning etc.

The biofouling management plan and record book may be stand-alone documents, or integrated in part, or fully, into existing operational and procedural manuals and/or planned maintenance system (PMS).

Readers should refer to the IMO Biofouling Guidelines for a more detailed description on the content of the biofouling record book.

Annex 1 shows a sample of a biofouling record book referring to in-water cleaning actions.
The biofouling record book must be retained on the ship for the life of the ship.

4.2 Reference areas

Reference areas should be used for monitoring biofouling and controlling the efficacy of the cleaning[2].

2 If the biofouling management plan does not include reference areas, alternative methods to inspect can be used to ensure that the entire underwater area will be inspected.

A minimum of ten reference areas, representing the entire underwater area forward to aft including vertical sides, flat bottom and niche areas, shall be determined and included in the biofouling management plan. The number of reference areas should increase in proportion to the size of the ship size to ensure an adequate representation of the fouling on the ships' hull and niche areas. The number of reference areas shall ensure that inspections can be carried out in accordance with chapter 6.

More information about determining the reference areas can be found in Annex 2. Examples of documenting management actions in the biofouling record book using reference areas are shown in Annex 1.

4.3 Photos and videos

Photos and videos of reference areas and other relevant areas shall document inspections and the results of in-water cleaning.

Photographs and videos shall have a scale that uses the metric system, so the size of the pictured area and the size of the biofouling can be estimated. The scale may be added electronically.

The following requirements should be fulfilled when the underwater visibility is minimum 0.5 metres:

a. Photographs and videos should clearly depict the condition of the AFS and biofouling growth
b. Photographs and videos should have an electronic stamp with the following details:
    - the number of the reference area or the location of the area on the ship by using for example distance from deck line or bottom, frame number or any other relevant description, to depict where the picture has been taken, and date and time
c. Name of the ship or other unique identifier, if possible.

The time stamp can also include:

- depth
- location (port)
- details about the cleaning itself such as water pressure or speed of brush rotation.

If the visibility is less than 0.5 metres, inspections or cleanings should not be carried out unless there is a special reason for doing so, and the system is able to navigate safely under such conditions.

More information about photographs and/or videos can be found in Annex 3.

5 In-water inspection planning

This chapter describes methods that can be used to determine when to perform an in-water inspection to initiate in-water cleaning before the biofouling growth and coverage become severe.

The biofouling management plan should specify under which conditions in-water inspections may be conducted. Some inspections are prescheduled in accordance with the ship's planned maintenance system (PMS) while others are planned in accordance with the operational profile of the ship. The decision to conduct an in-water inspection should be based on, but not limited to the following:

1. risk assessment of biofouling growth
2. assessment of the propulsion power and fuel consumption over a specified period (hull performance monitoring)
3. statutory and class IWS (in-water survey) between dry docks
4. availability of services provided by divers eg regular propeller polishing or cleaning or underwater repair
5. idle periods or specific lay ups for example as stipulated in a charter party or in a contract with the AFS manufacturer
6. mandatory inspection requirements according to relevant regulatory regimes before proceeding to an arrival port or waters of a coastal state
7. requested by the charterer eg due to failure of the AFS
8. inspections carried out at planned intervals in accordance with the PMS
9. inspections requested by the AFS manufacturer.

5.1 Assessment of biofouling growth

Biofouling growth is dependent on the operational profile of the ship and the biofouling management practices applied. A risk assessment is a useful tool to help determine how often in-water inspections will be necessary.

The following factors should be considered when determining the risk of biofouling growth and the need to carry out an in-water inspection:

Environmental	
Factors affecting biofouling growth	**Specific associated risk**
Water salinity	Biofouling growth increases with salinity up to 25-36 PSU (Practical Salinity Unit), after which it levels off. This is due to an increase in species' richness.
Water temperature	It is generally understood that the world's oceans are divided into three main water temperature areas: Tropical, temperate and polar. The risk of accumulating biofouling will vary in each of these areas as a result of the variation in sea water temperature. For example in tropical waters, where the temperature of the water is >25°C, there may be an increase in biofouling growth as the settling-competent larvae is dispersed in the water throughout the year whereas, colder waters <15°C tend to have a seasonal risk of biofouling growth.
Depth of water and distance from shore	An increase in depth of water decreases the risk of biofouling owing to the increase in distance to adult biofouling organisms, which reduces the likelihood of organisms settling on the ship.

Condition of hull, niche areas and anti-fouling system	
Factors affecting biofouling growth	**Specific associated risk**
Hull roughness	High roughness provides an ideal settlement surface for biofouling organisms.
Age of anti-fouling coating	The effectiveness of an AFS may decrease with age if for example the active substance has diminished.

Ship's operating characteristics	
Factors affecting biofouling growth	**Specific associated risk**
Utilization rate and idle time	Depending on local environmental conditions and type of AFS used, extended idle periods may allow an increase in biofouling. For example, calcareous organisms establish on a ship within 5-8 days. Some species may significantly affect the AFS capabilities.
Speed	Biofouling growth may increase when the ship operates at a lower speed than that which is recommended for the specified AFS.
Damage to the anti-fouling coating	A ship which frequently visits ports will tend to damage the anti-fouling coating due to friction with fenders etc. Ports or anchorages, where high tidal variations result in the ship standing on the seabed during low tides, may damage the bottom paint. The areas that are more prone to coating damage are tug-points, fender points, anchor chain abrasion, areas that are left dry during ballast voyages etc. The above is a non-exhaustive list.

Table 1: Factors affecting biofouling growth and specific associated risk.

5.2 Assessment of the propulsion power and fuel consumption

Biofouling on the hull will result in an increase in a ship's propulsion power demand and subsequently fuel consumption. A hull performance monitoring system can be used to assess the changes in the propulsion power and fuel consumption of the ship, and the changes may indicate a degradation of hull or propeller condition.

The following is a non-exhaustive list of methods available:

1. online hull performance monitoring systems using sensors and collecting high frequency data
2. semi-automatic or manual calculations using data collected from ship's staff (eg noon reports)
3. conducting speed trials and comparing the performance data with previous speed trial reports.

6 Inspections

As mentioned in chapter 5, in-water inspections should be carried out to determine if a cleaning is necessary. The reason for initiating the inspection shall be included in the biofouling record book. The inspection should give an overview of the condition of the hull and niche areas and be used to determine the most appropriate method of in-water cleaning based on the level of fouling.

During the inspection of the underwater area (hull and niche areas) of the ship, the following shall be ascertained:

1. types of biofouling
2. percentage of biofouling coverage
3. height of hard calcareous biofouling
4. condition of the AFS on the hull and reference areas.

The photos and videos from the underwater inspection should be retained in the biofouling record book and used to compare the result of the cleaning activity.

The inspection shall be carried out after having taken into consideration the in-water conditions such as tidal flow, sea state and visibility etc and shall ensure that the result provides a realistic representation of the overall condition of the submerged area of the hull to the shipowner, AFS manufacturer, port, local authority etc.

Inspections and cleaning activities may be carried out by either the same company or different companies providing each company has the necessary approval. When doing so, all safety concerns must be taken into consideration.

6.1 Biofouling types

For the purpose of in-water cleaning, communication with AFS manufacturers, authorities etc the following details about different biofouling types shall as a minimum be reported for each reference area or other inspected niche areas:

1. percentage of biofouling cover for each reference area as well as biofouling cover of the total underwater area
2. for soft biofouling
   a. slime
   b. soft macrofouling
3. for hard calcareous biofouling, the height of the organisms.

The below table gives examples of the biofouling types mentioned above:

Soft biofouling		**Hard calcareous biofouling**
Micro	**Macro**	**Macro**
Slime	Soft corals	Barnacles
	Sponges	Mussels
	Hydroids	Tube worms
	Anemones	Bryozoa
	Algae	Oysters
	Tunicates	

Table 2: Examples of biofouling types.

6.2 Biofouling coverage

During inspections as well as before and after the cleaning, the biofouling coverage scale as depicted below should be used to define the extent of biofouling on the hull and niche areas.

An estimation shall be recorded of the total biofouling coverage and total hard calcareous biofouling coverage of the hull. The extent of biofouling observed during the inspection shall also be given for each reference area.

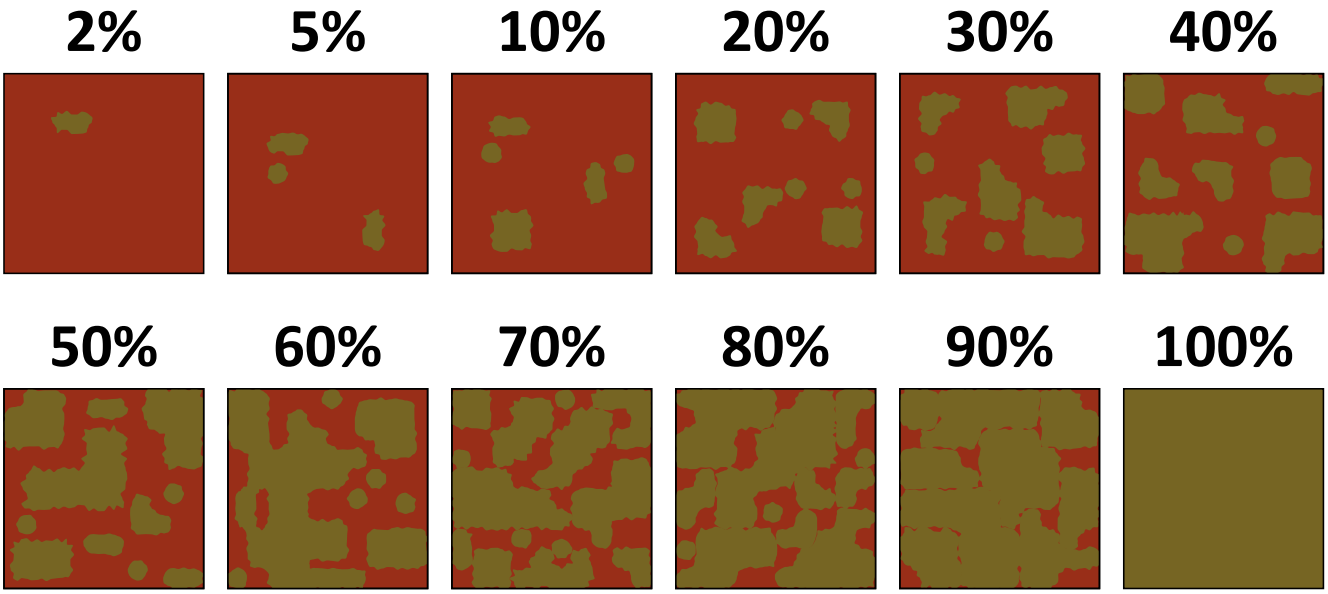


Figure 1: Coverage of biofouling in reference areas.

6.3 AFS' condition

Any damage to the condition of the AFS, which is observed during an inspection or cleaning, shall be reported. The following descriptions as visualised in the table below should be used for reporting:

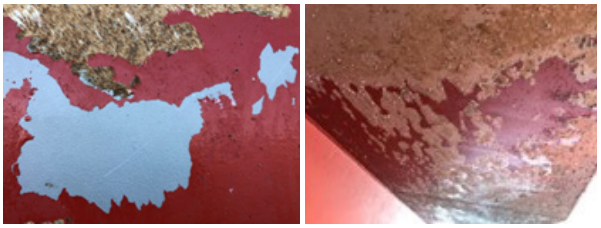
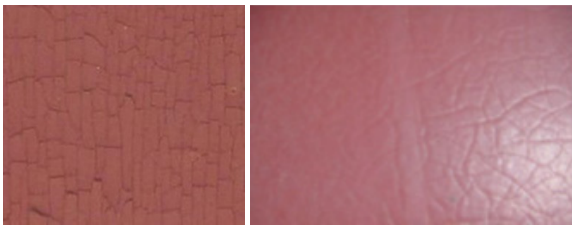
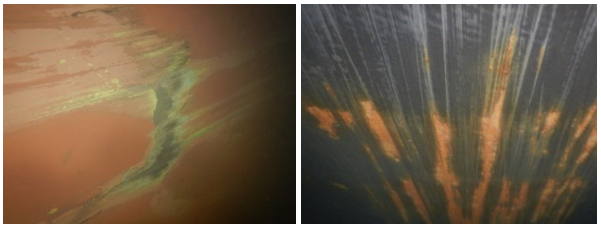
Type	Description	Examples
Adhesion	The failure of adhesion between a coating and a metallic surface that is directly attributable to cathodic protection conditions. It is often initiated by a defect in the coating system, such as accidental damage, imperfect application or excessive permeability.	
Blistering	Dome shaped projections or blisters in dry paint film.	
Cracking	Paint coatings with visible cracks which may penetrate down to the substrate.	
Cold flow	Viscous flow of solid at ordinary temperatures. The distortion of solid coating under sustained pressure during curing.	
Delamination /peeling/ detachment	Defects associated with detachment of coating.	
Polishing off	The continuous release of the outermost binder material into the seawater during the ship's operation.	
Grounding/ general damage	The effect on the antifouling coating system caused by contact with the seabed or bank.	

Figure 2: Examples of coating damage.

6.4 Service report after inspection

The service report contains basic information about the inspection that was carried out. This service report shall be completed by the inspection company and be handed over to the masteror another representative of the ship. A format of the service report can be found in Annex 5.

6.5 Inspection report

The inspection report is the final report of the inspection. It shall be completed by the cleaning company and contain the following: The ship's details and draft at the time of survey; names of stakeholders in attendance, anti-fouling system type and date applied. It shall include details of the inspection and any observations including detailed information about the biofouling types, condition of the AFS and biofouling coverage on the underwater area of the ship as well as the reference areas.

Photos and/or videos shall form part of the documentation.

A copy of the inspection report should be retained by the ship and kept with the biofouling record book.

An example of the minimum content for an inspection report is provided in the Annex 4 to this *Industry standard*.

7 Pre-communication

When the decision to clean the ship's hull and/or niche areas has been taken, the shipowner should request a list of approved cleaning companies from the port.

The shipowner shall send the following information to the appointed cleaning company:

1. age of AFS and its expected service life timespan
2. previous damage to the AFS if any
3. type of anti-fouling coating and the coating manufacturer's advice on cleaning
4. list or drawing arrangement of reference areas
5. the area(s) of the ship to be cleaned. For example, does the ship need a full cleaning or has a partial cleaning been done previously by another company?
6. niche areas needing to be cleaned and divided into the following categories:
   a. niche areas present on the vertical side or the bottom of the ship that can be readily cleaned
   b. propellers
   c. niche areas that need special cleaning equipment and procedures
7. previous inspection/cleaning reports since the AFS was applied
8. place where the cleaning is to be carried out (berth/anchorage)
9. available amount of time for cleaning
10. other operations planned by the ship such as repairs, bunkering, storing, etc
11. transfer of the ship within port area, alongside and at anchorage, if relevant
12. any other relevant information, such as idle periods.

The cleaning company shall inform the shipowner about the regulatory requirements and standards applicable for cleaning in the specified port and if the cleaning company can provide the required service.

The appointed cleaning company shall inform the shipowner about the following:

1. categories that the company has been approved to operate in accordance with the *Industry standard for in-water cleaning with capture*:
   a. hull, and niche areas present on the vertical side or the bottom of the ship that can be readily cleaned
   b. propellers
   c. niche areas or hull areas that due to bends, turns etc need special cleaning equipment and procedures
2. local cleaning permit (issued by the port and/or other relevant authority) and evidence of approval (certificate issued by an approval body in accordance with the *Approval procedure* of cleaning companies)
3. environmental conditions, in which the cleaning company is permitted to operate, including sea state, weather conditions, visibility, etc
4. the equipment that will be used for cleaning the ship's hull and/or niche areas such as cleaning units, umbilical, control unit, separation and treatment unit including use of active substances, if any

5. cleaning procedure, type of AFC or MGPS that the company has been approved to clean eg by a manufacturer etc
6. place of cleaning either alongside and/or anchorage area
7. the required length of time to conduct the cleaning
8. limitations associated with performing the cleaning
9. capture, separation, treatment and waste disposal processes
10. local port requirements
11. any other relevant information.

The cleaning company shall supply the information, which is required by the local regulations, to the port/relevant authorities in order to be allowed to proceed with the cleaning.

If niche areas on the vertical sides or the bottom of the ship contain soft and hard macro biofouling beyond the tested capability of the approved cleaning system, the standard allows the cleaning of the identified niche areas to proceed providing the total area of the fouled hull and niche areas does not cover more than 5% of the submerged area of the hull. If this limit is exceeded, the cleaning shall be undertaken either out of water or after obtaining special permission from the relevant authorities. If such permission is granted, then the cleaning system shall still adhere to the requirements detailed within this *Industry standard* to manage the risk to the port environment.

There are no exemptions for the approved special cleaning equipment that handle other niche areas, as the cleaning system must be able to capture the soft and hard macro biofouling in accordance with this *Industry standard*.

The cleaning company shall maintain communication with the ship, port and other relevant authorities throughout the cleaning operation and comply with any instructions in accordance with operational protocols specific to the ship and the port.

8 Pre-cleaning preparations

A meeting shall be held between the ship and the cleaning company's representative to determine appropriate safety parameters and relevant information on how to access niche areas.

The cleaning company shall plan the cleaning meticulously to ensure that the process is undertaken efficiently, safely and in an environmentally sound manner. The cleaning company should submit an outline of the operation plan to the ship and the port.

The cleaning company shall plan its resources to avoid/minimise breakdowns/interruptions.

Communication between the ship and in-water cleaner shall be planned and tested.

Before the planned operation, functional checks, pre-dive checks of the cleaning and capture system plus the associated ancillary equipment shall be conducted.

An approved pre-dive checklist for guidance shall be used and cross checked with the record of any possible defects and recent repairs[3].

The ship shall follow established procedures to ensure that equipment such as thrusters, propellers etc are locked or tagged out in order to ensure they cannot be used while the diver and/or ROV are in the water. The divers, if any, must witness the locking and tagging of equipment prior to entering the water.

8.1 Safety and environmental requirements for the cleaning company

Before the commencement of the cleaning activity, the cleaning company shall conduct an inspection of the area to be cleaned and a safety check of equipment etc, as per the list below:

1. The cleaning activity shall be planned to ensure the safety of the personnel, equipment and ship during the entire operation. The underwater cleaning route should be well planned to avoid losing orientation underwater. As a minimum, the planning should take into consideration water visibility, current, tidal variations, weather conditions, simultaneous operations such as bunkering, ballasting/de-ballasting, movement of cranes, obstructions at the quay such as fenders, mooring dolphins, other ships in the area, pinch points and location of surface support (for diver's emergency evacuation).
2. Establish safety procedures should the movements of other ships affect the cleaning operation.
3. Agree on a timeline regarding the securing of key systems and equipment. For example, the propeller shall not be able to move during the cleaning process and the cathodic hull protection system should be powered off whilst the hull is being cleaned.
4. Procedures shall be in place to ensure that all systems and equipment, including personal protection equipment (PPE) are functional and still within their operational life.
5. Establish how to minimise the risk of loss of material when planning the cleaning in complex areas eg in the vicinity of bends, turns etc.
6. Contingency plans and procedures shall be in place to prevent and mitigate the exceedance of any safety and/or environmental parameters and ensure that the cleaning operations are suspended and remain suspended until such parameters are safely restored.

3 Such checklists are dependent on local regulations and diving equipment and are thus outside the scope of this *Industry standard*.

7. Outline emergency shut down procedures designed to prevent the spill of biofouling effluent back into port waters.

8.2 Pre-assessment of the cleaning area

Based on a previous inspection report and/ or a pre-inspection of the submerged area of the ship, a pre-assessment of the cleaning areas shall be carried out by the cleaning company in accordance with the following:

1. To confirm that the observed biofouling lies within the cleaning systems capabilities.
2. The cleaning company should, if applicable, inform or seek approval of the port authority to commence operations.
3. A check of the operational area should be conducted to take note of the following:
   a. if there is enough clearance to clean the side of the ship. For example, quay side clearance, fender obstructions etc
   b. clearance under the ship throughout the operation, taking into consideration the expected rise and fall of tide and change in the draft of the ship
   c. any potential movements of ships which could affect the cleaning operation.
4. Any areas of concern as a result of the inspection, shall be discussed with the ship and/or port or other authorities before proceeding with the cleaning activity.
5. AFS damage shall be discussed with the ship to establish if the cleaning should proceed.
6. Any discrepancies between the records on the ship and the actual condition of underwater hull or niche areas of the ship, shall be discussed with the ship before proceeding with the cleaning activity.
7. The cleaning company must outline the sequence of cleaning with the ship to ensure best results in terms of safety, quality and protection of the environment.

The cleaning company shall inform the port/relevant authorities if it suspects that the type or coverage of biofouling on the ship is outside the capability of their system.

9 Operating requirements of the cleaning system with capture

An in-water cleaning system may consist of the units that are shown in figure 3.

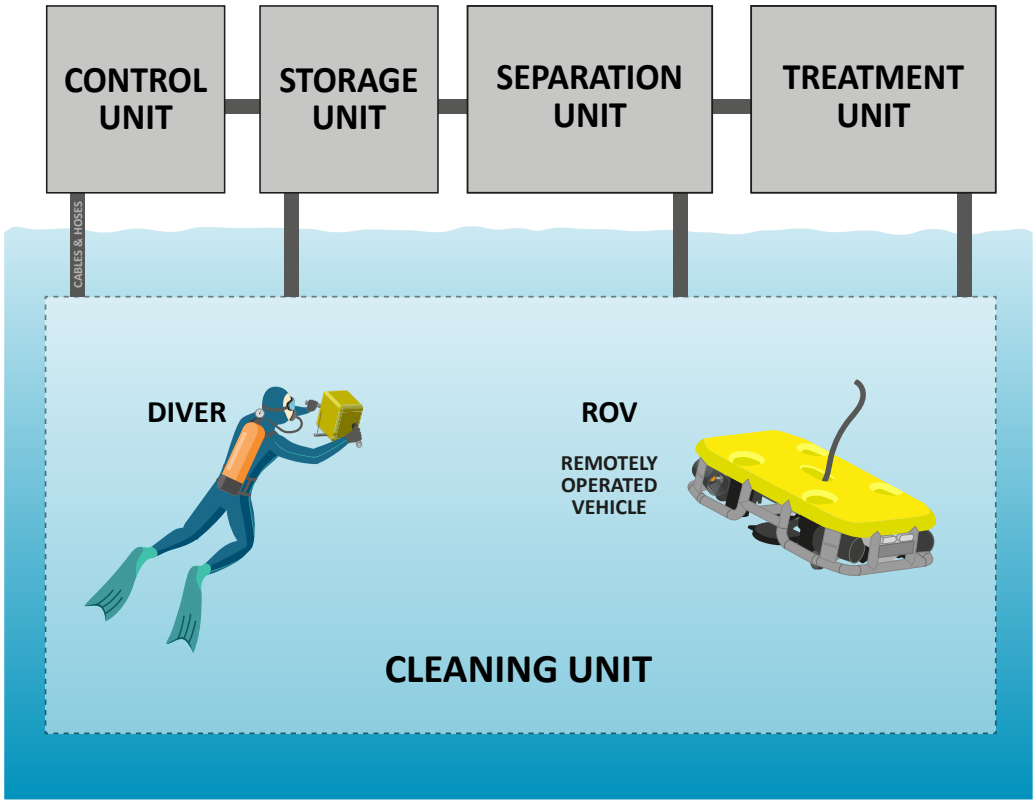


Figure 3: Schematic diagram of a cleaning system.

A control unit houses the controls such as remote control of ROVs, communication devices with divers, camera monitors etc.

The cleaning unit is used to clean the hull, propeller and/or niche areas. It can be operated by a diver using a cleaning technology or by a ROV. The cleaning unit removes and captures materials and is attached to the separation and treatment or storage unit by hoses.

The hoses provide means of transporting the captured material and seawater from the cleaning unit to the separation and treatment unit or a storage unit. Cables are used for communication purposes and to power the ROV or other cleaning technology.

Some cleaning systems pump the captured material and seawater into a storage unit eg a barge or mono-hull tanker. The captured material and seawater in the storage unit will subsequently be pumped to the separation and treatment unit(s).

The separation unit houses the equipment that removes the captured material and the seawater influent.

The treatment unit can be used as an integrated part of the separation unit or as an additional unit to treat the influent water further after the separation unit. Treatment may include use of heat, biocides, or ultra-violet light.

The cleaning must be conducted using approved systems and procedures as outlined in the *Approval procedure for in-water cleaning companies*.

1. When choosing the cleaning equipment, careful consideration should be given to the information received from the AFS manufacturers and/or ship to ensure the performance of the AFS is not impaired.
2. The cleaning unit must be able to safely reach the section of underwater area that has to be cleaned and be able to remove visible biofouling[4].
3. Procedures must be in place to avoid accidental releases into the water and the cleaning system shall capture the dislodged material. If a cleaning unit accidentally releases material into the sea, it shall be assessed to find the root cause. In case of consecutive malfunctions or when a malfunction results in the release of captured materials to the marine environment, the cleaning equipment shall be taken out of service and tested. Any accidental release should be recorded in the cleaning activity log with the contingency measures taken and the relevant authorities should be alerted of the incident.
4. Pictures and/or videos shall be used to document the effectiveness of the cleaning. The photographs and videos should conform to the specifications mentioned in the Annex 3 of this *Industry standard*.

The cleaning company shall maintain a log of all cleaning activities. It should include the name and IMO number of the ship, the AFS, type of cleaning, amount of material captured, records (or copies of records) of the disposal of all such material and sea water effluent, plus records of accidental discharges, if any. The log shall be available on request by the port and other relevant authorities and retained for 3 years or longer if so required by a port or other relevant authority. A representative video or photos of the entire cleaning for each ship shall be kept for a minimum period of 1 year.

9.1 Operating requirements of niche area cleaning

In-water niche area cleaning shall be carried out using systems and procedures that are approved in accordance with the *Approval procedure for in-water cleaning companies*.

Cleaning of niche areas shall be done by removal and capture of all material.

9.2 Propeller cleaning

When cleaning a propeller, which has biofouling growth, this *Industry standard* fully applies.

The *Industry standard* does not cover polishing a hard and tenacious layer of calcareous chalk without capture.

9.3 Post-cleaning inspection

1. A post-cleaning inspection shall be carried out upon completion of the operation.
2. The post cleaning inspection can be done during the cleaning process by using cameras installed on the ROV unit. It is important that the photos and videos are able to clearly depict the exact condition of the hull, and AFS plus any biofouling. If this cannot be achieved, then the cleaning company shall conduct a post-cleaning inspection after the cleaning activity is completed.

4 Some types of biofouling will adhere to the surface and will leave residual biofouling, often non-viable, skeletal remnants, even after cleaning, which cannot be removed without damaging the AFS. Examples include the baseplates of barnacles and bases of worm tubes.

3. This inspection shall cover the entire area that was cleaned with special attention to the reference areas.
4. Photographs and/or videos should be used to collect and retain evidence of the cleaning activity and demonstrate effective removal and capture of biofouling have taken place. Photos and/or videos of at least all the reference areas within the cleaned area shall be documented and retained as evidence.
5. A service report should be completed by the cleaning company in the format mentioned in Annex 5 of the *Industry standard*.
6. If the cleaning activity did not cover the entire planned area or areas, documentation shall be made to show where the cleaning started and where it stopped. The documentation shall be sufficiently detailed to enable another in-water cleaning company to continue the cleaning at the next available opportunity. This documentation should be recorded in the cleaning report and in the biofouling record book.

9.4 Post cleaning safety and environmental requirements

A post cleaning meeting must be held to terminate the permit and to confirm that ship's equipment and machinery can be reinstated to the normal operational status.

After the following procedures have been completed, a post cleaning meeting must be held:

1. After completing all in-water cleaning activities, the equipment should be removed from the water and brought back to their original positions.
2. All underwater gratings shall be safely restored to their original state.
3. All remaining material in the in-water cleaning system including the hoses, separation and treatment units shall be contained and disposed of in a safe manner. The cleaning company shall ensure the material does not find its way into the local marine environment.
4. When confirmation has been received that all cleaning equipment and personnel have been removed from the water, the ship can be made operational by releasing locked out or tagged out systems.

9.5 Service report after cleaning

This service report contains basic information about the cleaning that was carried out. The cleaning company shall hand over the service report to the master or another representative of the ship at the post cleaning meeting and before the ship's departure. A format of the service report can be found in Annex 5.

9.6 Cleaning report

The results of the cleaning operation shall be accurately documented in the cleaning report as described in Annex 6, and shall be retained on board the ship, along with the biofouling record book.

The cleaning report shall contain information based on documentation from reference areas or other areas if available about the biofouling observed prior to cleaning, details of the cleaning performed plus the state of the AFC before and after cleaning.

Further, it shall provide detailed information about the location of the cleaned areas to enable another in-water cleaning company to continue the cleaning if necessary.

Cleaning reports shall be retained for a period of two years on board the ship and thereafter with the shipping company until at least five years have elapsed since the date of the cleaning.

10 Systems used to prevent biofouling growth

According to the IMO Biofouling Guidelines, the ship's biofouling management plan should include details of the AFS, and operational practices used.

There are ways to reduce the likelihood of biofouling on the underwater hull and niche areas such as:

1. Anti-fouling coating system (AFC)
2. Marine growth prevention system (MGPS)

To ensure the use of appropriate methods and equipment, the cleaning company should prior to commencing the work gather information such as:

1. type/specification of the cleaning equipment to be used
2. manufacturer's recommendations for in-water cleaning based on the coating properties
3. details of the areas, to which each specific treatment/cleaning is to be applied
4. any other details relevant to the processes (eg chemicals required for treatment, any discharge standards).

10.1 Coating system

The IMO Biofouling Guidelines include a number of issues that needs to be communicated between the AFS supplier and the ship. The following information provided by the AFC supplier must be included in the biofouling management plan and record book:

1. type of AFC
   a. manufacturer, product names and the location on the ship where the AFS has been applied
   b. in case different coating types have been used for the hull and the niche areas, this should be specified
2. AFC specifications
   a. dry film thickness of coatings
   b. the expected service lifetime of the anti-fouling coating
   c. operating conditions required for coatings to be effective
   d. any other specifications relevant to the AFS performance
   e. any additional products/chemicals used in conjunction with the AFS (either to increase durability or prepare the surfaces)
   f. attachments in form of the material safety data sheet and technical data sheet.

This is a combination of all component coatings and/or surface treatments (such as primer, sealer, anti-corrosive tie-coat, and anti-fouling coatings etc) used on a ship to control or prevent the attachment of unwanted aquatic organisms.

The lifetime of an AFS depends on several factors such as thickness of the paint, operating parameters of the ship, cleaning frequency etc.

AFS manufacturers should supply information about the expected lifetime of the AFS applied on the ship, along with the conditions that need to be fulfilled in order to ensure the anti-fouling coating's durability.

If available, the following specific information used to determine the appropriate AFS and relevant scheme for the ship shall be recorded in the biofouling management plan and record book, in addition to the information already required in the biofouling management plan:

- assumed typical operating speed of the ship (knots)
- assumed activity period (%)
- maximum acceptable idle period (where relevant)
- assumed areas of operation
- other relevant information pertaining to ensuring AFS performance.

The above is the minimum information required but more may be needed depending on the specific coating system. It is critical that these assumptions are periodically reviewed during the ship's operations to identify periods that the AFS will or may not perform according to the manufacturer's technical specifications. Deviations from these parameters should be discussed with the coating manufacturer to determine the impact on the efficacy of the specified coating scheme.

10.2 Marine growth prevention systems (MGPS)

MGPS systems use several technologies to reduce the likelihood of biofouling growth in niche areas. Some of these are not technically robust and providing an overview of all available methods is beyond the scope of this document.

The MGPS manufacturer should provide instructions on the cleaning and protection of the MGPS during cleaning.

The following information provided by the MGPS supplier must be included in the biofouling management plan and record book as appropriate:

a. type of MGPS
b. date of application and performance period/lifetime
c. location(s) where MGPS was/were installed
d. the expected effective lifetime of consumable elements of the MGPS
e. operating conditions required for MGPS to be effective
f. dosing and application frequency of MGPS (as applicable)
g. any other specifications relevant to the MGPS' performance.

When using a system that injects chemicals such as chlorine or sodium hypochlorite, the manufacturer should provide information about the recommended amount of chemical that should be used and include chemical safety as well as emergency and neutralization protocols.

10.3 Communication between shipowner and AFS manufacturer after cleaning

When the cleaning activity has been completed and the cleaning report has been received, the shipowner should provide the following cleaning information to the AFS manufacturer:

- details from the cleaning report including any reported damage to the AFS, excluding commercially sensitive information
- date of cleaning

- number of previous cleans since the application or installation
- cleaning company
- method used during cleaning (diver, ROV)
- nechanism of clean (brush, waterjet, cavitation etc).

The AFS manufacturer should compare the available data of their product with the information received from the shipowner in order to be able to give an estimation of the remaining lifetime of the AFS. This assessment including any recommendations that need to be met for the remaining lifetime of the AFS should be communicated to the shipowner.

11 Management of materials and seawater effluent

This chapter sets the standards for the capture and handling of removed materials in connection with in-water cleaning. The handling of seawater effluent prior to its release back into the sea are also included in this chapter.

This chapter is not intended to replace requirements of local port state control and other relevant authorities. The cleaning company should seek advice regarding the required testing and environmental sampling regimes for each individual port, where the cleaning will take place. Local requirements concerning eg disposal of material captured during a cleaning operation must be met.

This chapter also outlines the standards according to which approved cleaning companies shall carry out internal auditing of their systems to ensure the required level of efficacy.

11.1 Procedures to manage materials and seawater effluent

The cleaning company shall have procedures in place to avoid release of materials throughout the entire cleaning operation, including when mobilising and demobilising the equipment. Use of non-return valves should be described, if available.

11.2 Material handling

The cleaning company shall have procedures in place that describe the handling of material as well as the capture, separation and/or treatment of seawater.

The approval certificate of the cleaning company shows that the following criteria have been tested and fulfilled:

1. The in-water cleaning process removes at least 90% of macrofouling (ie individuals or colonies visible to the human eye).
2. The separation and/or treatment of captured materials during in-water cleaning both: (1) removes at least 90% (by mass) of material from seawater influent and (2) at least 95% of particulate material in effluent water is 10 µm in equivalent spherical diameter (ESD);
3. Local water quality parameters of Total Suspended Solids (TSS) are not elevated above ambient levels during the same time period.

The approval certificate of the cleaning company may also show that the following criteria have been tested and fulfilled:

4. Local water quality parameters of dissolved and particulate biocides found in AFC are not elevated significantly above ambient levels during the same time period.

The testing of the system has been described in detail in the *Approval procedure for in-water cleaning companies*.

In addition, the separated material shall be disposed of in accordance with local regulations and sea water effluent shall conform with the specifications of the port.

11.3 Auditing of the cleaning system

The cleaning company shall carry out internal audits to check the cleaning system's safety requirements and ability to capture material during operation at least once every 12 months unless higher frequency is required by relevant authorities.

Prior reports in connection with internal auditing of cleaning systems shall be given to the approval body before the below mentioned audits are initiated. If required, internal audit reports should also be sent to the port and/or local authorities.

An annual verification audit is an external audit that involves verification of documents and a visual inspection of the cleaning system and its units.

After any major substantial technical change that has a direct impact on the operational manual and necessitates training of personnel, a renewal or re-endorsement of the certificate shall be carried out.

Every five years, the approval must be renewed though testing and external auditing. If required, outcomes of external audits should be submitted to the port and/or local authorities.

More details on approval, certification and quality insurance can be found in the *Approval procedure for in-water cleaning companies*. If required, outcomes of external audits should be submitted to the port and/or local authorities.

Date of audits must be entered into the cleaning company's log of cleaning activities and refer to audit reports and test results.

11.4 Documentation requirements

The cleaning company shall maintain a log of all cleaning activities. This should include the number of cleaning operations carried out, the name and IMO number of the ship, the AFS, type of cleaning, amount of material captured, records (or copies of records) of disposal of such material and sea water effluent, records of accidental discharges if any (including records of having reported this to the relevant authorities) and all relevant laboratory results to confirm the efficacy of the system.

Commercially sensitive information shall not be stored by the cleaning companies, unless authorised by the respective owners of such information. Should there be a need for any further information later, the same shall be sourced from the rightful owner of such information.

11.5 Underperforming systems

Underperformance of cleaning systems must be immediately reported to the port, the approval body and relevant authorities.

Any underperforming cleaning system shall be repaired or replaced to the satisfaction of the approval body issuing the certificate and local authorities issuing the permit.

ANNEX 1 Sample in-water cleaning actions in a biofouling record book

Details of all inspections and biofouling management measures undertaken on the ship shall be entered into the biofouling record book. The following shows a number of examples that have been entered into different biofouling record books.

The tables should be read in conjunction with Appendix 2 of the IMO Biofouling Guidelines. The item numbers in the table refer to this appendix.

SAMPLE OF BIOFOULING RECORD BOOK PAGES		
Date	**Item (number)**	**Record of management actions**
15-Jan-2018	2.2 a	05 Jan 2018, Dubai anchorage, assessment indicates biofouling growth on hull. Reference areas 1.1, 1.2, 2.1, 2.2,3 .1,3.2, 4.1, 4.2, 5.1, 6.1, 6.2 found to be covered with soft biofouling.
	2.2 b	Entire underwater hull including reference areas and 8 niche areas inspected.
	2.2 c	10% biofouling growth observed on the hull and niche areas. Hard calcareous biofouling covering between 2-5% of the entire underwater hull areas observed. Height of hard calcareous ranges between 5 to 15 mm.
	2.2 d	Refer to hull inspection report no: XXXX, dated: XXXX, for more information.
	2.2 e	Name of office in charge: Position: Signature:

Date	**Item (number)**	**Record of management actions**
15-Jan-2018	2.3 a	05 Jan 2018, Dubai anchorage
	2.3 b	Aft half of hull including reference areas 1.1, 1.2, 2.1, 2.2, 3.1, 3.2, 4.1, 4.2, 5.1, 6.1, 6.2 cleaned. Following niche areas cleaned – propeller, rudder, sea chest, aft echo sounder probe.
	2.3 c	High pressure water jets and vacuum suction used.
	2.3 d	**Before cleaning:** 10% Biofouling growth observed on the hull and niche areas. Hard calcareous biofouling covering less than 5% of the entire underwater hull areas observed. **After cleaning:** Aft half of hull, including reference areas 1.1, 1.2, 2.1, 2.2, 3.1, 3.2, 4.1, 4.2, 5.1, 6.1, 6.2 cleaned, and documentation shows no biofouling in these areas.
	2.3 e	See cleaning report no: XXXX, dated: XXXX And associated photographs and videos.
	2.3 f	Ship permit to work No: XXXX, dated: XXXX Port permit to work No: XXXX, dated: XXXX
	2.3 g	Name of office in charge: Position: Signature:

Date	Item (number)	Record of management actions
15-Jan-2018	2.3 a	05 Jan 2018, Dubai anchorage
	2.3 b	Aft half of hull including reference areas 1.1, 1.2, 2.1, 2.2, 3.1, 3.2, 4.1, 4.2, 5.1, 6.1, 6.2 cleaned. Following niche areas cleaned – propeller, rudder, sea chest, aft echo sounder probe.
	2.3 c	High pressure water jets and vacuum suction used.
	2.3 d	**Before cleaning:** 10% Biofouling growth observed on the hull and niche areas. Hard calcareous biofouling covering less than 5% of the entire underwater hull areas observed. **After cleaning:** Aft half of hull, including reference areas 1.1, 1.2, 2.1, 2.2, 3.1, 3.2, 4.1, 4.2, 5.1, 6.1, 6.2 cleaned, and documentation shows no biofouling in these areas.
	2.3 e	See cleaning report no: XXXX, dated: XXXX And associated photographs and videos.
	2.3 f	Ship permit to work No: XXXX, dated: XXXX Port permit to work No: XXXX, dated: XXXX
	2.3 g	Name of office in charge: Position: Signature:

Date	Item (number)	Record of management actions
15-Jan-2018	2.4 a	05 Jan 2018, Dubai anchorage
	2.4 b	Significant growth of biofouling was observed in the seawater cooling pipes. Predominant type of biofouling was goose neck barnacles.
	2.4 c	Cleaned to the extent possible
	2.4 d	Vacuum suction, manual tools
	2.4 e	See cleaning report no: XXXX, dated: XXXX
	2.4 f	Name of office in charge: Position: Signature:

Date	Item (number)	Record of management actions
01-Mar-2020	2.6 a	Ship anchored at Fujairah anchorage.
01-Apr-2020	2.6 b	Anchor aweigh and ship resumed voyage to Ruwais.
02-Apr-2020	2.6 c	Ship headed for an underwater hull inspection.
02-Apr-2020	2.6 d	Sea chest blanked off / Echo Sounder probe raised etc.

Date	Item (number)	Record of management actions
15-Feb-2019	2.9 a	During port entry, tug made metal to metal contact with ship's hull. AFS damage may have occurred. Hull to be inspected during ship's port stay.

ANNEX 2 Reference areas

A set of reference areas should be determined for use of inspection and to gauge the efficacy of the cleaning.

Reference areas located on the hull should be prepared as early as possible in the life of the ship, and preferably as soon as the hull has been coated or re-coated with a new AFS. The outline of the reference areas could be done using contrasting colours.

Selection of reference areas
Reference areas shall give a general representation of the submerged areas of the entire ship's hull and niche areas. When selecting the areas, it should be considered that different areas of the hull are affected by biofouling to varying degrees.

Already existing identification marks, such as draft marks, tank/hold marks, load line marks and other easily identifiable locations, sea chests, discharges, transducers, bottom plugs on the ship's hull should be used whenever possible. Ships, that are assigned in-water cleaning class notations, have additional hull markings that can be used.

When determining the reference areas, the underwater hull of the ship should be divided into vertically separated areas and each assigned a reference location.

The underwater hull area of the ship should be divided into enough longitudinally (fore and aft direction) separated sections. See figure 4.

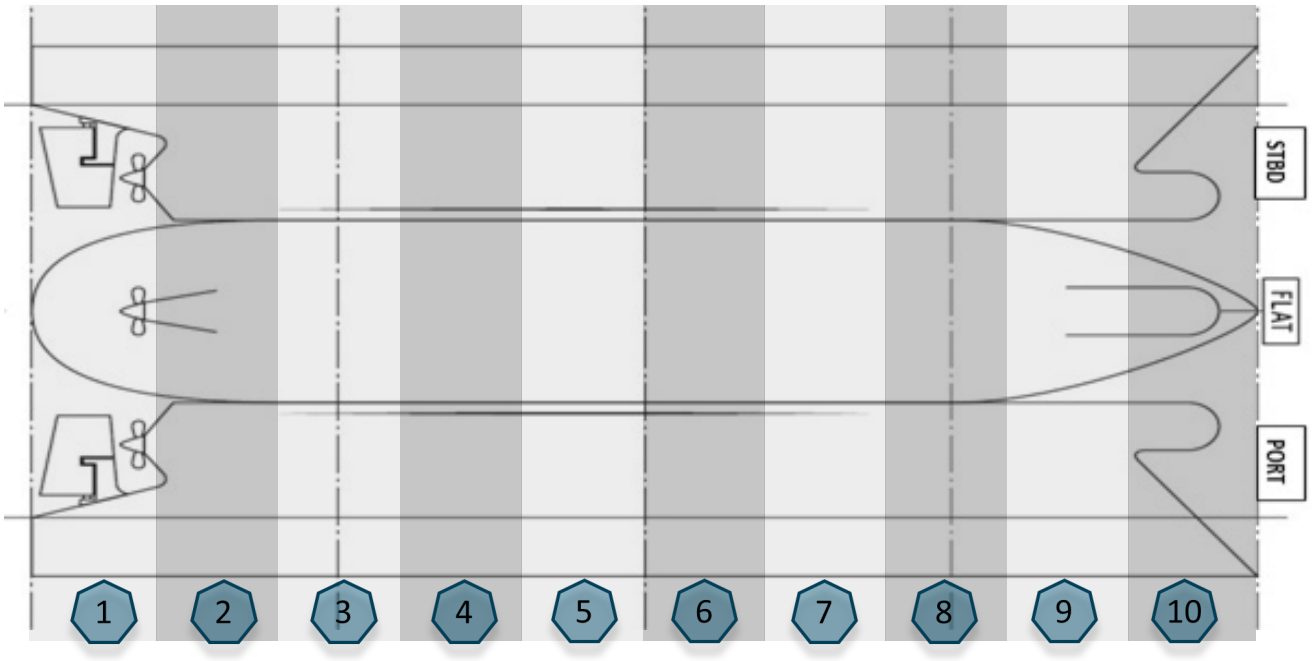


Figure 4: Ship divided into longitudinally separated vertical sections.

In each of these sections, one or more reference areas should be selected. Studying the following plans and reports may help in this process:

1. general arrangement plan
2. plans showing existing hull markings
3. bottom plug plan
4. shell expansion plan
5. previous in-water inspection reports that help to indicate which areas divers found easy to reach or identify, as there will be repeated mention of the same areas in multiple reports
6. dry-dock reports.

The result of a selection of reference areas can be seen on figure 5.

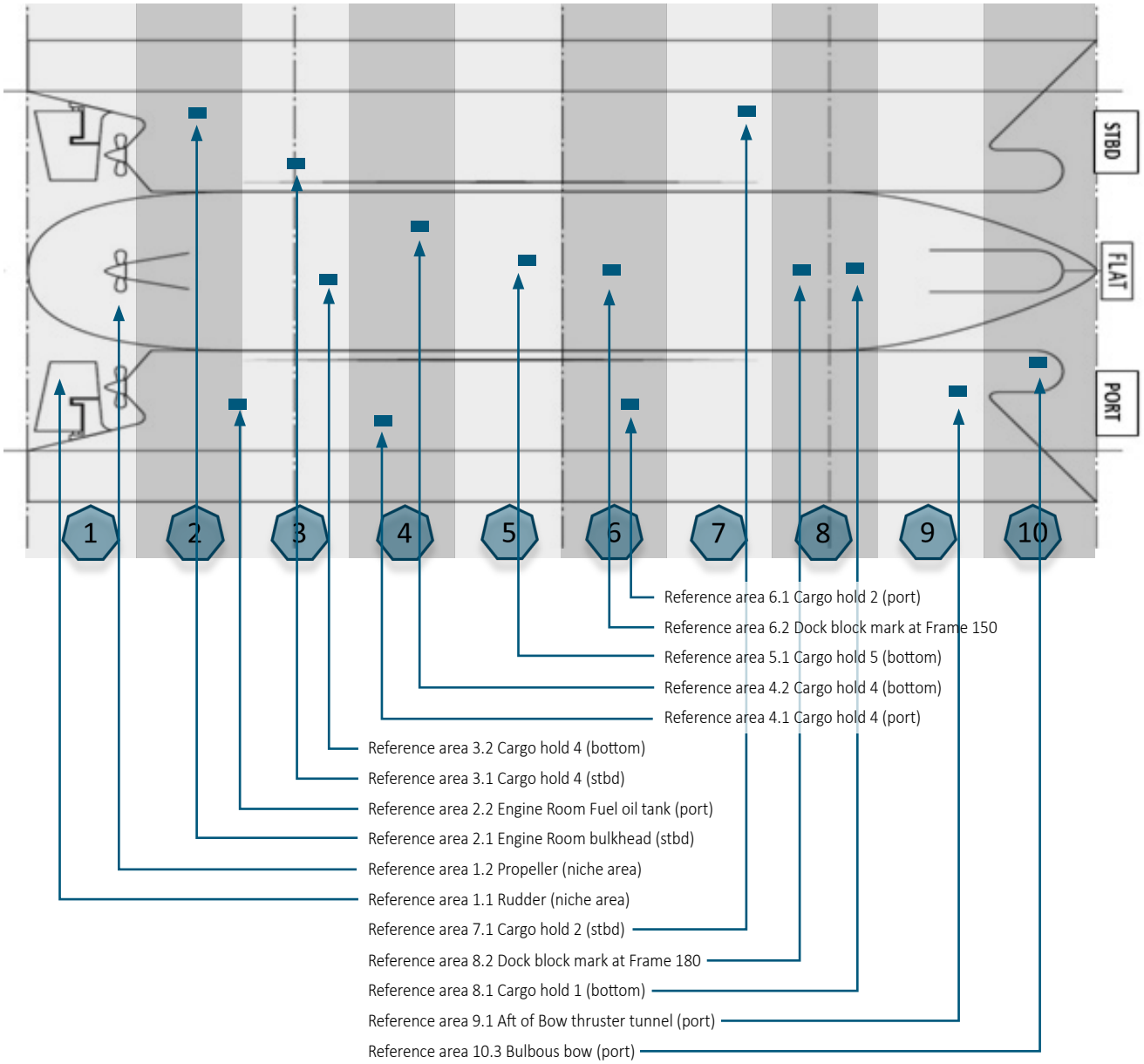


Figure 5: *Example of reference areas and their numbering.*

1. The number and location of the selected areas should represent the entire underwater hull and niche areas of the ship. This means choosing reference areas at various depths of the vertical hull as well as the bottom of the ship.
2. Reference areas should be named/numbered for easy identification. Numbering should be such that, it is easily identifiable, and easy to be sequentially inspected by a diver or camera/ROV.
3. The reference areas shall be inserted in the biofouling management plan and a similar entry shall be made in a separate section in the biofouling record book.

Alternative method in case the reference areas are not marked by contrasting colours etc:

1. The underwater hull area of the ship should be divided longitudinally into (fore and aft direction) separate sections that represent the whole underwater area.
2. In each of these zones, reference areas should be selected at preassigned drafts of the ship. For example, at the depth 6 meter, 4 meter, 2 meter and 0 meter (bottom) on each side of the hull.
3. For each of these areas, an existing hull marking above the water line such as draft mark, load line mark, cargo hold number, cargo tank number, pilot boarding area marking, tug marks should be chosen as pre-reference mark.
4. If there are not enough existing markings or distinguishing hull structures, the shipowner may choose to mark additional marking on the vertical surface above the water line for easy identification.

Figure 5 illustrates the choice of reference areas.

ANNEX 3 Standards of photographs and videos

Photographs and/or videos taken by a diver or ROV should follow certain specifications to conform with this standard. The purpose of the photographs/videos is to support the diver/ROV inspection and to document the biofouling and AFS condition.

Photograph of reference areas:

1. The photograph should depict the general condition of the area and should, if visibility permits, cover the entire reference area. In the event of restricted visibility, the reference area can be photographed using a mosaic of photographs.
2. The diver/camera operator should carefully choose the camera settings to ensure proper lighting, exposure, focus, colour, tone etc for capturing an accurate image.
3. The angle of the picture should be chosen carefully to ensure a true reflection of the marine growth and/or damages to AFS system, if any. The correct angle, without use of IT programs to compensate, is perpendicular to the surface.

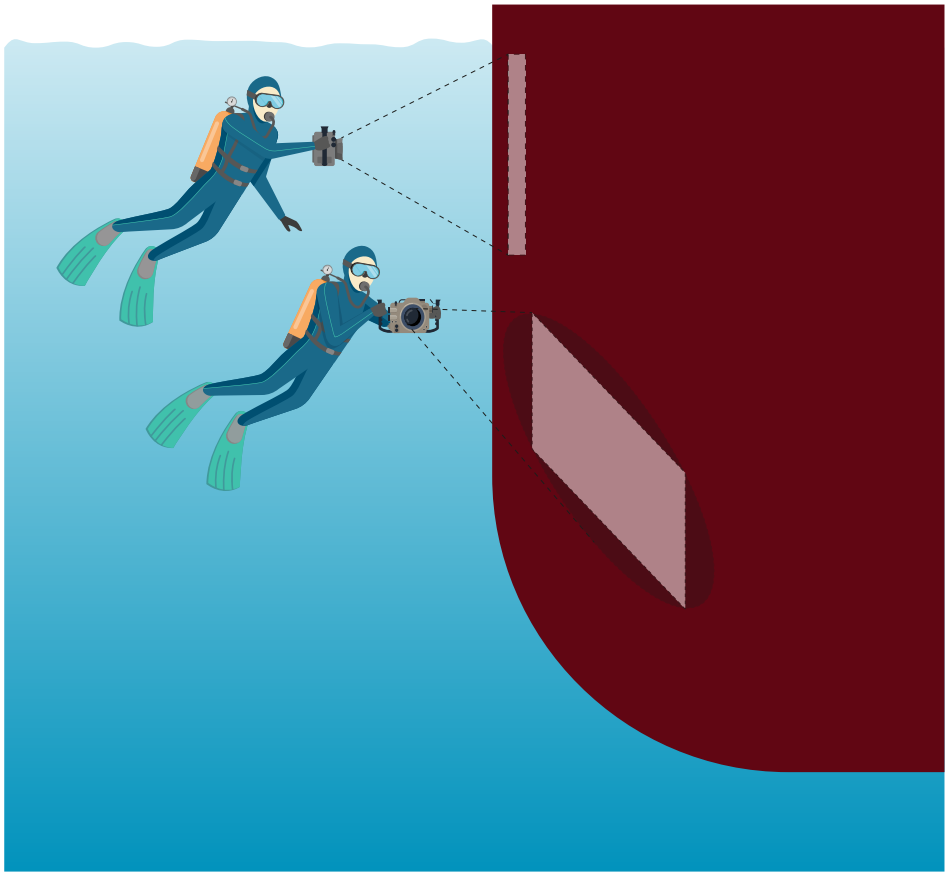


Figure 6: Camera angle and location.

The reference area number should be identifiable on the photograph. This may be done either during filming or later during the editing process.

NACE International has published a standard, SP21421 – 2017, for underwater evaluation of biofouling degree on ships hulls, which is designed to facilitate descriptions of degree of biofouling. This standard uses pictures with examples of high quality and gives standards for scale etc.

Video specification:

1. Speed: The diver or the cleaning supervisor should determine the speed keeping the following factors in mind:
   a. size of the field-of-view in video
   b. sunlight and associated glare
   c. area of the ship being videoed
   d. video equipment's capability.
2. In any case, the swimming speed over the hull should not exceed 30 cm/s (0.6 knots) to prevent blurring of the image in individual frames.
3. The reference areas should be captured within the video. If the video camera is unable to cover an entire reference area in one run, a system should be in place to enable sampling of recordings to show the entire reference area.

ANNEX 4 Inspection report

Inspection reports should as a minimum include the following:

Date of report:

General information	
Name of the ship	
IMO number	
Name of the company performing the service	
Evidence of cleaning company authorization	*This is evidence that the company is authorised to conduct operations as per this Industry standard. Could be authorization number or copy of the approval certificate.*
Document ID / job number	
Position of the ship / geographical location of ship	
Type, age, and size of the ship	
Date of inspection	

Arrival draft (forward, midships, aft)	F: M: A:
Current (knots)	*XX* knots
Visibility of water	*XX* metres
Sea state	*Calm, fair, rough etc*
Weather	*Sunny, cloudy, rainy etc*
Type and age of anti-fouling system(s)	*Self-polishing paint (SPC), foul release coating (FRC), hard paint, others* Date of application or number of years/months since application
Ship's specific details	Number of propellers – Number of rudders – Bow, stern, azimuth thrusters –

Time – contractor alongside	
Time – start operations	
Time – completed operations	
Delays, if any with reasons	
Description of inspection carried out	*Number of divers, ROVs and recorded timetables*
Damage and/or special events, if any	
Biofouling coverage observed (% of hull) and type observed	*The percentage should state the coverage of biofouling of areas inspected. For example, if only the aft half of the ship was inspected and 5% cover was seen in this area, then the report should state – "5% biofouling coverage seen from midships to aft end of the ship". Care should be taken to not mention this as 2.5% of the entire underwater surface or 5% of the entire underwater surface as this may differ significantly.*

Area Number *XX*: (reference to be made to biofouling management plan)	Each area that is inspected should be described below
Name of the anti-fouling system	
Type of anti-fouling or MGPS	
Condition of the anti-fouling system	
Type of paint defects observed and extent (% of area)	*Intact / detached / cracked / blistered / cold flow / orange peel / sagging (tears) / polished off / damage due to external contact (tug, fenders, grounding)*
Is biofouling observed?	
Type of biofouling observed and extent (% of area or dimensions in length and breadth)	

Soft biofouling, select applicable			Coverage (%)
	☐ Micro	☐ Slime	
	☐ Macro	☐ Soft corals ☐ Sponges ☐ Hydroids ☐ Anemones ☐ Algae ☐ Tunicates	
Hard calcareous biofouling, select applicable			Coverage (%)
	☐ Macro	☐ Barnacles ☐ Mussels ☐ Tube worms ☐ Bryozoan ☐ Oysters ☐ Other (specify)	

Predominant type of biofouling observed, if any. Please tick.	☐ Slime	☐ Soft corals ☐ Sponges ☐ Hydroids ☐ Anemones ☐ Algae ☐ Tunicates	☐ Barnacles ☐ Mussels ☐ Tube worms ☐ Bryozoan ☐ Oysters ☐ Other (specify)

Method used for the inspection (divers, ROV)	
Photos and/or videos of the area	
Any other comments	

Area number *XX*: (reference to be made to biofouling management plan)	Each area that is inspected should be described below
To repeat the items as mentioned above. The report should contain separate details of all inspected areas.	An entry should be made separately for every area inspected and details mentioned above to be included.

Area – Propeller	Each area that is inspected should be described below
To repeat the items as mentioned above. The report should contain separate details of all inspected areas.	An entry should be made separately for every area inspected and details mentioned above to be included.
Number of propellers	
Number of blades on the propellers	
Pods	Yes / No
Blade type	*Fixed pitch / Controllable pitch*
Boss cap fins	Yes / No
Propeller diameter	*XX* mm
AFS coating if any	
AFS condition	*Intact / detached / cracked / blistered / cold flow / orange peel / sagging(tears) / polished off / damage due to external contact (grounding)*

Biofouling	☐ Slime	☐ Soft corals	☐ Barnacles
		☐ Sponges	☐ Mussels
		☐ Hydroids	☐ Tube worms
		☐ Anemones	☐ Bryozoan
		☐ Algae	☐ Oysters
		☐ Tunicates	☐ Other (specify)
Other sediments	*Coverage of calcium*		
Boss cap	*N/A / secure / keepers intact / bolted cover secure / covered*		
Boss anode	*%* depleted		
Blade fastenings	*N/A / secure /keepers intact / covered / not visible*		
Visible damage	*Cavitation / pitting – details – depth of damage in mm*		
Any other findings			

Name and position of the person in charge of the service activity / cleaning company representative including signature and date:	
Name and position of the person in charge of the ship/shipowner representative including signature and date:	

ANNEX 5 Service report

The service report should at least include the following:

Date of report:

General information	
Name of the ship	
IMO number	
Name of the company performing the service	
Evidence of cleaning company authorization	*This is evidence that the company is authorised to conduct operations as per this Industry standard. Could be authorization number or copy of the approval certificate.*
Document ID / job number	
Position of the ship / geographical location of cleaning	
Last inspection/cleaning	Date, location, (company)
Date(s) of inspection/cleaning	

Arrival draft (forward, midships, aft)	F: M: A:
Current	*XX* knots
Visibility of water	*XX* metres
Sea state	*Calm, fair, rough etc*
Weather	*Sunny, cloudy, rainy etc*

Time – contractor alongside	
Time – start operations	
Time – complete operations	
Delays, if any with reasons	
Description of service activity carried out	*Should include a description of all the services carried out on the ship. This may include type of inspection, or type of cleaning etc. In case a cleaning was only partly finished the description should include enough information of the start and stop of the activity to enable another cleaner to continue the cleaning.*
Description of the materials captured and handling	*A short description of what was captured and how it was handled should be included.*
General description of evidence collected and evidence of cleaning that will accompany the cleaning report	*A short description of what will be included in the final report should be included here.*
AFS damage and/or special occurrences if any	

Name and position of the person in charge of the service activity / cleaning company representative including signature and date:	
Name and position of the person in charge of the ship/shipowner representative including signature and date:	

ANNEX 6 Cleaning report

The cleaning report should as a minimum include:

Date of report:

General information	
Name of the ship	
IMO number	
Principal dimensions (length * breadth * depth)	
Name of the company performing the service	
Document identification / job number	
Position of the ship / geographical location of ship	
Last cleaning	Date, location, (company)
Date(s) of cleaning (present cleaning)	

Arrival draft (forward, midships, aft)	F: M: A:
Exact position of cleaning	*Cleaning location ie berth number, terminal, mooring buoys, mooring dolphins, anchorage (name of anchorage) etc*
Description of position	*Availability of space for cleaning between ship and quay, presence of other ships such as bunker barges, lowest under keel clearance during the entire stay of the ship, blocking parts of the hull (eg fender area) etc*
Current	*XX* knots
Visibility of water	*XX* metres
Sea state	*Calm, fair, rough etc*
Weather	*Sunny, cloudy, rainy etc*
Type and age of anti-fouling system(s)	
Last cleaning details (if available)	Date, location, (company)
Vessel specific details	*Number of propellers, rudders, bow thruster, stern thruster, azimuth thrusters etc*

Time – contractor alongside	
Time – start operations	
Time – complete operations	
Delays, if any with reasons	
Description of cleaning activity carried out	*Should include a description of all the services carried out on the ship. This may include type of inspection, or type of cleaning etc. In case a cleaning was only partly finished the description should include enough information of the start and stop of the activity to enable another cleaner to continue the cleaning.*
Description of the materials captured and handling	*A short description of what was captured and how it was handled should be included.*
Damage and or special occurrences if any	*A short description of what will be included in the final report should be included here.*

Area number *XX*: (reference to be made to biofouling management plan)	Each area that is cleaned should be described below *Hull cleaning: Starting point, area cleaned and end point. A sketch eg on the general arrangement may be used.* *Detailed description of the niche areas in question*			
Condition of the anti-fouling system before cleaning.				
Type of biofouling observed and extent (% of area or dimensions in length and breadth)	Select applicable			
			Coverage before (%)	Coverage after (%)
	☐ Micro	☐ Slime		
	☐ Macro	☐ Soft corals ☐ Sponges ☐ Hydroids ☐ Anemones ☐ Algae ☐ Tunicates		
	☐ Macro	☐ Barnacles ☐ Mussels ☐ Tube worms ☐ Bryozoan ☐ Oysters ☐ Other (specify)		
Condition of the anti-fouling system after cleaning?				
Pictures of the area before cleaning				
Pictures of the area after cleaning				

Area number *XX*: (reference to be made to biofouling management plan)	Each area that is cleaned should be described below
To repeat the items as mentioned above. The report should contain separate details of all cleaned areas.	An entry should be made separately for every area cleaned and details mentioned above to be included.

Area – Propeller			
Number of propellers			
Number of blades on the propellers			
Pods	Yes / No		
Blade type	*Fixed pitch / Controllable pitch*		
Boss cap fins	Yes / No		
Propeller diameter	*XX* mm		
AFS coating if any			
AFS condition	*Intact / detached / cracked / blistered/ cold flow/ orange peel / sagging(tears) / polished off / damage due to external contact (grounding)*		
Biofouling	☐ Slime	☐ Soft corals ☐ Sponges ☐ Hydroids ☐ Anemones ☐ Algae ☐ Tunicates	☐ Barnacles ☐ Mussels ☐ Tube worms ☐ Bryozoan ☐ Oysters ☐ Other (specify)

Other sediments	*Coverage of calcium*
Boss cap	*N/A / secure / keepers intact / bolted cover secure / covered*
Boss anode	*%* depleted
Blade fastenings	*N/A/ secure / keepers intact / covered / not visible*
Visible damage	*Cavitation / pitting – details – depth of damage in mm*

Condition of the anti-fouling system after cleaning?	
Pictures of the area before cleaning	
Pictures of the area after cleaning	
Any other findings	

Treatment details	
What is the estimated amount of materials captured?	By weight
What treatment of seawater was done?	*eg technology used to separate and treat*

Name and position of the person in charge of the service activity / cleaning company representative including signature and date:	
Name and position of the person in charge of the ship/shipowner representative including signature and date:	

ANNEX 7 Explanatory notes to the *Industry standard on in-water cleaning with capture*

It has been necessary to divide niche areas into different categories because the same piece of equipment cannot be used to clean all of them:

a. The hull itself and niche areas present on the vertical side or the bottom of the ship that can be readily cleaned without using special equipment. On such areas, the equipment used is designed to clean large flat areas fast, which includes remotely operated vehicles (ROV's) and divers.

b. Propellers. The *Industry standard* addresses cleaning of the propeller with capture.

c. Niche areas that for example are built into the hull and/or have bends or corners have to be cleaned with special equipment and therefore are non-comparable to (a) and (b).

A cleaning company can be approved for one or more of the categories. The approval process involves a test of the equipment and the certificate will specify which category or categories the cleaning company is approved to perform.

Biofouling will build-up faster in areas, where it has not been possible to apply an AFS, for example dock block areas, which can be categorized as a niche area in the above-mentioned category (a).

On average dry-dock support strips situated on the bottom of the ship (also referred to as block marks) are defined as niche areas and can be calculated to cover between 0.6% and 1.5% of the submerged hull area dependant on the kind and size of the ship. The *Industry standard*, therefore, presumes that the above-mentioned category (a) niche areas may be equal to 5% of the submerged hull area and an ROV or a diver can use normal equipment to clean them.

Dock block areas may be more fouled than the surrounding coated areas, some of which may be hard calcareous biofouling with a height that lies beyond that for which the cleaning unit has been approved.

The references areas are used to estimate the total percentage coverage by taking the average coverage of all the reference areas as well as other observed areas.

The following is a non-exhaustive list of niche areas:

1. sea chests
2. thrusters (bow, stern, azimuth etc)
3. tunnels associated with these thrusters
4. propeller shafts
5. gratings (all gratings underwater)
6. access hatches and covers
7. rudder, rudder stock, hinge/pintle area
8. stern tube seal, rope guard external/internal
9. propeller and boss cap
10. bilge keels
11. cathodic protection anodes
12. stabilizers and associated fins, spoilers
13. inlet/outlet pipes (all pipes underwater)

14. transducers (echo sounder, speed log)
15. pitot tubes
16. bulbous bow
17. tug push points
18. areas of the hull that have been in contact with fenders
19. areas of the hull that have been in contact with anchor chains
20. waterline (boot top area)
21. anchor chains and chain lockers
22. edges and weld joints
23. any free flood spaces that may be immersed either wholly or partly when the ship is afloat.

There are a variety of methods available for cleaning the hull and niche areas. Some companies use ROVs and others use divers. Further, some cleaners use brushes, whilst others use water jets and other types of equipment. The *Industry standard* does not delve into the details of any specific cleaning methods and techniques nor does it provide any form of rating. Instead, the *Industry standard* concentrates on the processes for relevant stakeholders that will ensure a safe, efficient and environmentally sound in-water cleaning process.

Ship's documentation

In 2011, IMO adopted the guidelines recommending the use of a biofouling management plan and biofouling record book (Resolution MEPC.207(62), 2011 Guidelines for the Control and management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species (IMO Biofouling Guidelines). The information in the IMO Biofouling Guidelines has formed the basis of the *Industry standard*.

Biofouling management plan and record book
In this chapter, the requirements for the recordings that should be made by the ship in addition to the IMO Biofouling Guidelines are listed. Further, some coastal states and port states may require additional documentation.

The ship specific information that should be included in the biofouling management plan can be found from the initial ship specification documents and docking survey files. Other sources of this information are the shipyard or AFS manufacturer.

From a practical point of view, it may be beneficial to incorporate biofouling management in the PMS of the ship and/or the ship's SMS.

The biofouling record book should assist the shipowner and operator to evaluate the efficacy of the specific AFS, the operational practices on the ship and the biofouling management plan in general.

The biofouling record book should be completed, so that relevant authorities can assess the potential biofouling risk of the ship quickly and efficiently, thus minimising potential delays to the ship's operations.

The Institute of Marine Engineering, Science and Technology (IMarEST) and International Paint and Print Ink Council (IPPIC) have provided a template for the biofouling management plan, which is recognised by some coastal state authorities for invasive species prevention. It can be downloaded from the internet[5].

5 https://www.imarest.org/special-interest-groups/biofouling-management/item/3505-template-for-biofouling-management-plan

Reference areas
The *Industry standard* introduces reference areas, which will serve as areas that are used to measure the efficacy of the cleaning. By definition, a niche area is a reference area.

During every inspection, attention should be paid to the reference areas and ensure information is being recorded correctly. The condition of reference areas will help give an indication of biofouling growth, therefore, accurate inspection and recording of details will be of upmost importance. It may not be possible to inspect all reference areas during one inspection, so every new inspection should select different reference areas in order to represent the entire underwater area. A full inspection should cover the entire ship and in addition inspect other relevant locations between areas that are not designated as reference areas.

The minimum number of reference areas mentioned in the *Industry standard* is ten, but on a large ship and taking the number of niche areas into account, more areas will be needed. On flat surfaces, reference areas should be carefully chosen to ensure that they are sufficient in number and spread out in such a way that as a whole, they are representative of the entire underwater area of the ship. The total number of reference areas should be manageable, and the maximum number of reference areas should be chosen to ensure that the inspection will be practical.

Today, most reference areas on the hull are unmarked. When repainting the hull or when building a new ship, the marking of these areas should be considered.

Photos and videos
If the quality is good, a photo says more than a thousand words. The *Industry standard* sets minimum requirements for still photos and videos used for documentation both before and after cleaning.

In-water inspection planning

In general, biofouling management should be based on an assessment of the ship's condition in combination with visual in-water inspections. The assessment may include an on-line monitoring system collecting data from sensors, analysis of manually collected data such as from noon reports, dedicated speed trials, employment of diving contractors to conduct inspections, use of ROVs, or crew inspections using underwater cameras and drones.

At times, local regulations demand that a ship arrives after it has carried out an in-water inspection and, if necessary, a cleaning of the hull and niche areas. Also, certain commercial agreements as specified in the contract between the shipowner and the charterer or the AFS manufacturer can necessitate an inspection.

Whenever a propeller cleaning operation takes place, it is recommended that the scope includes a hull and niche areas inspection to determine the level of biofouling, condition of the AFC (existence of blisters, peeling off or any other sign of deterioration) and hull damage. Propulsion improvement devices, scrubber outlets and transducers may also be inspected to establish if cleaning is required.

Assessment of biofouling growth
A risk assessment can vary in sophistication depending on whether it is based on fleet statistics or on the actual trade of the ship. It should be noted that some coastal states perform a risk assessment on a ship, prior to arrival at port to determine if access may be granted or if an inspection of the biofouling is required.

Based on the predominant trading areas and operational profile of the ship, the risk of biofouling growth can be described by using the following risk groups, noting that active biofouling management

can be used to improve a ship's risk group:

Low	The ship trades and operates in a way that the risk of biofouling can be considered as low.
Medium	The risk of biofouling growth is present due to the trade and operation pattern of the ship
High	The ship's trade and operation pattern results in a high risk of biofouling growth.

The extent to which the operational profile of the ship is in the "high risk" or "medium risk" categories triggers shorter periods between in-water inspections.

The following explains the factors in more detail:

- Water salinity – Scientific evidence suggests that the number of living organisms increase in water, which has a higher level of salt and minerals.
- Water temperature – I0t has been shown that global marine biodiversity is correlated with water temperature. The western Pacific Ocean and broad equatorial regions of the oceans in general host the greatest diversity[6]. Locally, coastal regions and areas with higher water temperatures will host a greater diversity as a result of more favourable nutrients, sunlight and other factors associated with species' abundance. So, there is an increased chance of biofouling accumulation on the surface of the ships operating in these warmer areas compared with cooler water bodies.
- Depth of water and distance to shore – As the depth of water increases, the abundance of biofouling species typically decreases as a result of changing environmental conditions. As such, ships operating in trans-continental routes as opposed to coastal ones typically experience a lower biofouling challenge.
- Hull roughness – A rough hull provides an ideal substrate for biofouling organisms. With today's technology it is not possible to reliably measure the hull's roughness underwater on a commercial scale. This may change as technology evolves.
- Age of anti-fouling coating – By design, self-polishing or ablative AFS erodes over time, but the predictable characteristic of the product helps ensure proper efficacy. The impact of potential cleaning should be taken into consideration during the paint specification process. Unplanned cleaning may accelerate coating loss, thus making it difficult to reliably measure the remaining lifetime span of the AFS when the ship is in the water or to anticipate coating depletion. Different coloured layers of coating can give a visible indication of polishing/erosion speed. This will not be the case with non-polishing coatings, such as epoxy or silicone-based systems.
- Surface treatment – The extent of surface treatment done at last drydocking has an impact on the potential biofouling growth on a hull. Full blast means that there is a low risk, while spot blast (especially if consecutive spot blasts have been conducted on previous drydocking) constitute a significant risk.
- Utilisation rate and idle time – This has a very direct and large impact on attachment of biofouling organisms onto a ship's hull. The risk of biofouling for a ship increases with idle time and/or low utilisation rates. This is especially the case with coatings that are dependent on polishing or water friction to facilitate biofouling control, ie waterflow over the hull surface is necessary to maintain the coating's surface condition. The AFS manufacturer's recommendations regarding idle periods and speed profiles for the ship provided should be adhered to. Failure to do so increases the risk that accumulated biofouling may not detach even if the ship meets recommended cruising speeds. In such cases, cleaning may be required to correct the coating's surface condition.

6 Tittensor, D., Mora, C., Jetz, W. et al. Global patterns and predictors of marine biodiversity across taxa. Nature 466, 1098–1101 (2010) doi:10.1038/nature09329.

- Speed – Coatings should be chosen to match the operating profile and speed of the ship. In cases, where ships operate below the recommended speed, biofouling can accumulate, especially if this continues for extended periods. Only when a ship travels at speeds specified by the AFS manufacturer, will biofouling attachment be prevented. It should be noted that some niche areas will be exposed to different water flows when the speed changes and this may reduce the biofouling accumulation.
- Damage to the AFC – The AFC can get damaged by physical contact with hard and heavy objects such as fenders, tugs, anchor chain, sitting on seabed during low tides etc. Areas with damaged or missing AFC may no longer be protected against biofouling growth.

Assessment of the propulsion power and fuel consumption
The hull and propeller performance monitoring are carried out by analysing the data collected from the ship either manually for example by noon reports or automatically through high frequency data collection tools.

A standardized method to measure the performance of a ship's hull through the water can be found in the international standard ISO 19030, which outlines general principles on how to measure changes in hull and propeller performance, and defines the four performance indicators for hull and propeller maintenance as well as repair and retrofit activities. The standard outlines a series that consist of three separate parts:

- Part 1: General principles – Ships and marine technology – Measurement of changes in hull and propeller performance
- Part 2: Default method – Ships and marine technology – Measurement of changes in hull and propeller performance
- Part 3: Ships and marine technology – Measurement of changes in hull and propeller performance – alternative methods.

It should be noted that a high frequency data collection system gives a better estimation of the level of biofouling, the condition of the AFS on the hull and the state of the propeller. This information can help determine when a hull inspection may be needed, the outcome of which may lead to hull and/or propeller cleaning.

In the absence of an online data collection system, dedicated ship trials can also help determine the hull efficiency in terms of power and fuel consumption variations at certain loading conditions.

Ship trials require planning to minimise the disruption to the ship's schedule and crew's routine. Also, commercial commitments need to be taken into consideration in order to plan the possibility of performing return runs.

Besides the use of an effective hull and propeller performance monitoring system to ascertain if expected performance targets are met, an operator should also set up a documented drydocking procedure with quantified quality control metrics. Drydocking strategy comprises of the selection of the appropriate anti-fouling suitable for the type of ship, its expected trade profile, coating application and surface preparation (extent and quality).

Inspections

Hull inspections are carried out for various reasons and may be a part of the ship's operation cycle.

Documentation of an inspection is crucial to biofouling management. Missing or inaccurate documents can lead to delays, and/or extra costs. It is, therefore, important to ensure the inspection

is sufficiently documented to fulfil the following purposes:

- be a decision tool for the shipowner as to when to initiate a cleaning
- function as documentation for authorities
- provide enough information for the cleaning company to visualise and plan the cleaning regarding cleaning method, equipment and procedures.

This documentation may also be required when dealing with the commercial aspects such as assigning responsibility or financial burdens.

In this context, details should be provided about biofouling types, coverage, height or length, and the condition of the AFS.

Biofouling types and coverage
The *Industry standard* is based on an estimation of the biofouling coverage of the reference areas as well as an estimation of the total coverage. There are other standards that are based on the biofouling coverage. The table below is a comparison between different popular standards:

Industry standard	ASTM	NACE
Soft microfouling Slime	FR 0, FR 10, FR 20	Code L, Code M, Code H
Soft macrofouling Algae	FR 20	Code H
Soft macrofouling Soft corals, sponges, hydroids, anemones, tunicates	FR 30	Under revision
Hard calcareous macrofouling Soft corals, sponges, hydroids, anemones, tunicates	FR 40 (tubeworms), FR 50 (barnacles), FR 60 (tubeworms and barnacles) (less than 6.4 mm in height) FR 70 (tubeworms and barnacles), FR 80, Fr 90, (more than 6.4 mm in height) and Fr 100	Under revision

Table 1: Comparison between biofouling categorisations.

ASTM refers to: Naval Ships' Technical Manual, chapter 081, Waterborne Underwater Hull Cleaning of Navy Ships, 2006.

NACE refers to: SP21421 "Pictorial Standard for Underwater Evaluation of Fouling Degree on Ship Hulls", 2020.

Further NACE TG 581, "Standard Practice Inspecting and Reporting Biofouling and Antifouling Systems Condition during an In-water survey", 2020 provides an Appendix with indicative comparison of common biofouling ratings and scales used by the industry.

The different types and scales of biofouling listed in the *Industry standard* can be used as practical tools for planning and carrying out in-water cleaning.

Different types of biofouling will result from different hydrodynamic drag. This increase in drag can be up to 40%[7]. The impact depends on type, distribution and growth, which are rarely homogenous, thereby adding to the complexity of the problem.

7 See for example: Schultz, M. P., Bendick, J. A., Holm, E. R. and Hertel, W. M. (2011) Economic impact of biofouling on a naval surface ship, Biofouling, 27: 1, 87 – 98.

In order to make the *Industry standard* practical, it has been decided to use visual assessment tools and pictorial reporting. The reporting should describe the size, coverage and overall type of biofouling rather than delve into the detail of the different types of biofouling.

A ship's AFS may have a set of terms and conditions that ensure a specific performance level. The method, by which this is determined, will vary depending on the company and product. For example, performance can be measured according to the extent of biofouling observed on the ship during the lifetime or based on fuel consumption rates or other associated parameters such as power consumption of the ship. It is typical to set a threshold, which is defined as the "failure point". It is important to note that the failure point agreed upon with the manufacturer may not always correspond to regulatory requirements for hull cleanliness. Data sharing requirements may be required dependant on the basis of the agreement regarding performance measurement and the provision of the data used to confirm any failure.

Anti-fouling system condition
It is important for the shipowner, cleaner and AFS manufacturer to have knowledge of the AFS condition. The use of a pictorial guidance has been chosen to ensure the *Industry standard* is easy to use. Some types of damage and the extent of the damage may prevent cleaning from being initiated. This will have to be decided on a case by case basis after contacting the AFS manufacturer.

There are standards, which can also be used to assess the condition of the AFC. Examples can be found in the following standards ASTM D610, Standard Practice for Evaluating Degree of Rusting on Painted Steel Surfaces, and SSPC-VIS2-68T, Standard Method of Evaluating Degree of Rusting on Painted Steel Surfaces.

Service report after inspection
The full details of the inspection and/or cleaning are contained in the inspection/ cleaning reports. However, since the level of detail is high and time consuming, the report may not be ready at the same time as the work is completed. In these situations, a service report containing minimum details of the work will be submitted by the company to the master of the ship as a preliminary documentation.

Inspection report
The inspection report stipulated in the *Industry standard* is aimed at the inspection of biofouling and should not be confused with the in-water inspections carried out as part of class or statutory inspections.

It is important that the inspection describes the biofouling growth in the various reference areas, the condition of AFS and that the conclusion estimates the total percentage growth of biofouling on the hull.

Apart from appending the report itself to the biofouling record book, the ship should add all the relevant information from the inspection report into the biofouling record book.

Pre-communication

The cleaning should be seen as a part of the whole biofouling management process. Annex 1 provides an overview of the communication flow between the various parties using the *Industry standard* when conducting hull inspection and/or in-water cleaning.

Only approved cleaning companies should be used for cleaning activities. The shipowner should ask to see proof of approval and the cleaning company shall provide information about the permits and approval certificates in its possession.

The shipowner should provide enough information to enable the cleaning company to plan the practical cleaning. This information can be found in the ship's biofouling management plan as well as in previous in-water inspection and cleaning reports.

There is a reduction in the performance of some types of AFS during the second half of their lifespan. Sharing the age of AFS and its expected lifespan will give an indication of the growth of biofouling that can be expected on the hull and/or niche areas.

Details of other planned activities such as bunkering operations, storing operations etc should be shared with the cleaning company. This information is particularly relevant for the cleaning company's risk assessment if the inspection and/or cleaning operation is going to be conducted.

The cleaning company should be informed if the ship has had any prolonged idle periods or if any other risk of biofouling can be expected in accordance with the ship's operational profile.

Information about the type of equipment used for cleaning the ship's hull and niche areas is crucial and must be provided by the cleaning company. The ship should then check if the proposed method is in accordance with the AFS applied.

The information provided by the cleaning company will enable the ship to plan internal procedures to accommodate the in-water cleaning and any measures to be applied during the process.

If the AFS has exceeded its operational life, the cleaning company should refuse to conduct the cleaning operation. However, the master of the ship and cleaning company, can reach a special agreement with the local authorities to conduct the cleaning. It should be noted that during the cleaning of a ship coated with an expired AFS, the coating may have a higher risk of being damaged and present an increased risk of chemical contamination to the environment. Generally, in-water cleaning of coatings that have exceeded their operational life is not recommended.

Pre-cleaning preparations
The most noticeable difference between operating alongside or at anchorage is the ability of the ROV or diver to safely access all immersed areas of the ship to carry out a full inspection or cleaning.

When attending a ship alongside, due consideration should be given to the ship's berthing arrangement. The ship should be moored alongside in such a way that allows safe access to the in-board side of the ship.

In some countries, the authorities, who are responsible for issuing permits, will be located in the port whilst others are a central authority of a country or a region. In some instances, local regulations may call for a permit for each cleaning operation. A cleaning permit may include requirements for a communication plan outlining the emergency stops necessary to avoid damage to safety, health and the environment.

Permit conditions are likely to be country and port specific. The permit is issued according to the local health, safety, biosecurity and environmental regulations. Many of these permits only allow cleaning of ships once all the safety parameters are adhered to. Should any of the conditions change the cleaning may have to be suspended until such parameters are restored.

Pre-dive checks: This refers to pre-operation checks, which the cleaning company should perform using ROV or divers to assess the level and coverage of biofouling and AFS condition, and to ensure that the cleaning technology is suitable.

Lock out/tag out: This refers to a safety system, where key systems and equipment of the ship are isolated from operation in order to ensure the safety of the cleaning operation. For example, when cleaning is being carried out the propeller should be turned off and secured. The cathodic hull

protection system should also be powered off during the cleaning.

AFS performance: The cleaning procedure should not be conducted in a manner that impairs the current and future performance of the anti-fouling system. Certain cleaning procedures may damage the AFS without being immediately visible but may later accelerate biofouling growth. Rough edges on the wheels of the unit or other parts of the equipment that touches the ship's AFS during cleaning may cause slight damage to the AFS.

Any existing damage to the AFS should be carefully documented by the cleaning company and brought to the attention of the master. It should be noted that the performance of an impaired AFS should not be expected to be the same after the completion of the cleaning operation.

Part cleaning: There may be instances when the cleaning of the entire hull and niche areas are not possible. There could be several reasons for this, such as size of the ship, duration in port/anchorage, operational difficulties that led to the suspension of a cleaning activity midway etc.

In these circumstances, the ship should continue its cleaning activity at the next available opportunity.

To achieve this, the cleaning report should include specific details such as the reference areas to give an overview as to which areas were cleaned. This will enable other parties, including the next cleaning company, to continue cleaning from where it was left off.

Pre-cleaning preparations

The process necessary before the cleaning commences is described in this part of the *Industry standard*.

The ship and the cleaning company representatives should meet before the start of the cleaning operation. This meeting should address any last-minute changes of the planned operation and focus on safety during the cleaning process.

The risk assessment should take into consideration any applicable rise and fall of tide and/or change in draft of ship during loading and unloading/cargo operations. Changes to these may affect the operating clearance between the ship and seabed. A careful assessment of these conditions should be made prior inspection and/or cleaning activities. The clearance between the ship and quay side should also be carefully considered as part of the risk assessment.

Safety and environmental requirements for the cleaning company

The safety and environment elements of the *Industry standard* are based on the general approval of the in-water cleaner's equipment and procedures by an approval body and the permit given by local authorities that allows the cleaner to operate at certain locations. In some cases, to issue the permit, local authorities will also have to approve the equipment and procedures.

The cleaning permit is issued according to the local health, safety, biosecurity and environmental regulations and the cleaning of the ship is dependent on adherence to all the safety parameters and to adherence with the set environmental parameters. Should any of the conditions change or environmental limits be exceeded, the cleaning shall be suspended until such parameters can be restored.

Pre-assessment of the cleaning area
A pre-cleaning assessment can help safeguard the interests of both the ship and cleaning company. For example, when the actual biofouling observed on the hull is more than what is anticipated by the ship or when previous cleaning activities has resulted in damage, the cleaning company is

safeguarded by documentation from a pre-cleaning assessment. On the other hand, if the pre-inspection report is clean and damage is caused to the AFS by the cleaning company, the shipowner's interests are safeguarded.

A pre-assessment can be carried out by a suitably trained diver or by use of an ROV. This should include an inspection of the entire area that is planned to be cleaned in that session.

The inspection should also be used to assess any damage to AFS, any unexpected growth of biofouling.

If this assessment reveals things such as hard calcareous biofouling growth above the capability of the cleaning system and covering more than 5% of the entire underwater area of the ship, the condition is outside the scope of the *Industry standard*. However, the cleaning may be conducted subject to special permission from the port or other authorities and a special agreement between ship and cleaning company.

Mutual planning between the cleaning company and the ship is key to a safe and efficient cleaning operation that protects the marine environment.

Operating requirements of the cleaning system with capture

A system used for cleaning the ship's hull and niche areas may contain several parts. Depending on the technology used, the system may consist of a cleaning unit, cables, hoses, control unit, filtration unit, storage unit and a separation and/or treatment unit. Some of these may be combined into one unit.

The choice of cleaning system depends on many factors, such as:

1. Ship's condition – draft and trim. Since most cleaning systems can only clean below the waterline, it is ideal to clean the ship at its deepest draft ie fully loaded condition. However, this is not practical for all ship types. Commercial agreements for tankers and bulkers may restrict them from carrying out hull cleaning, when in fully loaded condition. Therefore, the ship should endeavour to be in the best possible draft/trim condition that is practical for its type and trading pattern when carrying out cleaning activities.
2. Water visibility – This is an important criterion for obtaining proper records in form of photographs and videos during inspections and cleaning. Generally, it is better to conduct the in-water inspections in clear water, but this is not always possible.
3. Availability of a cleaning company – Even if planned well in advance, the availability of an approved cleaning company may be a problem sometimes due to changes in other ships' schedules etc.
4. Other operations – At times, bunkering, ballasting or other maintenance operations may pose a hindrance to conducting in-water operations.
5. Port and terminal requirements – Some authorities may allow in-water cleaning only in a designated berth and/or anchorage while others may restrict cleaning to anchorages outside the port's limits. The risks are different when conducting a cleaning operation at berth compared to an anchorage. In the port, frequent movement of ships in close vicinity should be considered. At the anchorage, movement of other ships, swinging of one's own ship around the anchor cable, increased current and tidal flows etc should be considered. The ship should observe any operational procedures in the port that will make it necessary to suspend the cleaning activities for example if the permissible weather conditions are exceeded.
6. Weather, sea state, currents – It is more difficult to conduct in-water cleaning in rough weather and high waves. This factor is amplified when conducting the inspection and cleaning at anchorages in open water. The manoeuvrability of barges, carrying the cleaning equipment

and treatment units, will also be affected by rough weather conditions. The risk assessment should carefully capture all these points. If the cleaning operation is performed at anchorage, the anchor watch should observe wind, current, and waves to ascertain if and when it might be necessary to suspend the cleaning operations.

7. Cleaning area – Physical restrictions at berth such as fenders, oil protection booms etc may cause a hindrance to the cleaning activity. Water depth in some ports may not allow a diver or an ROV to move easily and safely under the ship.
8. While it is recommended to clean at the most convenient location, it is not always feasible. For example, regulations may require a ship to be cleaned prior to heading into the territorial sea of certain coastal states. Under such circumstances, the ship may be restricted in the choice of cleaning companies and locations.
9. The amount of time available compared to the time required to clean the designated area should be carefully checked. This check should ensure that quality is not compromised by trying to cover too big an area in too short a period of time.
10. The sequence of cleaning should be carefully planned and discussed with the master of the ship. For example: If the bottom area needs to be cleaned, then the vertical sides, which will come into contact with the cable, should be cleaned first. If the bottom areas are cleaned first, the cable may come into contact with the vertical sides, which could result in biofouling growth detaching and being released into the water.
11. Accidental dislodgement or release of biofouling may take place even if all countermeasures have been taken by the cleaners. The cause for any accident should always be examined and all incidents shall be recorded in the cleaning log and reported.
12. Cameras may be incorporated in the cleaning unit itself to capture the required pictures and/or videos while conducting the cleaning.

The risks involved in accidental release are related to both safety and environment. An accidental release may be caused by one or more of the following:

1. damage to cables between the cleaning and surface units
2. operating equipment in exceedance of operational limits (level of biofouling, weather conditions, current, etc)
3. damage to cleaning machines
4. inclement weather – posing a challenge for the cleaning machine to maintain the required suction and adhesion effect on the surface being cleaned
5. damage to the holding tank on the surface
6. failure to separate material or other associated components in the treatment unit of the system.

The result of accidental release could be one or more of the following, the list of which is non-exhaustive:

1. injury to personnel involved
2. release of invasive aquatic species that may result in damage to the marine environment
3. release of AFS materials, which may include biocides, heavy metal compounds into the local waters, affecting the marine environment
4. disruption of the service being carried out
5. possible clean-up operations as required by local authorities
6. possible delay to the ship operations.

Therefore, it is important to have a procedure in place to mitigate the risk to both safety and environment in case of an accidental release of material. This is akin to a spill response procedure. This procedure may include:

1. informing all relevant port and local authorities for example environmental protection agencies
2. engaging in spill containment operation and monitoring after the event
3. engaging in clean-up operations
4. assisting effected parties as appropriate.

In the event of a black out or total loss of power, care should be taken to recover the diver and the cleaning unit to the surface without releasing any biofouling into the water column.

In the event of a leakage of biofouling or other material into the water, operations should be stopped immediately. Every effort should be made to stop the leakage and minimise the spread in the water whilst safely recovering the hull cleaning unit.

Quantification of the captured material gives an indication of the amount of biofouling present on the ship. Quantification may also give an indication of any leakage of biofouling into the water at any other stage of capture such as the hose. For example, if the ship was found to be fouled uniformly over the entire surface of the hull but during the separation and quantification process, less biofouling was captured by the system than expected, then there is a strong likelihood that the system is not functioning correctly.

It is hard to separate all water or moisture from the solid materials immediately. As biofouling is a living organism with moisture, it will continue to lose moisture as it dries once removed from the water. Therefore, if the biofouling is allowed to dry, there will a significant change in the measurements of weight or volume, every time a new reading is taken. In order to maintain a balance and some standardisation in the quantification process, the *Industry standard* requires that quantification is done within one hour of the completion of the cleaning activity. This will also ensure that there is no undue delay to the ship/port operations and disposal of the material.

Operating requirements of niche area cleaning
Some niche areas will form structures inside the plating of the hull, and this will make cleaning of niche areas more difficult compared to hull cleaning and cleaning companies will have to be approved and tested accordingly. Niche area cleaning may be undertaken by divers using special equipment or by ROVs that can clean niche areas. Technology is evolving and in time better equipment may be available.

Due to different water flow patterns in niche areas compared to the hull, the growth of biofouling in niche areas is generally higher and more difficult to remove and capture.

Propeller cleaning
Aside from biofouling, propellers also develop a tenacious, hard, rough layer of calcareous chalk, produced as a by-product to the cathodic protection system. Ships usually have zinc or anodes that generate a flow of electrons to areas of AFC damage on the hull and propeller to prevent corrosion. This causes the areas of bare metal to become cathodic, which reduces oxygen and water to hydroxyl ions that react with calcium, magnesium and carbon dioxide to form calcium and magnesium carbonates (chalk). The chalk deposits add protection to the surface but also cause significant roughening. The amount, rate and type of deposit is dependent on cathodic current density and ambient seawater conditions. Chalk generally forms faster in tropical waters[8].

Cleaning of propellers is conducted by specialized cleaning companies approved in accordance with the *Approval procedure for in-water cleaning companies*. The *Industry standard* does not deal with such propeller polishing but rather in-water cleaning and capture of biofouling on the propeller that may be coated.

8 Propeller Polishing Condition and Definitions, compiled by Burkard T. Watermann, LimnoMar.

Post cleaning inspection
One of the most important inputs to the cleaning report should come from the post cleaning inspection. The post cleaning inspection helps in checking two important things:

1. The area cleaned is free of visible biofouling.
2. The AFS has not been damaged during the cleaning process.

This can help parties safeguard their own interests in the event of a future claim. When proper care is taken while cleaning the ship, it is in the interests of the cleaning company to ensure that this is well documented.

Systems, which use ROVs as cleaning equipment, may not have to conduct a separate post cleaning inspection but instead use strategically mounted cameras on the ROV that photograph the cleaned hull. Thus, the inspection is completed at the same time as the cleaning. However, it is essential that the photos and videos can clearly depict the exact condition of the hull: existence of any biofouling if there is any and the condition of the anti-fouling coating. Images must live up to the specifications required by the *Industry standard for in-water cleaning with capture*. If the ROV's photographs are not to specification, a diver or other equipment will have to be employed for the task.

The cleaning report and post cleaning inspection report may be combined into one report, providing all the necessary details have been sufficiently captured. This report will provide the ship with proof of compliance with various local regulations.

Post cleaning safety requirements
Once the cleaning operation is completed, all systems on the ship that were locked or tagged out from operation should be brought back into their normal operational state.

This cannot be done until the cleaning company representative has confirmed to the master that the divers and all the equipment have been taken out of the water to a safe area and that the cleaning and/or inspection operation has been completed.

Service report after cleaning
The cleaning report contains detailed information, which means that it is not available immediately after the cleaning operation. However, to provide the master of the ship with proof that the activity has been carried out in accordance with the requirements of various parties, the cleaning company shall issue a service report that contains the basic information on the job performed. This serves as preliminary documentation of the cleaning process. The service report contains less information than the cleaning report but can be used by the master to inform involved parties, such as port, commercial entities, regulatory bodies etc.

Cleaning report
The detailed cleaning report will be created and forwarded at a later date by the cleaning company to either the ship's master or the shipowner depending on the agreement.

This report contains all the information about the cleaning operation. The cleaning company should fill in all the details required.

The cleaning report should be sufficiently detailed to ensure the shipowner has all the necessary information on the cleaning operation. It is acceptable if due to various reasons, a full cleaning of the ship cannot be completed in one attempt. The cleaning report template is made in such a way to enable the next cleaning company to continue the process after the previous cleaning operation.

Apart from appending the report itself to the biofouling record book, relevant information should be also entered in the biofouling record book by the ship.

Systems used to prevent biofouling growth

There are many different systems used to prevent biofouling growth and the *Industry standard* has been limited to the most popular or promising systems that are currently on the market. This list is likely to change in accordance with technological developments and innovation.

An AFC is a paint coating system using biofouling resistant materials, which is applied on the immersed part of the ship's hull. It can be used for piping and other unpainted components of the underwater hull. Marine growth prevention systems (MGPSs) using ultrasound, cathodes, anodes and the process of electrolysis are used to control biofouling in niche areas such as sea chests and internal seawater cooling systems. Other innovative procedures are also available to control biofouling however, their use is not yet established in commercial shipping.

The biofouling management plan should also include a description of the submerged areas, where there is no AFS.

The shipowner shall enter the information provided by the AFS manufacturer into the biofouling management plan. This information will become the core reference document for all future in-water inspections and cleaning. It is important to obtain all relevant details of the AFS and in particular any recommendations on cleaning. The quality of a future in-water cleaning depends on the robustness of this information and therefore, it is essential to have all the details accurately recorded and retained onboard the ship.

Coating system
The AFS manufacturer should supply any information that may be required in order to properly plan and conduct an in-water cleaning operation. The IMO Biofouling Guidelines specifies the minimum level of information that should be supplied. Such information is necessary to ensure a sound foundation, on which the in-water cleaning can be carried out in accordance with the *Industry standard*.

Several different anti-fouling coatings are used on ship surfaces depending on the operating profile, therefore, using the right cleaning equipment and method is extremely important. The incorrect use of equipment and/or methods for cleaning may impair the performance, damage the surface or even remove the coating.

Any in-water cleaning damage to the AFC can have a significant impact on the performance of a ship often resulting in loss of time and increased costs. As such the primary aim of the AFS selection process, which is based on setting targets for the ship's performance between drydocking periods, should be to minimize the number of in-water cleanings.

Coatings systems can broadly be categorised into the following five groups:

Coating type	Description
Soluble matrix	In coatings of this type, the active substance(s) has (have) been physically mixed ("freely associated") into a resin matrix. Upon exposure to seawater, the slightly acidic matrix slowly dissolves releasing the active substance(s) into the water. Seawater is slightly alkaline (pH 8) and the acidic matrix dissolves. Continuous dissolution of the coating surface will occur resulting in fresh active substance(s) being released until eventually the film is depleted. Soluble matrix anti-fouling products typically show a biocide release rate curve, which decays exponentially. The soluble matrix coatings have reduced mechanical properties that limit their film thickness. The paint film's thickness of these coatings depletes over time in an imprecise manner and the film does not show smoothing characteristics on ships in service. Such coatings are normally specified for a lifetime of typically 12-36 months on a commercial ship.

Insoluble matrix	This type of coating contains a mixture of resins that together form an insoluble binder phase. One or more active substances are physically mixed into this matrix. As seawater enters the paint film, the biocides are released by dissolution and diffusion from within the insoluble matrix. After the active substance has been released from the film, the binder remains intact and an empty "honeycomb" structure (the leached layer) remains at the paint surface. This type of coating has a high initial release rate, which decreases exponentially with time as the active substance(s) has (have) to travel further through the paint film. The rate of diffusion of biocide from within the film then becomes a limiting factor in maintaining an effective biocide release rate, thereby preventing biofouling. Insoluble matrix anti-fouling coatings do not show film-depletion or polishing as the resin is insoluble. The biocide release process continues until the coating is depleted. The higher mechanical strength obtained with these coatings allows for applications of thicker systems and coating lifetimes of typically 12- 36 months are attainable for commercial ships, although some products (predominantly in the pleasure craft sector) can have lifetimes in excess of 5 years.
Self polishing	This group is currently the most common and covers a range of different technologies that deliver the active substance through a gradual depletion/ ablation of the paint film throughout the lifetime of the coating. These coatings use binder systems, which control polishing behaviour by different mechanisms. A broad range of binder technologies are found in this group that has replaced tributyltin (TBT) copolymer-based paints, which have been withdrawn from use. Binder systems range from those based on the dissolution of metal carboxylates and polymers relying on ion-exchange, to polymers relying on hydrolysis to control the rate of polishing. Modification of the binder systems and pigment phases of products within this group can be used to tailor them to different end users. The protection requirements of a fast moving and very active ship can be very different from that of a slow moving, less active one. Such modifications can also be used to tailor performance to accommodate the potential intensity of biofouling. The different binder technologies can be used alone or in combination, which results in products with varying levels of anti-fouling protection. Other binder components may also be added in order to modify the overall properties of the paint film. Typical dry-docking intervals for ships coated with self-polishing anti-fouling paints range from 24 to 60 months. However, these systems may also be specified for lifetimes beyond this period.
Fouling release	These coatings prevent biofouling growth by reducing the adhesion strength of the biofouling on the coating, thereby allowing the coating to "release" the biofouling once the ship has passed a certain speed through the water. This is achieved by using resin systems that provide a smooth, low surface energy, which reduces the tenacity of the biofouling organisms' "glue". Biocides may also be used in these systems to provide a "hybrid" coating that has both biocidal and biofouling release properties. These coatings are used in a wider range of applications within both pleasure craft and commercial sectors. Typical dry-docking intervals for ships coated with biofouling release coatings range from 12 to 60 months, unless specified for a lifetime beyond this period.
Biocide free insoluble matrix	This type of coating contains a mixture of resins that together form an insoluble binder phase, which are very hard, mechanically robust coatings. Biocide free insoluble matrix anti-fouling coatings do not show film-depletion or polishing as the resin is insoluble. Biofouling prevention is achieved by creating a smooth surface and regular hull cleaning. The process of cleaning achieves two things, biofouling removal and polishing of the coating surface to maintain the smooth surface. Such coatings require regular cleaning to ensure effective biofouling control.

Table 2: Different paint categories and their lifetimes (source: European Chemicals Agency, 2018).

Determining the remaining lifetime of an AFC is heavily dependent on the type of technology that is used in the coating system. The resins used and the fundamental properties of each resin will have a direct effect on the way that biofouling is controlled and on the maximum lifetime, during which acceptable biofouling control can be maintained.

The following methods can be used to estimate the remaining lifetime of an anti-fouling system:

- dry film thickness (DFT) measurements
- the layers in the anti-fouling system.

However, with the technology that is available today, these methods are not reliable, especially when measured under water. Future technology may evolve to ensure a higher degree of accuracy. Until such time, the *Industry standard* highlights the importance of communication with AFS manufacturers to obtain the best estimate of the remaining lifetime of the coating.

The following paragraphs give a more detailed description of these methods:

DFT measurements can be ascertained by using DFT gauges, varying in size from hand-held portables to rugged shore-power-supplied units. The variation in magnetic force between a metal surface and self-contained permanent magnets is measured. Instruments are available for use in drydock as well as underwater.

When the probe of the gauge is placed perpendicular to the surface of the ship, the gauge returns a measurement that represents the distance from the probe to the metal surface beneath.

This method is not free from errors. Most of the time, there is a layer of biofouling on the hull and the thickness measurement gauge returns a reading that includes this biofouling layer. Also, it does not consider the uneven wear and tear as a result of a ship's operational cycle.

Some of the AFS have several layers of paint in different colours. As a layer leaches out, a new layer is visible. This use of different colours helps to estimate the remaining lifetime of the coating. However, it is often difficult to clearly define between the layers due to the under-water visibility. When there is uneven leaching, due to different water flows over various areas, there is a risk, the estimation will sometimes be incorrect.

The AFS manufacturer will inform the shipowner about which methods should be used for cleaning each coating and this should be recorded in the biofouling management plan. Abrasive brushes are generally not recommended for the cleaning of AFC unless the fouling is particularly severe. Brush type should match the type of coating to be cleaned, so that biofouling can be effectively removed whilst minimising damage to the underlying anti-fouling coating.

Marine growth prevention system (MGPS)
A MGPS uses different methods to protect niche areas. The most common systems used are:

1. chemical dosing system
2. ultrasonic system
3. electrolytic system.

To ensure continual and effective operation, the manufacturer's maintenance routine should be carried out. This may include replacing the anodes at specified intervals.

A MGPS releases a small amount of chemical into the water of the niche area such as sea chests. While some systems require chemicals to be manually added, others produce chemicals by breaking down the water molecules of seawater. The presence of chemicals inhibits the settlement of marine growth to those parts of the ship.

Ultrasonic systems use pulsed acoustic energy (generated by electrical discharge causing an electrohydraulic shock) in pipes to prevent any settlement of biofouling in seawater systems used on board.

Electrolytical systems use copper, aluminium and ferrous anodes and sends metal ions through the water to form a thin film over pipelines, coolers, heat exchangers etc that come in contact with sea water. This layer of metal ions inhibits the marine organisms from attaching themselves to the surface.

Communication between shipowner and AFS manufacturer
The communication between shipowner and AFS manufacturer is very important especially when estimating the remaining lifetime of the coating system or MGPS.

AFS manufacturers may also comment on the method of cleaning used and if it had anything to do with the performance of the coating or MGPS.

Management of the handling of materials and seawater effluent

The *Industry standard* concentrates on cleaning systems used to remove and capture the biofouling from the ship's hull or niche areas.

Procedures to manage materials and seawater effluent
The material captured from the ship contains a mixture of biofouling, paint flakes and associated metals and compounds, which are hard to separate from each other.

Once the material is removed from the ship and captured, it should be separated from the water that may be treated further and discharged back into the sea, subject to approval from local authorities.

The captured biofouling material should be quantified. Quantification can be done either by weight or volume or a combination of both. Quantification can be done either before or after the separation process. It is recommended to separate as much solid material from the water, as reasonably practicable, before undertaking the quantification process.

The cleaning company has to have been approved before it is allowed to operate. During the approval process, an approval body will closely scrutinise the sea water effluent and capture specifications. The samples will be measured by an independent laboratory. This is described in detail in the *Approval procedure for in-water cleaning companies*.

Cleaning companies shall pay close attention to the sea water effluent specification and have procedures in place that include self-monitoring and the periodic maintenance of automatic effluent monitoring devices, separation equipment changes and back flush activities etc so as to avoid exceeding the sea water effluent parameters. The self-audit in this chapter is part of the intermediate control of the cleaning system.

In case the diver company is unable to provide a separation system, captured material can be collected in storage units and treated by mobile separation units.

Furthermore, the port or local authorities issue a permit that allows the cleaning company to operate under certain requirements.

Material handling
The aim of the *Industry standard* is to minimize biofouling or any other particulate materials entering the marine environment.

The standard also aims at avoiding affecting the environment negatively by addressing means to capture dissolved components such as copper or zinc that is linked to the AFS. As the requirements of various coastal states vary a lot with regards to dissolved components, a requirement of capture of dissolved components has been made optional. Some cleaning companies may be approved for this but if that is not the case it is recommended that that a risk-based approach is used to establish the potential impact on water quality in consultation with the local authorities in order to obtain a permit.

The selection of 10 micron as a measure allows a single analytical method to be used to measure both the particulate associated with the AFS and the biological components.

The selection of 10 microns is seen to be possible in accordance with today's technology. Filtration down to smaller sizes reflecting the risk of releasing spores or propagules around the 2 µm size category raises difficulties for cleaning companies in terms of best available technology to achieve this. Also, too strict a limit could hold back cleaning to the detriment of marine biosecurity.

The recommendations in the standard do not and are not intended to replace the requirements of local authorities meaning that any system approved according to this standard will also need to comply with local specifications prior to operation.

The rate at which biocide is released from AFC is complex as it depends on several factors. Such factors include coating type, coating age, water quality parameters (notably temperature, pH and salinity), the local hydrodynamic regime and history of the coating. In connection with cleaning, some AFS may leach more just after a cleaning operation because the layer is more exposed to the water.

Auditing of the cleaning system
Due to the variety of cleaning systems and various methods available to clean a ship, the best way to test their performance is to check the results of the cleaning.

Therefore, the performance of cleaning systems is evaluated by collecting samples and testing them in accredited laboratories. The results of such tests should conform to the specifications mentioned in the *Approval procedure for in-water cleaning companies*.

The cleaning company shall have a procedure to ensure that cleanings are carried out in accordance with the *Industry standard*. This shall be demonstrated by an internal audit mechanism not exceeding 12 months.

A good quality assurance system helps in ensuring that samples are collected in a responsible way, can be properly identified, safely transported, tested in an accredited laboratory etc. The results shall be properly documented and shared with relevant, authorised parties.

The approval body and/or port and relevant local authorities may be part of the process in various ways, for example, some may only need to see the results while others may want to witness the sampling and/or analysis processes. All this should be considered and accommodated to ensure that the robustness of the *Industry standard* is maintained.

Underperforming systems
This section describes the contingency measures that will have to be performed in case the cleaning system fails.

Communication flow chart