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GUIDELINES FOR CONTROLLING THE VECTORS OF INTRODUCTION INTO THE MEDITERRANEAN OF NON-INDIGENOUS SPECIES AND INVASIVE MARINE SPECIES

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1 General introduction

Non-indigenous species (NIS) are identified as one of the 5 leading causes of biodiversity loss with a multitude of impacts ranging from the organism to the ecosystem level (IPBES, 2019). In the Mediterranean Sea, biological invasions have been the cause of a range of impacts, from range shifts of native species, population declines or even local extinctions to large-scale biogeographic modifications (Katsanevakis *et al.*, 2014; Tsirintanis *et al.*, 2022). In this context, the management of biological invasions has emerged as a conservation priority globally (Essl *et al.*, 2021), with prevention the most cost-effective option and environmentally desirable option (Robertson *et al.*, 2021). In the marine environment in particular, where eradication and even long-term control are particularly challenging (Booy *et al.*, 2017; Giakoumi *et al.*, 2019), preventative measures applied at the vector/pathway level are the most important line of defense against species introductions (Ojaveer *et al.*, 2018; Katsanevakis *et al.*, 2022).

Uncertainties on pathway determination not-withstanding, fifty percent of the currently documented valid NIS in the Mediterranean have entered the basin via Corridor (i.e., the Suez Canal), while Transport-Stowaway pathways are responsible for roughly one third of primary introductions and contaminants on aquaculture for another 11 % (Galanidi *et al.*, 2023). Nevertheless, means and routes of entry vary considerably by region, with Corridor (i.e., the Suez Canal) being the most important one in the eastern Mediterranean and shipping-related vectors being responsible for the majority of introductions in the other 3 subregions, revealing the strong importance of shipping for intra-Mediterranean secondary spread. The latest data, compiled for the purposes of establishing national and (sub)regional NIS inventories for the Mediterranean indicate that ballast water and hull fouling combined account for 47%, 46%, 29% and 49% of introductions in the Western, Central, Eastern Mediterranean and the Adriatic respectively, while corridor contributes 57% of introductions in the Eastern Mediterranean and the third most important vector is aquaculture transports with 22%, 21% and 13% in the Western and Central Mediterranean and the Adriatic (UNEP/MED WG.520/5, 2022; Galanidi *et al.*, 2023).

Despite its limited size, the Mediterranean basin plays an important role in international merchant shipping, travelling along the Suez-Gibraltar route and entering the basin from the Bosporus Strait, as well as for intra-Mediterranean traffic, representing around 58% of the total traffic (REMPEC, 2021). According to REMPEC (2020), Mediterranean port calls in 2019 due to passenger and merchant vessels were about 453,000, made by 14,403 ships. These, together with ships transiting through the basin without making a port call (5,251 in 2019), represented a little more than 24% of the global fleet of ships. The lowest estimates of the volumes of ballast water taken-up, transferred and discharged into world oceans each year are around 10 billion tonnes (Interwies & Khuchua, 2017), whereas just one cubic metre of ballast water may contain from 21 up to 50,000 zooplankton specimens (Locke *et al.*, 1991, 1993; Gollasch, 1997) and a heavy bulk carrier can carry up to more than 130,000 tonnes of ballast water (GloBallast, 2009). At the same time, concerning ship hulls, a total global minimum Wetted Surface Area (WSA) (i.e., permanently submerged hull area available for colonisation) estimate of approximately 325 km^2 with an additional 33 km^2 surface for total niche areas has been calculated for the world's global commercial fleet (Moser *et al.*, 2016; 2017), with typically a quarter of the WSA occupied by biofouling but most fouling concentrated in hydrodynamically protected niche areas (Galil *et al.*, 2019 and references therein). It is therefore, evident that the potential for NIS transboundary translocations via shipping is considerable.

Aquaculture, both finfish and molluscs, has been steadily increasing globally as well as at the Mediterranean scale. In the Mediterranean Sea, marine aquaculture is dominated by finfish, comprising 83% of the total production, followed by molluscs (16%), together comprising 43% of the total fish and seafood production in the region and contributing significantly to food security and economic growth (Carvalho & Guillen, 2021). While finfish mariculture consists almost exclusively on native species, such as seabass and seabream, shellfish culture is centred around the native mussel *Mytilus galloprovinciallis* and the introduced Pacific oyster *Magallana gigas* as well as the Manila clam *Ruditapes philippinarum*, since their import to the region in the 1960s and 1970s. Importation of commercially important alien bivalve stock has been associated with the inadvertent introduction of numerous accompanying species, predominantly alien macrophytes, but also parasites and pathogens (Mineur *et al.*, 2014; Wolf *et al.*, 2018; Di Blasio *et al.*, 2023). At the same time, transfer activities of both native and introduced shellfish have contributed to the intra-Mediterranean spread of many introduced species towards the major aquaculture grounds of the basin and beyond. Moreover, even cage culture of native finfishes entails risks of NIS spread through cage fouling. In Europe, aquaculture is the only pathway for which a marked decrease in new introductions of alien species has been observed (Katsanevakis *et al.*, 2013), due to the political will to control the introduction of new species for aquaculture either with mandatory policies, such as Regulation 708/2007 ‘concerning the use of alien and locally absent species in aquaculture’ (EC, 2007) or with voluntary measures, such as the ICES Code of Practice on the Introductions and Transfers of Marine Organisms (ICES 2005). Nevertheless, such measures are not necessarily followed at the pan-Mediterranean scale or don’t apply to all types of stock transfers and translocations, such that stronger national legal and institutional systems are needed to effectively tackle the introduction and spread of alien species in aquaculture.

Recognizing the importance of controlling the introductions and reducing the impacts of NIS for the health and integrity of the marine environment, the Protocol concerning specially protected areas and biological diversity in the Mediterranean (SPA/BD Protocol) in its Article 13 invites the Contracting Parties to take “all appropriate measures to regulate the intentional or non-intentional introduction of non-indigenous species into the wild and prohibit those that may have harmful impacts on the ecosystems, habitats or species”. NIS are included as one of the Ecological Objectives (EO2) of the Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast (IMAP), with the main goals to minimize new introductions and limit the impacts of particularly invasive species to the feasible minimum (UNEP(DEPI)/MED IG.21/9, 2013). In alignment with these objectives and taking into consideration progress already made at the national and regional level, the draft updated NIS Action Plan concerning species introductions and invasive species in the Mediterranean Sea places emphasis on both preventative measures for pathway control and focused research on species impacts and prioritization (UNEP/MAP SPA/RAC, 2023). In synergy with the NIS Action Plan, the updated BWM Strategy and its Action Plan for 2022-2027 aims to contribute to the achievement of GES with respect to NIS by elaborating and promoting a regional harmonized approach in the Mediterranean on ships’ ballast water control and management (UNEP/MAP, REMPEC & IMO, 2021).

One of the roles of SPA/RAC in achieving these objectives is providing Guidelines and technical documentation to help coordinate and harmonize the efforts of the Contracting Parties in carrying out their tasks. Regarding corridors, a number of suggestions for preventative measures have appeared in the literature, including sonar detection, acoustic and electric fish deterrents and salinity manipulations (Castellanos-Galindo *et al.*, 2020 and references therein). Such methods have not been tested and applied in the Mediterranean context and would require careful consideration of possible unintended ecological consequences, not to mention socio-economic implications. Therefore, the guidelines will focus on the main vectors of NIS introduction in the Mediterranean that can be readily managed with instruments and tools currently at our disposal, i.e., Ballast water, Biofouling and Aquaculture. Meanwhile, for species (at risk) of entering via corridor, recommendations are outlined in the updated NIS Action Plan of 2023, in the form of Horizon Scanning exercises, early detection and the elaboration of early warning systems and rapid response plans, focusing on the prevention of establishment as well as the minimization of impacts.

Consequently, the current document presents the most up-to-date developments in guidelines and policies aiming to minimise NIS introduction and spread by managing their vectors and pathways and is intended to provide CPs with guidance on the current state of affairs and the next steps needed in order to strengthen their institutional capacity, harmonise their legal framework and strengthen their management response towards achieving the mandate of the SPA/BD Protocol.

2 Ballast water

The present conditions and criteria will apply to the evaluation of proposals for the awarding and the renewal of the awarding of the title of Regional Action Plan Partner.

No limit is set on the total number of the Partner to the Regional Action Plan. However, Parties agree that the awarding will be based the following criteria. Any Organization can request the title of Partner for more than one Action Plan.

2.1 IMO's Ballast Water Management Convention

Globally, the main instrument for the control of ballast water as a pathway of introduction of NIS is the Ballast Water Management Convention (BWMC) (IMO, 2004), adopted in 2004 and entered into force in 2017, accompanied by a series of Guidelines (Table 1). To date, it has been ratified by 86 States including 13 Mediterranean coastal States that are Contracting Parties to the Barcelona Convention.

In its basic principle, vessels are required to conduct BWM according to the requirements of the BWM Convention. However, measures and procedures are also considered at the port level, such as port reception facilities, port State controls and inspections.

Table 1. List of Guidelines for the uniform implementation of the BWM Convention

Guidelines for sediment reception facilities (G1)	MEPC.152(55)
Guidelines for ballast water sampling (G2)	MEPC.173(58)
Guidelines for ballast water management equivalent compliance (G3)	MEPC.123(53)
Guidelines for ballast water management and development of ballast water management plans (G4)	MEPC.127(53) Amended by MEPC.306(73) and MEPC.370(80)
Guidelines for ballast water reception facilities (G5)	MEPC.153(55)
2017 Guidelines for ballast water exchange (G6)	MEPC.288(71) Revokes MEPC.124(53) Amended by MEPC.371(80)
2017 Guidelines for risk assessment under regulation A-4 of the BWM Convention (G7)	MEPC.289(71) Supersedes MEPC.162(56)
Procedure for approval of ballast water management systems that make use of active substances (G9)	MEPC.169(57) Revokes MEPC.126(53)
Guidelines for approval and oversight of prototype ballast water treatment technology programmes (G10)	MEPC.140(54)
Guidelines for ballast water exchange design and construction standards (G11)	MEPC.149(55)
2012 Guidelines on design and construction to facilitate sediment control on ships (G12)	MEPC.209(63) Revokes MEPC.150(55)
Guidelines for additional measures regarding ballast water management including emergency situations (G13)	MEPC.161(56)
Guidelines on designation of areas for ballast water exchange (G14)	MEPC.151(55)
Guidelines for port State control under the BWM Convention (G15)	MEPC.252(67)

The requirements to be met by vessels, sequentially applied are:

Ballast Water Exchange Standard (BWE or **D1 Standard**), according to which ships to exchange a minimum of 95 % ballast water volume whenever possible at least 200 nautical miles (nm) from the nearest land and in water depths of at least 200 metres (200/200 requirements). When this is not possible, the BWE shall be conducted at least 50 nm from the nearest land and in waters at least 200 metres in depth (50/200 requirements) (G6). In areas where the distance from the nearest land or the depth does not meet the parameters, "the port state may designate areas, in consultation with adjacent or other States, as appropriate, where a ship may conduct Ballast Water exchange" (Reg. B-4.2).

Ballast Water Performance Standard (or **D2 Standard**), mandating that the discharge of ballast water have the number of viable organisms below the specified limits, which in relation to mesozooplanakton organisms (i.e. most NIS planktonic propagules) are: less than 10 viable organisms per cubic meter greater than or equal to 50 micrometers in minimum dimension. This can be achieved through an array of mechanical (filtration, separation), physical (heat treatment, ozone, UV light, deoxygenation treatment) and chemical methods (biocides) and their combinations, referred to as a Ballast Water Management System (BWMS). The deadline for mandatory installation of an approved BWM system is 2024. Until then, BWE is applied but it will be gradually phased out once D2 comes fully into effect.

Ballast Water Management Certificates, a Ballast Water Management Plan specific to each vessel as well as a Ballast Water Record Book for recording operations, reporting and verification are also required under the BWMC.

At the Port State Level, government agencies and other appropriate authorities are charged, among others, with providing Sediment reception facilities (G1), providing data from Port Baselines Surveys and regular monitoring, conduct inspections according to Port State Control (PSC) guidelines (G15) and following harmonized protocols (e.g., G2), assess applications for Exceptions and Exemptions following Risk Assessment (G7).

2.2 Ballast Water Management Strategy for the Mediterranean Sea

In the Mediterranean Sea, establishing a framework for the regional harmonized approach on ships' ballast water control and management consistent with the requirements and standards of the BWM Convention, is one of the primary objectives of the recently updated BWM Strategy (BWMS) and its Action Plan 2022-2027 (UNEP/MAP, REMPEC & IMO, 2021).

The BWMS for the Mediterranean Sea has 6 Strategic Priorities (SPs), the first one of which (SP1) is to 'Support the ratification and implementation of the BWM Convention'. Achievement of SP1 is associated with 5 Actions, namely:

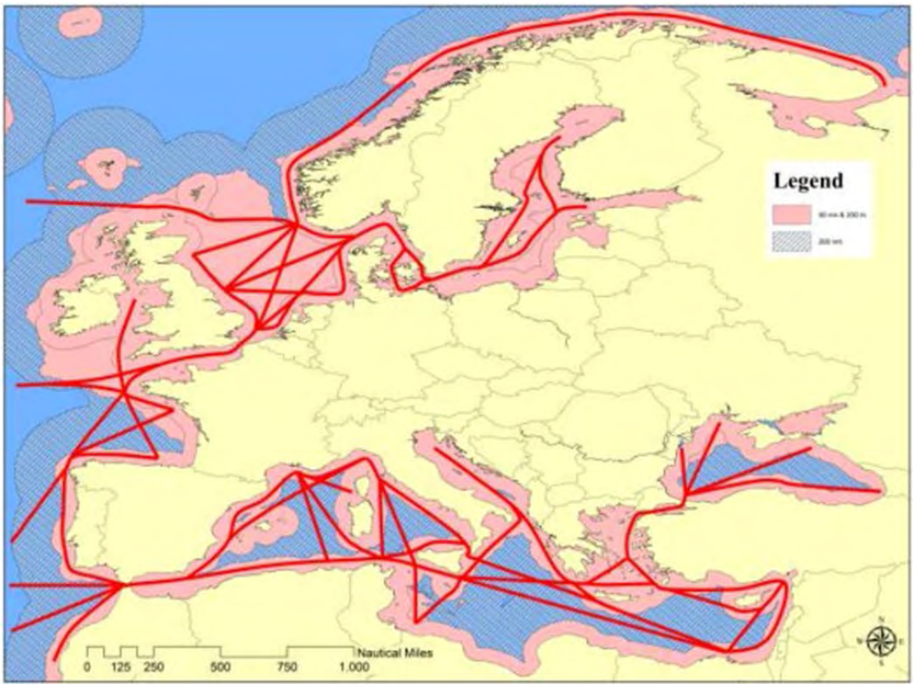
- Action 1: Ratification of the BWM Convention;
- Action 2: Harmonization of BWM measures in the Mediterranean region;
- Action 3: Development, adoption, and implementation of a regional protocol for port baseline surveys and biological monitoring in Mediterranean ports;
- Action 4: Promotion of the use of risk assessment (RA) as a tool to assist in ballast water (and, more generally, invasive alien species (IAS)) management and decision-making; and
- Action 5: Alignment of BWM measures with neighboring regions.

These actions are also supported by the updated NIS Action Plan of 2023 (UNEP/MED WG.548/CPR 4_Annex IV), which was developed and is implemented in tandem with the BWMS and requests Contracting Parties to carry out the above ballast water related management actions.

Under SP1, Action 2, regional harmonized procedures for the uniform implementation of the Ballast Water Management Convention in the Mediterranean Sea have already been produced (REMPEC/WG.56/5, Annex), pertaining to Ballast Water Exchange Areas, Regulation A-4 Exemptions and relevant risk assessment guidelines, Sediment Reception Facilities, Contingency Measures, Additional Measures and Warnings, as outlined below.

Ballast Water Exchange in the Mediterranean Sea

In the Mediterranean Sea, shipping traffic routes (Fig.1) indicate that many ships traverse waters that do not meet the 50/200 BWM Convention requirement for BWE. In such cases, exchange of ballast water should be undertaken in areas designated by the port State for that purpose, in accordance with the Guidelines on designation of areas for ballast water exchange (G14) and in consultation with adjacent States and all interested States.



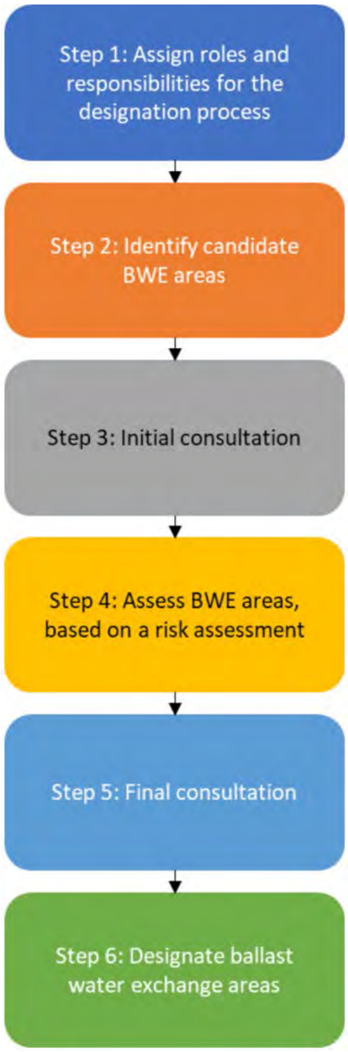


Figure 1. Left: The seas surrounding Europe with red lines showing the main shipping routes, from David & Gollasch (2015). The pink areas are less than 50 nautical miles from nearest land and/or in waters less than 200m deep, and the pink shaded areas are more than 200 nautical miles from the nearest land. Right: Steps for designating BWE areas in the Mediterranean Sea. Taken from REMPEC/WG.56/5 Annex (2023).

The harmonized procedure to designate ballast water exchange areas in the Mediterranean Sea, following G14 is summarized in the diagram of Figure 1 (REMPEC/WG.56/5). The designated ballast water exchange area should provide the least risk to the aquatic environment, human health, property, or resources as determined by a risk assessment that addresses at least the following parameters: Shipping route data; Oceanographic data to determine where the discharged ballast water will be discharged; Environmental and Biological data, aiming to avoid heavily polluted areas and areas affected by HAOP and pathogens; Important resources (e.g., fisheries grounds, aquaculture locations) and special protected areas.

Exemptions and relevant risk assessment guidelines

Regulation A-4 of the BWM Convention allows Parties to grant exemptions to the requirement for ships to conduct BWM (as per Regulation B-3) or to comply with any Additional Measures (as per Regulation C-1). Such exemptions may only be granted to ships on voyages between specified ports or locations or to a ship operating exclusively between specified ports or locations, following a risk assessment compliant with the G7 Guidelines. Exemptions are only valid for 5 years, after which applications will be reviewed taking into consideration new information. Harmonised procedures for the granting of exemptions in the Mediterranean Sea under G7 have been produced in the framework or the BWMS 2022-2027 (REMPEC/WG.56/5 Annex, 2023), using as a starting point the HELCOM-OSPAR Joint Harmonized Procedure for BWMC A-4 Exemptions (HELCOM-OSPAR, 2020a).

Data needs for the RA include the environmental conditions (i.e. salinity, temperature, etc.) in the two ports and species inventories with a focus on NIS. If such data is not available it can be acquired through port baselines surveys (PBS), carried out following an agreed Port Survey Protocol. A priority list of NIS Target Species (TS), the presence of which may act as a criterion to determine a shipping route as high risk, should be provided by Port State Authorities to the applicants, using as guidance a Protocol for Identifying Target Species. The RA process is detailed in document REMPEC/WG.56/5 Annex and may include considerations of natural dispersal of target species between the two ports with a methodology termed Same Risk Area (Hansen *et al.*, 2018; Stuer-Lauridsen *et al.*, 2018; HELCOM-OSPAR, 2020b), i.e., if dispersal modelling indicates that there is a high likelihood of natural dispersal of TS propagules within an area including the two ports, the risk of ballast water transfer may be modified/downgraded.

2.3 Recommendations for priority actions

(Identified through and carried out in conjunction with the BWMS 2022-2027 and the updated NIS Action Plan)

- Ratify the BWMC and transpose its provisions and regulations into national law;
- Designate Ballast Water Exchange areas where the 50nm/200m depth requirement cannot be met and establish an early warning system (EWS) to inform the designation of no-uptake areas due to known conditions (e.g. areas known to contain outbreaks, infestations, or populations (e.g. toxic algal blooms) which are likely to be of relevance to ballast water uptake or discharge; near sewage outfalls; or where tidal flushing is poor or specific times during which a tidal stream is known to be more turbid). The example of the EWS developed for the Adriatic Sea can serve as a model for the establishment of similar systems elsewhere (Magaletti *et al.*, 2013; Kraus, 2023);
- Identify key ports to be surveyed and risk-assessed. High risk recipient ports in the Mediterranean can be identified with existing methodologies, taking into consideration the environmental similarity with donor ports and/or regions within and outside the Mediterranean combined with vessel traffic information (see Keller *et al.*, 2011; Seebens *et al.*, 2013; Wang *et al.*, 2022);
- Prepare a regional Target Species list that can be applied to all exemption applications under regulation A-4. The TS list can be informed by survey data and complemented by existing inventories on NIS present in Mediterranean ports (e.g., Tempesti *et al.*, 2020), the NIS Baseline for the Mediterranean with associated pathway information (UNEP/MED WG.520/5, 2022; Galanidi *et al.*, 2023) and the latest review of marine NIS impacts in the Mediterranean by Tsirintanis *et al.* (2022);
- Develop a Decision Support System (DSS) or tool to assist with a standardized approach to BWM; A DSS model developed by David and Gollasch (2015) and used on a number of example routes in the Mediterranean (David and Gollasch, 2019) can be used as a roadmap;
- Elaborate and harmonize Port State Control inspection procedures, according to the G15 Guidelines, and PSC measures in cases of non-compliance;

- Establish mandatory data reporting both for vessels and Port State authorities and develop a Regional Information System (RIS) which should collate all mandatory data reported to aid in risk assessment and feed the early warning system;
- Develop regional and national capacity building programmes with training workshops and dissemination of protocols and tools to support the above actions.

3 Hull fouling

3.1 Introduction

Biofouling is the undesirable accumulation of aquatic organisms such as micro-organisms, plants, and animals on surfaces and structures immersed in or exposed to the aquatic environment (IMO 2011). For ships, this not only includes their hulls, but also the niche areas (i.e. sea chests, bow thrusters, gratings, propeller shafts, etc.), which may be more susceptible to biofouling due to different hydrodynamic forces, susceptibility to coating system wear or damage, or being inadequately, or not, painted (IMO 2011).

Biofouling on ships' hulls increases hull surface roughness, which in turn increases frictional resistance and ultimately increases fuel consumption and total GHG emissions. Thus, applying anti-fouling measures is a common industry practice in order to decrease fuel consumption; typically, this involves the application of anti-fouling coatings biofouling removal during dry-docking for regular maintenance and in-water cleaning in-between dry-docking. Due to the toxicity of previously used anti-fouling paints, IMO adopted the International Convention on the Control of Harmful Anti-fouling Systems on Ships (adoption: 5 October 2001; entry into force: 17 September 2008), prohibiting the use of harmful organotins (primarily tributylin TBT) in anti-fouling paints used on ships.

The effectiveness of antifouling coatings that are currently used can vary considerably depending upon a number of factors, such as ship type and construction, ship speed and operating profile, intervals between dry-docking events and the residence time of the ship in port (IMO, 2011; Galil *et al.*, 2019). There is evidence to suggest that anti-fouling coatings are efficient for up to 1-1.5 years – thereafter heavy fouling can start occurring (Sylvester *et al.*, 2011; Frey *et al.*, 2014). Since dry-docking frequency is determined by performance (fuel consumption below a certain threshold), it can range from 0.5-5 years (Bohn *et al.*, 2016). Vessels with larger docking intervals (up to 5 years) increasingly choose intermediate cleaning of the hull with in-water technologies (Bohn *et al.*, 2016). Thus, current practices are driven by financial interests, are essentially voluntary and are not targeted towards minimizing the transboundary introduction of biofouling-mediated NIS.

Recognizing these concerns, IMO developed in 2011 Biofouling Guidelines both for commercial vessels and recreational craft (see further in the document), which are however still voluntary, resulting in a low level of implementation, nationally, of either mandatory or voluntary measures (GEF-UNDP-IMO, 2018). Nevertheless, a small number of regional/national legally binding regulations regarding biofouling prevention and management have already entered into force, e.g., in Australia, New Zealand, California, which could form the basis for similar initiatives in the Mediterranean. Furthermore, the ongoing GloFouling Partnership project (GEF-UNDP-IMO, 2018) which aimed to build capacity and momentum for the adoption of anti-fouling measures, has developed a series of guidelines to help government agencies and other stakeholders to design and start implementing anti-fouling strategies.

3.2 IMO Guidelines

Resolution MEPC.207(62) “Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species” for large vessels was adopted on July 15 2011. In July 2023, IMO’s Marine Environment Protection Committee (MEPC) revised and refined the 2011 Guidelines and adopted resolution MEPC.378(80) (IMO, 2023) aiming to improve the uptake and effectiveness of the voluntary Guidelines. Furthermore, the revised Guidelines “recommend taking a proactive approach to biofouling through assessment of biofouling risk profiles for hull and niche areas and by monitoring various risk parameters during operation.”

The objectives of these Guidelines are “to provide practical guidance to States, ship masters, operators and owners, shipbuilders, ship repair, dry-docking and recycling facilities, ship cleaning and maintenance operators, ship designers, classification societies, anti-fouling paint manufacturers and suppliers and any other interested parties, on measures to minimize the risk of transferring invasive aquatic species from ships' biofouling.”

The guidelines outline measures and recommendations that include:

- The development of a biofouling management plan with details of the anti-fouling systems and operational practices or treatments used, including those for niche areas; the identifications of hull locations susceptible to biofouling, schedule of planned inspections, repairs, maintenance and renewal of anti-fouling systems;
- Maintenance of a Biofouling Record Book which should record details of all inspections and biofouling management measures undertaken on the ship and can assist interested State authorities to quickly and efficiently assess the potential biofouling risk of the ship;
- Application of an appropriate anti-fouling system (AFS) depending on the ship operating profile; including a Marine Growth Protection System (MGPS) for sea chests and special recommendations for other biofouling susceptible niche areas;
- Retention and safe disposal of the biofouling debris from cleaning and maintenance periods;
- Guidance on assessing a vessel’s risk profile and biofouling risk parameters that can affect this profile to be monitored;
- Contingency action plan when monitoring identifies a possible increase in biofouling accumulation;
- Detailed recommendations for scheduled periodic in-water inspections, with subsequent recommended cleaning actions depending on the extent of fouling (Table 2);
- Particular attention to niche areas, in a manner that will eliminate/minimise the release of viable NIS propagules and biocidal compounds of the anti-fouling coating;
- Ship design and construction that minimises biofouling risk.

Table 2. Rating scale to assess the extent of fouling on inspection areas (from MEPC.378(80))

<table>
<tr><th>Rating</th><th>Description</th><th>Macrofouling cover of area inspected (visual estimate)</th><th>Recommended cleaning</th></tr>
<tr><td>0</td><td>No fouling
Surface entirely clean. No Visible biofouling on surfaces.</td><td>-</td><td>-</td></tr>
<tr><td>1</td><td>Microfouling
Submerged areas partially or entirely covered in microfouling. Metal and painted surface may be visible beneath the fouling.</td><td>-</td><td>Proactive cleaning may be recommended as further specified in paragraph 9.4.</td></tr>
<tr><td>2</td><td>Light macrofouling
Presence of microfouling and multiple macrofouling patches. Fouling species cannot be easily wiped off by hand.</td><td>1-15% of surface</td><td rowspan="3">Cleaning with capture is recommended as further specified in paragraph 9.9.

It is recommended to shorten the interval until the next inspection. If the AFS is significantly deteriorated, dry-docking with maintenance and reapplication of the AFS is recommended.</td></tr>
<tr><td>3</td><td>Medium macrofouling
Presence of microfouling and multiple macrofouling patches.</td><td>16-40% of surface</td></tr>
<tr><td>4</td><td>Heavy macrofouling
Large patches or submerged areas entirely covered in macrofouling.</td><td>41-100% of surface</td></tr>
</table>

MEPC.1-Circ.792 "Guidance for Minimizing the Transfer of Invasive Aquatic Species as Biofouling (Hull fouling) for Recreational Craft" (IMO, 2012) for recreational vessels < 24m was approved in October 2012 and recommends, among others:

- The application of an anti-fouling coating;
- Minimisation of biofouling in niche areas (use antifouling coating, polish propellers and shafts, caulk recesses and gaps, maintain marine growth prevention system);
- Out of the water cleaning at least once a year, ensuring the capture of biological, chemical and physical debris;
- Cleaning trailered craft, gear, equipment and trailer before moving to another location;
- Entering biofouling management activities in craft logbook.

3.3 European Code of conduct on recreational boating and Invasive Alien Species of 2016

This Code of Conduct (T-PVS/Inf (2016) 13) (EC, 2016) is one of a number of voluntary instruments drawn up and adopted by the Bern Convention in sectors identified as possible pathways of NIS introductions.

This guidance builds and expands on the IMO 2011 guidelines for recreational craft, providing more detailed biosecurity guidance (especially for vessels used in freshwater) and placing particular emphasis on awareness, education and training.

3.4 National regulations

3.4.1 New Zealand

In order to manage the biosecurity risk associated with vessel biofouling, New Zealand has adopted mandatory requirements for arriving vessels, outlined in the "Craft Risk Management Standard (CRMS) for Biofouling on Vessels Arriving to New Zealand", which was approved on 15th May 2014 and entered into force in 2018 (Ministry of Primary Industries, 2014; 2018), after a 4 year period during which authorities engaged heavily with stakeholders in order to raise awareness of the Standard's requirements and promote best practices for biofouling management (Georgiades *et al.*, 2020). The 2018 CRMS has since been refined and was replaced by the 2023 CRMS (MPI, 2023) on 29 September 2023.

The CRMS requires vessel operators to take preventive measures to manage biofouling prior to arrival and defines an outcome to be met, requiring all vessels to arrive to New Zealand with a "clean hull", providing documentation for at least one of the following actions:

- The hull and niche areas have been cleaned within 30 days prior to the vessel's arrival
- The vessel has been continually maintained following best practice (e.g., IMO Biofouling Guidelines)
- The hull and niche areas have been treated with an approved treatment or have been cleaned out of water in a haul-out facility within 24 hours of arrival.

The thresholds for a "clean hull" are governed by the intended duration of a vessel's stay in New Zealand and were defined by Georgiades & Kluza (2014) for the Ministry of Primary Affairs.

Short-stay vessels: For those vessels intending to remain in New Zealand for up to 28 consecutive days, the threshold for short-stay vessels applies (Table 3).

Table 3. Recommended biofouling thresholds for short-stay vessels for the purposes of the Craft Risk Management Standard for Biofouling on Vessels Arriving to New Zealand (from Georgiades & Kluza, 2014).

Hull part	Allowable biofouling
All hull surfaces	Slime layer Goose barnacles
Wind and water line	Green algae growth of unrestricted cover, no more than 50 mm in frond, filament or beard length Brown and red algal growth no more than 4 mm in length Incidental (maximum of 1%) coverage of tubeworms, bryozoans and/or barnacles, occurring as isolated individuals or small clusters
Hull area	Algal growth occurring as: ▪ no more than 4 mm in length; and ▪ continuous strips and/or patches of no more than 50 mm in width Incidental (maximum of 1%) coverage of tubeworms, bryozoans and/or barnacles, occurring as isolated individuals or small clusters that have no algal overgrowth
Niche areas	Algal growth occurring as: ▪ no more than 4 mm in length; and ▪ continuous strips and/or patches of no more than 50 mm in width Scattered (maximum of 5%) coverage of tubeworms, bryozoans and/or barnacles, occurring as widely spaced individuals and/or infrequent, patchy clusters that have no algal overgrowth

Long-stay vessels: For those vessels intending to remain in New Zealand for more than 29 consecutive days and/or visit areas other those designated under the Act as Places of First Arrival, the threshold for long stay vessels applies (Table 4).

Table 4. Recommended biofouling thresholds for long-stay vessels and/or vessels that intend to visit areas other those designated under the Act as Places of First Arrival.

Hull part	Allowable biofouling
All hull surfaces	Slime layer Goose barnacles

3.4.2 California

"Biofouling Management to Minimize the Transfer of Nonindigenous Species from Vessels Arriving at California Ports" (hereafter referred to as the California Biofouling Regulations) was adopted and became effective on 1 October 2017 (see California Code of Regulations Section 2298.1 et seq.). Developed to maintain consistency with the IMO Biofouling Guidelines, California's Biofouling Regulations center around a vessel-specific Biofouling Management Plan (BFMP) with details about the antifouling systems in use and planned actions to manage biofouling associated with specific niche areas, a Biofouling Record Book (BFRC), as well as regular reporting. The key requirement is that "If a vessel is using an antifouling coating, the antifouling coating shall not be aged beyond its effective coating lifespan, as documented in the vessel's Biofouling Management Plan". The main components of California's and New Zealand's biofouling regulations can be seen in Table 5.

Table 5. Overview of general regulatory components in California's and New Zealand's biofouling regulations. BFMP refers to Biofouling Management Plan. BFRB refers to Biofouling Record Book. From Scianni *et al.* (2021)

	California only	**Both**	**New Zealand only**
Vessel types subject to requirements		Vessels over 300 Gross Registered Tons that are capable of carrying ballast water	All other vessels that arrive to NZ after visiting the territorial waters of another country
Documentation requirements	1. Marine Invasive Species "Program Annual Vessel Reporting Form (submitted once annually)." 2. BFMP (must include specific criteria regarding antifouling coatings and management of niche areas) 3. BFRB		Evidence showing that one of "three measures outlined in CRMS has been undertaken[a] 1. Cleaning the hull less than 30 days before arrival or within 24 hours of arrival 2. Continual maintenance using best practice (can include BFMP and BFRB) 3. Application of approved treatments
Inspection procedure		Inspection of documentation for compliance with requirements	Physical verification of suspected noncompliant vessels identified during documentation inspection.
Compliance actions	60-day grace period for vessels that incur violations during first inspection after becoming subject to requirements. Vessel will be compliant if deficiency is corrected prior to first arrival after the 60-day period. If deficiencies are not corrected, the vessel will receive a Notice of Violation.		Compliance action determined based on biosecurity risk posed by vessel, and may include actions such as itinerary restriction, directions for haul out/dry dock (when available), or directions to obtain additional evidence (i.e., hull inspection)
Options for vessels that cannot comply	Submit petition for alternative management to Division Chief for approval		Propose Craft Risk Management Plan (CRMP) for approval by MPI

[a] No specific requirements for the form of the documentation submitted, as long as evidence is sufficient to show that the hull is clean on arrival.

3.4.3 Australia

In Australia, the "Biosecurity Amendment (Biofouling Management) Regulations 2021" (Australia biofouling management requirements ABMR) entered into force on 15 June 2022 (DAWE, 2022). This requires operators of all vessels to provide information on biofouling management practices prior to arriving in Australia. An education phase for the requirements will apply until 15 December 2023.

The Australian regulations do not set specific thresholds for allowable biofouling but require that vessel operators can demonstrate proactive management of biofouling by implementing one of the 3 accepted proactive biofouling management options:

1) Implementation of an effective biofouling management plan (BFMP) with an associated biofouling record book (BFRB) and supporting evidence and documentation that meets specific requirements set out in the regulation.

2) Cleaned all biofouling within 30 days prior to arriving in Australian territory, accompanied by a cleaning report and supporting visual evidence according to the regulation's specifications.

3) Implementation of an alternative biofouling management method pre-approved by the authorities.

Lack of implementation of any of the three proactive management practices will lead to additional pre-arrival questions and possibly inspections of vessels' submerged hull and niche areas to inform an initial assessment of the risk that the vessel presents.

3.5 BWMS 2022-2027 Action Plan

Under Strategic Priority 2 of the BWMS 2022-2027 for the Mediterranean Sea ("Contribute to the Achievement of Good Environmental Status"), Contracting Parties to the Barcelona Convention commit to initiate preliminary activities to address the threat of biofouling on ships (Action 7). Planned activities include the undertaking of National Status Assessments of Biofouling and the development of national strategies and action plans to manage biofouling (UNEP/MAP, REMPEC & IMO, 2021). These actions can be greatly aided by a series of Guidance documents produced within the framework of the GEF-UNDP-IMO GloFouling Partnerships Project, to assist countries in conducting national status assessments (GEF-UNDP-IMO, 2022a) and in developing national strategies and action plans to manage biofouling (GEF-UNDP-IMO, 2022b) as well as specific guidance for Biofouling Management for Recreational Boating (GEF-UNDP-IMO, 2022c). These documents drew extensively from the existing biosecurity regulations of Australia, New Zealand and the USA and reflect the lessons learned from the experience of developing those strategies.

The first step in elaborating national strategies for biofouling management is conducting a national vector assessment to identify the main components of the problem and set the stage for strategic planning. In parallel, an Economic Impact assessment of biofouling species to human activities and wellbeing and to the broader ecosystem services will help raise awareness among stakeholders and the general public and enhance the message that prevention is the most cost-effective form of management.

GloFouling - Guide to developing National Status Assessments

GloFouling - Guide to National Economic Assessments of biofouling

When designing and preparing a national biofouling strategy it is essential to consider the following elements:

• Policy and legal frameworks to establish national standards against which such risks can be assessed and controlled (a policy statement with overarching goals and specific policy objectives and actions to achieve them as well as existing and proposed legal instruments and jurisdictions);

• Institutional arrangements to manage and respond to biofouling risks;

• Technical capacity to effectively implement and enforce those policy and legal frameworks (from legal and policy experts to inspection and enforcement procedures and marine environment as well as maritime sector expertise);

• Relevant infrastructure and facilities to respond to an identified biofouling risk (e.g., dry-dock and haul-out facilities, in-water cleaning capacity); and

• Emergency response capacity to deal with IAS incursions

Furthermore, it is important to include a consultation period to take into account stakeholder feedback and a preparation phase for training, monitoring and refinement.

GloFouling - Guide to developing National Biofouling Strategies

3.6 Awareness raising, public outreach, education and training

Raising awareness and involving stakeholders in biofouling management has emerged as a point of paramount importance for any successful biofouling strategy. Users (Table 6) need to be provided with clear information on the environmental and socio-economic impacts of biofouling species, the role of ships' biofouling as a vector for introducing and spreading NIS and the respective benefits, both individual and societal, of controlling introductions through vector management. In this sense, some recommended actions include:

- Operators, service providers and authorities should promote awareness of voluntary guidelines and codes of conduct, particularly among recreational boaters, and organize training and education programmes.
- Government agencies and authorities should engage with recreational boaters in programmes to prevent, early detect, eradicate or manage specific IAS on waters used by the sector.
- Adequate signage or guidance should be in place in marinas and boating hotspots and particularly with site specific measures in areas known to already contain aquatic IAS.
- Agencies should include communication strategies in the planning phase of all prevention and control programmes. Allowing for a consultation period with stakeholders can refine and increase the feasibility of proposed measures, while training programmes for best practices can lead to more effective and smoother implementation.

Table 6. Interested Parties who should be aware of IAS (from GEF-UNDP-IMO, 2022c)

Stakeholder categories	Type
Boat owners	Inland
	Coastal
	Power
	Sail
	Racing / performance
	Cruising
Commercial operators – providing services to boat owners	Marinas
	Ports
	Public authorities
	Contractors
	Divers
NGOs	National Sailing organisations / federations
	Media, magazines, commentators, bloggers
Regulators	International
	National
	Local authorities
	Border control / customs
	Environmental health (pollution control, water quality)
	Politicians to set Policy and regulations

GloFouling - Biofouling management for recreational boating

4 AQUACULTURE

4.1 Introduction

According to the ICES Code of Practice on the Introductions and Transfers of Marine Organisms (ICES, 2005), there are three main challenges associated with the introduction and translocation of an alien species for aquaculture purposes:

1. The first challenge lies in the ecological and environmental impacts of introduced and transferred species, especially those that may escape the confines of cultivation and become established in the receiving environment. These new populations can have an impact on native species.

2. The second challenge stems from the potential genetic impact of introduced and transferred species, relative to the mixing of farmed and wild stocks as well as to the release of genetically modified organisms.

3. The third challenge is posed by the inadvertent coincident movement of harmful organisms associated with the target (host) species. The mass transfer of large numbers of animals and plants without inspection, quarantine, or other management procedures has inevitably led to the simultaneous introduction of pathogenic or parasitic agents causing harm to the development and growth of the new fishery resources and to native fisheries.

In the Mediterranean Sea the main species responsible for accidental primary introductions of NIS are the bivalves *Magallana gigas* and *Ruditapes philippinarum*, although movements of other shellfish stock (i.e., native mussels) have undoubtedly played a role in the secondary spread of aquaculture related alien species (Marchini *et al.*, 2014; 2016). Besides pathogens and parasites (e.g., oyster viruses, *Perkinsus* spp.) that can spread to and affect other bivalve species (see Di Blasio *et al.*, 2023), a large number of accompanying non-target species introduced with shellfish stock have demonstrated strong impacts on entire ecosystem processes or on wider ecosystem functioning (Katsanevakis *et al.*, 2014). The most characteristic example is the unintentional introduction of a large number of alien species – mostly macrophytes – from the NW Pacific with pacific oyster *(Magallana gigas*) spat consignments in the 70's to the extent that North-western Pacific seaweeds are now the dominant biotic component of some Mediterranean lagoons (e.g., Thau, Mar Piccolo, and Venice lagoons) (Boudouresque *et al.*, 2011; 2020, Sfriso *et al.*, 2020).

In Europe, aquaculture is the only pathway for which a marked decrease in new introductions of alien species has been observed (Katsanevakis *et al.*, 2013), due to the political will to control the introduction of new species for aquaculture either with mandatory policies, such as Regulation 708/2007 'concerning the use of alien and locally absent species in aquaculture' (EC, 2007) or with voluntary measures, such as the ICES Code of Practice on the Introductions and Transfers of Marine Organisms (ICES, 2005). Nevertheless, such measures are not necessarily followed at the pan-Mediterranean scale or don't apply to all types of stock transfers and translocations, such that stronger national legal and institutional systems are needed to effectively tackle the introduction and spread of alien species in aquaculture.

4.2 Prevention

Existing regulations and instruments

A benchmark document for the management of aquaculture mediated NIS introductions was the ICES Code of Practice on the Introductions and Transfers of Marine Organisms (ICES, 2005), which "set forth recommended procedures and practices to diminish the risks of detrimental effects from the intentional introduction and transfer of marine organisms". On the blueprint of this document, the European Union adopted in 2007 compulsory measures for aquaculture transfers, in the form of Council Regulation (EC) No 708/2007 'concerning use of alien and locally absent species in aquaculture'. According to the Regulation, all aquaculture operators who intend to introduce an alien species, or translocate a locally absent species, must first apply for a permit from the competent authority of the Member State where the transfer will take place. The Regulation specifies the information to be provided by the applicant and the type of assessment that the competent authority must perform before granting the permit. Furthermore, the regulation discriminates between 'routine' and 'non-routine' movements and treats them separately, requiring a regulation-compliant ecological and genetic risk assessment, as well as risk assessment for non-target species for non-routine movements.

Under Article 3 of the regulation:

'routine movement' means the movement of aquatic organisms from a source which has a low risk of transferring non-target species and which, on account of the characteristics of the aquatic organisms and/or the method of aquaculture to be used, for example closed systems, does not give rise to adverse ecological effects; 'non-routine movement' means any movement of aquatic organisms which does not fulfil the criteria for routine movement

Application for permit

As per ANNEX I of the regulation, the application should include:

- The purpose and objectives of the introduction;

- The stage(s) in the life cycle proposed for introduction, the native range, the donor location, and the target area(s) of release;

- A review of the biology and ecology of the species as these pertain to the introduction (such as the physical, chemical, and biological requirements for reproduction and growth, and natural and human-mediated dispersal mechanisms);

- Any links of the species with known non-target species and their distribution in the area of origin of the stock to be introduced;

- Known pathogens and parasites of the species or stock including epibionts and endobionts;

- Information on the receiving environment;

- The ecological, genetic, and disease impacts and relationships of the proposed introduction in its natural range and donor location as well as in the release site;

- Monitoring plans of the proposed introduction and any potential impacts;

- Management plan, with information on measures taken to ensure that no other species (non-target species) accompany the shipment and a contingency plan for the removal of species in case of an accidental escape or release.

Some ways to reduce the risk of transferring accompanying pathogens, parasites and other hitchhiking species include (ICES, 2012):

- Health inspection and certification;
- Pre-treatment for pathogens, diseases and parasites;
- Inspection for other non-target species;
- Disinfection prior to discarding water in which the organisms arrived;
- Vaccination;
- Disinfection of eggs;
- Importation as milt or fertilized eggs only;
- Quarantine incoming organisms and use as broodstock, release F1 progeny only if no pathogens, parasites or other hitchhikers appear.

Conditions for Introduction/Translocation after issue of a permit

The organisms of each authorized introduction should be used to establish a broodstock in quarantined facilities (i.e. containment). If appropriate, only progeny of the authorized quarantined broodstock may be transferred into the natural environment, after an environmental impact assessment, and/or risk assessment indicates minimal or no impact.

Species of Annex IV – RISK-BASED APPROACH

A number of species outlined in Annex IV of the regulation, including the bivalves *Magallana gigas* and *Ruditapes philippinarum*, constitute an exception and can be moved without any risk assessment or quarantine “except in cases where Member States wish to take measures to restrict the use of the species concerned in their territory”; also the regulation does not apply to movements of locally absent species within the Member States (e.g., mussel species) “except for cases where, on the basis of scientific advice, there are grounds for foreseeing environmental threats due to the translocation, Art. 2 para. 2.”

Such aquaculture transfers however still constitute risks for alien species introduction and secondary spread, thus it strongly recommended that operators adopt voluntary measures, adhering to the ICES Code of practice (ICES, 2005) or adopting a similar risk-based approach, including the following steps:

a) all products should originate from sources in areas that meet current codes, such as the OIE International Aquatic Animal Health Code or equivalent EU directives.

b) For organisms to be released into the natural environment, there should be documented periodic inspections (including microscopic examination) of material prior to exportation to confirm freedom from exotic accompanying (non-target) species including disease agents (for an indicative example of a translocation sampling protocol see the Dutch management system for control of impacts of translocation of mussels into the Oosterschelde – Gittenberger *et al.*, 2014, outlined in Gascoigne *et al.*, 2015).

c) if required, there should be inspection, disinfection, quarantine or destruction of the introduced organisms and transfer material (e.g., transport water, packing material, and containers) based on OIE or EU directives.

4.3 Eradication

Eradication (i.e., complete removal of the introduced species) in the marine environment is challenging and unlikely when a species has been established and started spreading with natural dispersal. The few successful eradication cases have been achieved when the introduced species had sessile adult stages, the populations were small and restricted, human and financial resources were available, and early action was taken (Williams & Grosholz, 2008, see also Katsanevakis, 2022). This showcases the importance of early detection together with the capacity to take rapid action for successful and cost-effective eradications. Especially concerning aquaculture operations, a local extirpation could be considered a sufficient outcome.

Hence, it is recommended that horizon scanning for emerging incursions, impact assessment and eradication feasibility assessment (Booy *et al.*, 2017; 2020) are utilized to arrive at priority species to attempt to eradicate so that concrete plans and procedures are in place if/when the need arises. These rapid response plans for high-risk species should be disseminated to appropriate authorities and stakeholders throughout the Mediterranean. Furthermore, frequent monitoring is the safest way to ensure early detection happens.

4.4 Control

In the context of aquaculture operations, population control of pest organisms (native or non-native) is a desirable and commonly employed practice to avoid/minimize negative impacts from predation, parasitism, pathogens or fouling organisms that may affect fitness and production and increase the cost of operations. Methods vary according to the cultured species, culture practice and pest organisms to be removed but commonly include one or more of the following (see IOC-UNESCO and GEF-UNDP-IMO, 2022 for a more detailed list of management methods against fouling in aquaculture in particular): Manipulation of the timing and placement of aquaculture gear and stock to minimize exposure; manual/mechanical removal of the pest organisms (scraping, power washing, etc.); air drying; sprays and dips (freshwater, brine, hot water, acetic acid, lime, etc.).

As with eradication, it is important to select high priority species to target for control depending on their impacts and potential for spread.

Collaborate with the industry to develop protocols and processes for population control that will not only be effective at removing undesired species populations but will also minimize spread (if e.g. biological residue is generated).

Encourage research and development on novel control methods, among which biological control with predators and grazers is receiving increased attention recently (Katsanevakis, 2022).

4.5 Recommended actions at the national level

Legal and Institutional framework

- Enact national legislation for controlling the introduction of marine species through aquaculture operations and promote voluntary codes of conduct in the interim.
- Develop a contact network involving members of industries involved with spread.
- Develop and implement education and outreach programmes for aquaculture operators.
- Document the movement of live aquatic organisms and set up a reporting system for escapes.
- Develop an early warning system for aliens in aquaculture.
- Elaborate rapid response and management plans for invasive NIS, including eradication or population control measures as appropriate. Ensure the necessary administrative powers are in place and provide emergency funding to support rapid responses to emerging invasions.

4.6 Recommended actions at the regional level

Develop knowledge base

- Develop a GIS-based platform to collate and visualize information on aquaculture facilities, species cultivated, methods of culture etc., as well as the regional/point presence of aquaculture associated and other high-risk (invasive) NIS and parasites/pathogens.
- Develop the regional knowledge base (including, but not limited to distribution, biology, invasive characteristics, impacts and control options) of cultured marine alien species currently in containment in the Mediterranean.
- Conduct a Horizon Scanning exercise for potential future species of mariculture interest and the risks associated with their introduction. Considering the growing interest in seaweed species cultivation and their bio-products (Armeli Minicante *et al.*, 2022), it is recommended that this taxonomic group receives particular attention.
- Conduct a regional vector risk assessment to identify a) high-risk locations and operations where interventions can effectively reduce risk of new invasions and b) high-risk non-target species that warrant early detection.
- Develop an early warning system for aliens in aquaculture.

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