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Ten recommendations for advancing the assessment and management of non-indigenous species in marine ecosystems

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ABSTRACT

The main objective of recent international legislative measures and policies concerning marine ecosystems is to ensure sustainable environmental management to maintain a good status for marine waters, habitats and resources, with the ultimate target of achieving an integrated ecosystem-based approach to management. Because bioinvasions pose significant threats to marine ecosystems and the goods and services these provide, non-indigenous species (NIS) are included in the more recent legislative documents. A major challenge for the scientific community is to translate the principles of the legislative directives into a realistic, integrated ecosystem-based approach and at the same time provide stakeholders with best practices for managing NIS. The aim of this paper, prepared by members of the Working Group on Introductions and Transfers of Marine Organisms (WGITMO) of the International Council for the Exploration of the Sea (ICES), is to provide guidance for the application of NIS related management in the European Union Marine Strategy Framework Directive (MSFD). Ten recommendations, including NIS identification, standardization of sampling and data, indicators, propagule pressure and management issues are considered in this paper. While most of these suggestions were developed to improve the implementation of the MSFD, several may be more widely applicable.

1. Introduction

Because of increasing and diversifying human pressures and the associated degradation of marine ecosystems, several policies

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and framework legislations were adopted during the early 1990s. The goal of these legislations was to restore good environmental quality, with the ultimate aim to be part of an integrated environmental management. Such measures include the Clean Water Act and National Oceans Policy Executive Order in USA, the Water Act Canada, the Environmental protection and Biodiversity Conservation Act in Australia, the Water Framework and the Marine Strategy Framework Directives in the European Union and the National Water Act in South Africa. The main objectives of these legislative measures and policies are to achieve or maintain a good status for marine and fresh waters, habitats and resources by providing integrated ecosystem-based approach to management [1]. The latest legislation, the European Union Marine Strategy Framework Directive [2] lists 11 descriptors that constitute the basis for the evaluation of "Good Environmental Status" (GES) of marine ecosystems: (1) biodiversity; (2) non-indigenous species; (3) exploited fishes and shellfishes; (4) food webs; (5) human-induced eutrophication; (6) sea-floor integrity; (7) hydrographical conditions; (8) contaminants in water and sediment; (9) contaminants in fish and shellfish; (10) marine litter; and (11) introduction of energy/noise.

Non-indigenous species (NIS) are considered one of the major threats to global marine ecosystems for impacting their structure and function [3], with socio-economic consequences that may lead to social conflicts, economic and production losses [4]. These NIS are mainly introduced unintentionally by discharges of ballast water (BW) and accumulated sediments, as vessel hull hitchhickers [5–7], by the aquaculture industry [8] and through canals [9,10]. NIS have negative impacts on biodiversity and ecosystem function, whereas some form an important basis for commercial fisheries by providing an increased production over similar native species, or otherwise provide economically important cultured products [11,12].

To manage the main introduction pathways and vectors of potential NIS arrivals and secondary spread, several dedicated policy/legislative frameworks/tools are already in place. These include the Code of Practice on the Introductions and Transfers of Marine Organisms of the International Council for the Exploration of the Sea [13], the IUCN Considerations for Responsible Use of NIS in Culture [14], the International Maritime Organization's the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWMC) [7,15], the European Community Regulation Concerning Use of Alien and Locally Absent Species in Aquaculture, with detailed rules for their implementation [16–18], the European Code of Conduct on Zoological Gardens and Aquaria and Invasive Alien Species [19] and an EU biodiversity strategy to 2020 [20]. Further measures are under development: such as the international ship hull fouling guidelines [21], and the Invasive Species Strategy of the EU [22].

In the present paper, members of the ICES Working Group on Introductions and Transfers of Marine Organisms (WGITMO) identify and discuss issues relating to the assessment and management of NIS. These range from taxonomic expertise and identification of NIS, data collection/monitoring, limitations of data usage, assessment of pressures and impacts and industry-involved multivector management. Whilst these points were developed towards the implementation of the MSFD GES Descriptor 2 [2,23], several are of general nature and may be applied more widely.

2. Definitions and EU MSFD D2 criteria and indicators

The following definitions were adopted [24]:

Non-indigenous species (NIS; synonyms: alien, exotic, non-native, allochthonous) are species, subspecies or lower taxa introduced outside of their natural range (past or present) and outside of their natural dispersal potential. This includes any part, gamete or propagule of such species that might survive and subsequently reproduce. Their presence in the given region is due to intentional or unintentional introduction resulting from human activities. Natural shifts in distribution ranges (e.g. due to climate change or dispersal by ocean currents) do not qualify a species as a NIS. However, secondary introductions of NIS from the area(s) of their first arrival could occur with or without human involvement due to spread by natural means. Species of unknown origin that cannot be ascribed as being native or alien are termed cryptogenic species. Invasive alien species (IAS) are a subset of established NIS that have spread, are spreading or have demonstrated their potential to spread elsewhere, and have or might have an adverse effect on biological diversity, ecosystem function, socio-economic values and/or human health in invaded regions.

The European Commission Decision [23] contains two criteria and three indicators for assessing progress towards good environmental status relevant to the MSFD Descriptor 2 "Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem":

Criterion 2.1: Abundance and state characterization of non-indigenous species (NIS), in particular invasive species.
Indicator 2.1.1: Trends in abundance, temporal occurrence and spatial distribution in the wild of non-indigenous species, particularly invasive non-indigenous species, notably in risk areas, in relation to the main vectors and pathways of spreading of such species.
Criterion 2.2: Environmental impact of invasive non-indigenous species.
Indicator 2.2.1: Ratio between invasive non-indigenous species and native species in some well studied taxonomic groups (e.g. fish, macroalgae, molluscs) that may provide a measure of change in species composition (e.g. further to the displacement of native species).
Indicator 2.2.2: Impacts of non-indigenous invasive species at the level of species, habitats and ecosystem, where feasible.

3. Ten key requirements for NIS assessment and management

The following were identified as crucial issues for dealing with the European MSFD Descriptor 2, as well as global management of marine NIS.

3.1. Availability of taxonomic expertise

"Taxonomy provides a basic understanding of the components of biodiversity which is necessary for effective decision making about conservation and sustainable use" [25].

Marine environmental issues associated with the current rapid biodiversity change require multidisciplinary approaches. Yet, taxonomy and systematics—the foundational disciplines that distinguish, classify, and document biodiversity—are at their nadir. Despite Europe's proud history of contributions to marine taxonomic research, its present state is a cause for concern [26–28]. Loss of taxonomic expertise in highly diverse and poorly understood marine taxa results in reduced capacity to evaluate the response of marine biodiversity to global change, its value for mitigation and adaptation, to assess decline in native species, and risks the mis-identification of NIS and inaccurate information about their spread and potential for harm. This knowledge gap means that Europe lacks sufficient capacity to manage, conserve,