Marine Policy 54 (2015) 26–35

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Dose of truth—Monitoring marine non-indigenous species to serve legislative requirements

Maiju Lehtiniemi [a,*], Henn Ojaveer [b], Matej David [c], Bella Galil [d], Stephan Gollasch [e], Cynthia McKenzie [f], Dan Minchin [g,i], Anna Occhipinti-Ambrogi [h], Sergej Olenin [i], Judith Pederson [j]

[a] Finnish Environment Institute, Marine Research Center, PO Box 140, 00251 Helsinki, Finland
[b] Estonian Marine Institute, University of Tartu, 2a Lootsi, 80012 Pärnu, Estonia
[c] Dr. Matej David Consult, Korte 13e, SI-6310 Izola, Slovenia
[d] National Institute of Oceanography, PO Box 8030, Haifa 31080, Israel
[e] GoConsult, Grosse Brunnenstr. 61, D-22763 Hamburg, Germany
[f] Fisheries and Oceans Canada Northwest Atlantic Fisheries Centre, PO Box 5667, St. Johns, NL, Canada A1C 5X1
[g] Marine Organism Investigations, Ballina, Killaloe, Co Clare, Ireland
[h] Department of Earth and Environmental Sciences, University of Pavia, Via S. Epifanio, 14, I-27100 Pavia, Italy
[i] Marine Science and Technology Center, Klaipeda University, H. Manto 84, 92294, Klaipeda, Lithuania
[j] MIT Sea Grant College Program, E38-300 Cambridge, MA 02139, United States

ARTICLE INFO

Article history:
Received 3 October 2014
Received in revised form
19 December 2014
Accepted 21 December 2014

Keywords:
Non-indigenous species
Legislative requirements
Early detection
Port
Rapid assessment
Long-term monitoring

ABSTRACT

Non-indigenous species (NIS) are recognized as a global threat to biodiversity and monitoring their presence and impacts is considered a prerequisite for marine environmental management and sustainable development. However, monitoring for NIS seldom takes place except for a few baseline surveys. With the goal of serving the requirements of the EU Marine Strategy Framework Directive and the EU Regulation on the prevention and management of the introduction and spread of invasive alien species, the paper highlights the importance of early detection of NIS in dispersal hubs for a rapid management response, and of long-term monitoring for tracking the effects of NIS within recipient ecosystems, including coastal systems especially vulnerable to introductions. The conceptual framework also demonstrates the need for port monitoring, which should serve the above mentioned requirements but also provide the required information for implementation of the International Convention for the Control and Management of Ships Ballast Water and Sediments. Large scale monitoring of native, cryptogenic and NIS in natural and man-made habitats will collectively lead to meeting international requirements. Cost-efficient rapid assessments of target species may provide timely information for managers and policy-advisers focusing on particular NIS at particular localities, but this cannot replace long-term monitoring. To support legislative requirements, collected data should be verified and stored in a publicly accessible and routinely updated database/information system. Public involvement should be encouraged as part of monitoring programs where feasible.

1. Introduction

Recognition of the significant threats posed by marine non-indigenous species (NIS) is evident in the recent bevy of national, regional and international conventions and legislations which require scientifically validated data for evaluation of their efficacy. Monitoring[1] and surveys[2] of NIS are, therefore, prerequisites for marine environmental management and sustainable development. Baseline surveys have been conducted in certain ports (*e.g.* [35,46,34]), however, consistent monitoring for NIS seldom takes place. Canadian and German monitoring programs of marine NIS are examples of long-term commitments. The program in Canada has been conducted since 2005 with the aim of early detection of NIS, rapid response and providing advice for management decisions [13]. A recent national risk assessment for ballast water introductions to Canada was conducted for the Arctic, Pacific and Atlantic to determine the relative risk of coastal and domestic shipping and to determine the effectiveness of current regulations by Transport Canada in preventing NIS from entering Canadian waters [14]. In Germany a targeted monitoring program for alien species along the German North Sea and Baltic Sea coasts including port monitoring was started in 2009 [6]. Biennial or

* Corresponding author.
E-mail address: maiju.lehtiniemi@ymparisto.fi (M. Lehtiniemi).

[1] Monitoring: program of collection of data by standardized methods at regular intervals, related to specific factors, designed to provide information on the characteristics of the factors and their changes with time.

[2] Survey: collection of data providing a snapshot view of a particular area at a particular time.

http://dx.doi.org/10.1016/j.marpol.2014.12.015
0308-597X/

triennial monitoring of native and NIS of macroalgae and macroinvertebrates have been conducted in marinas and harbors on the northeast coast of the USA, from Maine to New York City [81]. The European Union has undertaken legislative measures to manage NIS, including the EU Marine Strategy Framework Directive (MSFD), Biodiversity Strategy and most recently Regulation on the prevention and management of the introduction and spread of invasive alien species. The MSFD places emphasis on the "trends in abundance, temporal occurrence and spatial distribution in the wild of non-indigenous species …". Marine biological monitoring in European waters is regionally or nationally based, covering specific environments or taxonomic groups and often conducted as part of international programs (*e.g.* Baltic Marine Environment Protection Commission, HELCOM, Convention for the Protection of the Marine Environment of the North-East Atlantic, OSPAR). However, monitoring seldom targets NIS and does not cover all habitats and areas that NIS may occupy [41].

NIS are defined as species introduced outside of their natural range (past or present) and outside of their natural dispersal potential by intentional or unintentional human activities [76]. Further invasive alien species (IAS) are defined as spatially expanding NIS which may threaten biological diversity, impact the environment and humans [76]. The most common pathways for marine NIS introductions are vessels (via ballast waters and as ships' and leisure craft biofouling), culture activities, and through canals and canalized waterways, with regionally varying magnitudes [61,24,9]. However, the scope and focus of the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention) is broader and includes, in addition to NIS dealt with in detail in the current account, potentially harmful cryptogenic and native species and pathogens (*i.e.* harmful aquatic organisms and pathogens, HAOP) (*e.g.* [30]).

This paper presents a review of monitoring approaches, encompassing a range of coastal environments which are especially vulnerable to introductions (*e.g.* [51,71,65,100,25]), to provide a conceptual framework for practical monitoring. The importance of early detection of NIS in bridgehead sites and dispersal hubs is highlighted; and different approaches how monitoring for NIS within marine ecosystems may be undertaken is demonstrated. The following sections identify current international requirements concerning NIS monitoring.

2. Monitoring requirements under international instruments

The EU Biodiversity Strategy [20] seeks an extensive knowledge concerning marine NIS. Target 5: "Combat Invasive Alien species" of the Biodiversity Strategy requires that "…by 2020, Invasive Alien Species and their pathways are identified and prioritised, priority species are controlled or eradicated, and pathways are managed to prevent the introduction and establishment of new Invasive Alien Species…". While it is unlikely that the target will be fully met by the deadline, there is a pressing need to undertake surveys and monitoring as further NIS are continually recorded and earlier introductions expand their range (*e.g.* [24,26]). Early confusion in setting out the necessary actions to fulfill the aim set out by the EU Biodiversity Strategy led to the failure to meet the 2010 target [19]. One area that requires action is the identification of high-risk NIS that are deemed invasive and may cause harm. The goal is to develop approaches to prevent further introductions, identify potential invaders, document secondary spread and dispersal of already present NIS, and implement approaches to eradicate, manage, and control priority NIS where this is practicable. With this in mind the Regulation on the prevention and management of the introduction and spread of IAS has been recently adopted [18].

The EU MSFD requires Member States to take measures to achieve or maintain Good Environmental Status (GES) by 2020 [16]. The MSFD Commission Decision on criteria on GES of marine waters includes NIS under Descriptor 2 [17]. In order to fulfill the requirements of MSFD, Member States are charged with gathering data as to '…NIS trends in abundance, temporal and spatial distribution notably in risk areas, in relation to the main vectors and pathways, ratio between invasive NIS and native species in some well-studied taxonomic groups that may provide a measure of change in species composition and impacts of non-indigenous invasive species at the level of species, habitats and ecosystem, where feasible…'.

A federal regulatory proposal to manage Aquatic Invasive Species (AIS) as part of the Canadian Fisheries Act is being developed in collaboration with the Canadian provinces [13]. The monitoring requirements to support these regulations have not been established.

The BWM Convention, adopted by the International Maritime Organisation (IMO) in February 2004, enters into force twelve months after the date on which more than 30 States, with combined merchant fleets not less than 35% of the gross tonnage of the world's merchant shipping, have signed this Convention. As of July 2014, 40 states have ratified the BWM Convention, representing 30.25% of the world merchant shipping gross tonnage (Status of Convention at www.imo.org). The BWM Convention sets global standards and requirements to avoid the transfer of HAOP including harmful NIS within ballast water and its associated sediments. The BWM Convention calls on the Parties to individually or jointly monitor the effects of ballast water management in their waters. The BWM Convention further states that a Party should inform mariners of areas under their jurisdiction where ballast water should not be taken up due to known unfavourable conditions implying that monitoring should be undertaken to document the presence (or absence) of HAOP [42]. The BWM Convention also states that vessels on certain routes can be exempted from the application of BWM requirements based on a risk assessment (RA) according to the IMO Guidelines requiring reliable data on HAOP in related ports [42,43]. Both the United States and Canada adopted approaches for managing ballast water and the risk of NIS introductions which require monitoring [95,96].

Although managers and policy makers have recently come to recognize the importance of biofouling of commercial vessels and recreational boats in the dispersal of NIS, no international convention exists to address this issue. Yet guidelines for management and minimizing the transfer of biofouling on both ships and recreational craft have been adopted at IMO [44,45] including assessments of the biofouling. The objectives of the guidelines are to provide practical guidance to related states, ship crews and owners, shipbuilders, ship yards, anti-fouling paint manufacturers and suppliers and any other involved in shipping industry, on measures to minimize the risk of transferring IAS as biofouling.

3. Surveys and monitoring approaches

Survey results form a baseline of information against which the future change may be monitored. Surveys are often conducted at high risk sites and may be more or less comprehensive, ranging from a single species [91] to a multi-taxa harbor surveys [35]. Once surveys have provided 'baseline' data, risk-based priorities concerning pathways, 'hot spots' and NIS monitoring are identified. Bridgehead sites and dispersal sites ('hot spots') are high volume recipient and donor locales, perhaps at the convergence of more than a single vector/pathway (*e.g.* species arriving in ballast water may be transported in fouled leisure craft). Monitoring implies a long-term continuous sampling at defined intervals to detect changes in population distribution, size and impact. Priorities for monitoring, particularly in large or complex areas, need to take into account the physical forcing, operating vectors and their relative propagule delivery, the mosaic of