



Viewpoint

Recommendations on methods for the detection and control of biological pollution in marine coastal waters

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ABSTRACT

Adverse effects of invasive alien species (IAS), or biological pollution, is an increasing problem in marine coastal waters, which remains high on the environmental management agenda. All maritime countries need to assess the size of this problem and consider effective mechanisms to prevent introductions, and if necessary and where possible to monitor, contain, control or eradicate the introduced impacting organisms. Despite this, and in contrast to more enclosed water bodies, the openness of marine systems indicates that once species are in an area then eradication is usually impossible. Most institutions in countries are aware of the problem and have sufficient governance in place for management. However, there is still a general lack of commitment and concerted action plans are needed to address this problem. This paper provides recommendations resulting from an international workshop based upon a large amount of experience relating to the assessment and control of biopollution.

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1. Introduction

Marine biological invasions are increasingly changing coastal biota. They can alter ecosystem functioning and often seriously affect an economy and human health, and so remain high on the environmental management agenda (Lodge et al., 2006; CBD, 2004; European Commission, 2008a; Pyšek and Richardson, 2010). The bioinvasion problem in the marine environment has recently been described as an *exogenic unmanaged pressure*, i.e. a pressure emanating from outside a system and with the potential to change or damage marine systems and the human uses of those systems to which

we have to respond (Elliott, 2011). As long as we have a need to move materials around the globe, we have a limited capacity to control the cause of the pressure yet we should respond to the consequences.

Not all non-indigenous species (NIS), which were deliberately or accidentally introduced by humans outside their native range, will necessarily cause harm to the environment. However, it is very difficult to predict which of NIS introductions may result in detrimental effects on environmental quality which result in changes to the biological, chemical and/or physical properties of an invaded ecosystem. Despite this, environmental managers are mainly interested in those species that have significant impacts on the environment, quality of life, economy and/or human health.

While plans for the management of NIS, in general, and marine introduced species in particular, have been and are being developed (e.g. Lodge et al., 2006; European Commission, 2008a; Johnsen et al., 2011), the implementation of such plans would

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benefit greatly from a synthesis of international knowledge. Accordingly, an international workshop “Indicator based methods to assess and map biological pollution in the coastal waters of Norway” was arranged in Bergen, May 27–29, 2009 with the objective to consolidate the existing international knowledge on methods of assessment and mapping biological pollution (biopollution) in marine coastal waters. This paper gives the recommendations from the workshop summarizing modern methods for early detection and mapping of NIS, approaches for the assessment of consequences of biopollution and information needs for supporting marine bioinvasion management.

2. Conceptual framework

The terminology of invasion ecology yet is not well established due to the rapid development of this discipline. Therefore, to ensure consistency and for the sake of simplicity the following definitions, derived from Olenin et al. (2010), are used throughout the text.

2.1. Non-indigenous species

Non-indigenous species (synonyms: alien, exotic, non-native, allochthonous) are species or 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. It also includes hybrids between an alien species and an indigenous species, fertile polyploid organisms and artificially hybridized species irrespective of their natural range or dispersal potential (Council Regulation, 2007). Their presence in the given region is due to intentional or unintentional introduction resulting from human activities, or they have arrived there without the help of people from an area in which they are alien.

Increasingly, global warming will become a cause of species distribution change. Despite this, natural changes in distribution ranges (e.g. due to climate change or dispersal by ocean currents) do not qualify a species as being a non-indigenous one. However, the secondary spread of non-indigenous species from the area(s) of their first arrival could occur without further human involvement due to dispersal by natural means.

2.2. Invasive alien species (IAS)

Invasive alien species are a subset of established NIS which have spread, are spreading or have demonstrated their potential to spread elsewhere, and have an adverse effect on biological diversity, ecosystem functioning, socio-economic values and/or human health in invaded regions. Species of unknown origin which cannot be ascribed as being native or alien are termed cryptogenic species (*sensu* Carlton, 1996), some of these also can cause significant impacts. They may also demonstrate invasive characteristics and should be included in IAS assessments.

2.3. Biological pollution

Often the impact of IAS has been interpreted as a decline in ecological quality resulting from changes in biological, chemical and physical properties of an aquatic ecosystem. These changes include (but are not confined to): local elimination or extinction of sensitive and/or rare species; alteration of native communities; algal blooms or other outbreak formations and massive population expansions; modification of substratum conditions including shore zones; alteration of oxygen and nutrient concentration, pH and transparency of the water and accumulation of synthetic pollutants. Biological pollution is defined as the adverse impacts of invasive alien species at the level that disturb ecological quality by effects on one or more levels of biological organization: an individual (such as internal biological pollution by parasites or pathogens), a population (by genetic change, e.g. hybridization), a community (by a structural shift), a habitat (by modification of physical–chemical conditions), or/and an ecosystem (by alteration of energy and organic material flow) (Elliott, 2003; Olenin et al., 2010). The biological and ecological effects of biopollution may also cause adverse economic consequences.

2.4. Pathway

A pathway is the route a NIS takes to enter or spread through a non-native ecosystem. Each pathway may have a number of vectors. A vector is a transfer mechanism and is the physical means by which species are transported from one geographic region to

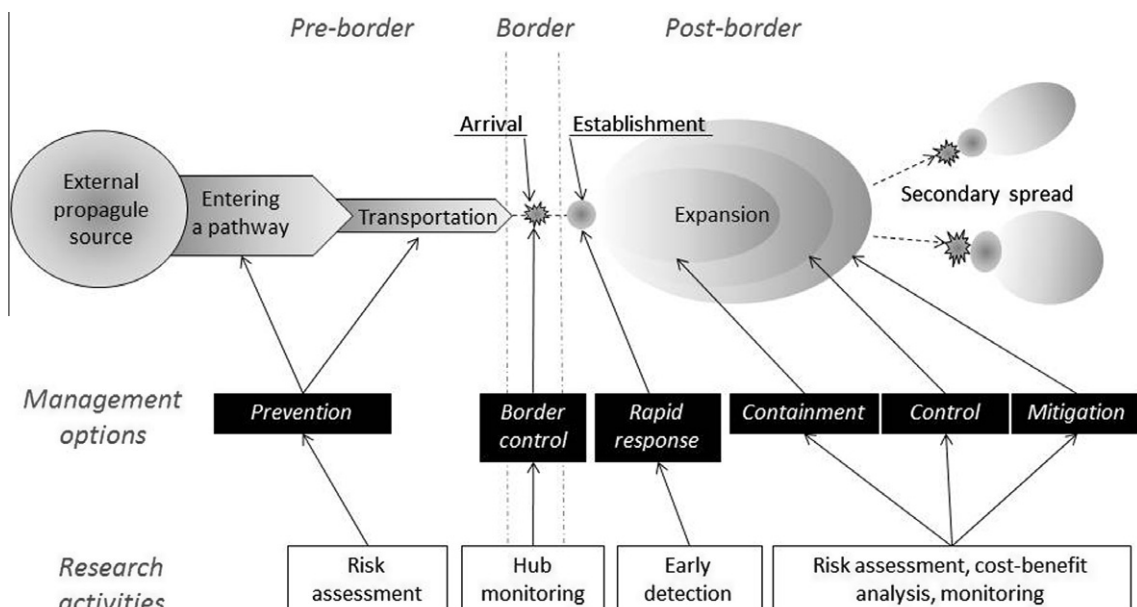


Fig. 1. A conceptual model of an invasion process (the size of shapes indicates a relative number of propagules involved at each stage of invasion); pre-border (prevention), at border (rapid response) and post border (control, containment and mitigation) management options, and related research activities. Explanation in text.

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