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Only half of the truth: Managing invasive alien species by rapid assessment

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ABSTRACT

Marine environments are threatened by biological invasions that are transported via ship hulls or ballast water at increasing rates around the globe. Most management strategies that should prevent or reduce the impact of alien species include prevention and eradication programs that both rely on an early detection of introduced species. Early detection requires an up to date inventory of present species and efficient monitoring programs to identify newly arrived species. This study surveyed potential invasion 'hot spots' in the coastal waters of the central Wadden Sea, including commercial ports ('port' stations) as well as fairways, roads, groynes and oyster reefs ('Wadden Sea' stations) to establish lists of macrobenthic species as baseline for future monitoring. In the ports we also applied simultaneously the HELCOM/OSPAR protocol (H/O) and a regional established rapid assessment (RA) to enable the evaluation of the effectiveness and comprehensiveness of both methods. While the RA is mainly based on the visual screening of species in easy accessible habitats in the field, the H/O includes an extensive sampling by operation of scientific divers and boat times and a 4-times higher time effort for sample processing. We identified among all sites 273 species including 37 alien species. The fauna was composed of 210 native and 32 alien species, while the flora was composed of 26 native and 5 alien species. The ports were a diverse habitat with species numbers from 65 to 109. At the Wadden Sea stations, exclusively monitored by the less extensive RA, only half of the species numbers (36-66 species) were detected. However, on the oyster reefs the relative occurrence of alien species compared to natives was similar to the ports and one oyster reef (Nordland) even had the highest ratio (25%, 14 species) of alien species of all investigated sites. The H/O protocol identified 179 species compared to 114 species identified by the RA. Concerning to alien species, the H/O provided 85% of alien species, the RA only 67%. Especially with regard to the actual discussion on harmonized monitoring protocols within the Northeast Atlantic and Baltic regions, we recommend that future port surveys should apply the more extensive H/O protocol, since restrictions to the RA decrease drastically the chance of an early detection of alien species. We also recommend complementing the survey of ports with natural invasion 'hot spots' like the oyster reefs by rapid assessment. This combined monitoring design would increase significantly the early detection of alien species as demonstrated in our study.

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1. Introduction

Invasion by alien species is one of the major threats to the stability of marine communities and the functioning of ecosystems (World Resources Institute, 2005). Facilitated by global trade the

* Corresponding author. E-mail address: sven.rohde@uni-oldenburg.de (S. Rohde). number of alien species that were accidentally or deliberately introduced into new regions has increased rapidly during the last decades (McGeoch et al., 2010; Pyšek et al., 2012; Simberloff et al., 2013). Alien species from all major animal and algal phyla have established in most coastal regions worldwide with serious consequences for marine ecosystems (e.g. Carlton, 1979; Castilla and Neill, 2009; Davidson et al., 2015; Hewitt et al., 2004a). Marine environments are especially accessible to biological invasions since it is estimated that at any time several thousand marine species are







transported between biogeographic regions (Johnson and Chapman, 2007). Most of the marine organisms are transported on ship hulls or in the ship's ballast water. Other transport paths include aquaculture purposes, fishing gear or aquarium trade (Carlton, 1989; Hewitt et al., 2007; Schaffelke et al., 2006). Alien species can cause significant economic and environmental damage, even though the impact of alien species is rarely predictable (Anderson, 2007: Ribera and Boudouresque, 1995: Schaffelke and Hewitt, 2007; Thresher, 1999). There are only a few studies that investigated rigorously the impacts of aliens (Grosholz, 2002; Ruiz et al., 1999). While some examples show no or only a limited impact of marine alien species on the invaded environment, serving merely as an addition to the ecosystem (Farnham, 1980; Reise et al., 1998), other examples include catastrophic effects of marine alien invaders on ecosystems (Kideys, 2002; Nichols et al., 1990; Ross et al., 2003). In general, it is hypothesized that global change induced ecosystem alterations coupled with species introductions result in a "biotic homogenization" (Olden and Poff, 2004; Olden et al., 2004; Wilkinson, 2004). Biotic homogenization describes a process by which ecosystems will be dominated more and more by generalists and opportunistic species (Schaffelke and Hewitt, 2007). To prevent or reduce the impacts of alien species, costly surveillance, eradication and control programs have been proposed and frequently established. Managing plans include strategies to prevent new introductions in the first place and programs to eradicate or control established alien species (Hewitt, 2002; Hewitt et al., 2004b). It is evident that prevention measures are the most efficient way of combating biological invasions (Puth and Post, 2005: Pyšek and Richardson, 2010). Also, the effectiveness of eradication or control requires the early detection of nonindigenous species to limit their spread and prevent their establishment (Anderson, 2007).

The North Sea is characterized by its coastal tidal flats, the Wadden Sea. The Wadden Sea ranges from the Netherlands and Germany to Denmark. Most of the area is protected by nature conservation laws and was placed on the World Heritage list by the UNESCO in 2009. The European Marine Strategy Framework Directive (MSFD, 2008/56/EG,) aims to achieve a good environmental status of the coastal waters by the year 2020, which includes monitoring and documentation of alien species (Descriptor 2). Consequently, national and regional monitoring programs were initiated to compile an inventory of native fauna and flora of the Wadden Sea and to obtain a reliable species lists of already established alien species. These programs have been conducted under different spatial scales and methodological efforts. Current monitorings of alien species include assessments of macrofauna and macroflora on diverse hard substrata in the Dutch Wadden Sea (Gittenberger et al., 2010) and at different recreational ports (marinas) along the German North Sea coast (Buschbaum et al., 2012). These programs were established in 2009 using a rapid assessment (RA) methodology similar to the survey protocol by Pederson et al. (2003). Another survey approach for the Baltic Sea and later the Northeast Atlantic has been developed in context with the 'International Convention for the Control and Management of Ships' Ballast Water and Sediments' of the International Maritime Organization. To identify alien species introduced via ballast water, the HELCOM contracting states developed an extensive survey protocol that was adopted by OSPAR and jointly amended in 2013 (HELCOM/ OSPAR, 2013). This protocol describes a comprehensive sampling for non-indigenous species in ports. The HELCOM/OSPAR protocol has been suggested to be used for the MSFD monitoring (HELCOM, 2013), albeit regional or national neobiota monitoring rely on less extensive RA protocols (Buschbaum et al., 2012; Gittenberger et al., 2010). So far, there is no vigorous study that compared the effectiveness of both monitoring methods to provide an objective costbenefit analysis. Therefore, it is unknown to what extent RAs miss introduced species and impede consequent risk assessments.

This study was conducted to assess a current state inventory of native and non-native macrobenthic species in the coastal waters of the German Federal State Lower Saxony. Potential invasion 'hot spots', e.g. commercial ports, fairways, or oyster reefs, were selected for the investigation. The resulted species inventory serves as a neobiota baseline for the identification of future nonindigenous species and indicates monitoring sites with the highest invasion potential. The simultaneous application of a RA and the HELCOM/OSPAR protocol in the ports enabled the evaluation of the effectiveness and comprehensiveness of each methods, which can additionally be set in relation to the rendered effort (work hours/ costs). This will authorities allow to design a suitable and effective sampling protocol for an alien species monitoring.

2. Material and methods

2.1. Study area

The study area is situated in the central part of the Wadden Sea, southern North Sea (Fig. 1). The coast of Lower Saxony provides the longest coast line of the North Sea in Germany and the study area also includes the largest international ports of the German North Sea.

During low tide a large coherent system of sandy to muddy tidal flats emerge between the mainland and the barrier islands. Most of the coastline is secured by dikes or groynes. Approximately 1% of the tidal flats are covered by epibenthic bivalve accumulations, e.g. oyster reefs, which provide habitat to a variety of species (Markert et al., 2010, 2013). Complex channel systems discharge the tidal basins during the ebb-phase towards the tidal inlets. The tidal range of the semidiurnal tide varies between 2.3 m at Borkum, 3.3 m in Emden, 3.8 m in the Jade and 3.0 m in Cuxhaven. The salinity in the tidal basins ranges seasonally between 27 and 32. Mean water temperature changes from 1 °C in winter to 21 °C in summer. In long lasting freezing periods the backbarrier zone is covered by drift ice (long-term average: 19 days per year)(Wehrmann, 2016). Most of the study area is part of the Wadden Sea National Park, which has also the status of a UNESCO world natural heritage site. The commercial ports are situated in the estuaries of the rivers Ems, Weser and the Jade embayment, respectively. The ports are specialized to specific types of commercial maritime traffic of which most have a global character, i.e. container shipping, bulk carrier, car carrier, oil transport, naval shipping, and fishery. Additionally, the world's most frequent shipping route (southern German Bight) with a traffic volume of approx. 100,000 units per year (Wasserstrassen- und Schifffahrtsamt, 2016) borders the study area. Aquaculture is restricted to mussel fishery activities in the sublitoral.

2.2. HELCOM/OSPAR (H/O)

The surveys in the commercial ports ('port'stations) were conducted from 11.11.2014 through 02.12.2014 by adopting the port survey protocol of the joint HELCOM/OSPAR guidelines (OSPAR Agreement 2013-09) in its substantial constituents (Table 1). The port survey protocol is based on the assumption that especially commercial ports represent potential bioinvasion 'hot spots' resulting from ballast water discharge and/or hull-fouling as the main vectors of introduction. In this context, the survey of alien species has to detect a multitude of organism groups, i.e. hard substrate organisms, soft bottom epi- and endobenthos, mobile epifauna and plankton colonizing a broad variety of port-related subhabitats (subsites). Download English Version:

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