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# A risk based approach to non-native species management and biosecurity planning



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## ABSTRACT

The introduction of non-native species (NNS) is becoming an increasing problem across the globe. The need to identify and manage the pathways of their introduction has been identified as a priority for biosecurity management. There is a clear role for marine spatial planning to provide a multi-sector framework to assist in this management. A risk-based approach to identifying pathways and areas of introduction has been developed for the Shetland Islands (north Scotland), as part of the Shetland Islands' Marine Spatial Plan, Scotland. Working closely with local stakeholders was key to this process, which incorporates local and national data sets to form a high resolution model. It has been successfully used within the SIMSP and to guide the development of the Biosecurity Plan for the Shetland Islands. It also highlights the requirements for national and local legislation and policy to address and reduce all pathways within a region.

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## 1. Introduction

The distributions of marine taxa are limited by natural barriers to their dispersal [1], including geographical distance, temperature gradients, and current regimes. Over the last 150 years, human activities have increasingly been altering and bridging these barriers [2] leading to an increased and unnatural distribution of many species. Species which have been intentionally or unintentionally introduced outside their native range are referred to as 'non-native species' (NNS) [3].

The introduction of NNS has the potential to have significant impacts on biodiversity as well as serious economic and social consequence [4], with the rate of introduction increasing across Europe [5]. As a result a range of legislative measures have been developed which target the vectors and pathways of introduction of NNS, and their subsequent impacts [5]. Within the European Union the main policy and legislative drivers to target marine NNS are the Marine Strategy Framework Directive (MSFD), the Biodiversity Strategy [6,7], and EU Regulation no. 1143/2014 on Aquatic Invasive Species [8]. Internationally the Convention on Biological Diversity (CBD) sets a series of guiding principles to address the impacts of NNS [3].

The MSFD requires that all member states achieve 'Good Environmental Status' (GES) of marine ecosystems by 2020, evaluated across 11 descriptors [9]. The impacts of NNS are evaluated as one of these descriptors, with member states required to ensure

that "non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem" [9]. Whilst the EU Biodiversity Strategy aims that by 2020 "Invasive alien species (IAS) 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 IAS" [7].

The CBD proposes a hierarchical structure for tackling the spread of NNS, with prevention identified as the initial most cost-effective strategy, with eradication, containment, control and mitigation necessary if an introduction occurs. The management of the pathways of NNS introduction is therefore central to preventative management [10].

Introduction pathways may involve either accidental or intentional movement of species as a consequence of human activities [11,12]. Ballast water and hull fouling, associated with maritime activity, are responsible for the vast majority of accidental marine translocations around the world [13–16]. Non-native species have also been introduced deliberately for aquaculture purpose, which has also caused the accidental introduction of other NNS as hitchhikers [17].

The ability for a NNS to survive and become established in a new area is dependent on a number of environmental factors such as temperature, pH, salinity and pollution levels [18]. However, manmade structures can act as stepping stones for NNS in areas where they otherwise would not be able to survive, through the provision of hard substrate. These physical habitats, or habitat-islands, (e.g. piers, breakwaters, seawalls, docks and marinas, boat hulls, and ballast tanks) often support assemblages that are distinct from neighbouring communities [19]. This can make them more susceptible to the establishment of NNS.

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Reducing the risk of the introduction of a NNS through pathway management of NNS is complex, especially in the marine environment [20]. However, by identifying the areas around the coastline where there are high levels of activity related to introduction pathways it is possible to obtain an indication of the likelihood of a species being introduced at that location [20]. This approach has been used to identify introduction hotspots around the UK in 70 × 70 km grid squares [20]. The purpose of an assessment will influence the level of spatial detail or resolution that will be appropriate, however the availability, accuracy, and resolution of the underlying data may also have a significant influence. For strategic national decision making it is likely that a lower resolution would be adequate to drive decision making compared to more localised planning, where a higher resolution is likely to be required.

In Scotland management of NNS is primarily driven by the Wildlife and Natural Environment (Scotland) Act 2011 (WANE Act) and the Wildlife and Countryside Act (1981). The WANE Act places personal responsibility directly onto all marine users (both commercial and recreational users) to prevent the spread and introduction of NNS. Whilst the overarching management and use of the marine environment is primarily driven by the Marine Scotland Act 2010 (the 'Marine Act'). The Marine Act sets out a framework for the development of both a National Marine Plan for Scotland and also a series of 11 locally managed regional marine plans. These plans can help to provide an overarching multi-sector framework for the development of biosecurity plans, which can help to identify pathways of introduction to ensure compliance with both national and international legislative and policy requirements relating to NNS.

The National Marine Plan for Scotland was formally adopted in March 2015, and is now being followed by the phased development and implementation of regional marine planning. The first areas identified to develop regional marine plans are the Shetland Islands and the Clyde. One of the reasons these areas have been chosen is they initially trialled marine planning through a Scottish Government funded pilot 'Scottish Sustainable Marine Environment Initiative' (SSMEI) from 2006 to 2010. Since the end of the pilot scheme support from Marine Scotland has allowed their continued development. This has enabled both areas to integrate biosecurity planning into the marine spatial planning process through the development of biosecurity plans. These biosecurity plans have incorporated NNS monitoring, awareness raising, and advice on prevention and eradication of NNS.

To identify the areas of the Shetland coast subject to the highest risk of the introduction of NNS an assessment of pathways and stepping stones has been undertaken using 5 × 5 km grid square resolution. In addition, an assessment has been undertaken to identify areas which are most sensitive to the impacts from the introduction of NNS, either through their economic or ecological value to enable the monitoring of these areas. The model outputs will enable targeted monitoring for marine NNS. The outputs will

also help the development of specific policies to reduce the risk of introduction of NNS, helping to guide decision making.

## 2. Method

### 2.1. Risk mapping

To identify spatially varying 'risk level' for the introduction and establishment of NNS a model was developed in ArcGIS® 10.2, using the spatial analysis toolbox and model builder. This was developed through a five step process:

- Identification of pathways and stepping stones (see Section 2.1.1)
- Collection and mapping of spatial data (see Section 2.1.2)
- Assigning a risk score to each activity (see Section 2.1.3)
- Model creation in ArcGIS
- Mapping overall risk.

#### 2.1.1. Identification of pathways and stepping stones

Potential pathways for the introduction of NNS were identified from the current literature. The pathways identified as relevant to the Shetland marine area were:

- Vessel biofouling
- Transport within ballast water
- The movement of farmed finfish and well boat water into Shetland from other parts of the UK and Europe.

Other identified pathways include the import of live seafood, ornamental fish and bait. However, these industries do not exist in Shetland. In addition the import of shellfish for aquaculture purposes can pose a biosecurity risk, however in Shetland this does not currently occur, with the shellfish industry relying on natural spat settlement.

Manmade structures that can form stepping stones for the establishment and spread of NNS were identified as:

- Marine access infrastructure e.g. marinas, jetties, breakwaters, piers
- Marine renewable devices
- Aquaculture equipment (finfish, shellfish, and seaweed farms).

#### 2.1.2. Collection and mapping of spatial data

Data on the distribution of marine activities identified as potential NNS pathways and stepping stones were compiled from publicly available data held within the Shetland Islands' Marine Spatial Plan (SMSP) [21], with the exception of shipping data which utilised Automatic Identification System (AIS) data held by

**Table 1**  
Data sets used within the of the risk assessment model.

Pathway/ stepping stone	Risk	Dataset	Year	Source	Confidence assessment score <sup>a</sup>
Pathway	Vessel biofouling	AIS data	2013	NAFC Marine Centre	Medium-high
Pathway	Ballast water	Port statistics	2013	NAFC Marine Centre	High
Pathway	Aquaculture species movement	Finfish farm location	2014	SMSP/Shetland Islands Council	High
Stepping stone	Marine access infrastructure	Marina, jetty, breakwater, pier locations	2014	Various compiled by SMSP	High
Stepping stones	Marine renewable devices	Works licence locations	2014	SMSP/Shetland Islands Council	High
Stepping stones	Aquaculture equipment finfish, shellfish and seaweed farms	Site consent locations (planning consent or works licence)	2014	SMSP/Shetland Islands Council	High

<sup>a</sup> Source: NAFC Marine Centre [22].

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