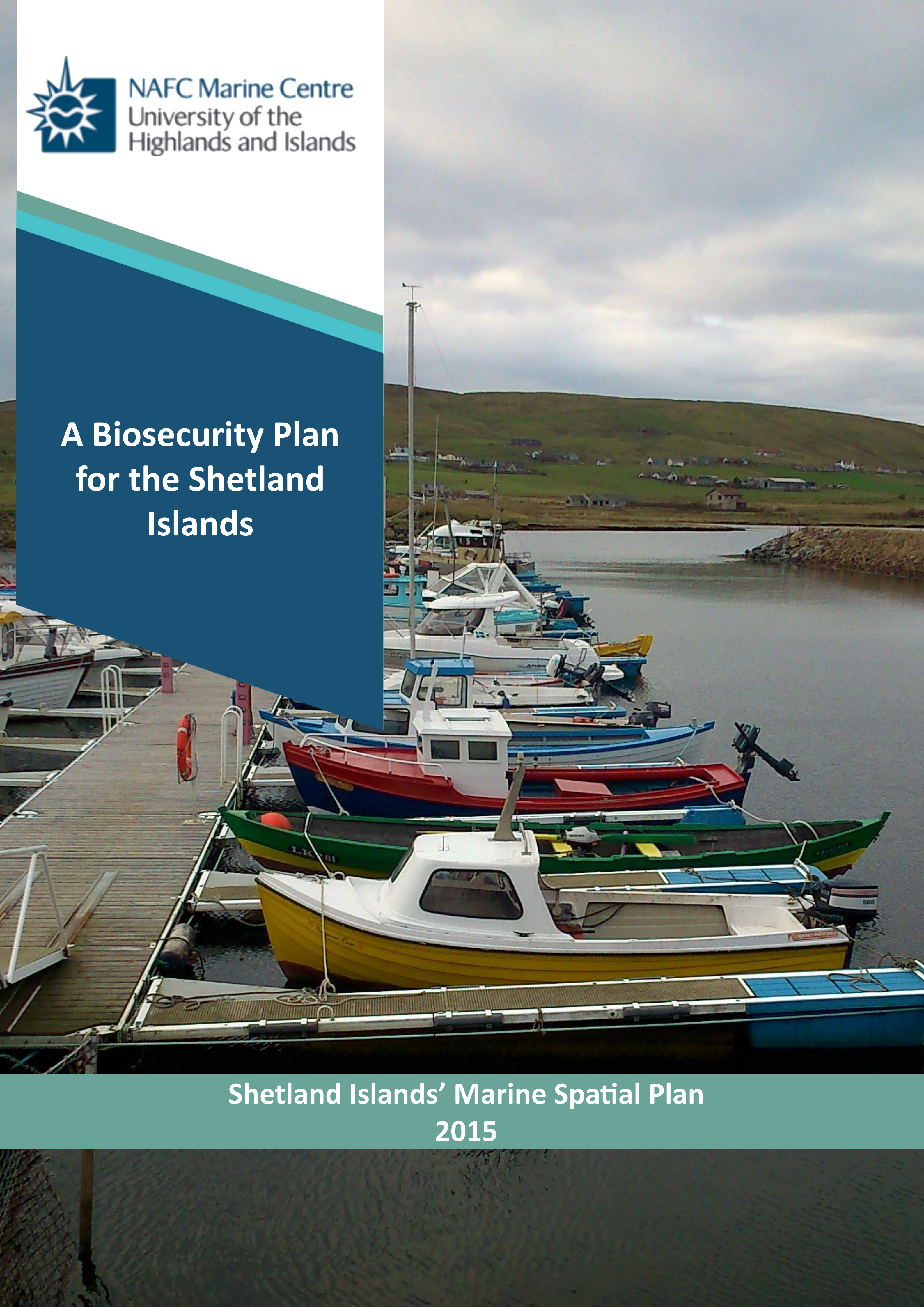
NAFC Marine Centre
University of the Highlands and Islands

A Biosecurity Plan for the Shetland Islands



Shetland Islands' Marine Spatial Plan
2015

This report has been prepared as part of the 'Shetland Islands' Marine Spatial Plan' (SMSP) which is administered by the NAFC Marine Centre and is guided by a local advisory group. Funding for the SMSP and this biosecurity plan was provided by Marine Scotland and the NAFC Marine Centre.

This report should be referenced as:
Collin, S.B., MacIver, K., Shucksmith, R. (2015). A Biosecurity Plan for the Shetland Islands.

This document is available from our website at http://www.nafc.ac.uk

NAFC Marine Centre
Port Arthur
Scalloway
Shetland
ZE1 0UN
01595 772000
marineplan@uhi.ac.uk

Contents

Executive summary

The purpose of the Biosecurity Plan for the Shetland Islands is to provide a useful and practical guidance framework for reducing the potential for non-native species (NNS) introduction and minimising their associated impacts. The need for a comprehensive marine biosecurity plan was identified in the fourth edition of the Shetland Islands' Marine Spatial Plan, by highlighting the importance of identifying and assessing pathways and vectors that may lead to the introduction and spread of problematic 'invasive' non-native species (INNS).

This Biosecurity Plan provides information on best practice procedures for all marine users that will contribute to the effective management of marine NNS. This Plan proposes a four-stage approach to ensure best practices are put in place:

Stage 1
Identify key pathways of non-native species transportation and reduce or eliminate the risk of introduction to the Shetland Islands marine area.
Stage 2
Identify which non-native species are present in the Shetland Islands and detect any newly introduced non-native species as early as possible.
Stage 3
Contain or potentially eradicate non-native species prior to population expansion, spread, and detrimental impact on the local environment.
Stage 4
Control and mitigate the impacts of any established invasive non-native species and, where feasible, attempt eradication.

Of the four stages in the proposed approach, priority should be given to Stages 1 and 2: prevention of introduction and early detection. Preventing the introduction of NNS is the ideal and most cost-effective solution to NNS management and steps towards achieving this include open-ocean ballast water exchange, hull cleaning, and restrictions on vessel movement. However, given the scale of marine industries and the large number of marine users, preventative actions are difficult to implement and NNS introductions still occur. Therefore, focus should also be directed towards surveillance, monitoring, and early detection. By detecting an NNS early in the invasion process, management effort can be focused on smaller, more isolated populations, which increases the potential for control, containment, and potentially eradication prior to any impact. Once an NNS population is detected, subsequent management effort should be rapid to minimise population expansion and spread. The window for effective management of marine NNS is short and, therefore, it is essential to have a reliable monitoring strategy and protocols for NNS management in place to ensure the potential for any detrimental impacts is kept to a minimum.

Marine industry is an essential part of Shetland's economy and therefore the potential for damage by marine NNS is considerable. The implementation of the Biosecurity Plan for the Shetland Islands will address the concerns posed by marine NNS by providing the following benefits:

- Ensuring NNS monitoring and management in the Shetland region is cost effective, efficient, and follows national guidelines
- Reducing the potential for NNS introduction and establishment in Shetland
- Reducing the impacts posed by NNS on the local aquaculture and fisheries industries
- Reducing the threat to Shetland's marine biodiversity from NNS
- Conservation of natural habitats and ecosystems that are of local, national, and international importance
- Ensuring all marine users, including aquaculture, fishing, commercial shipping, and recreational boating, are aware of codes of best practice for reducing the introduction and spread of NNS

1. Purpose and scope

What are non-native species?

Non-native species (NNS), also known as alien species, are animals or plants that have been introduced to a new location, outside of their natural range, by human activity. These introduction events can occur either accidentally or intentionally.

What are invasive non-native species?

Invasive non-native species (INNS) are a subset of NNS, which have successfully established self-sustaining populations, that cause negative economic, environmental, and/or health impacts on the recipient environment/community.

The purpose of the Biosecurity Plan for the Shetland Islands is to provide a useful and practical guidance framework for reducing the potential for non-native species (NNS) introduction and minimising their associated impacts. The success of this plan will be achieved by close and regular collaboration and communication with local organisations, industries, and the general public. Within this Plan, marine biosecurity issues for the Shetland Islands are highlighted and options for preventing NNS introduction, early detection and monitoring strategies, rapid response, mitigation, and control are presented and discussed.

The Biosecurity Plan for the Shetland Islands has been developed by the Marine Spatial Planning Section at the NAFC Marine Centre in Scalloway, with funding provided by Marine Scotland and the NAFC Marine Centre. The Biosecurity Plan aims to support the Shetland Islands' Marine Spatial Plan (SMSP), which is now in its fourth edition. The SMSP contains a specific policy to reduce the spread of NNS that states the following:

Policy MSP INNS1 - Reducing the spread of invasive non-native species

> *'Applications for marine-related developments should demonstrate that the potential risks of spreading INNS have been adequately considered in their proposal, particularly when moving equipment, boats or live stock (e.g. fish and shellfish) from one water body to another or introducing structures suitable for settlement of INNS.*
> *Development proposals in areas where INNS are known to exist must include mitigation measures or a contingency plan, approved by the local authority, that seeks to minimise the risk of spreading the INNS or identifies ways to eradicate the organisms and set up a scheme to prevent reintroduction.'*

This Biosecurity Plan covers the area laid out in the SMSP, which includes all territorial waters out to 12 nautical miles as well as the terrestrial and coastal habitats/ecological processes that are affected by marine use. This Biosecurity Plan has been developed for commercial marine users, who are required to adhere to the SMSP, and non-commercial marine users, such as recreational boaters, who fall outside the management remit of the SMSP but have a key role to play in biosecurity planning. Within this Biosecurity Plan, the following key sectors are discussed and sector-specific guidance is provided:

- Aquaculture
- Commercial fisheries
- Oil industry
- Renewable energy
- Ports and harbours: commercial shipping
- Tourism and recreation

The objectives, outputs, and recommended guidance presented within this Biosecurity Plan were developed in conjunction with the Biosecurity Working Sub-Group, a subset of the SMSP advisory group, as well as other interested parties. This Biosecurity Plan, therefore, represents an agreed approach to biosecurity by the NAFC Marine Centre, local stakeholders, and public bodies (Appendix I).

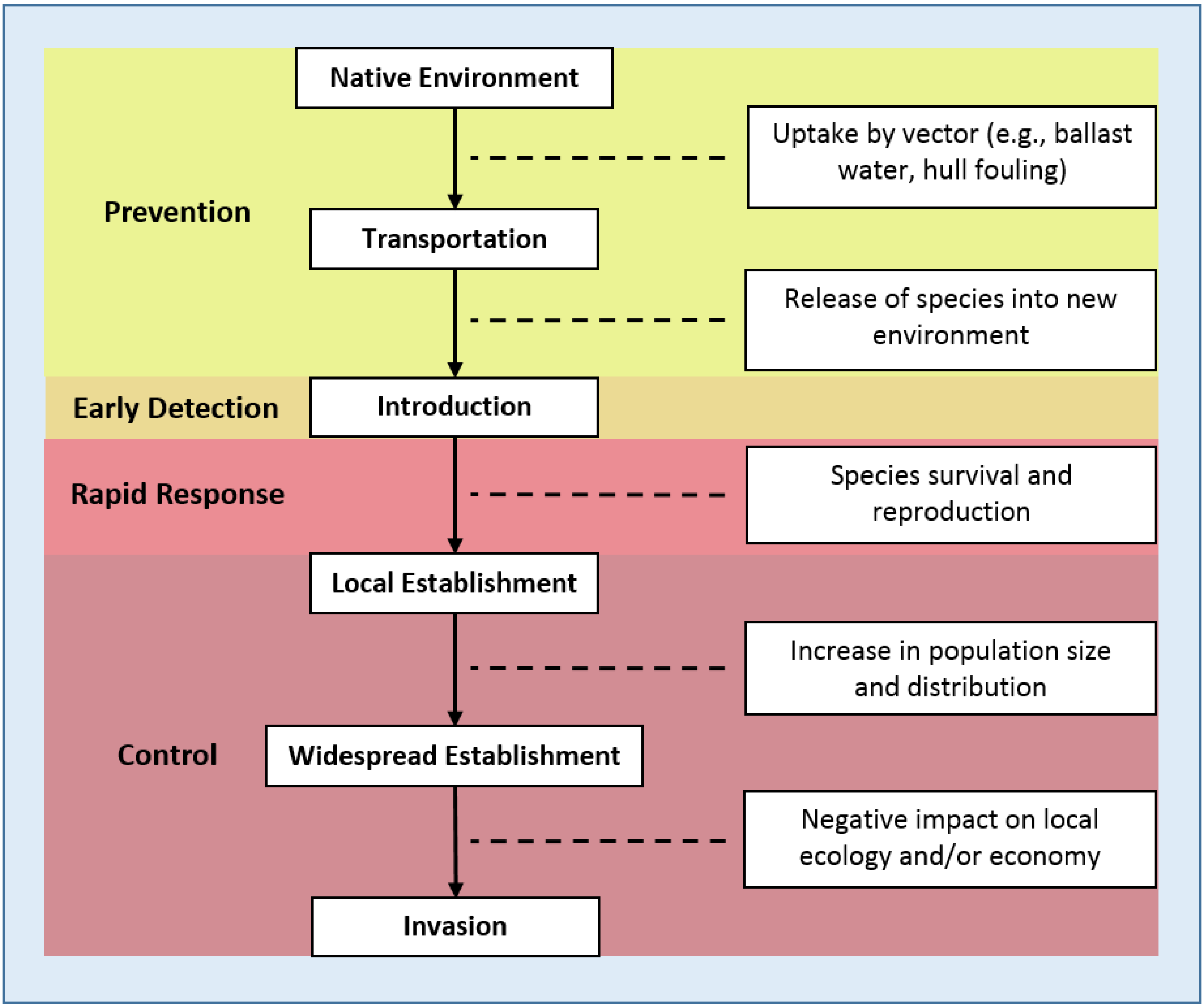


Figure 1.1. Flow diagram of key stages of the invasion process, highlighting the four stages of management proposed in the Biosecurity Plan for the Shetland Islands

This Plan focuses on four key objectives that encompass all stages of the invasion process (Figure 1.1):

Objective 1 - Prevention: Identify key pathways of non-native species transportation and reduce or eliminate the risk of introduction to the Shetland Islands marine area.

Objective 2 - Early detection: Identify which non-native species are present in the Shetland Islands and detect any newly introduced non-native species as early as possible.

Objective 3 - Rapid response: Contain or potentially eradicate non-native species prior to population expansion, spread, and/or any detrimental impact on the local environment.

Objective 4 - Control: Control and mitigate the impacts of an established invasive non-native species and, where feasible, attempt eradication.

2. Non-native species: the need for biosecurity

The potential for damage caused by non-native species (NNS) and the need for effective biosecurity measures are becoming increasingly concerning for local governments, industries, and conservationists. Advances in marine technology, and the expansion of international trade, have broadened the scope for travel and transportation, which, in turn, has led to widespread transportation of marine species around the globe and an increase in NNS introductions. The main vectors (pathways) that contribute to the redistribution of marine species around the world are:

- Ballast water exchange
- Hull fouling of commercial and recreational vessels
- Movement of equipment and live animals in aquaculture
- Marine litter, including discarded or lost fishing and aquaculture gear/equipment
- Aquarium trade, including the escape or release of plants and animals from aquaria

While some NNS have been intentionally introduced for cultural or economic benefit, e.g. the Pacific oyster (Crassostrea gigas) for shellfish cultivation, most introductions are unintended. Predicting whether an NNS will become problematic is very difficult, as it depends on both species and environmental characteristics, but once introduced, NNS have the potential to affect the recipient environment, both ecologically and economically, in the following ways:

Ecological impacts

- Compete with native species for food and space
- Prey upon native species
- Provide alternative food sources for native predators
- Spread disease
- Alter the physical structure of the local seabed (substrata)

Economic impacts

- Increase cleaning costs for aquaculture and port authorities (fouling)
- Reduce shellfish production (competition for food and space)
- Damage boats and marinas (fouling)
- Impact tourism

In addition to the threat posed by increasing numbers of NNS introductions, climate change is expected to have a significant impact on the invasion 'success' of NNS in the coming years. Changes in the marine environment, such as increases in temperature and sea level, can influence NNS in four key ways:

1. A shift in the natural range, or extinction, of native species, in accordance with environmental change, could create vacant niches and leave the ecosystem vulnerable to invasion
2. The survival rate of NNS once introduced could increase if conditions become more favourable (particularly for species that prefer warmer conditions)
3. The population growth and spread rate of NNS already present could increase as conditions change, thus becoming problematic and invasive
4. The spread rate and distribution of an established INNS could increase, thus augmenting the associated impact

Monitoring changes in the marine environment and the distribution and abundance of important species that act as climate change indicators, such as the snakelocks anemone, *Anemonia viridis*, is important for identifying ecological shifts that may contribute to the success of NNS.

All NNS have the potential to become invasive, but the reality is only a few actually do. The difficulty lies with identifying which species will become problematic and when. However, as the potential for damage is so great, it is considered advisable to assume that all NNS will become invasive and a precautionary approach should be applied whenever an NNS is detected.

The Shetland Islands have important fishing, aquaculture, and oil and gas industries, all of which create a very busy and highly dynamic marine environment. Additionally, Shetland is home to a wealth of much smaller scale recreational activities – such as leisure boating, recreational fishing (boat and shore), yachting, SCUBA diving, and sea-kayaking. The high levels of marine activity around the Shetland Islands suggests there are potentially many vectors for NNS introduction from distant locations and, once introduced, the high level of

Image © NAFC Marine Centre

local recreational and commercial activity can lead to rapid local spread. Therefore, a reliable and effective monitoring strategy needs to take into account multiple scales of marine activity and multiple vectors of spread to ensure NNS are detected early and controlled.

In addition to human activity, natural system dynamics, such as winds and currents, can assist the dispersal of marine NNS on both regional and local scales. These systems cannot be controlled by humans, but an understanding of how they influence NNS dispersal can be essential for allocating monitoring effort and predicting the direction of spread of an NNS population. In the Shetland Islands, the prevailing winds and currents of the North Atlantic can be an important driver of spread of NNS from mainland Scotland and Orkney. Therefore, regular monitoring on the southern and western coastlines of the Shetland Islands would increase the probability of detecting newly arriving NNS transported by natural dynamics.

As the spread of NNS around the UK increases, either by natural dispersal from the point of introduction or by local human activity (secondary spread), it is important that marine users are trained in NNS identification, vectors of spread, and codes of good practice. Factors such as climate change, pollution, and habitat disturbance all have the potential to facilitate the survival and spread of NNS and it is expected that the costs associated with control, mitigation, and eradication will increase over time. Therefore, to increase the probability of early detection, the sighting and recording of NNS by the general public is an essential part of a biosecurity plan.

The main concern for the Shetland Islands is the potential economic impact INNS can have on local marine industries, such as aquaculture and fisheries. The economic impact of INNS (marine and terrestrial) throughout the UK has been significant and, as estimated in a CABI report (commissioned by the DEFRA, Scottish Government, and the Welsh Assembly in 2010), costs approximately £1.7 billion per year (£250 million in Scotland). The estimated cost to aquaculture in Scotland is more than £700,000 per year. Considering the substantial contribution marine industries make to the Shetland economy, any detrimental impact by INNS could be highly costly. It is, therefore, vital that a coordinated and systematic approach to the prevention and control of NNS is adopted.

Despite the well-documented impacts of INNS around the world, our understanding of what drives a problematic invasion is still at an early stage, mainly because each invasion event has unique characteristics – the combination of a species biology, ecology, and environmental tolerances, mixed with the environmental and ecological context of the recipient location. The idiosyncratic nature of marine invasions means that there is no general procedure to NNS management and often approaches need to be site specific. Therefore, by designing a biosecurity plan that is specifically tailored to the Shetland Islands – by identifying key vectors of spread, NNS that pose the biggest threat, and designing a monitoring strategy that incorporates these concerns – we can increase the potential for effective management.

2.1. Policy and legislation

The threat posed by the introduction of NNS has been recognised worldwide and to minimise future risks of introduction various legislation have been introduced that identify governmental and personal (individual marine user) responsibilities. It is important to acknowledge that NNS management

Image © NAFC Marine Centre

is still a relatively new subject and, therefore, legislation towards NNS is constantly evolving as our understanding of impacts, risk, and management develop.

2.1.1. Governmental responsibilities

Within the European Union, the main legislative drivers to tackle non-native species in the marine environment are the Marine Strategy Framework Directive (MSFD) and the Biodiversity Strategy (EC 2012, 2014).

The MSFD requires all member states to achieve 'Good Environmental Status' (GES) of marine ecosystems, evaluated across 11 descriptors (EC, 2008). 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' (EC, 2008). The EU Biodiversity Strategy (EC 2011) has proposed 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'.

In addition, there are a number of other pieces of legislation and conventions which require nations to manage the introduction and spread of NNS including:

EU Regulation No. 1143/2014 on Aquatic Invasive Species (2014)
'This Regulation sets out rules to prevent, minimise and mitigate the adverse impact on biodiversity of the introduction and spread within the Union, both intentional and unintentional, of invasive alien species.'

Convention on Biological Diversity (1993)
'Promote the protection of ecosystems, natural habitats, and the maintenance of viable populations of species in natural surroundings'.
'Prevent the introduction of, control, or eradicate those alien species which threaten ecosystems, habitats or species'.

United Nations Law of the Sea (1994)
'Prevent, reduce and control pollution of the marine environment resulting from the use of technologies under their jurisdiction or control, or the intentional or accidental introduction of species, alien or new, to a particular part of the marine environment, which may cause significant and harmful changes thereto'.

International Convention for Control and Management of Ships' Ballast Water and Sediment (2004)
'Prevent the spread of harmful aquatic organisms from one region to another, by establishing standards and procedures for the management and control of ships' ballast water and sediments'.

This piece of legislation will come into force 12 months after ratification by at least 30 states that represent 35% of the World's merchant shipping tonnage. As of 14th October 2014, 43 states have ratified the Convention that represent 32.02% of the World merchant shipping tonnage.

ICES Code of Practice on the Introductions and Transfers of Marine Organisms (1994)
The code of practice (updated in 2005) follows a precautionary approach with the goal of 'reducing the spread of exotic species'. It accommodates the 'risks associated with current commercial practices including trade in ornamental species and bait organisms, research, and the import of live species for immediate human consumption'.


Image © NAFC Marine Centre

Convention on the Conservation of European Wildlife and Natural Habitats (The Bern Convention 1979)
The Bern Convention imposes legal obligations on contracting parties to ensure conservation and protection of wild plant and animal species and their natural habitats. Chapter 5 – Supplementary Provisions, Article 11.2.b states a need to 'strictly control the introduction of non-native species.'

European Strategy on Invasive Alien Species (Bern Convention) 2004
This strategy is targeted at governments of Contracting Parties to the Bern Convention and of other European states. It addresses 'nature conservation agencies and all other sector agencies with responsibility for activities relevant to IAS (Invasive Alien Species) prevention or management'. It seeks to 'engage stakeholders involved in the movement, use, and control of potentially invasive alien species (industry and trade, transporters, retailers, resource managers, the public etc.) and to build on the expertise and commitment of competent non-governmental organisations and research institutes'.

2.1.2. Personal responsibilities

There are two key pieces of legislation in Scotland which specifically place personal responsibility directly onto all marine users (both commercial and non-commercial) to prevent the spread and introduction of NNS: the Wildlife and Countryside Act (1981) and the Wildlife and Natural Environment (Scotland) Act 2011 (WANE Act), which makes a number of amendments to the 1981 Act.

The WANE Act makes specific amendments to the Wildlife and Countryside Act relating to NNS, including changes to section 14, which now states that 'any person who (a) releases, or allows to escape captivity any animal (i) to a place outside its native range; or (ii) of a type the Scottish Ministers by order specify; or (b) otherwise causes any animal outside the control of any person to be at a place outside its native range, is guilty of an offence.'

The WANE Act also details specific changes to the release of NNS, based on a 'general no-release approach', as well as additional sections on keeping, notification, and control of NNS. The 2011 Act introduced a new regime of Species Control Orders, which enables relevant bodies to dictate which measures must be taken to control NNS. In accordance with this legislation, Marine Scotland are responsible for the control of marine and coastal waters, which grants them access to 'carry out investigations or control work and the ability to recover costs, if appropriate'. To encourage individuals, businesses, and public bodies to act responsibly, the Scottish Government has issued a 'Code of Practice on Non-Native Species', which sets out a guidance on how to act responsibly within the law to ensure that non-native species under ownership, care, and management do not cause harm to our environment. This Code came into effect in July 2012 and, although failure to comply is not itself an offence, it could be used in court as evidence in the event of criminal proceedings.

Table 2.1. Support provided by the 'Biosecurity Plan for the Shetland Islands' to other relevant environmental management plans

Existing Plans	Action in Biosecurity Plan
Shetland Islands' Marine Spatial Plan	
Suggests the development of a biosecurity plan to include a range of management measures	This Biosecurity Plan for the Shetland Islands is the suggested biosecurity plan
SIC Local Development Plan	
The Council is legally obliged to further the conservation of biodiversity and seeks to minimise negative impacts to native species.	Supports the conservation of biodiversity and the reduction of ecological impacts on the native ecosystem by NNS.
RBMP for Scotland and the Orkney & Shetland Area Management Plan	
To maintain and improve the ecological status of the rivers, lochs, estuaries, coastal waters and groundwater areas in Orkney and Shetland.	Reduce the likelihood of NNS introduction and spread, which will help to maintain the coastal water ecosystems around Shetland.
Designated conservation areas (SSSIs, SPAs, SACs)	
Avoid deterioration of the qualifying habitat, species or habitat of the species.	Support the conservation of marine habitat and species protected by preventing the introduction and spread of INNS.

2.2. Existing planning framework

This Biosecurity Plan links to existing government-led policy, legislation, and strategic action and reflects the provisions and requirements of the following existing plans:

- Shetland Islands' Marine Spatial Plan (SMSP)
- The Shetland Islands Council (SIC) Local Development Plan (LDP)
- The Orkney and Shetland Area Management Plan (River Basin Planning)

This Plan also supports the conservation objectives of Special Areas of Conservation (SACs), Sites of Special Scientific Interest (SSSIs) and Special Protection Areas (SPAs) within the Shetland Islands. Table 2.1 highlights the specific provisions and requirements that are supported by this Plan.

2.3. Further reading

Governmental responsibilities

Convention of Biological Diversity (1993)
www.cbd.int

United Nations Law of the Sea (1994)
www.un.org

International Convention for Control and Management of Ships' Ballast Water and Sediment (2004)
www.imo.org

European Strategy on Invasive Alien Species (Bern Convention) 2004
www.cbd.int

Personal responsibilities

Non-native species and the law
www.snh.gov.uk

Wildlife and Countryside Act (Scotland) Regulations 2001
www.legislation.gov.uk

Shetland Island's Marine Spatial Plan
www.nafc.uhi.ac.uk

Code of practice on non-native species
www.scotland.gov.uk

Great Britain Non-Native Species Secretariat (GB NNSS) advice for biosecurity in the field (specific information for anglers & boat users)
www.nonnativespecies.org

GB NNSS – EU AIS Regulation
www.nonnativespecies.org

3. Biosecurity concerns

3.1. The Shetland marine environment

The marine environment is critical to Shetland's economy, providing over 2900 jobs and contributing £435 million annually, which equates to approximately 40% of Shetland's total economic output (Shetland in Statistics, 2013). The marine environment is used by a wide range of industries that often utilise the same areas and infrastructure, which places added pressure on marine resources and requires a holistic approach for effective management. At present the marine environment surrounding the Shetland Islands is used by:

- Aquaculture
- Commercial fisheries
- Oil industry
- Renewable energy
- Commercial shipping
- Tourism and recreation

All of these activities have the potential to introduce and facilitate the spread of NNS to and around the Shetland Islands through vessel movements and marine developments. Therefore, a management plan that addresses all associated risks is required to ensure any impacts will be kept to a minimum.

3.2. Artificial structures

Human activity has had a large impact on the marine environment, not only in the transportation and redistribution of marine species, but also on its physical structure. Close to shore, developments, such as marinas, ports, and coastal defences, have created a vast array of hard surfaces suitable for the attachment of sessile species, such as barnacles, mussels, and sea squirts. These hubs for recruitment, both coastal and offshore, provide a safe haven for NNS to establish – particularly in marinas, which tend to be in more sheltered environments. It is in these environments that NNS can establish large populations from which they can disperse into the surrounding natural environment. If the natural habitat available is not suitable for recruitment, or competition with the native community restricts colonisation, artificial structures can act as 'stepping stones' and provide a pathway for NNS to spread along or between coastlines. This is of particular concern for close-to-shore and offshore developments, where structures can facilitate the spread of NNS between two distant, but similar, habitats.

NNS are strongly associated with artificial structures and have been found to dominate the communities found on artificial habitats. The reasons for this are complex and most likely include the following:

- NNS tend to be rapid colonisers (e.g. high fecundity, short dispersal range) and can quickly take advantage of available space
- NNS tend to be highly competitive (e.g. predation) and can outcompete native species
- NNS tend to have high environmental tolerances and can survive in sub-optimal conditions
- Native species have evolved to the surrounding natural habitat and may be less successful in artificial environments

Many NNS fail to establish in natural habitats, most likely because native communities have evolved to optimally utilise all available resources (e.g. food, space), leaving few gaps for NNS to exploit. For example, wireweed (*Sargassum muticum*) tends to be scarce in areas that have an already established community but more successful on artificial structures.

In some cases, NNS are incapable of surviving in natural habitats and are restricted to artificial environments, posing little threat to the native community. However, if an NNS is capable of dispersing the distance between artificial environments, it can continue to spread along a coastline without requiring natural habitats. The planktonic stage (the period of time suspended in the water column) of marine species plays an important role in dispersal and can influence rates of spread. Both long and short planktonic stages can influence invasion success – long dispersal allows new populations to establish far from the adult population and short dispersal increases retention, which allows for local population growth.

The high variability in the dispersal potential of NNS presents a challenge for environmental management, as designing monitoring strategies and control


Image © C.Slater (NAFC)

methods will vary depending on the species. For example, NNS with short planktonic stages that can quickly develop a localised population may be easier to contain and treat locally than a species capable of long-distance dispersal.

Around the Shetland Islands, permanent structures, such as coastal defences, anchored buoys, submerged pipes, and oil rigs, are of particular concern, as they provide hard surfaces where much of the natural seabed consists of mud and course sand. The natural seafloor is often unsuitable for NNS that prefer hard surfaces and would have acted as a natural barrier and restricted their spread. By introducing artificial structures, corridors of suitable substrates are created that allow NNS to cross these natural barriers and continue to spread. For example, the development of North Sea oil fields, and the subsequent construction of oil rigs, has the potential to create a pathway between Shetland and Scandinavia for marine species capable of long distance dispersal.

3.3. Looking beyond the UK

The Shetland Islands are located almost equidistantly between mainland Scotland and Norway and, therefore, NNS found in Norway should also be considered potential biosecurity risks for Shetland. As a highly productive coastal region with a long coastline, Norway has a high risk of NNS introduction and currently contains over 45 established marine NNS, considerably higher than those found in the Shetland Islands. The high number of NNS is thought to be the result of hull fouling, ballast water exchange, accidental/intentional release of animals, and the use of NNS for aquaculture. More information on why marine NNS have successfully established in Norway will be essential for identifying which species pose a threat to Shetland, but until then careful attention should be paid towards potential vectors between Shetland and Norway.

Considering the global scale, international transportation by large vessels is a major vector of spread for NNS but keeping track of vessel movements can be challenging. Today, all marine vessels over 300 gross tonnage on an international voyage, all cargo vessels greater than 500 gross tonnage, all EU fishing vessels over 15 m in length, and all passenger vessels irrespective of size are required to be fitted with an Automatic Identification Systems (AIS), which can track their movements and store vessel information, such as the last port of call and destination. Using these data, the number of vessels travelling through or docking in the Shetland Islands with a high probability of transporting NNS, in particular high-risk NNS, can be quantified.

The map in Figure 3.1 was created using AIS data for vessels travelling to the Shetland Islands and gives an indication of the geographical spread of their last ports of call and the potential for long and short-distance transportation of NNS. The last port of call for the majority of shipping vessels in Shetland waters was recorded within the UK or northern Europe, although many vessels had travelled far larger distances, including the USA, South America, the Middle East, and Africa. Vessel movements pose two key biosecurity threats: firstly, the introduction of new NNS to a region (e.g. North America to Europe) and secondly, assisting with the regional spread of an already-established NNS (e.g. transporting a species native to North America from southern Europe to northern Europe). The high level of connectivity between European ports suggests that NNS introduced to Europe have a high probability of spreading to multiple sites, including the Shetland Islands.

Using the AIS data and current information on

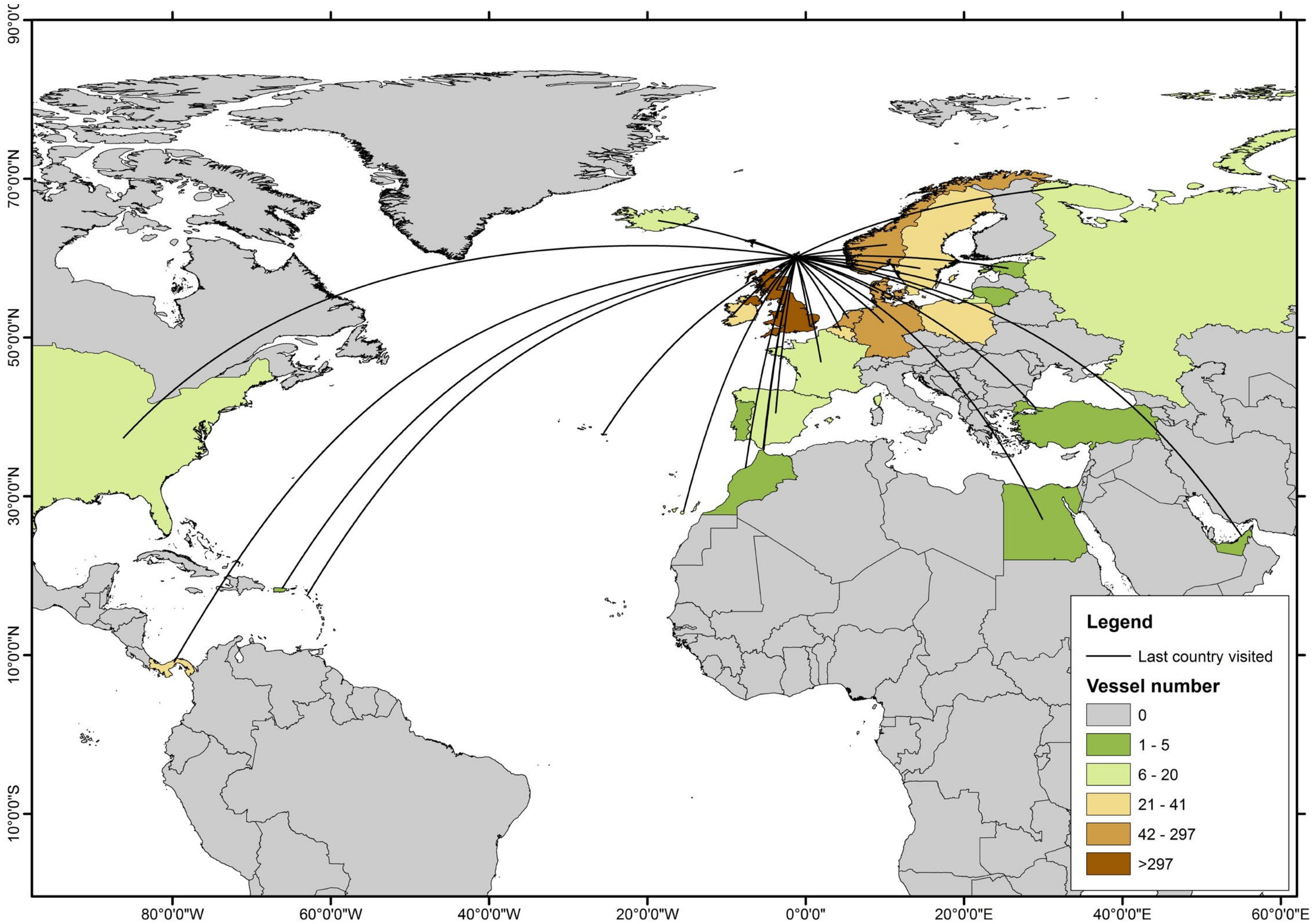


Figure 3.1. Last port of call recorded by ships passing within 3 nautical miles of the Shetland Islands

the location of marine industries, the risk of NNS introduction around the Shetland Islands was examined and graded in 5×5 km grid squares, from 'low' to 'very high' (see Appendix II for further details). This assessment takes into account the probability of an NNS being introduced, the frequency and type of activity being assessed, and the confidence of being able to precisely map where the activity takes place (e.g. confidence is high for aquaculture with a fixed location, but low for ballast water exchange). These factors are used to calculate a cumulative risk value of NNS introduction for the Shetland Islands, as illustrated in Figure 3.2, and identifies areas where monitoring and surveillance effort should be focused.

The cumulative risk assessment for NNS introduction to the Shetland Islands has identified the Lerwick harbour area as 'very high' risk. Additionally, Sullom Voe and Scalloway harbour have been identified as 'high' risk. These sites correspond with areas of high activity, principally for shipping and boating traffic (e.g. Lerwick, Scalloway, Sullom Voe) and/or sites with higher intensities of aquaculture activity (Scalloway area).

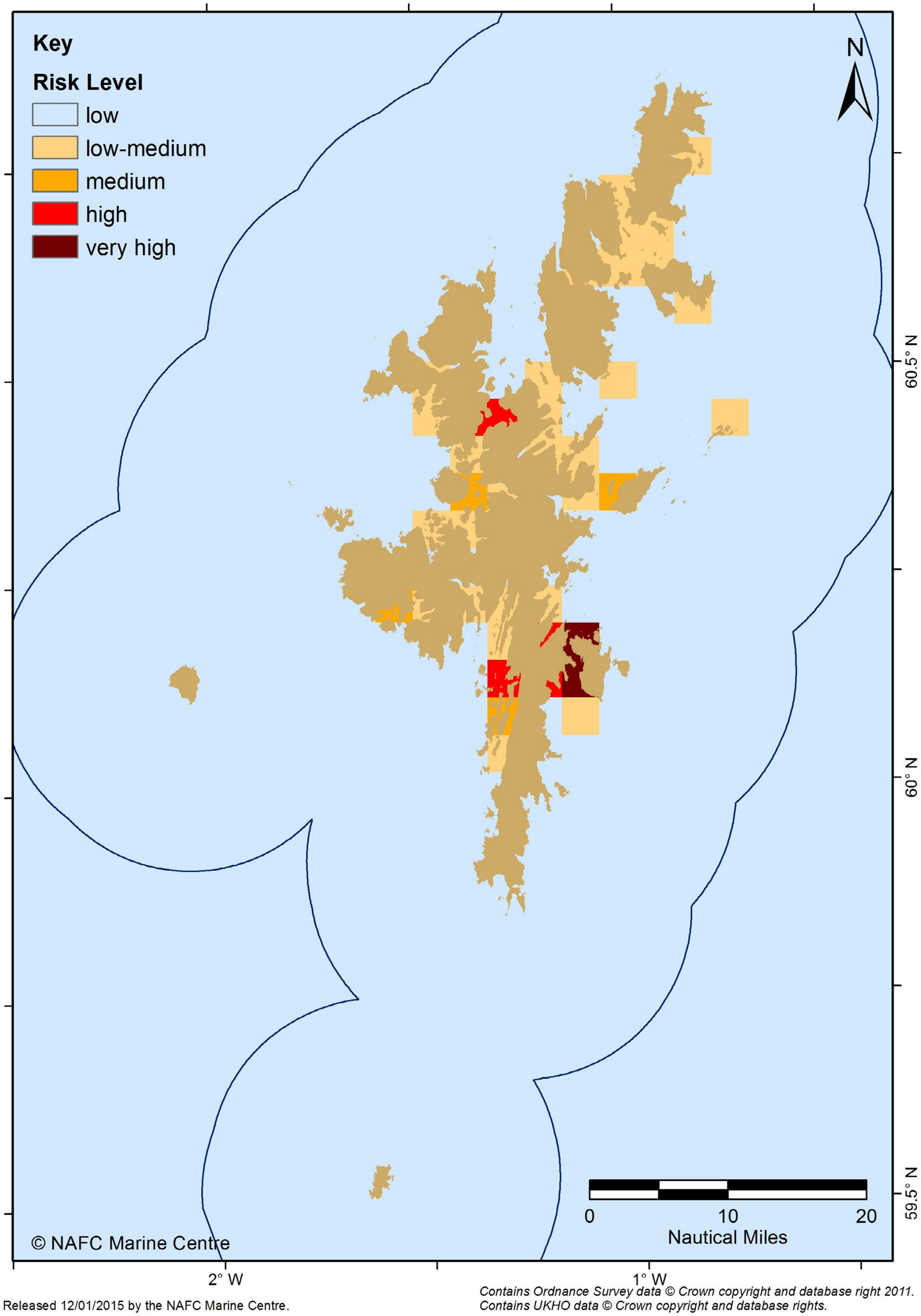


Figure 3.2. Risk of introduced NNS to the Shetland Islands based on fouling and ballast water exchange from national and international vessels

Image © NAFC Marine Centre

3.4. Biosecurity - current and potential threats

At present, there are eleven marine NNS identified within the Shetland Islands but, as of yet, none of them have had a considerable impact on surrounding industries or the environment.

This section provides an overview of the marine NNS already present around the Shetland Islands and also other NNS within the UK and northern Europe that have the highest potential of being introduced[1] . For additional information on the dispersal potential and environmental preferences of the species within this section, see Appendix III.

[1] The 'Environmental' and 'Economic' threat assessments for each species have been determined specifically for the Shetland Islands by means of a literature review of the species biology (see Appendix III), assessing the suitability of local environmental conditions, and evaluating the invasion history of the target species at other sites outwith the Shetland Islands.

3.4.1 Current Threats

Orange-Tipped Sea Squirt
Corella eumyota
Status – Present in Scalloway, Lerwick, Sullom Voe, and Yell
Environmental threat – Medium
Economic threat – Low

Background
Corella eumyota is a solitary sea squirt that is native to the southern hemisphere. It was first de-tected in the UK in 2004, along the southern coast of England, and has since spread to Ireland, mainland Scotland, and more recently Shetland (first detected in 2014). *Corella eumyota* can grow up to 8 cm in length, but are generally between 2 and 4 cm. They have two distinctive orange siphons; an inhalant siphon at the extreme end of the body and an exhalant siphon on the right-hand side of the body. The body is translucent and smooth to touch and has a clearly visible U-shaped gut. It can be easily mistaken for the native sea squirt, *Ascidiella aspersa*, but the key distinctive characteristics are that *A. aspersa* has a rough surface, the exhalant siphon is on the left-hand side of the body, and the visible gut is S-shaped.

Corella eumyota reproduces during the warmer summer months. It is capable of self-fertilising, which suggests that only a few individuals need to be introduced to establish a larger population. During reproduction, larvae are retained within brooding chambers and released ready to settle. The result is a very short planktonic period (minutes) and a short dispersal range.

Vectors of spread
The most likely vector for spread is hull fouling on large ships and recreational boats. The larvae of *C. eumyota* attach to dark, hard surfaces, which makes the underside of a boat an ideal location. As *C. eumyota* has a very short natural dispersal potential, the current distribution around the UK is most likely the result of hull fouling.

Impacts
Fouling of boat hulls, marina structures (e.g. pylons, chains, and pontoons), aquaculture equipment and mussel lines.

Image © R. Shucksmith (NAFC)

Bryozoan

Schizoporella japonica

Status – Widespread throughout Shetland on man-made structures

Environmental threat – Low

Economic threat – Low

Background

Schizoporella japonica is a species of bryozoan originally from Japan. It was first detected in the UK in Holyhead, north Wales, in 2010 and more recently in northern Scotland in 2011. It is now widespread throughout the Shetland Islands.

Schizoporella japonica is a small, colonial animal that is capable of forming encrusting mats across different types of surfaces – notably rocks, algae, and shells. It has an orange-red colour and can form colonies up to 20 cm in diameter. It is a cold-water species of bryozoan, which means its reproductive season extends into the UK winter seasons. This is an important characteristic as few species (native or non-native) in the Shetland Islands reproduce over winter and, therefore, competition for resources (e.g. space) is reduced.

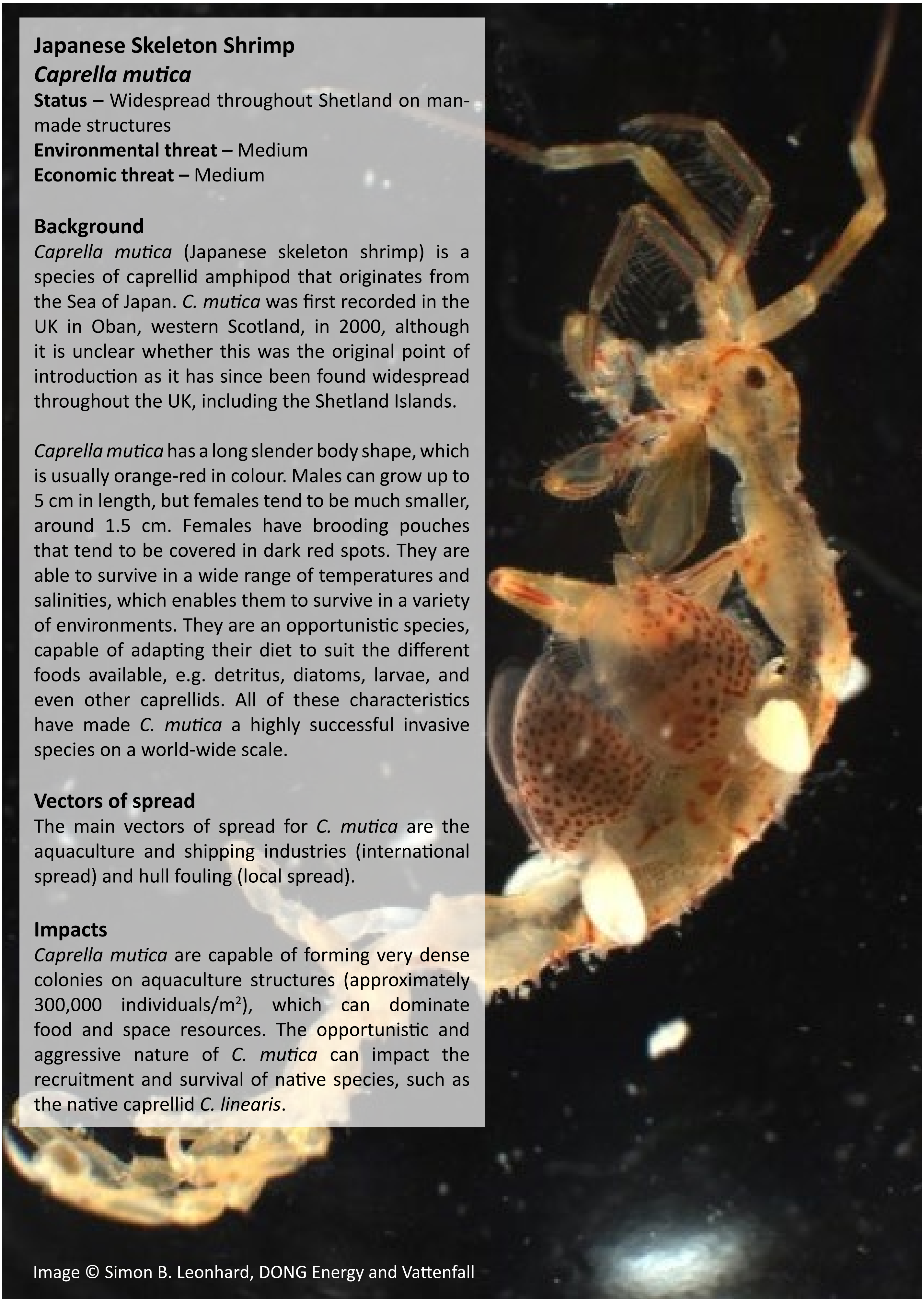
Vectors of spread

When *S. japonica* was first detected on the Pacific coast of North America, it was believed to have been introduced accidentally along with the intentional introduction of the Pacific oyster (*Crassostrea gigas*). However, it is now considered that its introduction to the UK and subsequent spread was the result of hull fouling on ocean-going vessels.

Impacts

Fouling of marinas, boat hulls, aquaculture equipment, and mussel and oyster shells, which can lead to increased cleaning costs. Additionally, *S. japonica* can dominate the fouling community and directly compete with native species for space and food.

Image © R. Shucksmith (NAFC)



Japanese Skeleton Shrimp
Caprella mutica

Status – Widespread throughout Shetland on man-made structures
Environmental threat – Medium
Economic threat – Medium

Background

Caprella mutica (Japanese skeleton shrimp) is a species of caprellid amphipod that originates from the Sea of Japan. *C. mutica* was first recorded in the UK in Oban, western Scotland, in 2000, although it is unclear whether this was the original point of introduction as it has since been found widespread throughout the UK, including the Shetland Islands.

Caprella mutica has a long slender body shape, which is usually orange-red in colour. Males can grow up to 5 cm in length, but females tend to be much smaller, around 1.5 cm. Females have brooding pouches that tend to be covered in dark red spots. They are able to survive in a wide range of temperatures and salinities, which enables them to survive in a variety of environments. They are an opportunistic species, capable of adapting their diet to suit the different foods available, e.g. detritus, diatoms, larvae, and even other caprellids. All of these characteristics have made *C. mutica* a highly successful invasive species on a world-wide scale.

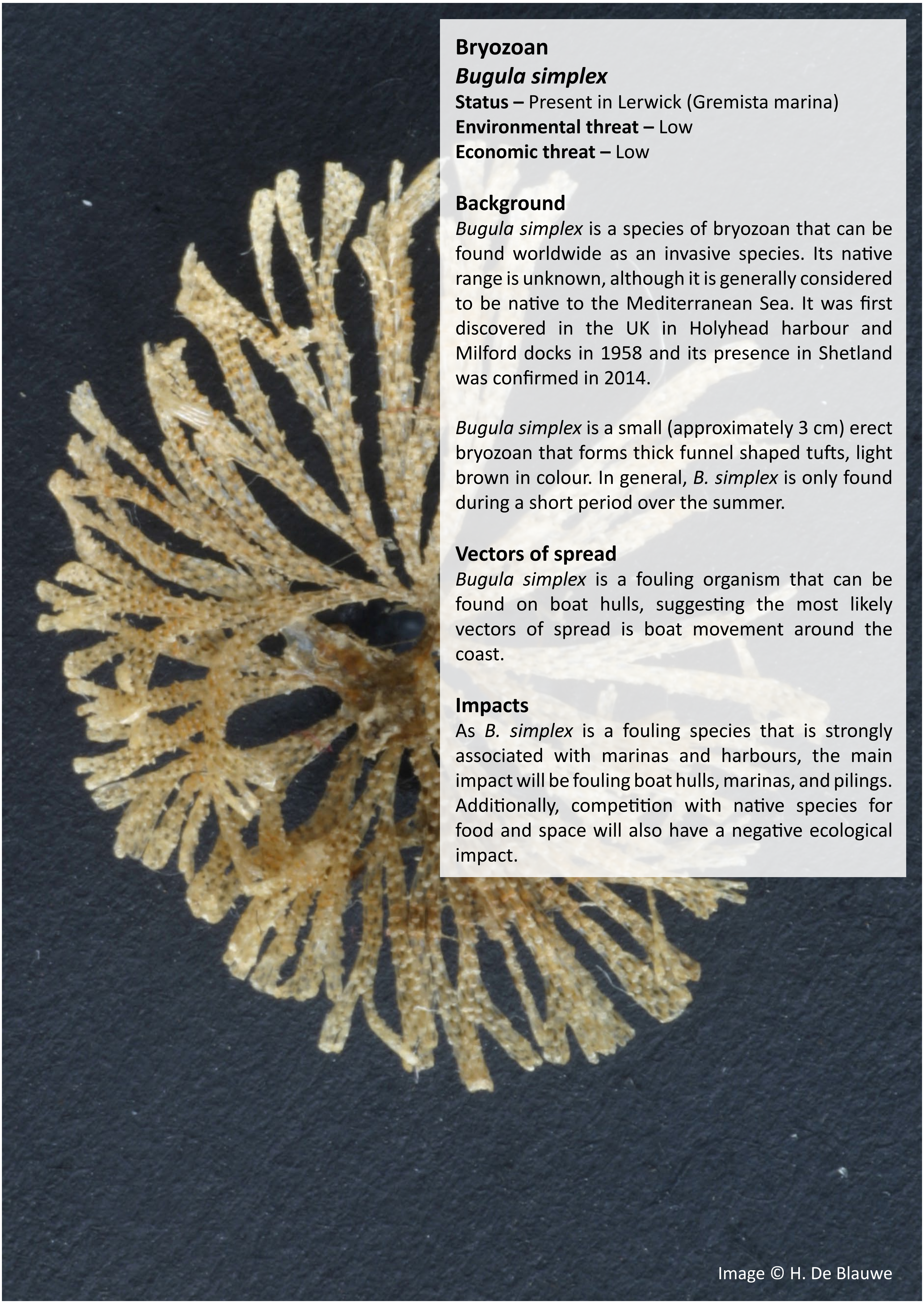
Vectors of spread

The main vectors of spread for *C. mutica* are the aquaculture and shipping industries (international spread) and hull fouling (local spread).

Impacts

Caprella mutica are capable of forming very dense colonies on aquaculture structures (approximately 300,000 individuals/m^2), which can dominate food and space resources. The opportunistic and aggressive nature of *C. mutica* can impact the recruitment and survival of native species, such as the native caprellid *C. linearis*.

Image © Simon B. Leonhard, DONG Energy and Vattenfall



Bryozoan

Bugula simplex

Status – Present in Lerwick (Gremista marina)
Environmental threat – Low
Economic threat – Low

Background

Bugula simplex is a species of bryozoan that can be found worldwide as an invasive species. Its native range is unknown, although it is generally considered to be native to the Mediterranean Sea. It was first discovered in the UK in Holyhead harbour and Milford docks in 1958 and its presence in Shetland was confirmed in 2014.

Bugula simplex is a small (approximately 3 cm) erect bryozoan that forms thick funnel shaped tufts, light brown in colour. In general, *B. simplex* is only found during a short period over the summer.

Vectors of spread

Bugula simplex is a fouling organism that can be found on boat hulls, suggesting the most likely vectors of spread is boat movement around the coast.

Impacts

As *B. simplex* is a fouling species that is strongly associated with marinas and harbours, the main impact will be fouling boat hulls, marinas, and pilings. Additionally, competition with native species for food and space will also have a negative ecological impact.

Image © H. De Blauwe

Fragile Green Sponge Fingers

Codium fragile ssp. fragile

Status – Widespread along the natural coastline throughout Shetland
Environmental threat – Medium
Economic threat – Low

Background

Codium fragile ssp. fragile is native to the coast of Japan but can be found all around the UK. It was first introduced to the river Yealm in Devon, UK, in 1939 and confirmed around the Shetland Islands in 2012. *Codium fragile fragile* is a dark green, tubular seaweed that has a soft, felt-like texture. It has swollen, finger-shaped branches that float in water and form a bush-like structure that can grow to approximately 60 cm across. It is very similar to, and can be easily misidentified for, the native Codium species.

Vectors of spread

Codium fragile fragile was most likely spread by human transport, particularly through the transfer of shellfish products. However, over shorter distances it is capable of dispersing through fragmentation as well as propagation through vegetative buds.

Impacts

Codium fragile fragile has the potential to grow in high densities, dominating canopy communities in rocky shores, and displace the native species *C. tomentosum*. It is not yet known if its introduction has resulted in any economic impacts.

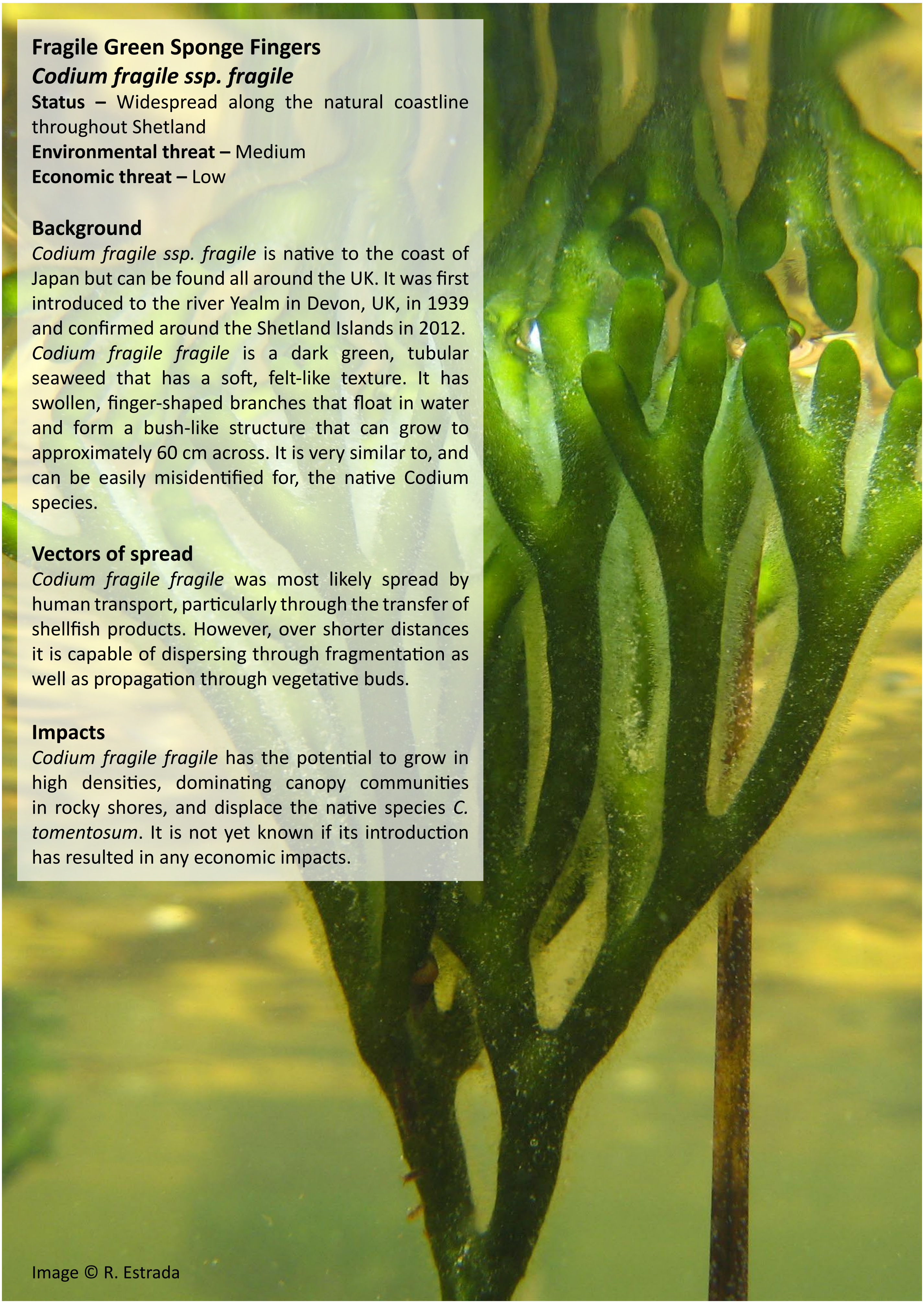


Image © R. Estrada

Japanese Weed

Dasysiphonia japonica

Status – Widespread along the natural coastline and manmade structures throughout Shetland
Environmental threat – Medium
Economic threat – Low

Background

Dasysiphonia japonica is a red alga originally from the north-west Pacific Ocean. It was first recorded as a non-native species in France in 1984 and subsequently spread throughout Europe and more recently throughout the UK. It was first recorded in the Shetland Islands in May 2014, although its widespread distribution suggests it may have been here for some time.

Dasysiphonia japonica has a dark red colour, a bushy appearance with a branching structure, and can grow to around 30 cm in height. Identification can be difficult due to similarities with other red algae. *Dasysiphonia japonica* is found in the lower intertidal zone, with a preference for sand-covered rocks and is tolerant to a wide range of environmental conditions (e.g. temperature and salinity), which have assisted with its success as an invasive species.

Vectors of spread

Internationally, the principal vector of spread for *D. japonica* is via ballast water on large commercial vessels, although some transportation is attributed to the importation of oysters for cultivation. Over shorter distances, hull fouling is a possible vector, although *D. japonica* is capable of dispersing via fragmentation, suggesting ocean currents may have been influential.

Impacts

As *D. japonica* is a fouling species, it can be problematic for marinas, aquaculture structures, fishing gear, and mussel lines. It is widespread throughout natural communities and has been found to significantly impact the composition of native seaweed assemblages.

Image © V. Husa.

Orange-Striped Anemone
Diadumene lineata

Status –Recorded in the Vadills
Environmental threat – Low
Economic threat – Low

Background

Diadumene lineata is a small anemone, originating in East Asia that can now be found on both east and west coasts of North America, Europe, Indonesia, New Zealand, and the Hawaiian Islands. There is only one record of *D. lineata* in the Shetland Islands, which dates back to 2003.

Diadumene lineata have a green or brown cylindrical shape, with orange, or less commonly yellow or white, vertical stripes. It has roughly 50-100 clear tentacles that are fully retractable. It can grow up to 3 cm in height and is found attached to solid substrata (e.g. the underside of stones and shells) in intertidal pools or shallow waters.

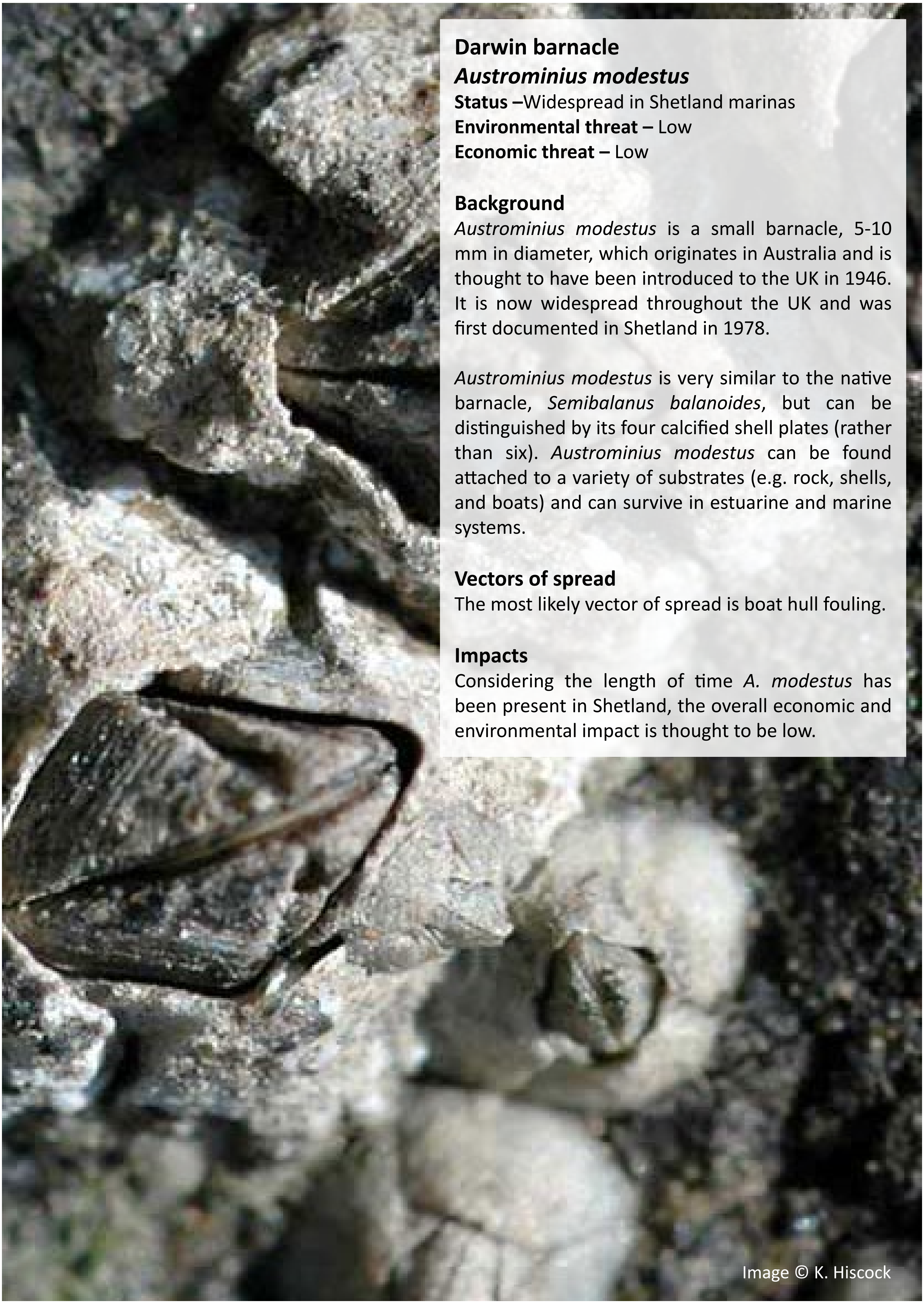
Vectors of spread

The most likely vectors of spread are as a contaminant in aquaculture stock or through boat hull fouling.

Impacts

Diadumene lineata is a fouling species that can be found on harbour and marina structures, mussel lines and oyster beds, and boat hulls. Its economic impact is thought to be low.

Image © G. Watson



Darwin barnacle

Austrominius modestus

Status –Widespread in Shetland marinas
Environmental threat – Low
Economic threat – Low

Background

Austrominius modestus is a small barnacle, 5-10 mm in diameter, which originates in Australia and is thought to have been introduced to the UK in 1946. It is now widespread throughout the UK and was first documented in Shetland in 1978.

Austrominius modestus is very similar to the native barnacle, *Semibalanus balanoides*, but can be distinguished by its four calcified shell plates (rather than six). *Austrominius modestus* can be found attached to a variety of substrates (e.g. rock, shells, and boats) and can survive in estuarine and marine systems.

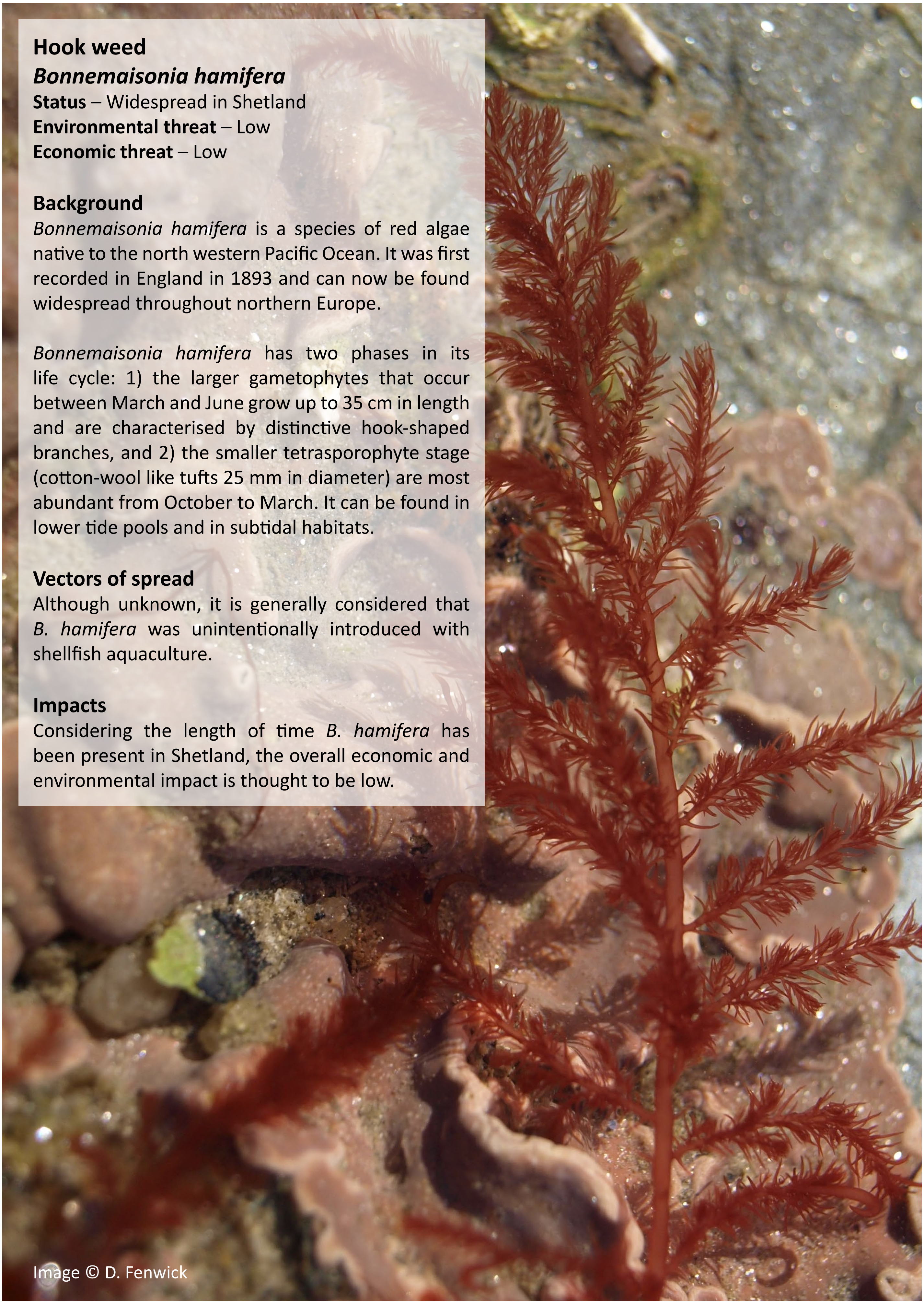
Vectors of spread

The most likely vector of spread is boat hull fouling.

Impacts

Considering the length of time *A. modestus* has been present in Shetland, the overall economic and environmental impact is thought to be low.

Image © K. Hiscock



Hook weed

Bonnemaisonia hamifera

Status – Widespread in Shetland
Environmental threat – Low
Economic threat – Low

Background

Bonnemaisonia hamifera is a species of red algae native to the north western Pacific Ocean. It was first recorded in England in 1893 and can now be found widespread throughout northern Europe.

Bonnemaisonia hamifera has two phases in its life cycle: 1) the larger gametophytes that occur between March and June grow up to 35 cm in length and are characterised by distinctive hook-shaped branches, and 2) the smaller tetrasporophyte stage (cotton-wool like tufts 25 mm in diameter) are most abundant from October to March. It can be found in lower tide pools and in subtidal habitats.

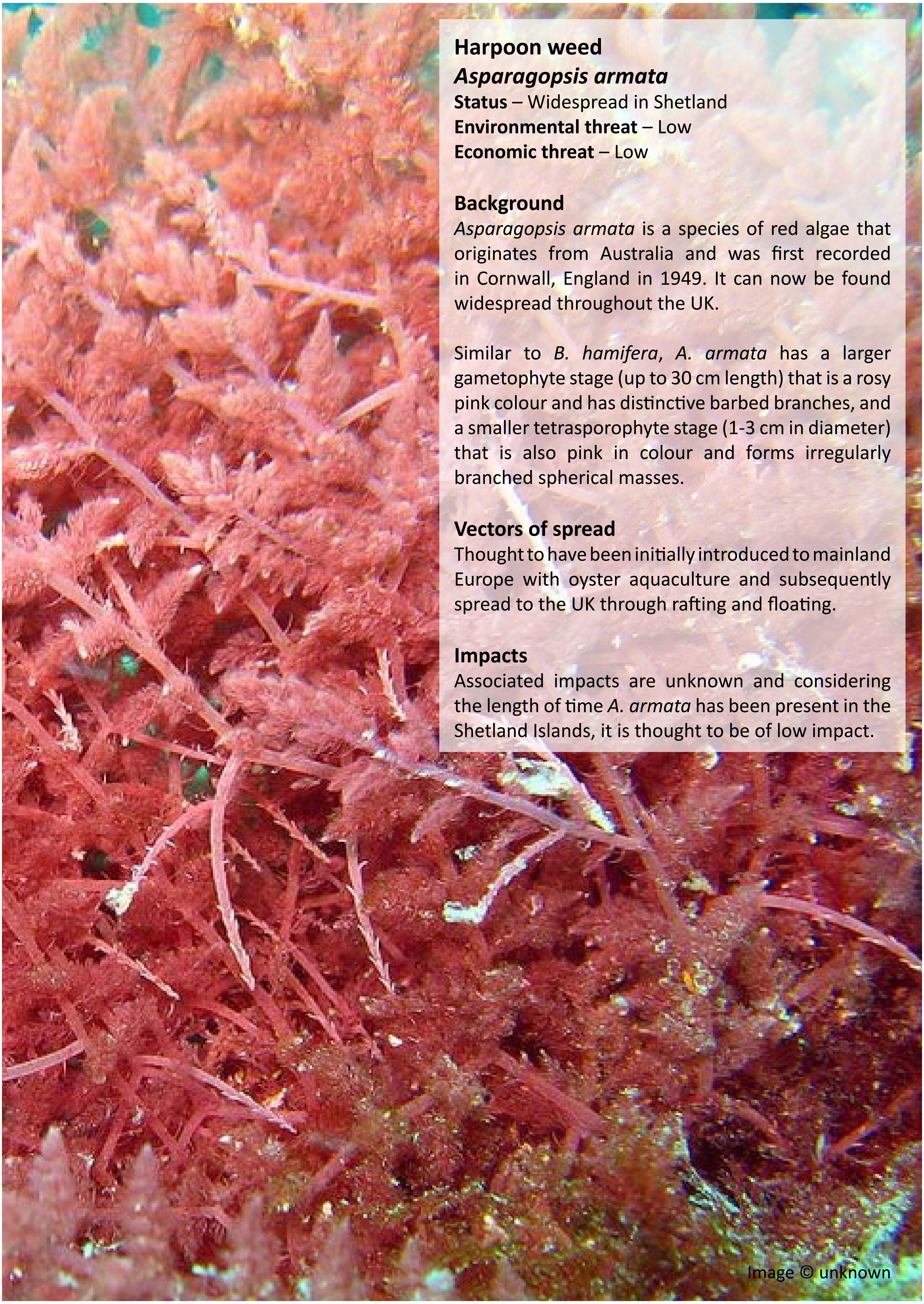
Vectors of spread

Although unknown, it is generally considered that *B. hamifera* was unintentionally introduced with shellfish aquaculture.

Impacts

Considering the length of time *B. hamifera* has been present in Shetland, the overall economic and environmental impact is thought to be low.

Image © D. Fenwick



Harpoon weed

Asparagopsis armata

Status – Widespread in Shetland
Environmental threat – Low
Economic threat – Low

Background

Asparagopsis armata is a species of red algae that originates from Australia and was first recorded in Cornwall, England in 1949. It can now be found widespread throughout the UK.

Similar to *B. hamifera*, *A. armata* has a larger gametophyte stage (up to 30 cm length) that is a rosy pink colour and has distinctive barbed branches, and a smaller tetrasporophyte stage (1-3 cm in diameter) that is also pink in colour and forms irregularly branched spherical masses.

Vectors of spread

Thought to have been initially introduced to mainland Europe with oyster aquaculture and subsequently spread to the UK through rafting and floating.

Impacts

Associated impacts are unknown and considering the length of time *A. armata* has been present in the Shetland Islands, it is thought to be of low impact.

Image © unknown

Bryozoan

Fenestrulina delicia

Status – Single observation in Sullom Voe
Environmental threat – Low
Economic threat – Low

Background

Fenestrulina delicia is a species of bryozoan that has, as of yet, an unknown origin but can be found widespread throughout northern Europe. In the Shetland Islands, *F. delicia* has been detected only once at Orka Voe, close to the Sullom Voe oil terminal, in 2012. It is unknown if *F. delicia* has successfully established in Shetland or if this was a one-off observation as there are no other records in the north of Scotland.

Fenestrulina delicia can be found offshore on both natural and artificial hard substrata and closer to shore on empty shells and boulders.

Vectors of spread

The importation of shellfish for aquaculture is considered to be an important vector for introduction. Surprisingly, *F. delicia* has not been found on ship hulls or marinas but on offshore windfarms. Therefore, an important vector of spread could be rafting on debris or large algae.

Impacts

It is unknown whether *F. delicia* has established in Shetland or not, but it is generally considered to be a low-threat species.

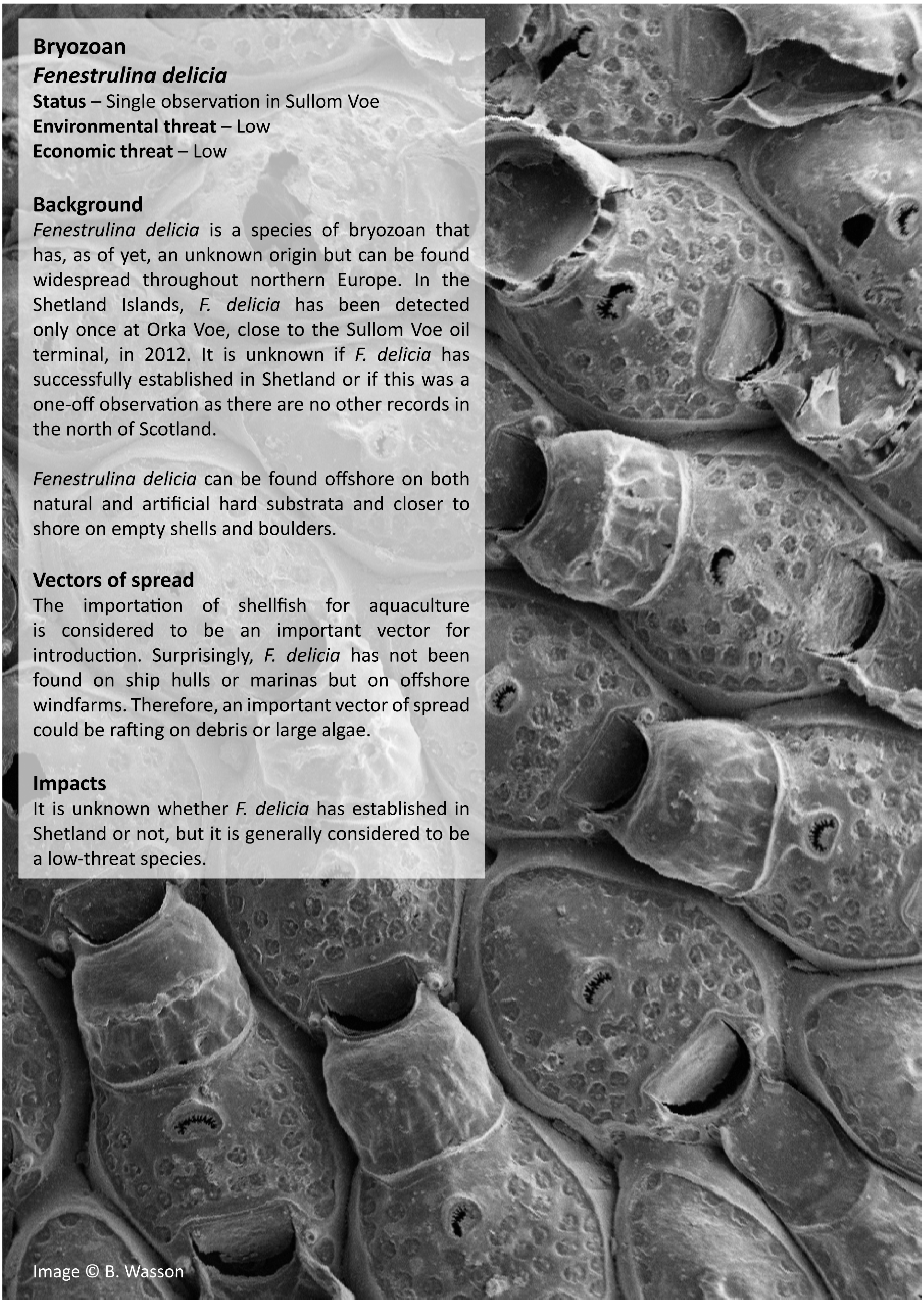
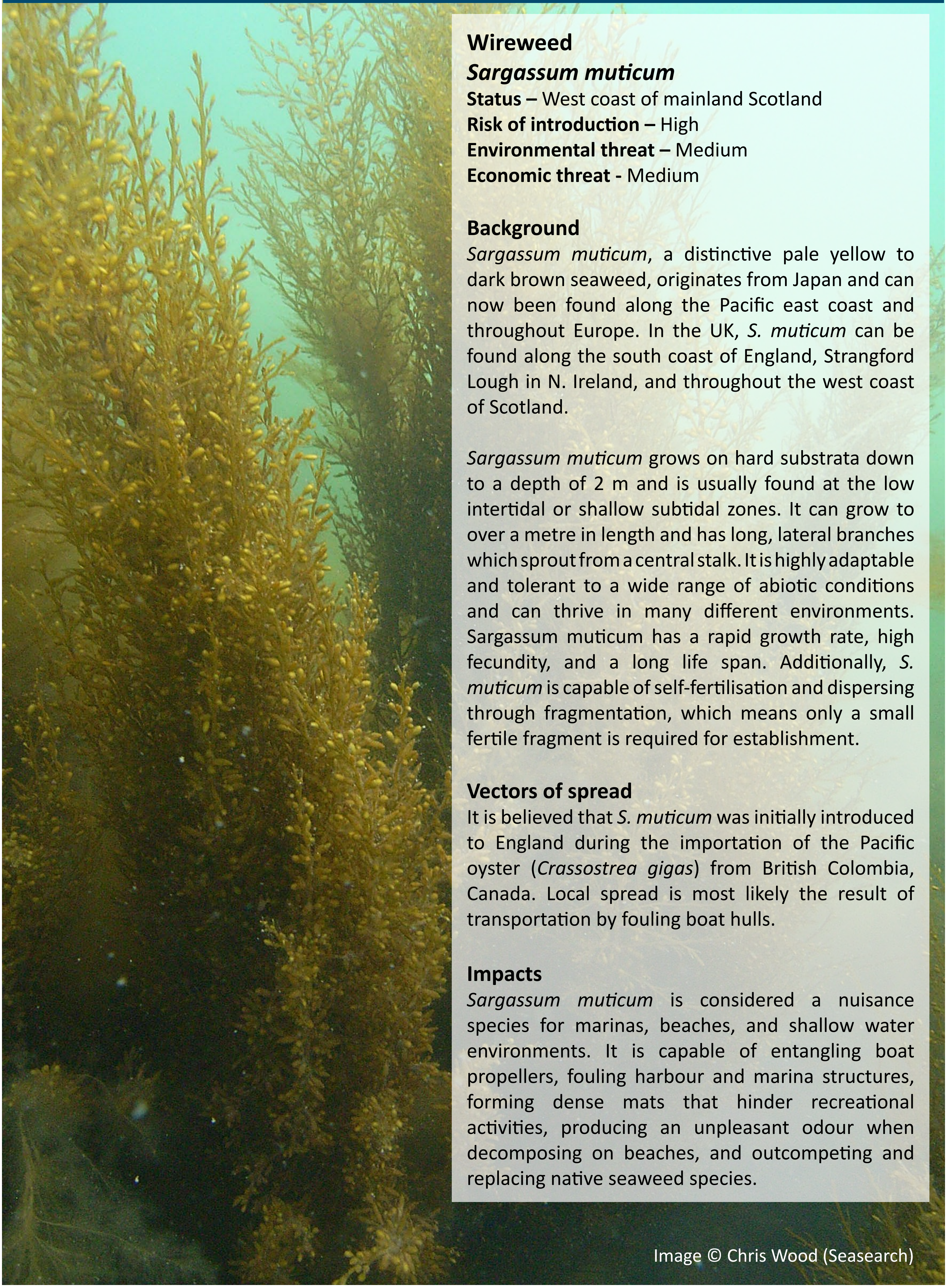


Image © B. Wasson



Wireweed

Sargassum muticum

Status – West coast of mainland Scotland
Risk of introduction – High
Environmental threat – Medium
Economic threat - Medium

Background

Sargassum muticum, a distinctive pale yellow to dark brown seaweed, originates from Japan and can now been found along the Pacific east coast and throughout Europe. In the UK, *S. muticum* can be found along the south coast of England, Strangford Lough in N. Ireland, and throughout the west coast of Scotland.

Sargassum muticum grows on hard substrata down to a depth of 2 m and is usually found at the low intertidal or shallow subtidal zones. It can grow to over a metre in length and has long, lateral branches which sprout from a central stalk. It is highly adaptable and tolerant to a wide range of abiotic conditions and can thrive in many different environments. Sargassum muticum has a rapid growth rate, high fecundity, and a long life span. Additionally, *S. muticum* is capable of self-fertilisation and dispersing through fragmentation, which means only a small fertile fragment is required for establishment.

Vectors of spread

It is believed that *S. muticum* was initially introduced to England during the importation of the Pacific oyster (*Crassostrea gigas*) from British Colombia, Canada. Local spread is most likely the result of transportation by fouling boat hulls.

Impacts

Sargassum muticum is considered a nuisance species for marinas, beaches, and shallow water environments. It is capable of entangling boat propellers, fouling harbour and marina structures, forming dense mats that hinder recreational activities, producing an unpleasant odour when decomposing on beaches, and outcompeting and replacing native seaweed species.

Image © Chris Wood (Seasearch)

Red Ripple Bryozoan
Watersipora subatra

Status – Southern England and Norway coastlines
Risk of introduction – Medium
Environmental threat – Medium
Economic threat - Medium

Background

Watersipora subatra is a species of bryozoan that has been a successful invasive species throughout the World, although its place of origin is unknown. It was first recorded in Plymouth, England, in 2008 and its distribution around the UK is expected to expand rapidly, suggesting the Shetland Islands would be a suitable location for further spread.

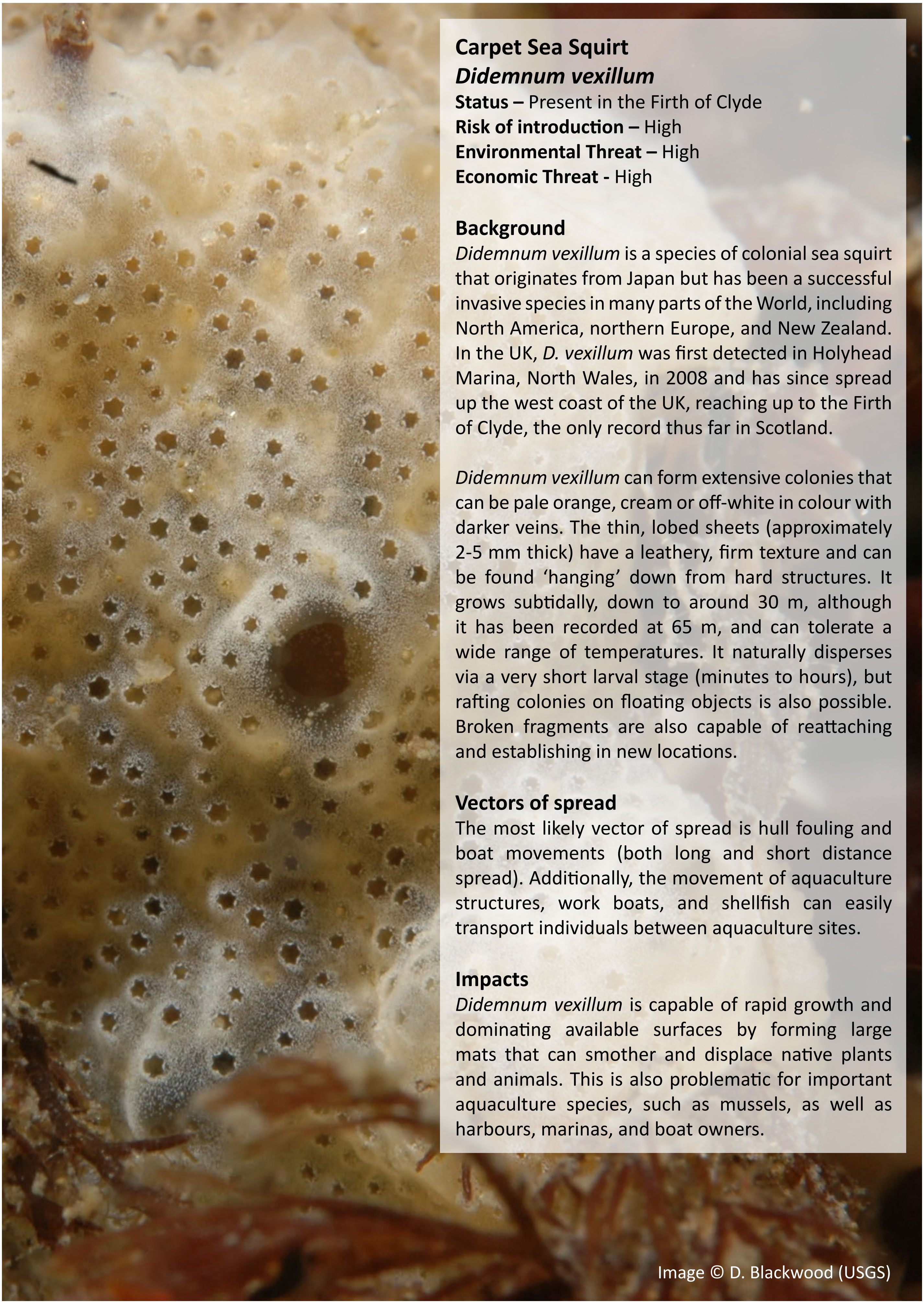
Watersipora subatra has a bright orange-red colour and forms rigid, encrusting colonies that grow on rocks, shells, boat hulls, marinas, kelp holdfasts, and other bryozoans. It forms circular colonies that, if in sheltered areas such as marinas, can grow quite large and begin to expand outward from the surface, creating lobes and frills.

Vectors of spread

The most likely initial vectors of spread for *W. subatra* was the importation of shellfish for aquaculture (e.g. *Crassostrea gigas* from Japan) and hull fouling. Hull fouling and boat movements are a potential vector of spread around the UK and Europe.

Impacts

Watersipora subatra is a fouling species and therefore can recruit onto boat hulls, marinas, and aquaculture structures. In particular, *W. subatra* can grow extensively on mussel shells, although the potential impact on mussel farming is unknown. Additionally, *W. subatra* is copper tolerant and, therefore, is unaffected by many anti-fouling treatments.



Carpet Sea Squirt

Didemnum vexillum

Status – Present in the Firth of Clyde
Risk of introduction – High
Environmental Threat – High
Economic Threat - High

Background

Didemnum vexillum is a species of colonial sea squirt that originates from Japan but has been a successful invasive species in many parts of the World, including North America, northern Europe, and New Zealand. In the UK, *D. vexillum* was first detected in Holyhead Marina, North Wales, in 2008 and has since spread up the west coast of the UK, reaching up to the Firth of Clyde, the only record thus far in Scotland.

Didemnum vexillum can form extensive colonies that can be pale orange, cream or off-white in colour with darker veins. The thin, lobed sheets (approximately 2-5 mm thick) have a leathery, firm texture and can be found 'hanging' down from hard structures. It grows subtidally, down to around 30 m, although it has been recorded at 65 m, and can tolerate a wide range of temperatures. It naturally disperses via a very short larval stage (minutes to hours), but rafting colonies on floating objects is also possible. Broken fragments are also capable of reattaching and establishing in new locations.

Vectors of spread

The most likely vector of spread is hull fouling and boat movements (both long and short distance spread). Additionally, the movement of aquaculture structures, work boats, and shellfish can easily transport individuals between aquaculture sites.

Impacts

Didemnum vexillum is capable of rapid growth and dominating available surfaces by forming large mats that can smother and displace native plants and animals. This is also problematic for important aquaculture species, such as mussels, as well as harbours, marinas, and boat owners.

Image © D. Blackwood (USGS)

Leathery Sea Squirt

Styela clava

Status – West coast of Scotland
Risk of introduction – Medium
Environmental threat – Medium
Economic threat - Medium

Background

Styela clava is a species of solitary sea squirt that originates from the North West Pacific Ocean, but can now be found worldwide and has been particularly problematic for aquaculture in Prince Edward Island, Eastern Canada. It was first recorded in Plymouth, England in 1953, possibly introduced on the hulls of war ships following the Korean War in 1951. *Styela clava* can now be found widespread around the coastline of England, the Channel Isles, Cork and Fenit Harbours, Ireland, and in the Firth of Clyde in Scotland.

Styela clava has a dark brown, club-like body with a rough, leathery texture and a tough stalk. Its firm exterior often results in fouling from other species, such as colonial sea squirts and bryozoans. *Styela clava* has a short dispersal range, which allows it to rapidly establish dense colonies. It can grow up to 12 cm in length and is usually found in shallow water on hard substrata. It can occur abundantly in sheltered bays and harbours.

Vectors of spread

The principal vector of spread for *S. clava* is hull fouling and boat movements.

Impacts

Styela clava has been highly problematic for mussel farms (e.g. Prince Edward Island, Canada), by fouling shellfish in high numbers, which results in mussel loss and damage to equipment through additional weight.

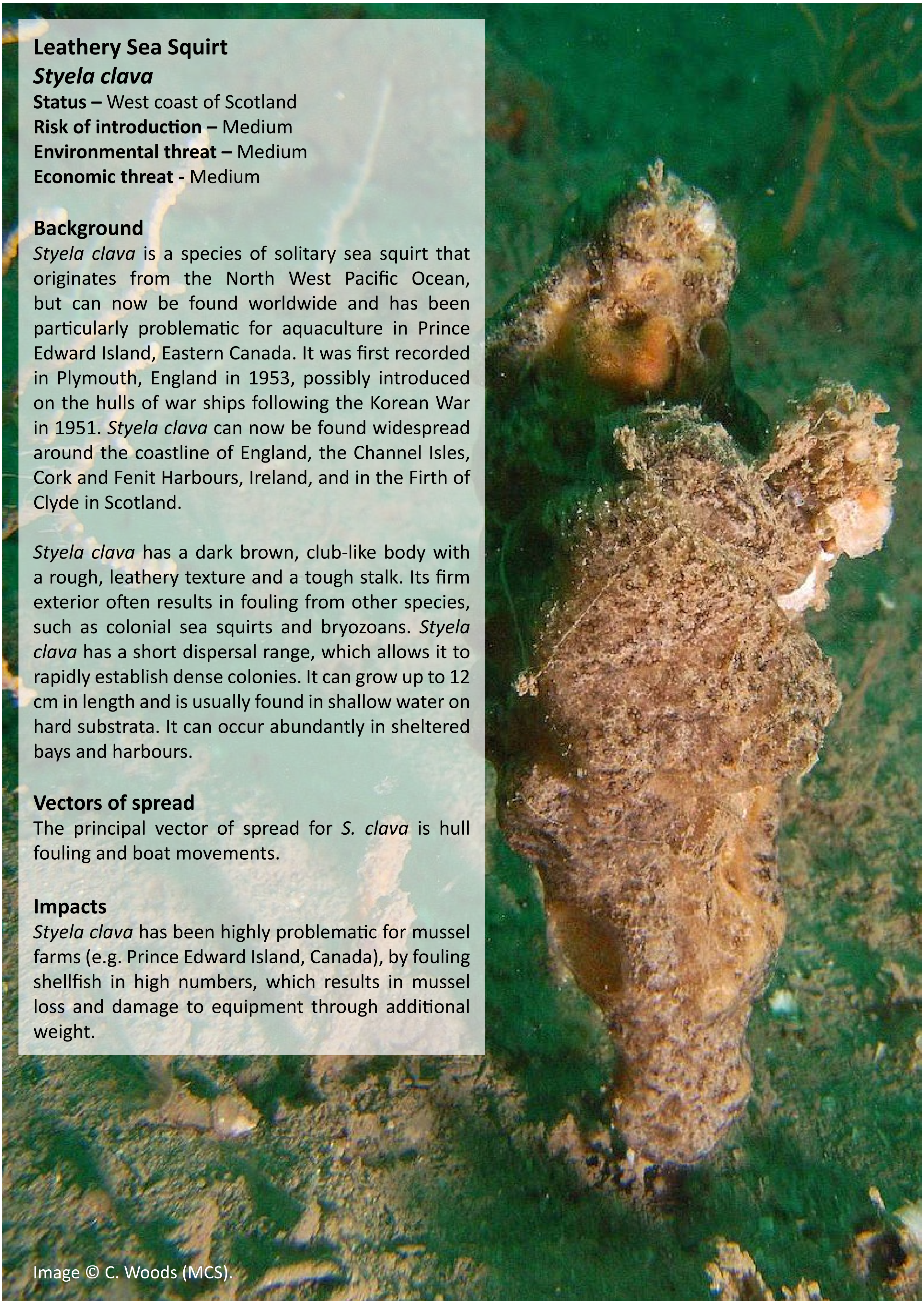


Image © C. Woods (MCS).

Bryozoan

Tricellaria inopinata

Status – West coast of mainland Scotland
Risk of introduction – Medium
Environmental threat – Low
Economic threat – Low

Background

Tricellaria inopinata is a species of bryozoan that does not have a confirmed origin, although it is considered to be from the Northern Pacific, in particular the west coast of North America. It was first found in Poole Harbour, on the south coast of England, in 1998 and can now be found along the west coast of the UK, up to the Clyde, and along the east coast, up to Grimsby.

Tricellaria inopinata forms erect colonies, up to 4 cm in height that attach to hard surfaces. It disperses via a short larval stage, which limits its ability to disperse long distances and spread rapidly. However, the short dispersal range does allow for rapid colonisation and dominance of surfaces close to the adult. The larvae of *T. inopinata* are capable of settling on other bryozoans and kelp, as well as hard surfaces, which is a distinct advantage for a non-native species at the beginning stages of establishing a new population.

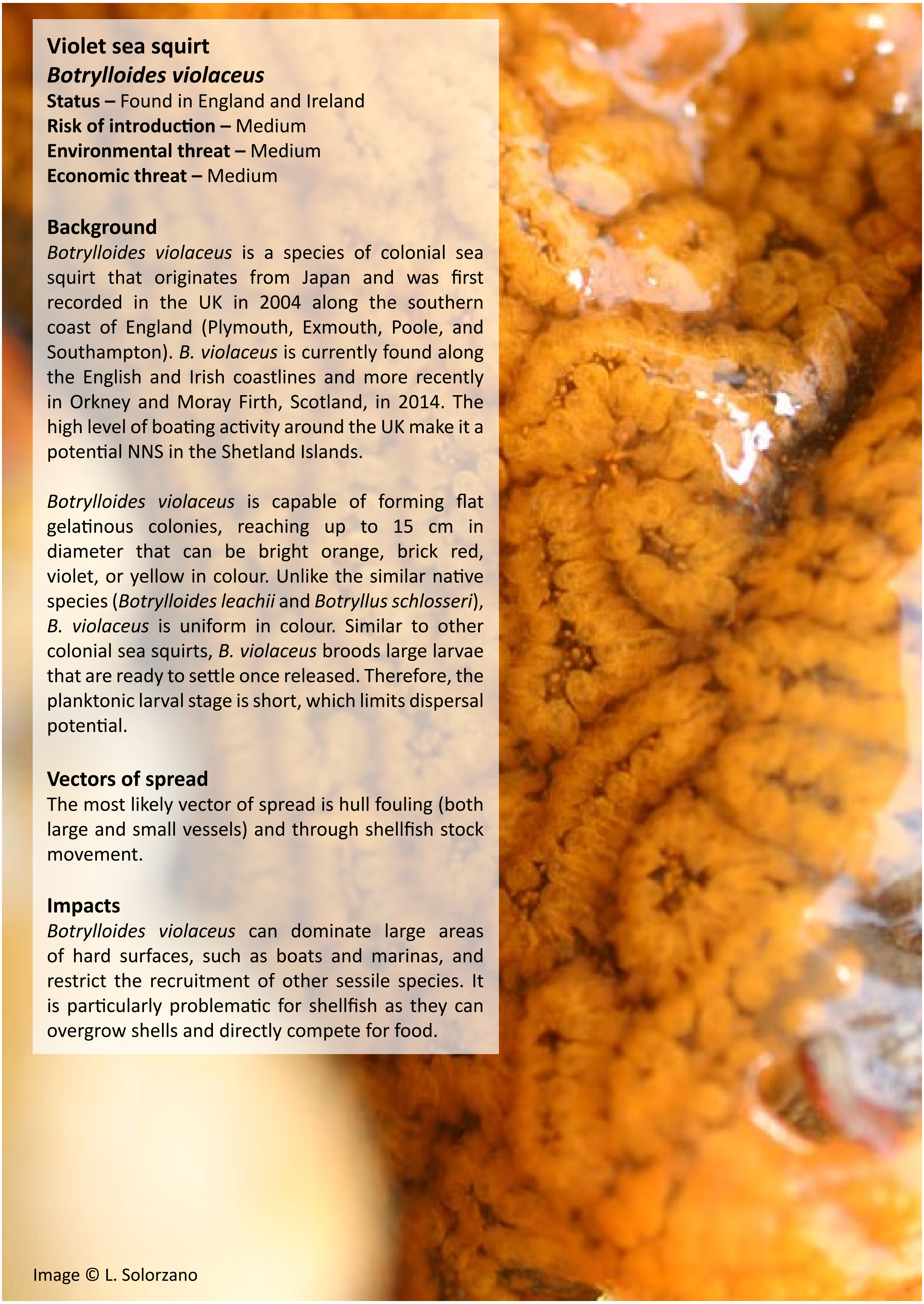
Vectors of spread

The principal vector of spread for *T. inopinata* is hull fouling of both large and small vessels and transportation with commercial oysters is a possibility.

Impact

Tricellaria inopinata is a fouling species that can form large colonies on artificial structures, such as marinas, buoys, and boats, which compete with native species for space and food.

Image © H. De Blauwe



Violet sea squirt

Botrylloides violaceus

Status – Found in England and Ireland
Risk of introduction – Medium
Environmental threat – Medium
Economic threat – Medium

Background

Botrylloides violaceus is a species of colonial sea squirt that originates from Japan and was first recorded in the UK in 2004 along the southern coast of England (Plymouth, Exmouth, Poole, and Southampton). *B. violaceus* is currently found along the English and Irish coastlines and more recently in Orkney and Moray Firth, Scotland, in 2014. The high level of boating activity around the UK make it a potential NNS in the Shetland Islands.

Botrylloides violaceus is capable of forming flat gelatinous colonies, reaching up to 15 cm in diameter that can be bright orange, brick red, violet, or yellow in colour. Unlike the similar native species (*Botrylloides leachii* and *Botryllus schlosseri*), *B. violaceus* is uniform in colour. Similar to other colonial sea squirts, *B. violaceus* broods large larvae that are ready to settle once released. Therefore, the planktonic larval stage is short, which limits dispersal potential.

Vectors of spread

The most likely vector of spread is hull fouling (both large and small vessels) and through shellfish stock movement.

Impacts

Botrylloides violaceus can dominate large areas of hard surfaces, such as boats and marinas, and restrict the recruitment of other sessile species. It is particularly problematic for shellfish as they can overgrow shells and directly compete for food.

Image © L. Solorzano

3.4.3. Further Reading

GB Non-native Species Secretariat
www.nonnativespecies.org
Marine Biological Association UK Non-native Species Guide
www.mba.ac.uk
Delivering Alien Invasive Species Incentives for Europe (DAISIE)
www.europe-aliens.org
The Marine Life Information Network
www.marlin.ac.uk
The NAFC Marine Centre
www.nafc.uhi.ac.uk
Scottish Biodiversity Forum
www.biodiversityscotland.gov.uk
Scottish Natural Heritage
www.snh.gov.uk
National Biodiversity Network
www.nbn.org.uk

4. Management of non-native species

This Plan sets out four key objectives that are designed to alleviate and prevent the risks associated with marine NNS in the Shetland Islands. They are:

- Prevention
- Early detection
- Rapid response
- Control

To achieve these objectives, close collaboration and compliance to recommended guidelines of best practice will be required from all marine users and industries. The NAFC Marine Centre is the local institute taking responsibility for the initial survey and monitoring work and will be the immediate point of contact for advice or reporting possible NNS sightings. In the event of an NNS detection, advice will be sought from Scottish Natural Heritage and Marine Scotland for legal guidance on the most appropriate course of action. Within this section, the responsibilities of both marine users and the NAFC Marine Centre are discussed for each of the four key objectives.

4.1. Prevention

Objective

Identify key vectors of spread of NNS to the Shetland Islands and reduce the risk of introduction.

Personal responsibilities

Key stakeholders should be aware of the role their industry plays in the invasion process and follow the guidance provided within this plan on methods to reduce the probability of NNS transportation and introduction (see Chapter 5). This information can help stakeholders undertake industry-specific formal or informal biosecurity risk assessments for their activities.

Management responsibilities

Management priorities for the Shetland Islands will focus on increasing awareness of the invasion process and how disrupting pathways of introduction and vectors of spread of NNS is a key element of effective management. The transportation stage of the invasion process, for both initial introductions and secondary spread, holds the greatest potential for reducing the impact of NNS as any disruption would prevent introduction occurring.

4.1.1. Prevention options

The optimal approach for NNS management is preventing the initial introduction of NNS during the transportation stage. There are two main routes of introduction: the fouling of boats, equipment and stock; and the transportation and release of ballast water.

Hull and equipment maintenance

Antifouling paints are generally applied after the hull of a vessel has been thoroughly cleaned and have been found to effectively reduce the recruitment of fouling species. These paints can also be applied to aquaculture structures and equipment. Antifouling paints work by leaching heavy metals, such as copper and zinc, into the immediate surrounding water, which many species cannot tolerate.

Although an effective method for preventing fouling, antifouling paints do lose their effectiveness over time and, if even small areas are missed during the painting process or damaged (e.g. scratched), organisms can still attach and colonise thus reducing its overall effectiveness. Care should therefore be taken to ensure that boats and equipment are regularly cleaned and anti-fouling paint re-applied to maintain effectiveness. However, there are several NNS that can tolerate heavy metals, in particular bryozoans like *Schizoporella japonica* and *Watersipora subatra*, and, therefore, will not necessarily be deterred by anti-fouling treatments.

Ballast water

The intake, transportation, and release of ballast water, including all living organisms contained within, by large cargo vessels is considered the biggest contributor to NNS transportation around the Globe. The Ballast Water Management Convention aims to 'prevent the spread of harmful aquatic organisms from one region to another, by establishing standards and procedures for the management and control of ships' ballast water and sediments'. Under this convention, all vessels in international traffic are required to manage their ballast water and sediment, which includes maintaining a ballast water record book and obtaining an International Ballast Water Management certificate. The Ballast Water Management Convention, adopted by all

IMO member states in 2004, has yet to be ratified by all Contracting States and is therefore not yet in operation. There are recommended practices for on-board and open-ocean treatments (discussed below), but for optimal results it is suggested a combination of the following treatments is adopted.

Open-ocean ballast water exchange

Ballast water exchange at sea is encouraged by several countries at present and provides the most effective method for reducing the survival and subsequent transfer of potentially harmful marine organisms. An example of ballast water management is in operation around Scapa Flow, Orkney, where a designated ballast exchange area has been established (the Ballast Water Management Policy for Scapa Flow can be found on the Orkney Islands Council website). There are currently two main methods for ballast water exchange: sequential (complete emptying and refilling) and continuous flushing. For sequential exchange, the IMO guidelines recommend that water is discharged until suction is lost, however this approach may compromise the vessels stability and strength. A 70-90% water exchange is more realistic, but this reduces the effectiveness of removing NNS. The continuous flushing method is designed to allow original ballast water to overflow out of the tank as mid-ocean water is pumped in. It is expected that 95% of original ballast water will be replaced if up to three times its volume of mid-ocean water is flushed through. This method can be performed throughout the voyage and maintains the vessels stability and strength.

On board ballast water treatment

There are three principal methods proposed by the Maritime and Coastguard Agency for the treatment of ballast water:

- Filtration
- Mechanical separation
- Chemical treatment

Filtration is the most frequently used for treating ballast water, as it is effective against sediments and most types of organisms. A key benefit of this process is that it can take place either during ballast water loading or during the voyage. In addition to filtration, cyclonic separation of ballast water can also be used to separate sediment and other suspended solids. When combined with filtration systems, cyclonic separation has been found to be up to 90% effective for removing zooplankton and phytoplankton species from ballast water.

Mechanical separation includes techniques such as UV radiation treatment, heat treatment (microwaves, ultrasound), and electric pulse applications. These are considered secondary treatments, after filtration, but have been found to be highly effective at removing species of zooplankton, phytoplankton, and bacteria. A combination of these treatments with filtration, particularly UV, have been found to be >85% effective at removing potentially harmful organisms.

Chemical treatments, such as biocides, chlorine, and ozone are highly effective methods for ballast water treatment, often found to be >99% effective. However, their use has been questioned for several reasons, such as the discharge of toxins into the environment, their unknown effectiveness against target organisms, and their compliance with discharge regulations around the World.

4.2. Early detection

Objective

Detect NNS at the point of introduction, prior to population establishment, spread, and/or impact on the local ecology and/or economy.

Personal responsibilities

A key component of an early detection program is public awareness of the risks associated with NNS and encouraging all marine users to report any suspect or unusual sightings. Reporting the presence of suspected NNS to the NAFC Marine Centre, either via their website or by telephone, could prove vital for controlling and potentially eradicating NNS.

To increase public awareness of NNS, the NAFC Marine Centre have produced a range of identification leaflets that target a wide audience and assist primarily with quick and easy visual identification. These identification leaflets have been distributed amongst the various marine sectors in the Shetland Islands and have also been made available for download from the NAFC website.

Management responsibilities

To increase the probability of detecting a recently introduced NNS, the NAFC Marine Centre has set up a survey and long-term monitoring program around the Shetland Islands. Initially a rapid assessment survey was carried out at 18 sites to assess the

Table 4.1. A list of NNS monitoring sites around the Shetland Islands and their respective importance for early detection or economic and environmental sensitivity.

Site	Early Detection	Economic	Environmental
Sullom Voe	✓		✓
Lerwick	✓		
Scalloway	✓		
Cullivoe	✓		
Brae		✓	
Burra Isles		✓	
Walls		✓	
Basta Voe		✓	✓
Vidlin Voe		✓	✓

current status of NNS in the Shetland Islands and of those sites, nine have been selected for continued monitoring (Table 4.1). These nine sites include major ports, harbours, and high-risk areas identified in Figure 3.2. These sites also cover important locations for aquaculture (e.g. Scalloway, Burra Isles), commercial fishing (Cullivoe), commercial shipping (Lerwick), the oil and gas industry (Sullom Voe), and local traffic and tourism (Lerwick). By focusing our attention on a range of sites with different levels of activity and environmental conditions (e.g. sheltered and exposed), we greatly improve our ability to detect NNS early and also monitor the spread of NNS already found in the Shetland Islands. In addition to improving the probability of early detection, a number of these sites require monitoring due to their economic and environmental sensitivity. For example, Brae and the Burra Isles are important sites for the aquaculture industry, whereas Sullom Voe and Vidlin Voe are located in close proximity to SACs, and Basta Voe is adjacent to an MPA.

The initial rapid assessment surveys consisted of visual surveys of the marina/port (e.g. pontoons, ropes, buoys, chains) and any temporary structures upon removal (e.g. landing of pontoons for winter storage). Additionally, scrape surveys, using a long scraping pole and net, were carried out to sample underwater surfaces at depths that are not easily visible from the water's surface.

The principal component of the long-term monitoring program is the placement of plastic settlement panels that can be deployed for up to six months – but usually collected and replaced after three. These settlement panels provide a variety of suitable surfaces for many fouling organisms to recruit onto and, once collected, allow researchers at the NAFC Marine Centre to identify which species are present – a process that requires a well-equipped laboratory. This method of surveying has been accepted worldwide and the current design is consistent with the Marine Aliens Consortium UK, which allows for direct comparisons with other monitoring programs around the UK.

4.3. Rapid response

Objective

Respond quickly and appropriately once an NNS is detected in Shetland's waters to reduce the potential for further spread and detrimental effect on the local ecology and/or economy.

Personal responsibilities

After reporting the suspected presence of an NNS, the NAFC Marine Centre staff will provide information on the most appropriate course of action. These could include:

- If suspected NNS is on a piece of equipment (e.g. creel, buoy, rope), remove from the water and allow to dry on land
- Inform the local harbour master and marine users of the situation

Management responsibilities

Once a suspected NNS has been reported, the first step is to correctly identify the suspected NNS. Once the presence of an NNS has been confirmed, the following protocol will be carried out:

- Visual survey of the site containing NNS (including vessel hulls)
- An assessment of the risk posed by the NNS before any additional measures are taken

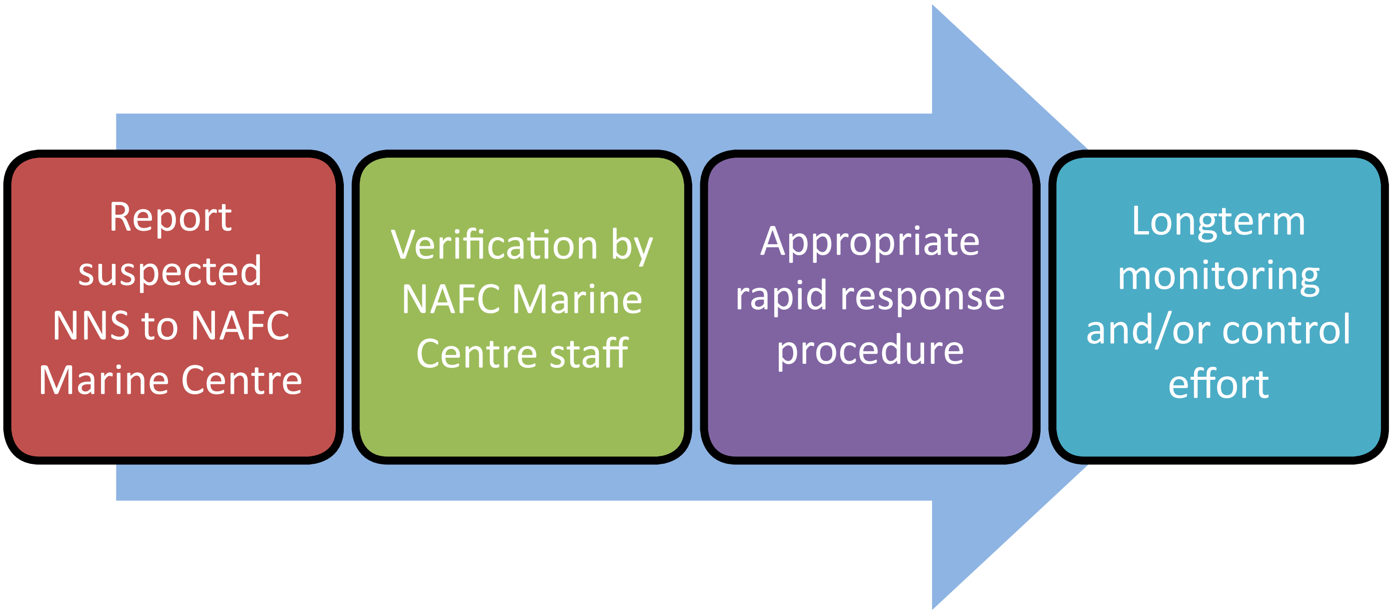


Figure 4.1. Flow diagram of the response procedure in the event of the detection of a suspected non-native species

- Where appropriate, inform SNH/Marine Scotland of presence of NNS species
- Determine the size and distribution of the NNS population at the site of introduction
- If possible, and considered necessary, identify vessel(s) carrying NNS and move away from the coastline to open-ocean waters or move to land and clean
- If possible, begin local treatment to remove the NNS
- If the NNS is a high-profile species or well-established within the site, the following treatments could be considered:

  -Quarantine the site of introduction by restricting access
  -Begin localised treatment of pilings/ pontoons/buoys/boats
  -Perform large-scale treatment of entire site

In addition to site survey, all other marine users (e.g. mussel farmers, fishermen, local recreational boaters), will be informed of the detection and advised that extra caution should be taken to avoid further spread.

4.3.1. Treatment options

Once introduced, the options for NNS management change and the environmental impact associated with treatments increases (i.e. non-target species can be affected as well as the surrounding environment). The following treatments are the options available to environmental managers for controlling or removing an NNS:

Exposure to air

Exposure to air (drying) is one of the more successful and inexpensive methods of NNS removal. The continued exposure to air can be detrimental to many marine NNS and, if carried out for enough time, can lead to mortality. This method is currently employed by the aquaculture industry to remove fouling species (both native and non-native) from structures, equipment, and mussel shells.

The lifting of boats and small craft out of the water for storage is an effective method for preventing hull fouling between uses, killing any fouling species (including any NNS) present on the vessel, and subsequently reduce the potential for spread between marinas.

Mechanical or manual removal

Mechanical and manual removal of NNS requires a more direct approach to management and can be an effective method for reducing any impacts associated with INNS. In addition to removing NNS by hand, either by strategic dive surveys or organised coastline searches, there are a number of tools to assist with NNS removal, such as:

- Suction or vacuum devices, particularly effective for NNS that can disperse by fragmentation (e.g. *Didemnum vexillum* and *Dasysiphonia japonica*)
- Mechanical stripping used in the mussel farming industry
- Dredging – disturbance and removal of suitable substrata containing NNS (note this would require a licence and assessment of environmental impacts)

Image © C.Slater (NAFC)

- High-pressure water spray – currently used by mussel farmers in Prince Edward Island, Canada, to clean mussels of invasive sea squirts and other fouling organisms.

The selected method of removal should be decided upon by the reproductive strategy of the target species and also the type of surface being treated. For example, species that can disperse and re-establish through fragmentation should be treated with a vacuum and net rather than by high-pressure water spray.

Enclosure

For many large or fixed structures that cannot be removed from the water, such as docks, treatment has to occur in the water and an effective method is enclosure. Enclosure involves wrapping a structure with sheets of plastic or specially manufactured coverings that can contain the surfaces being treated along with the surrounding water. By restricting the supply of fresh water, an oxygen deficient environment is created, which will kill the organisms contained within. This process can be further accelerated by adding chemicals (e.g. bleach, chlorine) or freshwater. Freshwater is the preferred choice as there is no risk of contamination of surrounding waters through spillages. This can be an effective method for treating the hulls of small boats: the placement of made-to-measure plastic coverings that create a bath around the boat, which can then be treated. Additionally, as a safety precaution, a boat that will be mooring for a long time can use the same process to prevent organisms settling on its hull and reduce the need to take the boat out of the water to be cleaned.

To improve the effectiveness of this strategy, managers should:

- Carry out treatment when sea temperatures are low (i.e. winter) to minimise re-colonisation risks
- Avoid leaving treated surfaces uncovered when next to untreated surfaces
- Due to expense and time-intensity of *in-situ* treatments, explore air drying as first choice of treatment

Chemical treatment of equipment

In addition to the chemical treatment of ballast water (see previous section on ballast water), chemical treatments, such as biocides, chlorine, ozone, and hydrogen peroxide, have been used directly and indirectly to remove NNS from structures and surfaces. Methods, such as spraying acetic acid and submergence in 0.5% bleach have also proven to be successful at removing fouling species from shellfish farms, which, importantly, did not have an impact on the shellfish themselves. For the shellfish industry a fairly cheap and safe option can be to submerge shells in a strong salt solution, which can effectively remove sea squirts and seaweeds such as wireweed (*S. muticum*) without harming the shellfish.

Other examples include the "BioBullet" – a biocide encapsulated within a particle that is ingested by the NNS. This has been extremely effective at treating large numbers of *Didemnum vexillum* as well as other species of sea squirt.

The main concern with chemical treatments is their potential to affect non-target species and the surrounding marine environment. However, when combined with enclosure techniques the treatment becomes focused to a specific area and secondary impacts are reduced.


Image © C.Slater (NAFC)

Quarantine

In the event of the detection of a highly problematic NNS, a more extreme measure for treatment, which can potentially lead to eradication, is the quarantine of an 'infected' marina. This involves preventing the movement of boats into and out of the marina and sealing off the entrance to prevent water exchange with the exterior. Once the marina is sealed off, the water contained within the marina can then be treated (chemically) to remove all species present (not just NNS). Quarantine has been successful in other sites around the world (e.g. Cullen Bay, Australia) but is a treatment reserved for those species that cause a significant threat and for sites that have suitable characteristics for quarantine (e.g. small entrance way that can be easily sealed). Performing a detailed risk assessment is essential, prior to any quarantine measures, to assess environmental impact, economic cost, probability of success, and probability of re-introduction if removal is successful.

4.3.2. Eradication

The eradication of NNS, prior to any impact, is the ideal solution but there are very few examples of successful marine eradication attempts. The main challenges with eradication are: 1) detecting the NNS early enough when eradication is feasible, 2) determining whether the NNS in question poses a big enough threat, and 3) having an eradication protocol prepared and ready to go as soon as an NNS is detected. With any eradication operation, a detailed risk assessment needs to be carried out, prior to any work, which addresses the following points:

- Which NNS to eradicate? It is difficult to determine whether a detected NNS will eventually become problematic or not and therefore the level of damage to the local economy and/or environment has to be assessed prior to a costly eradication program. A list of priority species should be established, each with a protocol for rapid response.
- How the cost of an eradication programme will be assigned amongst the parties involved?
- What is the probability of a successful eradication? This can be determined by considering the following factors: the species characteristics (e.g. does it have a dormant stage, does it have a wide environmental tolerance range, how does it reproduce/disperse), the size and distribution of the NNS population (e.g. is it isolated or low in number), the characteristics of the environment (e.g. is it a small isolated marina or an open stretch of coastline), and what methods of eradication are available (e.g. quarantine, manual removal, chemical)?
- Which method is most effective for the target NNS? The most effective method for eradication will vary between species, but at the same time each method will have a varying degree of impact on the surrounding environment and ecosystem. The optimal program will effectively eradicate the NNS with minimal impact on the surrounding environment.
- What is the probability of reintroduction? If an NNS is successfully eradicated, is there a high possibility that it will be re-introduced?

The success of eradication programs relies on many factors, but essential to all operations is the support from local people and industries, and compliance to the guidelines set out in the Biosecurity Plan by all marine users. This will ensure that any management action will be carried out as effectively as possible and that the risk of future reintroductions of NNS will be kept to a minimum.

4.4. Control

Objective

Control and mitigate the impacts of an established invasive non-native species and, where feasible, attempt eradication.

Personal responsibilities

In the event of detecting an NNS that has already become either well-established or widely dispersed, efforts should be taken to: 1) restrict any further spread, and 2) reduce abundance. See Chapter 5 for more information on sector-specific guidance on preventing the spread of NNS and also cleaning methods for reducing NNS abundance.

Management responsibilities

A key step in the controlling of an NNS is continued monitoring of the invading population to assess whether an eradication attempt is a feasible option, both logistically and financially. Any strategy for eradication or control will consider the potential for detrimental impacts on the surrounding environment and also the proximity of protected sites, areas of interest, or local infrastructure and assets. If eradication is not an option (which is most likely), a focused effort to control the spread rate of the invading population and minimise any impacts is the only remaining option.

All efforts to control an invasive population will be undertaken in line with national policy and will most likely be achieved using a combination of specialist contractors and agency staff, due to the specialist nature of these operations.

5. Sector-specific guidance

Although many of the current and potential biosecurity threats to the Shetland Islands could impact multiple sectors, some NNS pose a greater threat to specific industries and preventative action will vary between sectors. This section covers sector-specific guidance for NNS management, focusing specifically on aquaculture, commercial fisheries, oil and gas, renewable energy, ports and harbours (commercial shipping), and tourism and recreation. An overview of the potential impacts and specific NNS of interest are provided as well as management guidance for each sector.

In accordance with the four key objectives stated in Chapter 1, the recommended measures required for effective NNS management have been grouped into Prevention, Early Detection, Rapid Response, and Control measures. In addition to the sector-specific management protocols, a list of recommended cleaning practices is provided.

Each section within this chapter has been designed to be used separately as a stand-alone document, which can be more easily reproduced and distributed.


Image © C.Slater (NAFC)

5.1. Aquaculture

Overview

The main impact on the aquaculture industry (shellfish, finfish, and seaweed cultivation) is fouling of nets, cages, and static structures by NNS. The establishment of large, dense fouling populations of NNS can increase costs for cleaning and removal, damage equipment, and smother shellfish.

At present, the Aquatic Animal Health (Scotland) Regulations 2009 implements the European Council Directive 2006/88/EC on animal health requirements for aquaculture animals and products. This requires aquaculture businesses to produce and implement a biosecurity plan for their site(s) in order to reduce the spread of disease. Although not directly related to NNS, many of the protocols aimed at reducing the spread of disease will also assist with minimising the introduction and spread of NNS.

A comprehensive summary of suggested good practice protocols for finfish aquaculture is found in the 'Code of Good Practice for Scottish Finfish Aquaculture', which details a range of practices and procedures to help create and maintain a high standard of finfish aquaculture. Although voluntary, all Shetland finfish farmers have agreed to adhere to the code, which suggests that many of the practices for reducing the spread of NNS will already be in place.

In 2009, Cefas produced a Shellfish Biosecurity Measures Plan to provide biosecurity guidance and templates for the shellfish industry in England and Wales, which could provide useful guidance for management protocols in Scotland. Additionally, the Shellfish and Specialised Fish (Third Country Imports) Order (1992) implemented a license requirement for all third country (non-EU) imports of NNS for holding or releasing. In Shetland, however, there is little importation of shellfish species, with the mussel farming industry relying on natural spat settlement and, therefore, the likelihood of NNS being introduced via international trade is low.

Risks

The majority of NNS introductions to aquaculture are the result of exchanging equipment, stock, and boats between sites. Although the importation of NNS from other regions is unlikely, the local spread of already introduced NNS is a concern. The management of daily activities will contribute greatly to the detection, control, and containment of NNS and thus reduce their impact on the industry as a whole.

Responsible stakeholders

- Shetland Aquaculture
- Seafood Shetland
- Aquaculture companies and site managers

Preventative measures

- Ensure correct biosecurity and fish welfare protocols are employed when transporting fish populations
- When importing stock:
    - Research suppliers to ensure their standards of biosecurity are appropriate
    - Know the history of the area you are importing from and/or the area the shellfish originate from
    - Operate a "quarantine" system to isolate new stock from existing stocks until status has been adequately assessed
- Avoid the exchange of equipment, stock, and/or boats between aquaculture sites
- Keep abreast of recent NNS detections at other sites and use this information in decision making for any required equipment, stock, and/or boat exchanges

Table 5.1. Target NNS for the aquaculture industry, their potential impacts, and recommended response

Species of concern	Main impact	Response
Leathery sea squirt *Styela clava*	• Fouling • Mussel loss • Prevents shellfish recruitment • Competes with shellfish	• Air exposure • Manual removal • High-pressure hosing • Report sighting
Carpet sea squirt *Didemnum vexillum*	• Fouling • Increased cleaning costs • Competes with shellfish	• Air exposure • Chemical treatment • Enclosure • Report sighting
Bryozoan *Schizoporella japonica*	• Fouling	• Air exposure • Manual removal • Chemical treatment • Enclosure
Red ripple bryozoan *Watersipora subatra*	• Fouling	• Air exposure • Manual removal • Chemical treatment • Enclosure • Report sighting
Wireweed *Sargassum muticum*	• Tangles propellers • Forms large mats over seabed	• Manual removal • Report sighting
Japanese weed *Dasysiphonia japonica*	• Fouling	• Manual removal
Japanese skeleton shrimp *Caprella mutica*	• Fouling • Potentially preys on mussel spat	• Manual removal • Clean equipment

- Regularly clean site (equipment, stock) to remove any fouling organisms
- If replacing nets, clean older nets on land and allow to dry to ensure mortality of organisms present
- When possible, clean the hulls of working boats to reduce the spread of NNS to and from local marinas/ports
- Reduce access to aquaculture sites by general public (recreational boaters)
- Keep and maintain a log book of cleaning operations and site activity

Detection measures

- Keep staff up to date with current NNS in the Shetland Islands, their identification, and methods of avoiding their introduction and spread
- Distribute and display NAFC Marine Centre leaflets on NNS
- Regularly monitor for the presence of NNS within your site, particularly if new stock or equipment has recently been brought into a site

Rapid response measures

- Report any sightings of unknown species or increased and unusual recruitment of fouling species to the NAFC Marine Centre
- Share information on NNS detections with other aquaculture farmers around the Shetland Islands
- Seek advice on cleaning/removal method from the NAFC Marine Centre
- Prevent further spread by restricting all boat movements and equipment exchanges between sites

Control measures

- Plan cleaning operations for early in the year, between January and April, before the majority of NNS and other fouling species become reproductive (Table 5.2)
- Restrict all movements of boats and equipment between sites
- Where appropriate restrict access to aquaculture sites by general public (recreational boaters)
- Keep and maintain a log book of cleaning operations and site activity

Table 5.2. The reproductive season for NNS of concern, potential NNS, and problematic fouling species in the Shetland Islands.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean sea temperature (°C)	8.4	7.9	7.6	8.1	9.2	11	12.8	13.3	12.7	11.6	10.8	9.5
Present NNS												
Corella eumyota												
Schizoporella japonica												
Bugula simplex												
Codium fragile spp. fragile												
*Dasysiphonia japonica**												
Potential NNS												
*Botrylloides violaceus**												
*Didemnum vexillum**												
Styela clava												
Sargassum muticum												
Diadumene lineata												
Watersipora subatra												
Tricellaria inopinata												
Other Problematic Fouling Species												
Ciona intestinalis												
Ascidiella aspersa												
		Reproductive**										
		Lower end of temperature tolerance										
		Suggested time period for cleaning activities										

*Capable of dispersing by way of fragmentation all year round

**Reproductive seasons are estimated using data from published literature and average monthly sea temperatures in the Shetland Islands (NOAA satellite readings).

Cleaning methods

- Drying equipment
- High-pressure hosing
- Regularly changing/replacing equipment
- Manual removal
- Chemical treatments, such as lime (mussel farming)
- Lowering equipment to sea floor to allow access for predators of fouling organisms
- Introduction of non-native predators to control an invasive pest (biocontrol) – highly controversial and not recommended

5.2. Commercial Fisheries

Overview

Commercial fisheries are susceptible to fouling by NNS on gear (e.g. creels) as well as vessel hulls. Other NNS, such as wireweed (*Sargassum muticum*), are capable of causing damage by entanglement in the boats propeller. The presence of NNS can increase the costs of cleaning and lead to the replacement of damaged equipment.

Non-native species can indirectly impact the fishing industry through disrupting the balance of the native marine community. For example, many NNS are capable of dominating large areas of the seabed, which can result in the displacement, or smothering, of important prey species for fish or changing the composition of the surrounding water (e.g. the Zebra mussel, *Dreissena polymorpha*, invasion in Canada resulted in their consumption of important phytoplankton, a food source for other shellfish and fish). These changes can have negative knock-on effects on the surrounding fish stocks. With regards to commercial shellfish activities, NNS are capable of recruiting onto shells, overgrowing native shellfish species, and displacing native species.

Risks

The main concern for environmental management is the role the fishing industry plays in assisting the local spread of NNS. Fishing vessels often visit multiple grounds and dock at different marinas/ harbours around the Shetland Islands and the Scottish mainland, potentially transporting NNS via hull fouling or through the use of gear at multiple grounds.

Responsible stakeholders

- Shetland Fishermen's Association (SFA)
- Shetland Shellfish Management Organisation (SSMO)
- Vessel owners

Preventative measures

- Keep abreast of recent NNS detections at other sites and use this information to inform decision making where possible
- Regularly inspect gear after use for the presence of NNS
- When possible, clean the hulls of boats to reduce the spread of NNS to and from local marinas/ ports
- Use of antifouling paints on vessel hulls to reduce the number of fouling organisms
- If replacing nets, clean older nets on land and allow to dry to ensure mortality of organisms present
- If replacing creels, clean creels on land and allow to dry to ensure mortality of organisms present
- If fishing at multiple sites, ensure all gear is cleaned and dried between uses
- Minimise, where possible, the number of ports/ marinas visited to avoid local spread of organisms around Shetland

Detection measures

- Keep up to date with current NNS in the Shetland Islands, their identification, and methods of avoiding their introduction and spread
- Distribute and display NAFC Marine Centre leaflets on NNS
- Regularly monitor for the presence of NNS

Rapid response measures

- Report any sightings of unknown species or increased and unusual recruitment of fouling species to the NAFC Marine Centre
- Share information on NNS detections with other fishermen and marine industries around the Shetland Islands
- Seek advice on cleaning/removal methods from the NAFC Marine Centre
- Prevent further spread, where possible, by

Table 5.3. List of target NNS for the fishing industry, their impacts, and appropriate response

Species of concern	Main impact	Response
Carpet sea squirt *Didemnum vexillum*	• Gear and hull fouling • Displaces important prey species • Forms dense colonies on seabed and shellfish	• Air exposure • Clean boats regularly • Clean & dry equipment • Report sighting
Wireweed *Sargassum muticum*	• Fouling • Forms dense mats on seabed • Entanglement in propeller	• Manual removal • Report sighting
Japanese weed *Dasysiphonia japonica*	• Fouling • Form dense colonies on seabed	• Manual removal
Bryozoan *Schizoporella japonica*	• Fouling • Smothers shellfish	• Air exposure • Clean boats regularly • Clean & dry equipment
Red ripple bryozoan *Watersipora subatra*	• Fouling	• Air exposure • Manual removal • Clean boats regularly • Clean & dry equipment • Report sighting
Japanese skeleton shrimp *Caprella mutica*	• Fouling	• Manual removal • Clean equipment

limiting 'infected' vessels movement until NNS has been removed

Control measures

- Regular cleaning of vessel hull
- Use of antifouling paints on vessel hulls to reduce the number of fouling organisms
- Minimise the number of ports/marinas visited to avoid local spread of organisms around the Shetland Islands

Cleaning treatments

- Vessel removal
- Cleaning and drying of gear on land
- High-pressure water spray on gear
- Cleaning gear in bleach or other chemical treatment

Image © C.Slater (NAFC)

5.3. Oil & gas industry

Overview

The impact on the oil and gas industry from INNS is generally minimal, although there is some potential for damage. Heavy fouling can impede the safety of offshore structures, with large accumulations of fouling species thought to undermine their stability. Additionally, heavy fouling on vessel hulls will increase the cost of cleaning and reduce fuel efficiency (increased drag), although the majority of tankers visiting Sullom Voe will be open-ocean going vessels, which are required to be cleaned every five years.

Risks

A key concern for NNS management is the potential for man-made structures in the marine environment acting as 'stepping stones', which can facilitate the spread of NNS. These structures include offshore oil rigs, which offer a hard structure for colonisation in an otherwise uninhabitable environment. Considering NNS are predominantly found on artificial structures, oil rigs could provide crucial hubs for NNS that link two distant environments (e.g. the Shetland Islands and the coast of Norway).

An additional concern for NNS management is the potential for the oil and gas industry to contribute to the spread of NNS through vessel movement and ballast water exchange. Ballast water exchange is of particular concern for the Sullom Voe oil terminal, as its primary role is exportation – tankers arrive carrying ballast water, which is emptied before taking on oil. Any NNS contained in the ballast water would then be discharged into Sullom Voe, making this area a hotspot for NNS introduction.

Responsible stakeholders

- Port and Harbour authorities
- Oil and gas operating companies
- Vessel owner/operator

Preventative measures

- Keep up-to-date with the IMO's guidelines on ballast water management
- Where practical, mid-ocean ballast water exchange is encouraged, prior to entering and after leaving the Shetland Islands
- Install on-board ballast water filtering systems and/or chemical treatment protocols, where possible (see Section 4.2)
- Be aware of recent problematic NNS and assess whether your proposed voyage has the potential to contribute to the spread of these species
- Minimise the number of ports used by smaller vessels
- Keep and maintain a log book of all movements of equipment and vessels

Detection measures

- Keep staff up to date with current NNS in the Shetland Islands, their identification, and methods of avoiding their introduction and spread
- Distribute and display NAFC Marine Centre leaflets on INNS
- Regular monitoring and maintenance of oil and gas related structures

Rapid response measures

- Report any sightings of unknown species or increased and unusual recruitment of fouling species to the NAFC Marine Centre
- Share information on NNS detections with other marine users around the Shetland Islands
- Seek advice on cleaning/removal method from NAFC Marine Centre researchers

Control measures

- Regular cleaning of vessel hulls and related structures
- Use of antifouling paints on vessel hulls to reduce the number of fouling organisms

Table 5.4. List of target NNS for the oil and gas industry, their impacts, and appropriate response

Species of concern	Main impact	Response
Wireweed *Sargassum muticum*	• Clogs underwater pipes • Boat propeller entanglement	• Manual removal • Report sighting
Japanese weed *Dasysiphonia japonica*	• Clogs underwater pipes • Boat propeller entanglement	• Regular cleaning of vessels
Bryozoan *Schizoporella japonica*	• Fouling	• Regular cleaning of vessels
Red ripple bryozoan *Watersipora subatra*	• Fouling	• Regular cleaning of vessels • Report sighting
Carpet sea squirt *Didemnum vexillum*	• Fouling	• Regular cleaning of vessels • Report sighting
Leathery sea squirt *Styela clava*	• Fouling	• Regular cleaning of vessels • Report sighting

Cleaning practices

- Manual removal
- Antifouling paint
- Ballast water filtration/treatment

Further information regarding the management of NNS within the oil and gas industry can be found within the IPIECA report: Alien invasive species and the oil and gas industry from their website (www.ipieca.org).

5.4. Renewable energy

Overview

The increasing demand for renewable energy and the large tidal and wave resources available off the coast of the Shetland Islands has increased interest in offshore development, with several project proposals already submitted. However, new developments present additional challenges for environmental managers. Non-native species can negatively impact marine renewable energy structures primarily through fouling, particularly those that have submerged moving parts that are vulnerable to entanglement from seaweeds (e.g. *Sargassum muticum*).

Risks

The increase in offshore and coastal developments around the Shetland Islands will increase the potential for NNS to spread. For example, offshore wind turbines offer a wealth of hard surfaces ideal for recruitment and their close proximity to each other suggests that NNS could spread from one to another. Where possible, reducing the potential for facilitating the spread of NNS should be taken into account during the initial site design and location decision making for new developments.

Responsible stakeholders

- Project developer

Preventative measures

- Keep abreast of recent problematic NNS and their location. Assess whether your proposed development will contribute to their spread
- Design offshore structures that can be easily and regularly cleaned
- Minimise the number of ports used by smaller vessels
- Keep and maintain a log book of all movements of equipment and vessels

Detection measures

- Keep staff up to date with current NNS in the Shetland Islands, their identification, and methods of avoiding their introduction and spread
- Distribute and display NAFC Marine Centre leaflets on NNS
- Regular monitoring and maintenance of offshore structures

Rapid response measures

- Report any sightings of unknown species or increased and unusual recruitment of fouling species to the NAFC Marine Centre
- Share information on NNS detections with other marine users around the Shetland Islands
- Seek advice on cleaning/removal method from NAFC Marine Centre researchers

Control measures

- Regular cleaning of vessel hulls and related structures
- Use of antifouling paints on vessel hulls and offshore devices/equipment to reduce the number of fouling organisms

Cleaning practices

- Manual removal
- Antifouling paint

Table 5.5. List of target NNS for the renewable energy industry, their impacts, and appropriate response

Species of Concern	Main Impact	Response
Japanese skeleton shrimp *Caprella mutica*	• Fouling	• Manual removal • Clean equipment after use
Bryozoan *Schizoporella japonica*	• Fouling • Damage to structures	• Air exposure • Manual removal • Clean mobile surfaces regularly • Avoid exchanging equipment between sites
Red ripple bryozoan *Watersipora subatra*	• Fouling	• Air exposure • Manual removal • Clean mobile surfaces regularly • Avoid exchanging equipment between sites • Report sighting
Carpet sea squirt *Didemnum vexillum*	• Fouling	• Air exposure • Clean mobile surfaces regularly • Avoid exchanging equipment between sites • Report sighting
Leathery sea squirt *Styela clava*	• Fouling	• Air exposure • Manual removal • Clean mobile surfaces regularly • Avoid exchanging equipment between sites • Report sighting
Wireweed *Sargassum muticum*	• Entanglement • Fouling	• Manual removal • Report sighting

Image © C.Slater (NAFC)

5.5. Ports & harbours - commercial shipping

Overview

Ports and harbours are an important part of the invasion process, as, in most cases, they are the first point of introduction of NNS. They are often situated in low-energy areas, which provide sheltered conditions for boats but also ideal conditions for many NNS to survive and establish new populations. Therefore, effective monitoring and management of these environments can have a significant impact on NNS establishment.

The Shetland Islands have a number of active deep-water ports, which are used by a wide variety of commercial shipping vessels, oil tankers, ferries, and cruise ships. It is widely accepted that the commercial shipping industry is a key vector for the transportation of marine NNS and, therefore, Lerwick Harbour is considered a priority site for NNS monitoring. In addition the ports and harbours in Shetland are import centres for recreational activity, however this is assessed separately in Section 5.6 'Tourism and Recreation'.

Risks

Ports and harbours can act as 'hubs' for NNS and, without regular cleaning, can support a large number of introduced species. Therefore, any resident or visiting vessel is susceptible to hull fouling by NNS, which can lead to secondary spread to other sites.
The main concern for NNS management, with regards to the commercial shipping industry, is the release of marine organisms in close proximity to the Shetland Islands through ballast water exchange (see Section 4.1). This is of particular concern as the network of commercial vessels is worldwide, rather than regional (e.g. the fishing industry), which makes predicting which species will be introduced very difficult.

Responsible stakeholders

- Port and harbour authority
- Vessel owner

Preventative measures

Commercial shipping:

- Keep up-to-date with the IMO guidelines on ballast water management and shipping company requirements
- Where practical, mid-ocean ballast water exchange should be carried out prior to entering and after leaving the Shetland Islands
- Install on-board ballast water filtering systems and/or chemical treatment protocols, where possible (see Section 4.1)
- Use anti-fouling paint on vessel hulls to discourage fouling species
- Be aware of problematic NNS and assess whether your proposed voyage has the potential to contribute to the spread of these species

Ports and harbours:

- Regularly clean and land pontoons and non-permanent structures to reduce the survival rate of any NNS present
- Remove unused hanging objects (e.g. ropes, creels) from pontoons
- Monitor boat movements to and from the port/harbour
- Where practical, request that mid-ocean ballast water exchange is carried out prior to entering and after leaving the Shetland Islands
- Promote codes of best practice and encourage visiting vessels to clean their hulls before entering the site
- Ask vessel operators using the port/harbour when their vessel was last cleaned
- Inform marine users (commercial and non-commercial) of the risks of NNS, which species are high priority, and ways to prevent their spread

Table 5.6. List of target NNS for commercial shipping, their impacts, and appropriate response

Species of concern	Main impact	Response
Bryozoan *Schizoporella japonica*	• Fouling	• Air exposure • Manual removal
Red ripple bryozoan *Watersipora subatra*	• Fouling	• Air exposure • Manual removal • Isolate 'infected' area • Small-scale treatment • Report sighting
Wireweed *Sargassum muticum*	• Boat propeller entanglement • Fouling	• Manual removal • Report sighting
Japanese weed *Dasysiphonia japonica*	• Fouling	• Manual removal • Small-scale treatment
Carpet sea squirt *Didemnum vexillum*	• Fouling	• Air exposure • Isolate 'infected' area • Restrict boat movements to and from area • Enclosure of area – small scale treatment • Quarantine – large scale treatment • Report sighting
Leathery sea squirt *Styela clava*	• Fouling	• Manual removal • Isolate 'infected' area • Small-scale treatment • Report sighting

Detection measures

Commercial shipping:

- When possible, monitor which species are present in ballast water and/or fouling the vessel hull

Ports and harbours:

- Keep staff up to date with current NNS in the Shetland Islands, their identification, and methods of avoiding their introduction and spread
- Distribute and display NAFC Marine Centre leaflets on NNS
- During the landing and cleaning of vessels, carry out a survey of species present and verify if they are native or non-native
- Set up a monitoring program (usually carried out by NAFC Marine Centre researchers) that includes visual surveys and the deployment of settlement panels
- Be aware of where visiting vessels are arriving from and assess whether there is a risk of NNS introduction

Rapid response measures

Commercial shipping:

- Report the sightings of NNS to the NAFC Marine Centre
- Inform the local port/harbour of the presence of NNS

Ports and harbours:

- Report any recently detected or suspected NNS to the NAFC Marine Centre
- If detected NNS is high-profile and potentially problematic, try to isolate the 'infected' area and restrict movement of vessels to prevent further spread
- Visual survey of the site to identify the size and distribution of the NNS population
- If possible, local treatment of 'infected' area to try to eradicate
- If NNS population is large and widespread within the site, consider quarantine of site and large-scale treatment


Image © C.Slater (NAFC)

Control measures

Commercial shipping:

- Regular monitoring and cleaning of vessel hulls to prevent regional spread

Ports and harbours:

- Install a closed-loop wash-down system for cleaning vessels, where possible (see [Green Blue]() website for information)
- Regularly clean and land pontoons and non-permanent structures to reduce the survival rate of any NNS present
- Provide hull cleaning services to recreational boaters and promote 'clean' vessel maintenance to prevent local spread
- Monitor and keep records of the last port of call of vessels using the site
- If deemed appropriate, following a risk assessment (see Appendix IV for an example risk assessment), refuse access to the site if the vessel in question poses a high risk of introducing an NNS, in particular a high-profile and problematic NNS
- Promote codes of best practice and encourage visiting vessels to clean their hulls before entering the site
- Inform marine users (commercial and non-commercial) of the risks of NNS, which species are high priority, and ways to prevent their spread

Cleaning practices

Commercial shipping:

- Manual removal
- Landing of boats for cleaning
- Chemical treatment
- Ballast water exchange

Ports and harbours:

At present, Shetland Islands Council ports and harbours undertake regular cleaning and maintenance of structures and buoys to avoid build-up of fouling organisms, including NNS. Recommended cleaning practices include:

- Manual removal
- Landing of boats and non-permanent equipment/structures for cleaning
- Use of closed-loop wash-down systems
- Chemical treatment
- Enclosure


Image © C.Slater (NAFC)

5.6. Tourism & recreational activities

Overview

The introduction and transportation of NNS through tourism and recreational activities is a concern for marine management. Controlling and preventing the spread of NNS is challenging, due, in part, to the difficulty of monitoring all marine users. Effective management requires all marine users to be aware of their role in NNS transportation and to act in accordance with recommended codes of best practice.

Risks

One of the main contributors to local, secondary spread (spread that occurs after initial introduction of NNS) is recreational boating. Recreational vessels are susceptible to fouling species that are transported to different marinas and mooring sites when the boat is in use. These new sites can include other local destinations in Shetland and mainland Scotland, or sites further afield in Europe.

Recreational activities also pose a threat to marine conservation through NNS transportation. The Shetland Islands contain Nature Reserves, Marine Protected Areas, Special Protection Areas, and Special Areas of Conservation, with the features within these designated areas often attracting visitors. The potential for ecological damage to these sites through the introduction of marine NNS is considerable.

Responsible stakeholders

- Recreational boaters
- Recreational activity centres
- Vessel owner
- Marina associations
- Port and harbour authorities

Preventative measures

Marine users

- Be aware of the current status of NNS in your desired destination and take appropriate action to ensure you are not responsible for the introduction or spread of NNS
- Ensure that you and your companions are aware of the code of best practice for preventing the spread of NNS
- Check, clean, and dry all equipment and gear before and after use and between visiting sites
- Leave all marine organisms at the site where they were found
- If you find an NNS on your equipment/craft, remove it and dispose of it appropriately (e.g. place in a sealed plastic bag). **DO NOT** throw it into the water or leave it at the waters' edge

Marinas, ports and harbours

- Regularly clean fouling organisms from marine structures
- Encourage marine users to clean boats and to check, clean, and dry equipment
- Consider biosecurity when organising events which will attract visiting marine users from outside Shetland
- Ask visiting boaters when their vessel was last cleaned and, if there is a threat, to take appropriate action to prevent NNS introduction (e.g. refuse admission until vessel is cleaned)

Detection measures

- Ensure all marina users are aware of the problems associated with NNS and how they are spread
- Display posters and identification leaflets on NNS, supplied by NAFC Marine Centre, to marinas and other popular launching sites
- Rapid response measures
- Report NNS sightings, whether in marinas or on the natural coastline, to the NAFC Marine Centre

Table 5.7. List of target NNS for tourism and recreational activities, their impacts, and appropriate response

Species of concern	Main impact	Response
Japanese skeleton shrimp *Caprella mutica*	• Fouling • Competes with native species	• Manual removal • Clean equipment after use
Leathery sea squirt *Styela clava*	• Fouling	• Manual removal • Clean equipment after use • Report sighting
Carpet sea squirt *Didemnum vexillum*	• Fouling	• Clean equipment after use • Allow equipment to dry • Report sighting
Bryozoan *Schizoporella japonica*	• Fouling	• Clean equipment after use • Allow equipment to dry
Red ripple bryozoan *Watersipora subatra*	• Fouling	• Manual removal • Clean equipment after use • Allow equipment to dry • Report sighting
Wireweed *Sargassum muticum*	• Tangles in propellers • Fouling • Decomposing on beaches	• Manual removal • Clean equipment after use • Report sighting

- If NNS are found on a vessel, either land the vessel or clean the hull to remove NNS
- Depending on the size and distribution of the NNS population, attempt to manually remove it or begin a small-scale treatment
- If an NNS is found in a marina, consider quarantine measures (see Section 5.5, Ports and harbours)
- Restrict vessel movements and recreational activity within the 'infected' site

Control measures

- Provide information on the current status of NNS in the Shetland Islands and encourage marine users to adapt their route/voyage to minimise the risk of spreading NNS
- When possible, regularly take boats/leisure craft out of the water to clean. Cleaning should be carried out at an appropriate site where there is no immediate risk to the surrounding environment

6. Actions and timeframes

The Biosecurity Plan for the Shetland Islands has been co-ordinated by the NAFC Marine Centre and guided by a sub-group of the Marine Spatial Planning Advisory Group. Communication between the different marine sectors around the Shetland Islands has already begun and surveying and monitoring work, carried out by the NAFC Marine Spatial Management Team with support from Marine Scotland and SOTEAG, is already underway. Efforts to increase public awareness towards the risks associated with NNS is underway with the development and distribution of information and identification leaflets and guide books. Table 6.1 presents an overview of the proposed objectives of the Biosecurity Plan and an expected timeframe within which these objectives will be achieved.

Table 6.1.Timeframe for the four key objectives proposed in the Shetland Islands Biosecurity Plan

Action	Timeframe				
	2012	2013	2014	2015	2016
Objective 1 – Prevention of NNS introduction to the Shetland Islands					
Design and distribute informative posters and leaflets on NNS in the Shetland Islands		✓	✓	✓	✓
Arrange meetings with key stakeholders to inform and disseminate material		✓	✓	✓	✓
Develop marine Biosecurity Plan for the Shetland Islands to provide guidance for all marine users			✓	✓	✓
Update NAFC website to include information on NNS and provide practical guidance for NNS management		✓	✓	✓	✓
Perform public presentations at schools, town halls, and public events to inform the public of the threats of NNS			✓	✓	✓
Objective 2 – Early detection of NNS in the Shetland Islands					
Perform Shetland-wide survey for NNS in ports and marinas	✓	✓	✓	✓	✓
Deploy settlement panels	✓	✓	✓	✓	✓
Identify key ports and sites to focus continued monitoring effort			✓	✓	✓
Snorkel surveys of marinas and ports around the Shetland Islands				✓	✓
Encourage NNS sightings to be reported to NAFC Marine Centre	✓	✓	✓	✓	✓
Objective 3 – Rapid response to potential NNS sightings in the Shetland Islands					
Collaboration with authorities in the UK working on NNS management	✓	✓	✓	✓	✓
Keep up-to-date with NNS detections close to the Shetland Islands	✓	✓	✓	✓	✓
Keep up-to-date on best codes of practice for managing all potential NNS in the Shetland Islands	✓	✓	✓	✓	✓
Objective 4 – Control and mitigation of NNS in the Shetland Islands					
Inform each relevant marine sector of codes of best practice and guidance for reducing NNS spread and impact		✓	✓	✓	✓
Keep up-to-date on current methods of control and eradication of NNS	✓	✓	✓	✓	✓

Appendix I

Stakeholders and key local contacts:

Name	Title	Location	Telephone Number	Email
Rachel Shucksmith Katrina MacIver/ Dr Samuel Collin	Marine Spatial Planning Manager Marine Spatial Planning Project Officer	NAFC Marine Centre	(01595) 772000	rachel.shucksmith@uhi.ac.uk samuel.Collin@uhi.ac.uk
Pete Ellis Helen Moncrieff	Shetland Area Manager	RSPB Shetland	(01950) 460800	pete.ellis@rspb.org.uk helen.moncrieff@rspb.org.uk
Ruth Henderson	Chief Executive Officer	Seafood Shetland (Shellfish)	(01595) 693644	ruth@fishuk.net
Janet Davies	Specialist II (Aquaculture)	SEPA	(01595) 696926	janet.davies@sepa.org.uk
Karen Hall	Policy & Advice Officer, Marine Ecology	SNH	(01595) 693345	karen.hall@snh.gov.uk
Paul Harvey	Biological Records Centre Manager	Shetland Amenity Trust	(01595) 694688	paul@shetlandamenity.org
Simon Collins	Executive Officer	Shetland Fishermen's Association	(01595) 693197	simon@shetlandfishermen.com
Martin Holmes	Coastal Zone Manager	SIC (Coastal Zone Management)	(01595) 744800	martin.holmes@shetland.gov.uk
Colin Reeves	Harbour Master	SIC Ports & Harbours	(01806) 244200	colin.reeves@shetland.gov.uk
David Sandison	General Manager	SSPO Shetland	(01595) 695579	dsandison@scottishsalmon.co.uk
Dr Jonathon Wills	Councillor	Shetland Islands Council	(01595) 693535	info@shetland.gov.uk

Key contacts outside the Shetland Islands:

Name	Title	Location	Telephone Number	Email
Lyndsay Brown	Phytoplankton Biologist	Marine Scotland – Science, Aberdeen	(01224) 295506	lyndsay.brown@scotland.gsi.gov.uk
Jenni Kakkonen	Biologist	Marine Services, Orkney Islands Council	(01856) 885244	jenni.kakkonen@orkney.gov.uk
Prof. David Paterson	Coastal ecology and biodiversity	SOTEAG Office, St Andrews	(01334) 463613	mkr3@st-andrews.ac.uk

Appendix II
Description of mapping methodology and data

Risk Assessment Methodology:

To identify the areas of the Shetland Islands which are subject to the highest risk of NNS introduction relative risk levels have been modelled. This information will be used to target monitoring effort for marine non-native species. Activities that were identified as representing a 'risk' included aquaculture (finfish, shellfish and algae cultivation), marine renewables, shipping, and shore access points. The Shetland Islands' Marine Spatial Plan (SMSP) has previously identified the location of these activities and this data was used to map intensity of these activities in 5×5 km grid squares.

Each of these activities was assigned a risk score based on their potential to spread non-native species or to assist in their establishment, including the risk of bio-fouling and the risk associated with ballast water exchange. The Options for Delivering Ecosystem-based Marine Management (ODEMM) risk assessment criteria were adapted for the risk assessment. Scores assigned to each activity, based on a risk assessment score were combined with information of the intensity of the activity in each 5×5 km grid squares to provide a relative risk map for the Shetland Islands.

Appendix III

Table A1: Dispersal and environmental preferences of NNS found in the Shetland Islands

	Corella eumyota	*Bugula simplex*	*Codium fragile ssp. fragile*	*Dasysiphonia japonica*	*Caprella mutica*	*Schizoporella japonica*	*Diadumene lineata*	*Fenestrulina delicia*	*Asparagopsis armata*	*Bonnemaisonia hemifera*	*Austrominius modestus*
Dispersal method	Larvae	Larvae	Spawning Rafting Floating	Spawning Fragment	Adult movement	Larvae	Larvae	Larvae	Spawning Rafting Fragment	Spawning	Larvae
Dispersal potential	Minutes	Hours (max 2 days)	m to km depending on current	Fragments: at least 3 weeks	Minimal movement of adults Floating	2 days	2 weeks	Hours	m to km depending on current	m to km depending on current	Days (≥6)
Temperature range	No data found	No data found	-2 to 34 °C	Wide tolerance range	Wide tolerance range	No data found	14 to 24 °C	No data found	12 to 21 °C	5 to 20 °C	Wide tolerance range
Salinity range	No data found	No data found	12 to 40 ppt Short periods in freshwater	Cannot tolerate low salinities	Cannot tolerate low salinities	No data found	18 to 34 ppt	No data found	35 to 38 ppt	No data found	Wide tolerance range
Exposure to air	Intertidal (hours)	Short exposure	<6 h	Can tolerate	Can tolerate	Short exposure	Short exposure	Short exposure	Short exposure	Short exposure	Up to 10 days
Habitat	Hard surfaces	Hard surfaces	Bivalve shells Rocky shores Hard surfaces Eel grass	Hard surfaces Seaweeds	All surfaces Artificial structures	Hard surfaces	Hard surfaces Seaweed Bivalve shells	Hard surfaces Shells	Hard Surfaces Other seaweeds	Hard Surfaces Other seaweeds	Hard Surfaces
Environmental preference	Sheltered	Sub-tidal	Exposed and sheltered	Sheltered	Sheltered	Sheltered	Bays and estuaries	Offshore	Sub-littoral Deep littoral pools	Sub-littoral	Sheltered bays and estuaries

Table A2: Dispersal and environmental preferences of potential NNS to the Shetland Islands

	Didemnum vexillum	*Styela clava*	*Sargassum muticum*	*Watersipora subatra*	*Tricellaria inopinata*	*Botrylloides violaceus*
Dispersal method	Larvae Fragmentation	Larvae	Fragmentation Spawning	Larvae	Larvae	Larvae Fragmentation
Planktonic duration	Larvae: a few hours Fragments: up to 30 days	Larvae: 12 to 24 h	Embryos: minutes Fragments: up to 3 months	<1 day	Hours	Larvae: a few hours
Temperature range	-2 to 24°C Reproduction: 14 to 20°C Fragmentation: 11 to 25°C	-2 to 23°C Reproduction >14°C	10 to 30 °C	12 to 28°C	20 to 35°C	-1 to 27°C
Salinity range	> 26 ppt	Adults >10 ppt Larvae >18 ppt	7 to 34 ppt	25 to 49 ppt	20 to 35 ppt	15 to 33 ppt
Exposure to air	Up to 6 hours	2-3 days	Cannot tolerate	Short exposure	Short exposure	Short exposure
Habitat	Hard surfaces Seaweeds Bivalve shells Other sea squirts	Hard surfaces in shallow water	Rocks, shells, and other hard surfaces	Hard surfaces Kelp Bivalve shells	Hard surfaces Kelp	Hard surfaces Seaweeds Bivalve shells Other sea squirts
Environmental preference	Sheltered	Sheltered	Sheltered	Shallow subtidal Estuaries	Shallow subtidal	Sheltered

Appendix IV

Example Risk Assessment for Organised Marine Events in the Shetland Islands

Purpose

The aim of this risk assessment is to ensure all marine events held within the Shetland Islands that attract visitors (and vessels) from further afield, either from regions within or outside the UK, are appropriately managed to reduce the risk of introducing non-native species.

Introduction

The threats posed by marine non-native species (NNS) has been widely acknowledged and the increase in marine activity, both long and short-distance voyages, has had a significant influence on the transportation, introduction, and spread of marine NNS. A key vector for local and regional spread of marine NNS is the movement of recreational boats. Many marine NNS attach to the hulls of boats and 'hitchhike' to new locations, determined by the boats' movements.

Organised events, such as boating regattas and demonstrations, attract visitors from far afield that often travel by boat. The concentration of many vessels from different regions can create a hot spot for NNS, with many vessels potentially transporting NNS to the site and also potentially returning to their port of origin with additional NNS. By encouraging vessel owners to clean their boats, in particular the removal of fouling organisms from the vessel's hull prior to attending any organised events, the spread of marine NNS can be controlled and their introduction to new sites can be prevented.

The effective management of marine NNS requires the support and cooperation of all persons involved, from event organisers to attendees. It is important for event organisers to ensure the risks associated with marine NNS are widely publicised to all attendees and that all visiting vessel owners are aware of the regulations in place, including potential costs. Similarly, it is important that all visitors acknowledge the concerns over the spread of NNS and their associated risks, and act in accordance to recommended management practices.

Non-native species of most concern

- Carpet sea squirt – *Didemnum vexillum*
- Violet sea squirt – *Botrylloides violaceus*
- Leathery sea squirt – *Styela clava*
- Slipper limpet – *Crepidula fornicata*
- Wireweed – *Sargassum muticum*
- Red ripple bryozoan – *Watersipora subatra*

Risk assessment

Event evaluation

The magnitude and type of event being held can be important for gauging whether there is a high risk of NNS introduction or not. The following information needs to be collated to determine whether the event poses any risk of NNS introduction:

- Size of the event – is the event contained within a single site or are there multiple sites involved around the Shetland Islands and/or further afield?
- Reach of the public draw – has the event been widely advertised and are visitors expected from other regions of the UK or Europe?
- How many visitors – what is the number of vessels expected to attend the event?
- Length of the event – what is the maximum amount of time a visiting vessel will spend on site during the event (1 day – weeks)?
- Time of year – does the event take place during the summer when most marine species are reproductive and the risk of introduction and spread is higher?

Site evaluation
The physical characteristics of the site play an important role in the survival 'success' of an introduced NNS. A key stage of the Risk Assessment is to determine whether the site (e.g. marina, port) is suitable for NNS survival. The assessment should take into account the following:

- Is there a wealth of suitable surfaces available for species recruitment (e.g. pontoons, ropes, chains)?
- How large is the site – how many berths are available?
- What size/type of vessel can be accommodated?
- Are there additional mooring lines available outside the site that could be used?
- Is the site sheltered or exposed?
- Does the site have a small channel entrance or is it open?
- Is there a nearby landing/cleaning facility available?
- Are there any environmentally sensitive areas in close proximity?

Vector evaluation
There are multiple vectors that can contribute to the spread of NNS, each posing different challenges for management. Upon arrival, it is important for site managers to record the type of vessel, where it has been prior to arriving in the Shetland Islands, and how long the planned visit is for. The main vectors and points of concern are discussed below.

Boats
Port of origin:
Within the UK – high risk of transporting species already established within other regions of the UK and contributing to their local spread.
Outside the UK – high risk of transporting and introducing new NNS to the UK.

Type of boat:
Speed boats – Faster moving and generally intended for short trips to nearby locations. Capable of transporting and introducing NNS, especially if hull is heavily fouled and organisms are dislodged during visit

Yacht – Slower moving and generally intended for long trips to nearby and distant locations. Capable of transporting NNS via hull fouling and introducing NNS to new locations. A longer residency at a single site suggests fouling organisms could have time to spawn and reproduce within new site, leading to recruitment on surrounding vessels, marinas, and natural environment.

Tall ships – Slower moving and generally intended for long trips, often from international locations. Capable of transporting NNS via hull fouling and introducing NNS to new locations. A longer residency at a single site suggests fouling organisms could have time to spawn and reproduce within new site, leading to recruitment on surrounding vessels, marinas, and natural environment.

Ballast water:
Smaller vessels do not normally have ballast water systems, but small amounts of water can be retained within the vessel, which could potentially contain NNS. In general, the risk of species being introduced via ballast water from small vessels is low.

Pontoons
If additional pontoons are brought to the site to accommodate a large number of vessels, they should be cleaned and dried prior to deployment to ensure no living organisms are attached.

Critical control points and control measures
In consideration of the identified risks associated with organised marine events, the following control points and measures have been identified, which should be considered in the design of a management strategy:

Critical control point 1 – port of origin/prior to departure

Boats
Ensure all persons planning to visit the organised event have taken sufficient measures to clean and remove any fouling organisms from their vessels prior to departure, preferable as close to the departure date as possible.

Pontoons
Ensure all pontoons are clean and dry prior to deployment at site of use.

Critical control point 2 – on site assessment of visiting vessels
All visiting vessels should be inspected upon arrival to ensure all are free of fouling species and, subsequently, any NNS. All inspections will be carried out by trained personnel at the time of arrival and will be assessed against the scale in Table 1.

Table 1. Density scaling of fouling organisms on boat hulls.

Rank	Description	Visual estimate of fouling cover
0	**No visible fouling**. Hull entirely clean, no biofilm on visible submerged parts of the hull.	0
1	**Slime fouling only**. Hull partially or entirely covered in biofilm, but absence of any plants or animals.	0
2	**Light fouling**. Hull covered in biofilm and one to two very small patches of one species of plant or animal.	1 to 5 % of submerged surfaces
3	**Moderate fouling**. Presence of biofilm and patches of clearly visible fouling assemblages, consisting of one or more species of plants and/or animals.	6 to 15 % of submerged surfaces
4	**Heavy fouling**. Abundant fouling assemblages consisting of multiple species of plants and/or animals.	16 to 40 % of submerged surfaces
5	**Very heavy fouling**. Many different species of plants and/or animals covering most of hull surface.	41 to 100 % of submerged surfaces

Management measures
Ensuring that the vessels are clean before arriving in the Shetland Islands is the responsibility of the vessel owner/operator. Depending on the results of the visual inspection, the following action may be taken:

Boats
- **Rank 0 to 2** – No action
- **Rank 3 to 4** – No action (manual removal of larger organisms where possible, but advise boat owner of the risks of transporting and introducing NNS)
- **Rank 5** – Haul out vessel and clean (at the owner's expense). Re-entry to event will require a clean hull. If owner refuses to clean their vessel, they will be asked to leave the event.

Pontoons
- **Rank 0 to 2** – No action
- **Rank 3 to 5** – Clean before deployment and dispose of any removed material into landfill bins

During the visual inspection, the vessel owner will be informed of the issues associated with NNS transportation and introduction, why the inspection is being carried out, and how they can contribute to the management of NNS by adopting general maintenance practices.