

Invasive Non-native Species Action Plan for Wales:

American slipper limpet (*Crepidula fornicata*)



May 2026

Lucinda Lintott, Tom Hill, Dr Kate Dey & Dr Paul Stebbing

With contributions from Holly Peek and Chloe Powell-Jennings

APEM Ltd. And Natural Resources Wales

With thanks to Dr Joe Ironside from Aberystwyth University

This project was delivered by APEM Ltd. and NRW and funded through the Welsh Government's Nature Networks Programme, to strengthen the resilience of Wales's protected land and marine sites.

Table of Contents

Crynodeb.....	5
Summary	7
Background	8
What are Invasive Non-Native Species (INNS)?.....	8
What are pathways?	9
What is biosecurity?	11
A biosecurity framework: what is the context for this Species Action Plan?	11
Scope, aims and objectives	13
The slipper limpet: Background	14
Where did it come from?.....	15
What does it look like?.....	15
What habitat does it live in?	15
Behaviour and life cycle.....	16
Does it have any predators?.....	17
What are its pathways and vectors?	17
What are its impacts?.....	19
Slipper limpets in Wales: National context	22
Distribution of the slipper limpet.....	22
MPA features at risk from the slipper limpet	23
INNS and the Law	25
Challenges to INNS management	26
Biosecurity to manage the slipper limpet	27
Who are the key stakeholders?	27
Recommended strategic actions for authorities	29
Recommended actions for all stakeholders.....	33
1. Understanding roles and legal responsibilities.....	34
2. Information, guidance and research on the slipper limpet	36
3. Raising awareness.....	39
4. Biosecurity processes and procedures.....	42
5. Species management	43
6. Monitoring and reporting.....	45
7. Collaborative working.....	50
Control and management methods	52
Useful Resources	55

Bibliography	57
General references.....	57
Control and management table's references.....	58
Data References.....	59

List of Figures

Figure 1. An overview of the Pathway Action Plans that have been developed for Wales, and the vectors associated with the pathways. Note that the list of vectors is not exhaustive.	10
Figure 2. A flowchart showing the relationships between the Pathway Action Plans, Species Action Plans and the Biosecurity Action Plans created for the Natural Resources Wales Biosecurity Planning Project with APEM Ltd.....	12
Figure 3. Photographs of the slipper limpet showing some of the key features for identification. Sources: RPS Group PLC, Charlotte Colvin, Misjel Decler and Filip Nuytens.	16
Figure 4. Map of recorded and confirmed slipper limpet occurrences in (A) the UK and (B) Wales from open source NBN Atlas data as of July 2023 (black circles), data received directly from Natural Resources Wales and ad hoc sightings from organisations such as Seasearch. Contains public sector information licensed under the Open Government Licence (OGL) v3.0, Public Domain Dedication (CC0) v1.0, Creative commons with attribution v4.0 (CC-BY). Data rightsholders, data providers, and dataset references are provided in Data References.	23
Figure 5. Habitat risk (concern level) from the Slipper limpet, <i>Crepidula fornicata</i> , based on the assessment carried out in the NRW evidence report “Assessing the impact of key Marine Invasive Non-Native Species on Welsh MPA habitat features, fisheries and aquaculture” (NRW Report 454).....	24

List of Tables

Table 1. A summary of the slipper limpet (<i>Crepidula fornicata</i>) background information.....	14
Table 2. Impacts to key protected marine features by the slipper limpet. References to the papers and reports used for this table can be found in the Bibliography.	20
Table 3. Impacts to commercially important species from habitat alteration by the slipper limpet. References to the papers and reports used for this table can be found in the Bibliography.	21

Table 4. Impacts to commercially important species from fouling by the slipper limpet. References to the papers and reports used for this table can be found in the Bibliography....	21
Table 5. Species impact and risk assessments for the slipper limpet.....	26
Table 6. Recommended strategic actions for authorities to address the introduction and spread of marine INNS via all pathways in Wales. The ID letters SS (Species Strategic) denote that the actions are aimed at addressing the management of species, differing from the ID letters PS (Pathway Strategic) in the Pathway Action Plans (PAPs) that are aimed at addressing the management of pathways.....	29
Table 7. A list of control methods for the slipper limpet that have been utilised elsewhere and are reported in scientific literature. The references used can be found in the control and management table's references section of the bibliography.	52

Crynodeb

- Mae [rhywogaethau estron goresgynol](#) yn blanhigion, anifeiliaid neu bathogenau nad ydynt i'w cael yn naturiol mewn ardal ond sydd wedi cael eu symud yno, fel arfer gan weithgareddau dynol (naill ai'n ddamweiniol neu'n fwriadol) ac maen nhw'n achosi effeithiau amgylcheddol, cymdeithasol neu economaidd sylweddol. Rhai o effeithiau rhywogaethau estron goresgynol yw eu bod yn cystadlu'n llwyddiannus â rhywogaethau brodorol am fwyd a gofod, eu bod yn newid cynefinoedd, lledaenu clefydau ac achosi costau uniongyrchol ac anuniongyrchol i economïau lleol a chenedlaethol.
- Mae symudiad (h.y. cyflwyno a lledaenu) rhywogaethau estron goresgynol yn cael ei hwyluso gan drywyddau a gweithgareddau dynol o'r enw "[Llwybrau](#)", er enghraifft, llongau, cychod hamdden a dyframaethu.
- Er mai'r ffordd sy'n cael ei mabwysiadu fel arfer i leihau effaith rhywogaethau estron goresgynol yw ymdrechu i atal cyflwyniad a lledaeniad ar lefel y llwybr, mae sawl rhywogaeth estron goresgynol wedi cael ei blaenoriaethu gan Cyfoeth Naturiol Cymru.
- Nod cyffredinol y Cynllun Gweithredu Rhywogaethau hwn yw lleihau'r risg o gyflwyno a lledaenu Ewin mochyn (*Crepidula fornicata*), drwy gyflwyno camau gweithredu y gellir eu rhoi ar waith ar lefelau cenedlaethol (Cymru), rhanbarthol a lleol.
- Mae'r Cynllun Gweithredu Rhywogaeth hwn yn rhoi trosolwg o Ewin mochyn, ei [ymddygiad a'i gylch bywyd](#), [llwybrau lledaenu](#) ac [effeithiau](#), yn ogystal â chamau y gellid eu rhoi ar waith i [fynd i'r afael â lledaeniad y rhywogaeth hon](#).
- Ymysg effeithiau negyddol Ewin mochyn mae: bygythiadau i fioamrywiaeth; newid cynefinoedd morol; cystadlu â rhywogaethau brodorol (gan gynnwys rhywogaethau o bwysigrwydd masnachol; a throsglwyddo pathogenau a pharasitiaid. Gall y problemau hyn olygu gwaith rheoli costus, yn ogystal ag achosi difrod uniongyrchol i'r amgylchedd morol.

- Mae'r camau gweithredu a amlinellir yn y Cynllun Gweithredu Strategol hwn yn darparu cyfres o gamau gweithredu i randdeiliaid amgylchedd morol Cymru y gellid eu rhoi ar waith lle mae Ewin mochyn Tsieina wedi'i nodi fel blaenoriaeth neu risg uchel.
- Rhanddeiliaid yw'r rhai sy'n defnyddio, yn elwa o, neu sy'n gyfrifol am (e.e. rheoli, amddiffyn neu reoleiddio) yr amgylchedd morol. Yma, mae hyn yn cynnwys awdurdodau (h.y. cyrff sydd â phwerau i gyflwyno, diwygio a gorfodi rheoliadau, deddfwriaeth a pholisi), cyrff statudol, rhanddeiliaid anllywodraethol cenedlaethol (e.e. cyrff llywodraethu hamdden, cyrff anllywodraethol, cymdeithasau ac ymddiriedolaethau), gweithrediadau masnachol, awdurdodau porthladdoedd a harbwrfeistri, defnyddwyr hamdden ac unigolion. Gweler [Rhanddeiliaid allweddol](#) am enghreifftiau pellach.
- Mae'r Cynllun Gweithredu Rhywogaeth yn amlinellu saith cydran o ffocws bioddiogelwch i'w gwneud gan randdeiliaid sy'n mynd i'r afael ag Ewin mochyn o fewn ardaloedd morol Cymru.
 1. [Deall rolau a chyfrifoldebau cyfreithiol.](#)
 2. [Gwybodaeth ac arweiniad ar Ewin mochyn](#)
 3. [Codi ymwybyddiaeth](#)
 4. [Prosesau a gweithdrefnau bioddiogelwch](#)
 5. [Rheoli rhywogaethau](#)
 6. [Gwyliadwriaeth ac adrodd](#)
 7. [Gweithio ar y cyd](#)
- Bwriedir i'r cynllun hwn gael ei ddefnyddio i gefnogi'r [Cynlluniau Gweithredu Llwybrau \(PAPs\)](#) a'r [Cynlluniau Gweithredu Bioddiogelwch \(BAPs\)](#) cysylltiedig.

Summary

- [Invasive non-native species](#) (INNS) are plants, animals or pathogens that do not naturally occur in an area but have been moved there, usually by human activities (either accidentally or deliberately) and cause significant environmental, social or economic impacts. The impacts of INNS include outcompeting native species for food and space, altering habitats, spreading disease and incurring direct and indirect costs for local and national economies.
- The movement (i.e. introduction and spread) of INNS is facilitated by human mediated routes and activities called “[Pathways](#)”, for example shipping, recreational boating and aquaculture.
- Although reducing the impact of INNS is commonly approached through efforts to prevent introduction and spread at the pathway level, there are several INNS that have been prioritised by National Resource Wales.
- The overall aim of this Species Action Plan is to reduce the risk of the introduction and spread of the American slipper limpet, *Crepidula fornicata*, by putting forward actions that can be applied at national (Welsh), regional and local levels.
- This SAP provides an overview of the invasive American slipper limpet, its [behaviour and life cycle](#), [pathways of spread](#) and [impacts](#), as well as actions that could be implemented to [address the spread of this species](#).
- The negative impacts of the American limpet include: threats to biodiversity; alteration of marine habitats; competition with native species (including commercially important species; and transmission of pathogens and parasites. These issues can lead to costly management as well as direct harm to the natural marine environment.
- The actions outlined within this SAP provide stakeholders of the Welsh marine environment with a series of actions that could be implemented where the American slipper limpet has been identified as a priority or high risk.
- Stakeholders are those that use, benefit from or are responsible for (e.g. managing, protecting or regulating) the marine environment. Here, this includes authorities (i.e. bodies with powers to introduce, amend and enforce regulations, legislation and policy), statutory bodies, national non-governmental stakeholders (e.g., recreational governing bodies, NGOs, associations and trusts), commercial operations, port authorities and harbourmasters, recreational users and individuals. See [Key stakeholders](#) for further examples.
- The SAP outlines seven components of biosecurity focus to be undertaken by stakeholders that address the American slipper limpet within Welsh marine areas.
 1. [Understanding roles and legal responsibilities](#)
 2. [Information and guidance on the slipper limpet](#)
 3. [Raising awareness](#)
 4. [Biosecurity processes and procedures](#)
 5. [Species management](#)
 6. [Surveillance and reporting](#)
 7. [Collaborative working](#)
- This plan is intended to be used in support of the associated [Pathway Action Plans \(PAPs\)](#) and [Biosecurity Action Plans \(BAPs\)](#).

Preface

Safeguarding Wales's marine environment and native biodiversity requires robust biosecurity measures to prevent the spread and impact of invasive non-native species (INNS). The guidance in this Species Action Plan provides information and guidance to support stakeholders with their biosecurity efforts in Welsh marine areas, where the American slipper limpet is considered a priority threat.

It is acknowledged that no single activity is solely responsible for the spread of INNS, and no single species should be targeted at the expense of wider holistic efforts. All users of the marine environment are encouraged to take the time to understand more about the slipper limpet and how they can contribute to tackling it.

Collective effort is ideal, but individual actions are equally vital. Proactive steps by stakeholders, even when taken independently, strengthen national INNS biosecurity and help to protect our marine environment — every action counts. Stakeholders are encouraged to raise awareness of biosecurity as widely as possible by sharing this plan, the guidance within it, and the actions they choose to undertake.

The significance of this issue is recognised by Natural Resources Wales, who commissioned, and will manage this plan under a wider framework of INNS biosecurity planning.

Background

What are Invasive Non-Native Species (INNS)?

Non-native species (NNS) are plants, animals or pathogens that do not naturally occur in an area but have been moved there, by human activities (either accidentally or deliberately). NNS are also sometimes referred to as “alien species”, “non-indigenous species” or “exotic species”. Most NNS do not cause issues within the area where they have been introduced. However, 10-12% cause significant environmental, social or economic impacts. These are known as Invasive Non-Native Species (INNS) and, in Wales, include the American slipper limpet, carpet sea squirt and Japanese wireweed, among many others. The impacts of INNS include threats to biodiversity, habitat alteration, fouling underwater structures (including aquaculture equipment, navigational aids and piers) and the introduction of diseases. The impacts of INNS (in all environments including marine) are estimated to cost the British economy £4 billion per year, of which, £499 million per year is attributed to impacts in Wales (see the [2023 paper from Eschen](#)).

Marine INNS are resilient and often capable of surviving harsh and variable conditions, making them particularly challenging to manage. Many species can endure high levels of drying, temperature fluctuations, and low nutrient availability, allowing them to persist in damp conditions for extended periods. For instance, mussels, barnacles and algae can remain viable (i.e., still able to live and/or reproduce) when attached to damp equipment, nets or boat hulls, even after days or weeks out of the water. The resilience enables them to travel long distances, hitchhiking on fishing gear, recreational boats, or clothing/equipment.

What are pathways?

The mechanisms and routes by which INNS are moved from one location to another by humans are termed “pathways”. This movement of species by humans, accidentally or deliberately, allows INNS to overcome natural barriers that would otherwise prevent them from spreading between their native and non-native ranges, e.g., an ocean. For instance, Pacific oysters, native to Japan, would not be able to reach UK waters through natural spread, but when introduced into UK waters by human activity can survive and establish as the environmental conditions in the UK are compatible with their native range.

Animals can be moved as eggs and in their larval, juvenile and adult life stages. Seaweed can be moved as fragments or spores. Larvae can be planktonic (drift with currents, unable to propel themselves against water movement) or free-swimming (can actively move and maintain their position in the water column).

Pathways are broadly classified as two types:

- 1) Pathways of initial introduction: Those which transfer NNS to regions or locations that are geographically separate and isolated from their native range (referred to as “introduction(s)” in this document). An example of this would be the movement of transoceanic vessels.
- 2) Pathways of further spread: These facilitate the movement of NNS populations beyond their initial introduction point (referred to as “spread” in this document):
 - a. Facilitating the short-range dispersal (i.e. spread from place of introduction to wider area) of an NNS population within a single habitat or location (e.g. paddle boarders spreading a seaweed within a bay), or
 - b. Facilitating regional spread where some small barriers exist (e.g., the movement of recreational boats between two nearby but separate harbours).

The frequency and magnitude of pathways in the marine environment have been increasing since the 1800s with the beginning of rapid globalisation. A significant movement of marine INNS has been through the trans-oceanic voyages and shipping that has long supported growing global economies and international supply chains. For more information on other pathways in the marine environment, please see the Welsh Pathway Action Plans. Links can be found on the [Wild Seas Wales website](#).

Vectors are the specific, discrete parts of a pathway that facilitate the movement of INNS from one location to another. For example, vectors within the aquaculture pathway could include the escape of a cultured INNS from the aquaculture site, INNS hitchhiking on the cultured species or INNS-fouled equipment that is brought to a site. For boating pathways, vectors could include INNS fouling the boat hull or INNS being taken up in water-retaining features (e.g., bilge or ballast tanks). The relationship between pathways and vectors in the marine environment is illustrated in Figure 1.

Natural spread of INNS e.g., larvae distributed along a coastline by tides and currents, may also occur following introductions. However, unlike the spread caused by human activities, natural spread is generally limited by the inherent barriers between locations. Natural spread is generally gradual and organic (i.e. slow outward spread from a point-source of introduction). Although natural spread is more challenging to manage, improved biosecurity procedures, particularly at high-risk/vulnerable sites, can reduce the risk of impact and improve the chances that introductions are detected early.

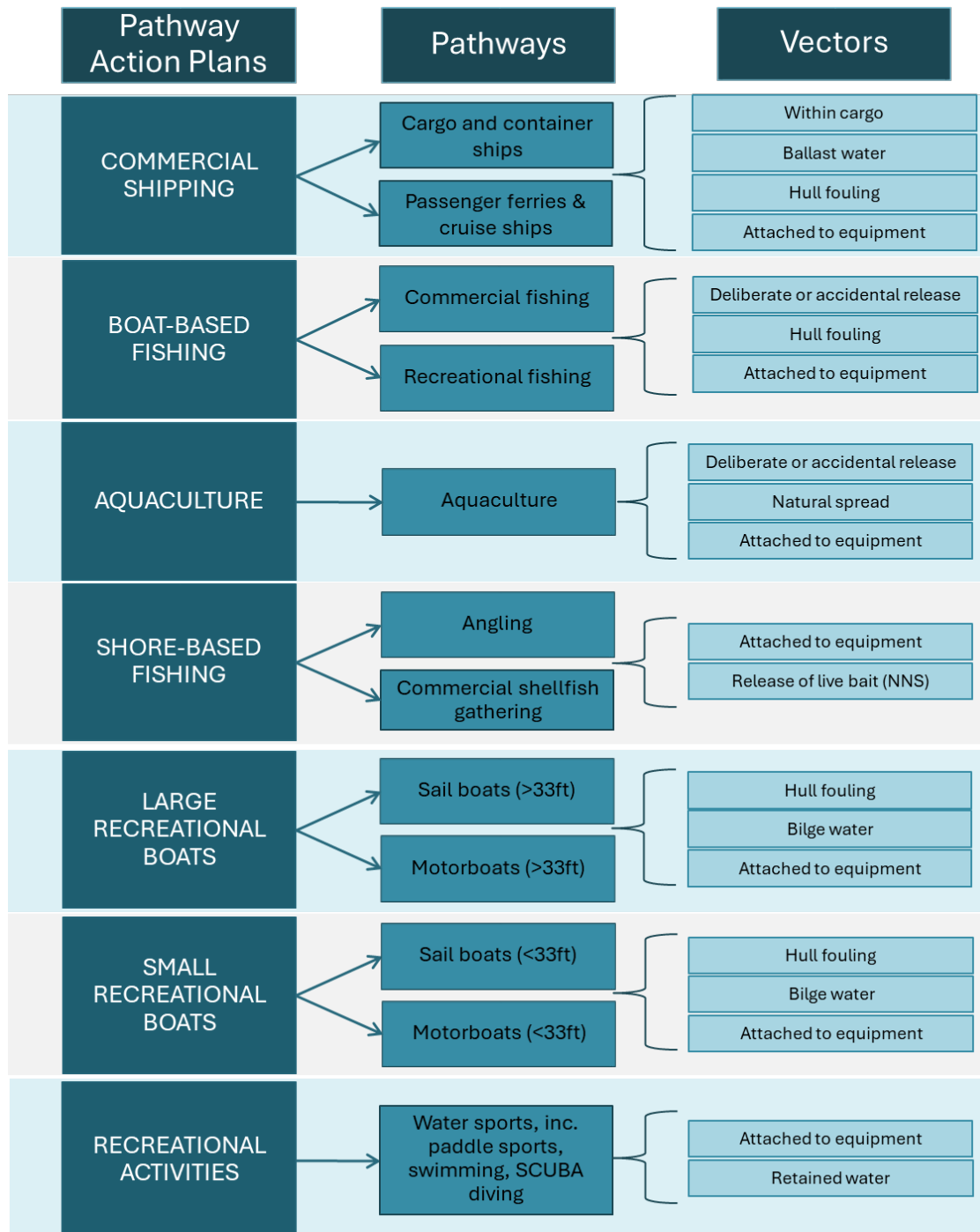


Figure 1. An overview of the Pathway Action Plans that have been developed for Wales, and the vectors associated with the pathways. Note that the list of vectors is not exhaustive.

What is biosecurity?

Biosecurity measures are actions, procedures and behaviours put in place to reduce the risk of INNS introduction and spread within and outside of a given area. Biosecurity measures should be realistic, pragmatic and cost-effective. Preventing the introduction and spread of INNS is by far the most effective way to reduce the impact of INNS. Eradication and control of INNS is often not possible in the marine environment and any attempts are more costly, difficult, and time-consuming compared to preventing the arrival and establishment of INNS in the first place.

A biosecurity framework: what is the context for this Species Action Plan?

This Species Action Plan forms part of a biosecurity planning framework commissioned and endorsed by Natural Resources Wales. The driver behind the framework is the wider goal of improving the condition of and increasing biodiversity in protected marine sites. Within the marine environment, this goal includes reducing the introduction and spread of INNS. The Species Action Plans (SAPs) and the Pathway Action Plans (PAPs) produced for this framework are intended to provide a basis for biosecurity planning for all marine sites throughout Wales, as well as presenting standalone guidance for pathway management. Figure 2 shows the relationships between each of the action plans.

Pathway Action Plans (PAPs) describe the pathway and list possible actions that could be undertaken to address the risk of the introduction and spread of INNS via that pathway into or around Wales. Links to the other PAPs can be found on the [Wild Seas Wales website](#).

Species Action Plans (SAPs) describe priority INNS and list possible actions that could be undertaken to address the introduction and spread of that species into or around Wales. Links to the SAPs can be found on the [Wild Seas Wales website](#).

Biosecurity Action Plans (BAPs) are site-specific. BAPs can be scaled as appropriate but there are no barriers to producing a BAP for a whole region (i.e. as has been done for the Pembrokeshire Marine, Cardigan Bay, Menai Straits and Carmarthen Bay Special Areas of Conservation (SACs)) or for an individual port, harbour or aquaculture site. They will identify the pathways relevant for that site and the species at or near the site that are of concern. The actions listed in the PAPs and SAPs are relevant to all stakeholders (see [Key stakeholders](#)) and should be considered and incorporated into a site's BAP. Due to the wide breadth and scale of the different stakeholder groups, the scope of these actions is equally broad. It is therefore important that individual stakeholders review their activities and use of the site to decide which of the biosecurity actions are applicable and practicable.

Biosecurity To-Do-List trackers have been created to make it easier for stakeholders to log what actions they plan to carry out and track what progress is being made on each action. The need for using to-do-list trackers will be dependent on the scope and scale of the BAP. For example, the BAPs produced for the Welsh SACs cover such large areas that it is necessary to provide individual stakeholders with an additional support tool that makes it easier to log and

track their actions. The tracker also enables NRW, as the SAC BAP manager, to effectively oversee the implementation of biosecurity within each SAC, highlighting progress and pinpointing where further assistance or support may be needed. This approach is also intended to facilitate coordinated monitoring and collaborative efforts to share and enhance biosecurity practices between stakeholders. Biosecurity planning at smaller scales (e.g. an individual port or aquaculture facility) are unlikely to require a BAP and a to-do-list tracker in parallel. Stakeholders can decide which is the most appropriate method for facilitating their biosecurity efforts.

This framework has not been created with punitive or intentionally burdensome measures, and we encourage aquaculture operators to consider the benefits of improved biosecurity to both the sustainability and profitability of the industry.

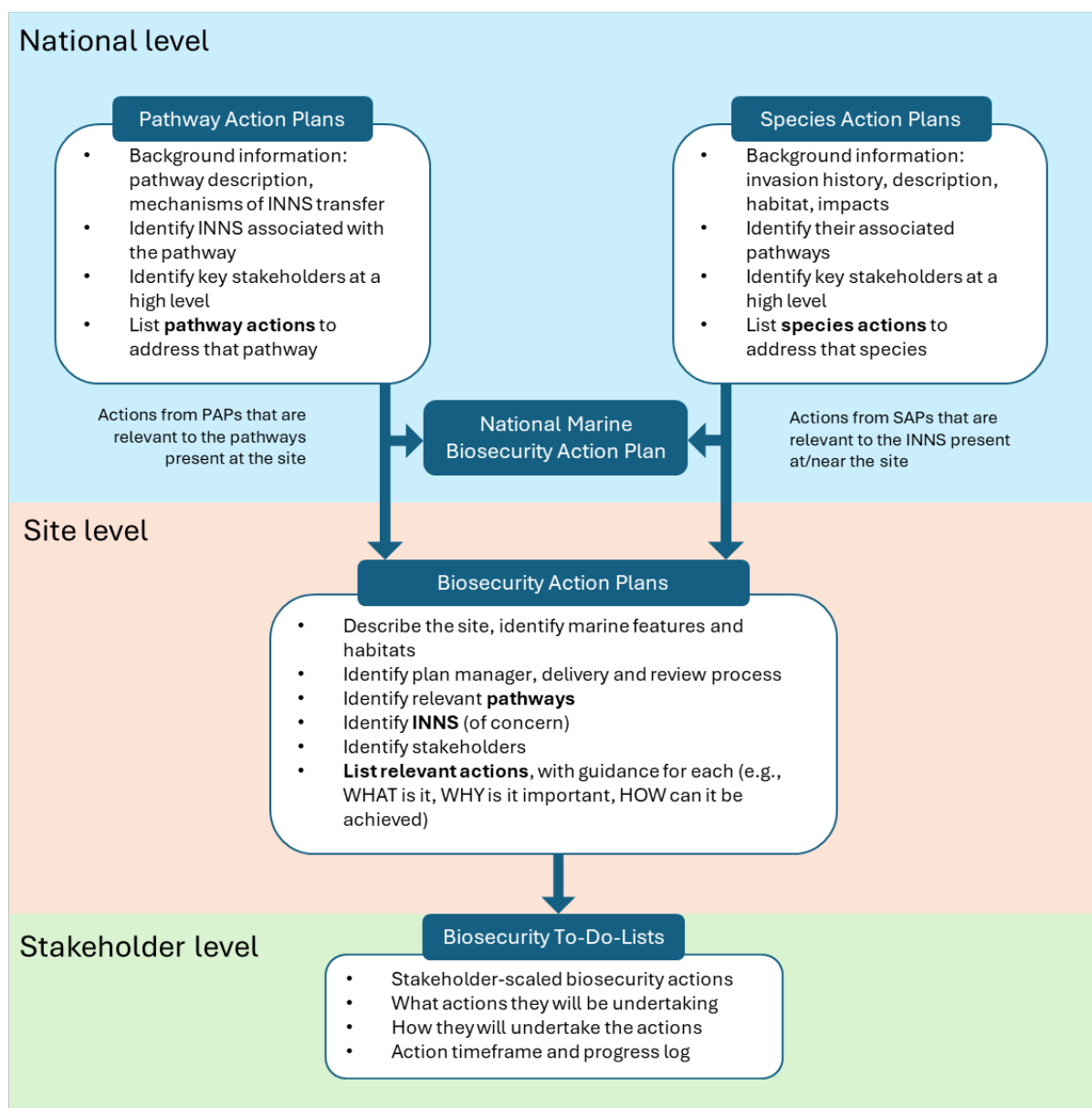


Figure 2. A flowchart showing the relationships between the Pathway Action Plans, Species Action Plans and the Biosecurity Action Plans created for the Natural Resources Wales Biosecurity Planning Project with APEM Ltd.

Scope, aims and objectives

Scope

This Species Action Plan (SAP) is intended to be applicable across all Welsh marine areas, presenting actions that can be undertaken by relevant parties (outlined below) to manage the introduction and / or spread of the American slipper limpet, *Crepidula fornicata* (referred to as the slipper limpet from here onwards). The actions outlined in this document are intended to complement those within the PAPs (available on the [Wild Seas Wales website](#)) in order to be more readily incorporated into BAPs, as described in the [framework](#) above. As such, there will be some overlap between the actions recommended in this SAP and the actions recommended in the PAPs. This document is aimed at:

- Individuals, organisations or groups undertaking activities in the marine environment.
- Regulators, governmental organisations and local authorities planning the implementation of policy, legislation or regulations.

The actions and guidance outlined in this document encompass several dimensions of INNS management for the slipper limpet, including:

- Strategies for effective INNS biosecurity;
- Strategies to enable early detection and quick reaction to new records;
- Coordination of efforts, resource sharing and collaboration;
- Research, development and innovation; and
- National policy and regulatory frameworks

Aim

The overall aim of this SAP is to reduce the risk of the introduction and spread of the slipper limpet by putting forward actions that can be applied at national (Welsh), regional and local levels. The goal is to use existing INNS and slipper limpet specific awareness raising communications and biosecurity resources, wherever available, and adapt them to fit specific requirements. This approach aims to avoid any duplication or unnecessary additional effort. This will facilitate a consistent approach to biosecurity for this species across Wales.

Objectives:

- Increase public awareness of the slipper limpet and the risks it poses.
- Put forward recommendations for actions that aim to reduce the further introduction and spread of the slipper limpet into and around Wales and improve surveillance and reporting of new individuals.
- Outline possible control methods for the slipper limpet that have previously been employed elsewhere.

The slipper limpet: Background

Table 1. A summary of the slipper limpet (*Crepidula fornicata*) background information.

Attribute	Details
Native range	Northwestern Atlantic
Appearance	Kidney-shaped. White to brown shells. Blotched or streaked with reddish-brown patches. Slightly spiralled.
Substrate	Wherever there is a suitable hard surface for them to attach to (e.g., shells and stones), including shingle, rocky, sandy, and muddy substrates, other organisms.
Depth	Between 0m to 15m depth in bays or estuaries, however, have been found at 23m depth in Cardigan Bay.
Temperature tolerance	5-30°C. Optimum growth and reproduction 15-20°C.
Salinity tolerance	18psu to 40psu. Optimum 30psu.
Feeding method	Active suspension feeder
Reproduction/Propagation	Protandrous hermaphrodites (changing sex from male to female), sexual reproduction (cross-fertilisation).
Predators	Predation by flatclaw hermit crab (<i>Pagurus pollicaris</i>) and the American oyster drill (<i>Urosalpinx cinerea</i>) in native range. Predation by the shore crab (<i>Carcinus maenus</i>) and the common starfish (<i>Asterias rubens</i>) in non-native range.
Pathways and vectors	Fouling (on vessels and infrastructure), hitchhiking (aquaculture stock), recreational and commercial fishing bait collection, ballast and bilge water, dredging and hopper water and natural spread.
Impacts	Competition and habitat alteration, predation on native species, biofouling, transmission of disease or parasites and socio-economic impacts.

Where did it come from?

The American slipper limpet, *Crepidula fornicata* is native to the Atlantic coast of the USA and Canada.

Non-native range

In the UK, it was first observed on oyster beds in Liverpool Bay in 1872 having been accidentally introduced with imported American oysters (*Crassostrea virginica*) and later spread with Pacific oysters (*Magallana gigas*). Finding favourable conditions, it established and thrived, rapidly spreading over oyster beds and into surrounding areas.

What does it look like?

The slipper limpet is a mollusc with a kidney-shaped, white to brown coloured shell sometimes blotched or streaked with reddish-brown patches. Individual shells can reach up to 6cm in length and are slightly spiralled. The septum, a white projecting plate inside the limpet which divides the shell interior into two parts, is characteristic of this species (see Figure 3). Individuals settle on top of each other, forming stacks or chains of 5 to 6 individuals. In dense populations, the number of individuals in a stack can be much higher and the structure of the stack more complex with juveniles attaching anywhere and supporting new chains. Larger shells are found at the bottom of the stack, with shells on top becoming progressively smaller.

Identification guides have been developed by several organisations and links can be found linked in [Useful Resources](#).

What habitat does it live in?

The slipper limpet can tolerate a wide range of environmental conditions. More developed populations are generally found between 0m (below the low tide line) to 15m depth in bays or estuaries that are protected against waves, indicating that this is their preferred habitat. They have, however, been found in deeper waters, including records at depths of approximately 23m off the Welsh coast in Cardigan Bay. Similarly, they can be found on a variety of substrates, from rocky to sandy and from shingle to mud, wherever there is a suitable hard surface for them to attach to (e.g., shells and stones). They have a preference for typical marine levels of salinity (around 30psu (practical salinity units)) but are able to tolerate salinities ranging from 18psu (estuarine) to 40psu. The optimum sea temperature for their growth and reproduction is between 15°C and 20°C, but they can survive in temperatures as low as 5°C and as high as 30°C. It has been suggested that the density of slipper limpet populations in Northern Europe to date have been kept under control as a result of deaths in the cold winter temperatures. However, as water temperatures increase with climate change, the winter survival of the limpet is expected to improve, allowing it to spread further north.



Figure 3. Photographs of the slipper limpet showing some of the key features for identification. Sources: RPS Group PLC, Charlotte Colvin, Misjel Decleer and Filip Nuytens.

Behaviour and life cycle

A slipper limpet feeds by filtering particles from water that it draws in under the edge of its shell and over its gills. This method of feeding is known as active suspension feeding. The size and composition of the particles they feed on can be very varied, including plankton, detritus and dissolved nutrients. In their adult phase, they feed at a similar rate to other molluscs that use the same feeding method, however, their ability to be non-selective with their food gives them an advantage. Slipper limpets can reject some particles that they filter from the water which they then embed in mucus and discharge - this deposit is known as "pseudofaeces".

The slipper limpet has a high rate of reproduction with each female laying between 10,000 to 20,000 eggs at a time during their 3 to 4 laying periods in a year. The larvae spend the first month living in the water (known as a pelagic or planktonic phase) during which time they can be dispersed by currents, travelling several kilometres a day. The larvae grow to around 1mm before they metamorphose into their juvenile stage and sink to suitable ground. If the juvenile

settles in isolation (i.e., not on an existing chain), it will experience a brief male period before rapidly entering a female stage. This sex change can take approximately 60 days. If the juvenile settles on an existing chain, it will develop and remain in the male stage for up to 6 years, fertilising the eggs of the female below. Juveniles have been seen to preferentially settle on adults and there is higher juvenile settlement in denser aggregations of adults. This may be as a result of waterborne cues (e.g., pheromones) from the adult slipper limpets, among other conditions that encourage settlement. Within a chain, the lower, larger individuals are female, the smaller, upper individuals are male, and the central individuals are able to change sex. The expected lifespan of the slipper limpet is between 5 and 10 years.

Does it have any predators?

In its native range, the limpet has several predators including the flatclaw hermit crab (*Pagurus pollicaris*) and the American oyster drill, (*Urosalpinx cinerea*). In its non-native range (i.e., areas that it has been introduced to), predators may include the shore crab, (*Carcinus maenus*) and the common starfish (*Asterias rubens*). However, some studies have shown that these predators prefer to feed on native species over the limpet so the pressure of predation for it may be low.

What are its pathways and vectors?

Pathways are the mechanisms and routes by which INNS are moved from one geographic location to another, and vectors are the means within a pathway that facilitate the movement of INNS from one location to another. The pathways and vectors for the slipper limpet are described below.

Fouling on hulls and infrastructure

Hull fouling, of both commercial shipping and recreational boating, is a process by which animals, plants, algae and/or microorganisms attach to and accumulate on submerged parts of vessels (e.g., hulls, rudders, sea chests, propellers), also known as 'biofouling'. Vessels that spend extended periods of time in ports or marinas (days to months) present a higher risk of being colonised by species such as the slipper limpet, and therefore of spreading INNS. If the biofouling is not cleaned off and the vessel departs to a new location, the organisms might be transported to, or release eggs, larvae or propagules into the water at this new location, resulting in potential introduction of new species to an area. Hull fouling is thought to be a likely introduction pathway of the slipper limpet into Milford Haven Waterway with individuals attached to the hulls of merchant and naval ships which were brought into the Haven after the 2nd World War.

Aquaculture and commercial fishing

The slipper limpet was unintentionally introduced to Europe and the UK with the import of aquacultural species from North America. The ongoing cultivation of commercial shellfish species continues to act as a pathway of secondary spread around the UK. Adults and juveniles can hitchhike on shells and colonise (i.e., biofouling) equipment, like oyster frames,

trestles and pots, and can be unintentionally transferred to new locations when these are moved during operations.

Anecdotally, slipper limpet by-catch (i.e., not the target species) captured during shellfish dredging operations may be discarded overboard while the vessel is underway, as well as at the destination harbour where the shellfish is landed, having been sorted and separated from the commercial species. Slipper limpets that have been sorted and discarded may accidentally remain on the vessel and could be released into the water at the vessel's home port when the deck is cleaned. This may spread viable adults and juveniles into new locations.

Ballast and bilge water

Ballast water is taken up by some vessels (e.g., cargo ships and some ferries) to aid stability while underway. Slipper limpet larvae can be taken up in ballast, transported and then introduced into new locations when the ballast water is discharged. The terms of the Ballast Water Convention mandate the offshore exchange of ballast water or the treatment of ballast water to remove or destroy organic matter (e.g., larvae, phytoplankton) before the water can be released. If this legislation is enforced, this would decrease the risk that this pathway poses as an introduction pathway for the slipper limpet.

Bilge water on smaller leisure crafts, however, is not regulated. Similar to ballast, bilge water that may be carrying organic matter is taken up at one location and moved to another location, releasing water and associated propagules into the receiving environment, potentially introducing new species. As such, these smaller leisure craft are typically viewed as pathways of spread within the UK.

Dredging and hopper water

Slipper limpets might be transferred during dredging operations via ballast water carried in the vessels and fouling on vessel hulls themselves. Another potential vector is the dredged sediment itself, however the potential of INNS to be transferred via dredged sediment has received limited research and as such the viability of this pathway is poorly understood. Estimations of survival rates are complicated by the fact that survival is probably dependent on a wide variety of factors including a species' characteristics, the dredging equipment and methods used, and the environmental conditions at the disposal site. Characteristics of the slipper limpet that could facilitate its survival include its relatively broad environmental tolerances and its hard shell, protecting it from physical impact. However, slipper limpet mortality can be caused by sediment burial (>6 cm) which is likely to occur during sediment transfer and upon discharge at the disposal site (for more information, see the [Powell-Jennings](#) paper). More research is needed to understand if the slipper limpet can be spread via the transfer of dredged sediment.

Another potential vector is hopper water. Instead of ballast, some barges used to transport dredged sediment will fill the hopper (cavity that holds the sediment) with water to stabilise the vessel. In this way, the pelagic larvae of INNS (such as the slipper limpet) could be taken into the hopper. Once the barge arrives at the dredging site, the hopper water is released.

While this could result in the transfer of INNS, hopper water is often exchanged at specified boundaries to mitigate for this risk. Similarly, larvae could also be transferred in water that is mixed in with sediment when it is dredged. However, as previously mentioned, survival is not guaranteed.

For dredging operations to take place in Wales, a licence is required from NRW unless conditions for an exemption are met. As part of the licence application, a marine INNS [Biosecurity Risk Assessment and Management Plan](#) must be completed. The risk assessment requires consideration of the presence of INNS at both the source and receiving sites as well as the INNS at the locations previously visited by the dredging vessel. Management measures must be identified which would mitigate the risk of introducing or spreading INNS.

Recreational fishing and bait collection

Anecdotally, slipper limpets have been gathered from an angler's local shore and then transported live to another location for use as bait. Unused limpets have then been discarded live, possibly with eggs, at the secondary location where they have the potential to establish and form a new population.

A note on natural spread

Although not a human-mediated pathway, natural spread by currents can facilitate the dispersal of a species beyond the initial site of introduction in its non-native environment. Slipper limpet larvae can be carried by water movements during their month-long pelagic stage, travelling several kilometres per day depending on the currents. Adults and juveniles, once settled, have limited mobility. However, they can settle on material that can float and be moved by wind or currents to new locations, for example driftwood, vegetation and marine litter. They can also hitchhike on migratory or mobile organisms, like crustaceans, who then moult and discard their shell with the limpet, or stack of limpets, attached.

What are its impacts?

Environmental

Competition and threats to biodiversity

Slipper limpets form dense clusters (or aggregations), outcompeting native species, like oysters and other bivalves, for space. Their dense coverage can smother areas previously dominated by other bivalves and prevent the larvae and juveniles of other species from settling. The limpet will also compete for food (e.g., plankton and particles of organic material) with other suspension feeders like oysters and mussels. The impacts to key marine protected features, which support diverse and important ecological niches, are outlined in Table 2.

Dense populations of slipper limpets can cause a change in species composition by leading to a habitat that is dominated by an individual species (the limpet), which results in a reduction in the diversity of other species. For example, scallops may be made more vulnerable to predation (see Table 3) or may be unable to reproduce effectively, which may decrease their abundance and potentially lead to a decrease in biodiversity. In seabed environments that are already biologically rich, it is expected that slipper limpets (in medium to high densities) will lead to a decline in biodiversity.

However, it should be noted, that in some instances slipper limpets are thought to provide a new niche habitat. This has the potential to increase biodiversity in that area but any change to a habitat structure could conflict with conservation objectives for a particular site and therefore be an unfavourable outcome for that site.

Table 2. Impacts to key protected marine features by the slipper limpet. References to the papers and reports used for this table can be found in the [Bibliography](#).

Key protected features	Impacts on protected features by the slipper limpet
Maerl beds	Smother with silt (faeces and other excretions) and trap sediments by restricting water movement
<i>Sabellaria spinulosa</i> reefs	Potential impacts through changes in substrate suitability
Mussel and oyster beds	Smother other species with silt (faeces and other excretions (pseudofaeces))

Habitat alteration

Dense aggregations of slipper limpets can change the physical, chemical and structural aspects of habitats. Populations can completely cover the substrate (e.g., seabed), restricting the movement of water (and therefore food and oxygen) to the sediment and species below them. This disturbance of the normal water flow can lead to fine particles becoming trapped between the shells and, in combination with the excretions (faeces and pseudofaeces) produced by the limpet, can result in the level of the sea bottom rising. This accumulated material is muddy, high in organic matter and low in oxygen, making it unsuitable for many other species. For example, in Milford Haven, the increased proportion of silt in the seabed sediment from the increased presence of slipper limpets is impacting maerl beds, which are an important protected habitat and are extremely sensitive to siltation (for more information, see [NRW report 454](#)). A summary of impacts to commercially important species is outlined in Table 3.

Table 3. Impacts to commercially important species from habitat alteration by the slipper limpet. References to the papers and reports used for this table can be found in the [Bibliography](#).

Commercially important species	Impact from habitat alteration by the slipper limpet
Whelks (<i>Buccinum undatum</i>)	General negative impact to their success from competition for space (due to habitat alteration)
Scallops (<i>Pecten maximus</i>)	Reduced ability to bury themselves when there is dense coverage of slipper limpet shells, thereby remaining exposed and more vulnerable to predation, smother maerl beds (which are a key habitat for scallops)
Mussels (<i>Mytilus edulis</i>)	Potential disruption of seafloor boundary layer impacting feeding, impact to on-bottom mussel culture assessed as major
Oysters (<i>Magallana gigas</i>)	Pseudofaeces deposits can suffocate oysters and prevent oyster spat settlement
Finfish (flatfish and sole, <i>Solea solea</i>)	Reduced availability of soft sediments for juveniles to feed on and bury in (to evade predators),

Predation

As the limpet feeds indiscriminately on the particles in the water, they are known to consume the larvae of other species. This includes larvae of the native oyster, *Ostrea edulis*, increasing the pressure on the population of this important species.

Biofouling

The slipper limpet is known to attach to the shells of other species, some of which are commercially important (e.g., mussels and scallops). This behaviour can cause a negative impact on the 'host' by impeding their natural functions. The impacts to commercially important species are outlined in Table 4. These disturbances can impact the ability of the host organism to grow, spawn, feed and migrate, and can also lead to the death of the host.

Table 4. Impacts to commercially important species from fouling by the slipper limpet. References to the papers and reports used for this table can be found in the [Bibliography](#).

Commercially important species	Impact to the species from fouling slipper limpets
Whelks (<i>Buccinum undatum</i>)	Extra energy expended carrying the limpet (mobile species), reduced growth
Scallops (<i>Pecten maximus</i>)	Extra weight opening their shells to feed, prevention/hindrance for burial and escape
Mussels (<i>Mytilus edulis</i>)	Reduced shell growth, extra weight opening their shells to feed, increased drag leading to the need for increased byssus production and energy expenditure, decrease in overall fitness
Oysters (<i>Magallana gigas</i>)	No direct threat from fouling reported but some impact to fitness assumed

Transmission of disease or parasites

The slipper limpet is known to host two non-native parasites: the mussel redworm (*Mytilicola intestinalis*) and the oyster redworm (*Mytilicola orientalis*), which are both known to be present in the UK. However, though infestation of the slipper limpet by these parasites has been shown in the laboratory, recorded instances of infestation in the field are limited. There is a risk that the slipper limpet could be infected by these parasites and spread them directly to native species (e.g., mussels and oysters). Shellfish infected with these parasites can experience delayed spawning, reduced shell growth, decreased feeding rates and a weakening of their byssus (also known as the beard, which bivalves, like mussels, use to attach to surfaces). This, in turn, can lead to socio-economic costs to aquaculture and shellfish harvesting.

Socio-economic

With their numerous impacts on commercially important species (summarised in Table 3 and Table 4), slipper limpets may be considered as a competitor species for commercial fisheries as their impacts can lead to a reduction in income and a lowering of the economic viability of some fisheries. The catch per unit effort (CPUE) decreases in shellfish bed areas where the slipper limpets are numerous, meaning that it requires more work (and time) to harvest the target shellfish species. Time must also be spent sorting through the catch to remove slipper limpets. Limpets that are attached to commercial shellfish must be removed before they can be sold. Not only does this increase processing time, but by removing limpets, the host shell can be damaged, decreasing their value on the market.

By altering habitats, slipper limpets can lead to a loss of fishing areas as they drive out other species, like scallops. The presence of slipper limpets within aquaculture areas also limits the relaying of stock into an area where slipper limpets are not known to be present due to legislation surrounding the movement of invasive species (see [INNS and the Law](#)). Additionally, the pseudofaeces that builds up around dense limpet beds can solidify, making it extremely difficult to undertake necessary navigational dredging operations.

Slipper limpets in Wales: National context

Distribution of the slipper limpet

In the UK, the distribution of the slipper limpet is widespread, but predominantly found in the south and east of England and the south of Wales. As an illustration, Figure 4 shows the distribution of slipper limpet records in the UK on the NBN Atlas database as of July 2023. Figure 4(B) shows the distribution of slipper limpet records in Wales and contains some *ad hoc* sightings that have not yet been integrated into the NBN Atlas dataset. An up-to-date map of slipper limpet records in the UK can be found on the [NBN Atlas](#). Areas with the highest number of records include around Milford Haven, the Menai Strait, the west coast of Anglesey, and in Swansea Bay. It is important to note the following.

- If a record is made at a location, it may not mean that there is an established population there. The record may be of an empty shell (e.g., at Barmouth) or in an area from where the species has since been removed.
- Conversely, if there is no record present, it may not mean that there is no population present. There may be a lack of monitoring, a delay in reporting or a lag in communication.

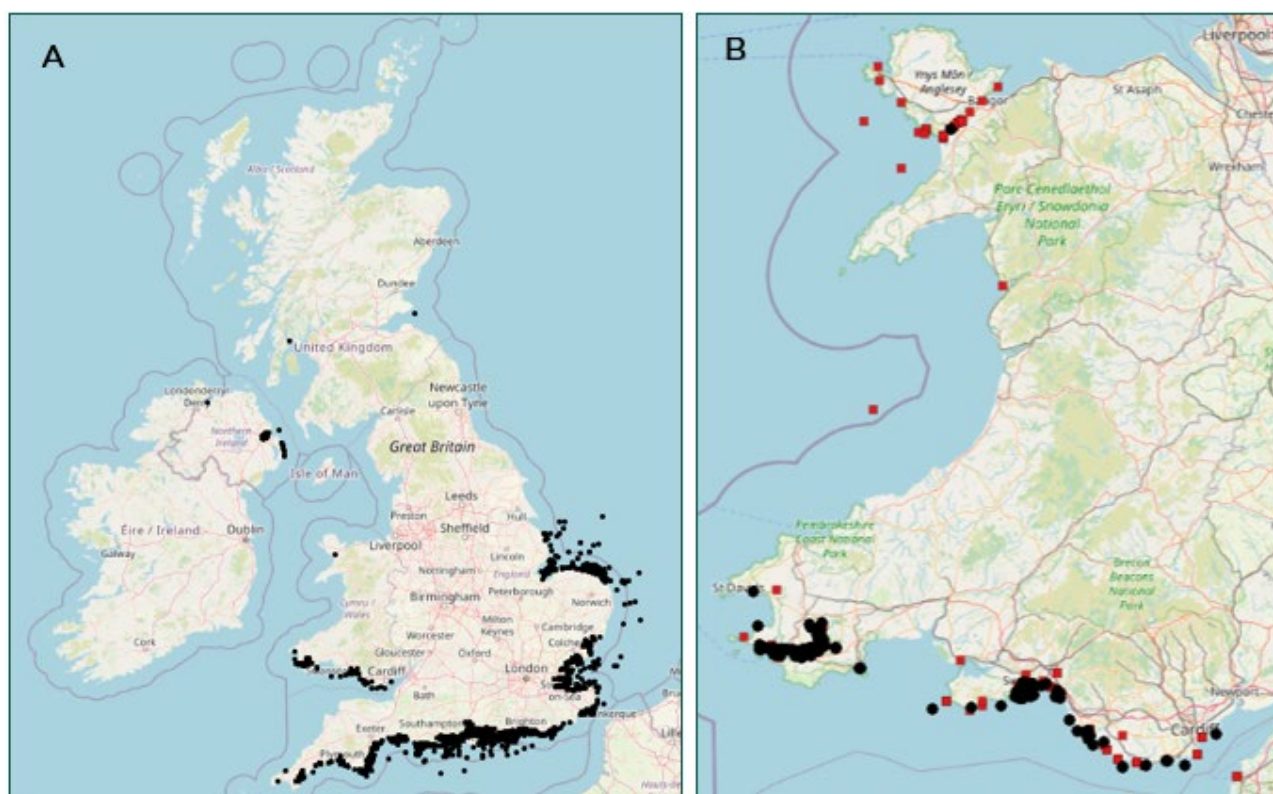


Figure 4. Map of recorded and confirmed slipper limpet occurrences in (A) the UK and (B) Wales from open source NBN Atlas data as of July 2023 (black circles), data received directly from Natural Resources Wales and ad hoc sightings from organisations such as Seasearch. Contains public sector information licensed under the Open Government Licence (OGL) v3.0, Public Domain Dedication (CC0) v1.0, Creative commons with attribution v4.0 (CC-BY). Data rightsholders, data providers, and dataset references are provided in [Data References](#).

MPA features at risk from the slipper limpet

The potential impact of the slipper limpet to MPA habitat features in Wales was assessed in a [2020 NRW report](#) and then mapped (see figure 5) in the [NRW evidence report](#) “Marine Protected Areas: Features at risk from marine invasive non-native species” (pending publication). The mapping shows that throughout Welsh waters there are habitats that are potentially suitable for this species to establish and that its impact on these could be massive across extensive areas. The widespread distribution of suitable habitats is likely to support natural spread of this species.

Slipper limpets can smother the seabed. Dense beds filter large quantities of suspended particles and produce faeces and pseudofaeces which are deposited and trapped within the beds, altering habitat structure and creating anoxic, muddy sediments. Where slipper limpets are likely to smother and significantly alter habitats, the impact was typically assessed as ‘Massive’ by the EICAT habitat impact assessment ([NRW Report 454](#)).

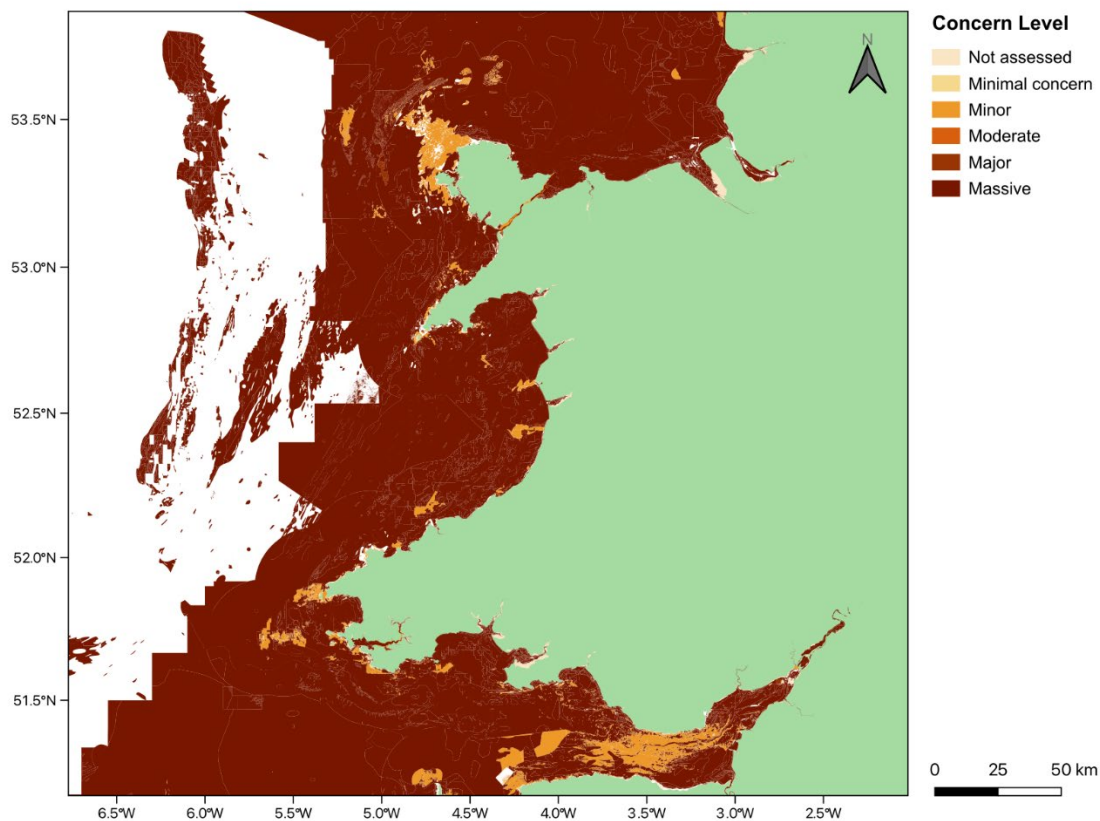


Figure 5. Habitat risk (concern level) from the Slipper limpet, *Crepidula fornicata*, based on the assessment carried out in the NRW evidence report: [‘Assessing the impact of key Marine Invasive Non-Native Species on Welsh MPA habitat features, fisheries and aquaculture’](#).

INNS and the law

The following points provide a brief summary of relevant legislation (at time of writing):

- [The Wildlife and Countryside Act 1981](#) makes it an offence to release or allow to escape into the wild any plant or animal which is not ordinarily resident in Great Britain (i.e. non-native) and is not a regular visitor to Great Britain in a wild state (i.e. migratory).
- [The Marine Strategy Regulations 2010](#) transpose into domestic law the EU Marine Strategy Framework Directive. The Directive aims to reduce human impacts on the marine environment, including INNS. The programme of measures is intended to reduce the introduction and spread of INNS. INNS pathway management helps to deliver the 2010 Regulations.
- [The Water Environment \(Water Framework Directive\) \(England and Wales\) Regulations 2017](#) transpose into domestic law the EU Water Framework Directive. The Directive establishes a framework for national measures to achieve or maintain a good ecological status, including transitional and coastal waters. While INNS are not specifically mentioned within the 2017 Regulations they could affect the ecological status of waterbodies. Pathway management is a key aspect of managing the potential spread of INNS.
- Pathway management and the development of pathway action plans are specifically mentioned under the EU Regulation ([1143/2014](#)) on the prevention and management of the introduction and spread of invasive alien species. This regulation was retained in domestic law under the European Union (withdrawal) Act 2018 as the [Invasive Alien Species \(Enforcement and Permitting\) Order 2019](#).

There are pathway-specific regulations that would relate to the movement of this species. Please see the relevant PAPs on the [Wild Seas Wales website](#) for more information.

Under the legislation and policy summarised above, slipper limpets have been assessed for the risks and impacts they pose to UK marine ecosystems. The outcomes of these assessments are listed in Table 5 below. The GB Non-native Species Secretariat (GB NNSS) commission and approve risk assessments of NNS to determine the risk of them entering, establishing, spreading and causing impacts in GB. These risk assessments support the Invasive Non-native Species Regulations and the wider GB legislative framework. Additionally, the Welsh Government's Marine INNS Priority Monitoring and Surveillance List for Wales summarises the INNS that are referred to directly in relevant legislation and/or their supporting documents. The list identifies INNS present in Wales and those that are "horizon species" (species that are likely to be present in the future). The document also includes an assessment of risk posed by INNS in Wales (in terms of invasiveness, spread and impact), which draws upon risk assessments developed by the GBNSS.

Table 5. Species impact and risk assessments for the slipper limpet.

Assessment	Legislative driver	Slipper limpet assessment outcome
INNS prioritisation (according to invasiveness, impact and spread)	Marine Strategy Regulations 2010	UK Priority Species
WFD UK Technical Advisory Group classification of aquatic alien species (according to their impact level)	The Water Environment Regulations 2017	High Impact
GB NNSS risk assessment	The Invasive Non-Native Species Regulations 2019. Wider GB legislative framework.	High Risk Entry Risk = Very Likely Establishment Risk = Likely Spread = Rapid Impacts = Massive
Marine Invasive Non-native Species Priority Monitoring and Surveillance List for Wales	Marine Strategy Regulations 2010	High Risk

Challenges to INNS management

1. As described above, the slipper limpet produces many offspring, and its larvae have a long planktonic stage (approximately 1 month) during which time they can be dispersed widely by currents. As such, eradication is extremely difficult. It is more feasible to focus efforts on preventing the introduction of the slipper limpet to new locations as much as is possible and reducing or controlling existing populations. By decreasing the population size there will be fewer spawning adults. This will mean that fewer larvae will be released, limiting the opportunity to disperse.
2. In the marine environment, control strategies that are undertaken to reduce the density of an INNS population can be both expensive and indiscriminately destructive, risking impacts to non-target species. Cost-benefit analyses must be undertaken in addition to considering the local ecosystem and minimising any impacts to protected species or sites. Habitat Regulations Assessments (HRAs) may be required for control strategies within European Marine Protected Areas.
3. Specific challenges for the control and eradication of slipper limpets include: the long duration of the larval planktonic stage, the species rapid growth, and the large-scale effort and logistics needed to physically remove dense populations.

4. More information is required to be able to undertake an assessment of the less well-understood (or less well-documented) pathways of slipper limpet spread, including the movement of the species for their use as bait in sea angling.
5. Feasibility studies should be undertaken for potential control and eradication programs to assess the efficacy and impacts of different methodologies (see [Table 7](#)).
6. More information is required on the conditions that influence the settlement of slipper limpet larvae. These might be physical (e.g., water temperature), chemical (e.g., water quality and nutrient levels) or biological (e.g., pheromones released by adult limpets) and may be different in its introduced range than in its native range. Research in this area may help to inform potential control or management solutions.
7. There are limitations and challenges for the enforcement, regulation and monitoring of national legislation, e.g., the Ballast Water Convention.

Biosecurity to manage the slipper limpet

The following sections present recommendations for actions that, if undertaken, will improve biosecurity in Welsh marine areas and, ultimately, reduce the risks posed to the environment and economy from the slipper limpet.

Who are the key stakeholders?

Within the context of this SAP, a stakeholder is anyone who uses, benefits from or is responsible for (e.g., managing, protecting or regulating) the marine environment. Biosecurity to address the slipper limpet requires engagement and action at national, regional and local scales by stakeholders including, but not limited to individuals, businesses, marina and harbour managers, statutory bodies, authorities (i.e., bodies with powers to introduce, amend and enforce regulations, legislation and policy).

For the successful implementation of the actions recommended in this SAP and across the [biosecurity framework](#), stakeholders must work together to engage, support and secure resources where needed.

Examples of authorities and stakeholders are included below.

Authorities

- Government departments, organisations and agencies (e.g., Welsh Government)
- Regulatory bodies (e.g., Natural Resources Wales)
- The Fish Health Inspectorate
- County councils and local authorities
- National Park Authorities

National stakeholders

- Non-regulatory government bodies (e.g., Cefas)
- Management bodies for protected sites (e.g., National Trust)
- Recreational boating governing bodies (e.g., RYA Cymru)
- Environmental charities and Non-Governmental Organisations (NGOs) (e.g., the Marine Biological Society and Wildlife Trusts)
- Commercial operations governing bodies, organisations and groups (e.g., International Maritime Organisation, Maritime UK, Association of British Ports)
- Major landowners (e.g., the Crown Estate)
- Commercial fishing associations (e.g., Welsh Fisherman's Association, WFA-CPC)

Local stakeholders

- Local environmental groups;
- Aquaculture site owners, managers and operatives
- Port authorities and commercial shipping operators (including dredge operators);
- Marina managers and harbourmasters
- Commercial boat businesses and operations (including shipping and dredging)
- Point of sale (e.g., marine brokers, boat manufacturers, chandleries)
- Commercial fishers
- Recreational boating tour operators and event organisers;
- Recreational anglers, shellfish gatherers and bait collectors
- Recreational clubs and boating organisations (including boating event organisers)
- Individual users

Recommended strategic actions for authorities

Table 6 contains a list of possible strategic actions which could be taken by national authorities. Achievement of these actions support a solid statutory basis for robust management of all INNS in Wales. However, it is acknowledged that any statutory changes require extensive and time-consuming legislative assessments and consultation which is at odds with the urgency required for pathway and INNS management at present. It is therefore recommended that these strategic actions act as long-term goals for authorities and that priority is placed on actions that can be undertaken and achieved on shorter timescales by all stakeholders (see [Recommended actions for stakeholders](#)).

Table 6. Recommended strategic actions for authorities to address the introduction and spread of marine INNS via all pathways in Wales. The ID letters SS (Species Strategic) denote that the actions are aimed at addressing the management of species, differing from the ID letters PS (Pathway Strategic) in the Pathway Action Plans (PAPs) that are aimed at addressing the management of pathways.

ID	Strategic action	Purpose
SS-1	Develop a national (Welsh) position statement for key marine INNS	The statement (and its guidance) should • Set out the position of the Welsh Government on pathway management and lay out a national approach for addressing key marine INNS. • Provide a clear objective for all marine stakeholders, supported through guidance and assistance where available. Top-down direction is a critical need for the facilitation of national, regional and local biosecurity planning. • Make it clear that improved biosecurity is the priority; however, also include goals in relation to surveillance and monitoring, early detection, rapid response and management. • Aim to clearly state what is expected of all stakeholders and provide realistic, measurable and agreed targets. The position should conceptually align with other GB strategies and existing regulation to ensure a consistent approach to INNS management throughout the British Isles. However, it must be grounded within a realistic Welsh focus, taking current limitations into account. To achieve the best outcomes, stakeholders should be consulted in policymaking, and policymakers should support the integration of industry expertise and experience into INNS management strategies.

ID	Strategic action	Purpose
SS-2	Review existing legislation	A review should be undertaken of current legislation relating to key INNS (and their pathways) to identify legislative gaps and highlight opportunities to strengthen INNS and biosecurity legislation. The review should identify primary legislation under which INNS management can be enforced (e.g., Wildlife and Countryside Act, 1981). The outcomes of this review could provide evidence, justification, and legislative support for national position statements or introducing / amending legislation relating to key INNS and their pathways in Wales.
SS-3	Review and prioritise resource allocation in support of policy and legislation related to INNS	Enforcement / enactment of existing and new policy and legislation should be considered. Resources, roles and responsibilities should be agreed and assigned to ensure that prioritised policy and legislation is being effectively enacted (e.g., provisions for enforcement officers to carry out inspections). Incentives for following legislation could be outlined in biosecurity-related award schemes or accreditations, which should be investigated, created and/or developed and endorsed by the Welsh Government or Natural Resources Wales. Penalties for offences could include fines or suspension of relevant licences as per The Invasive Alien Species Order 2019 . Importantly, legislative policy needs to be clearly communicated to stakeholders.
SS-4	Identify and prioritise high risk areas/locations for marine INNS introductions and impacts	Species and pathway risk assessments are a valuable tool for identifying and prioritising high-risk locations and more effectively allocating resources. Data gathered from previous reports (e.g., NRW Report 459 and NRW evidence report “Marine Protected Areas: Features at risk from marine invasive non-native species” (pending publication) and information from the SAPs and PAPs in the biosecurity framework should be used to inform strategies for species and pathway management and surveillance. It is recognised that data used to inform pathway risk assessments is currently limited and further data collection is required.

ID	Strategic action	Purpose
SS-5	Develop a national plan for monitoring marine INNS	A national plan should develop a standardised approach to monitoring marine INNS and their pathways and implementing inspection programs in high-risk locations (see SS-4). The procedures within this plan should be applicable and practical at local, regional and national levels with provisions included for necessary resources or support required to undertake actions. The plan could be developed in consultation with stakeholder from all levels. A cost-benefit analysis could also be undertaken to ensure that the implementation of inspections will not damage Welsh businesses.
SS-6	Continue to develop contingency plans for key marine INNS	Contingency plans put forward protocols for situations when a new record of an INNS is made in an area it has not been previously recorded. This can include INNS that are new to Wales and INNS that are found in some regions of Wales but not others. The protocol typically involves contacting relevant authorities and taxonomic experts for positive identification, as well as putting in place rapid actions to contain the spread of the newly recorded INNS. General contingency plans for marine INNS have been developed for England by the GB NNSS and a general INNS contingency plan for Wales is in draft (at time of writing, June.2025).
SS-7	National level curriculum	Lobby the Department for Education to include information on INNS and biosecurity in the national curriculum. Advice should be provided for the development of appropriate materials.

ID	Strategic action	Purpose
SS-8	Improve collaboration and links between stakeholders and authorities	Invite stakeholders to participate in existing platforms and/or forums for ongoing communication, collaboration, and knowledge exchange, such as the British Ecological Society Invasion Science Special Interest Group (BES IS SIG). Platforms like this serve as a hub where researchers, policymakers, government agencies, industry representatives, and wider stakeholders come together to share expertise, data, and resources related to INNS management. Key features should include: 1. Regular meetings and workshops; 2. Agreements for data sharing and data integration; 3. Collaborative research, leveraging the expertise and experience of the industry; 4. Capacity building; and 5. Research and monitoring priorities communicated between stakeholders.
S S-9	Improve national data flow	Data flow is fragmented, data administration slow, and existing mechanisms for priority species reports reaching authorities are inconsistent, which may delay management response. Different recording schemes have variable verification and data upload timescales as well as variable data restrictions and some records are lost in the data flow process. Authorities should work with partners including The UK Centre For Ecology & Hydrology, The Marine Biological Association, The National Biodiversity Network and Local Environmental Records Centres to ensure records arrive at the appropriate destination in a timely manner and are accessible to all. This may include continuing work with Defra on their 'improving marine NIS data access and flow efficiency' project.

Recommended actions for all stakeholders

The sections below outline seven components of biosecurity focus for the slipper limpet within Welsh marine areas. Stakeholder-specific guidance, including example actions for each, is provided to support the development of tailored actions. Stakeholders are encouraged to define their own biosecurity actions, appropriately scaled and proportional to their activities, using the guidance provided.

The components in this SAP are designed to complement those outlined in the PAPs and other SAPs. They can serve as a foundation for creating a new biosecurity plan or modifying and enhancing existing procedures. Following stakeholder engagement, high-level 'priority issues' have been identified for each component. These are intended to inform the initial context for developing tailored action for each component rather than represent specific objectives. Biosecurity implementation is an ongoing process. The components aim to support and sustain stakeholder-level actions over time.

A pathway-based approach to biosecurity is more robust and appropriate than a species-based approach as addressing a pathway will address all the species that might be moved via that pathway. However, species-specifics can still be considered and integrated into a BAP (or used in support actions from a PAP) for an area/site where the slipper limpet has been identified as a high-priority species, either for its management or for the prevention of its introduction or spread.

These components are:

1. [Understanding roles and legal responsibilities](#)
2. [Information, guidance and research on the slipper limpet](#)
3. [Raising awareness](#)
4. [Biosecurity processes and procedures](#)
5. [Species management](#)
6. [Monitoring and reporting](#)
7. [Collaborative working](#)

1. Understanding roles and legal responsibilities

To ensure that all stakeholders are aware of the relevant and current INNS legislation and national policy that relate to INNS.

PRIORITY ISSUE: There is a lack of clarity within stakeholder groups (for all pathways) regarding the legal requirements for INNS management. Stakeholders require more guidance on how their activities intersect with INNS legislation, and what is required under current policy (if anything) to achieve compliance (i.e. voluntary vs. mandatory actions).

Responsible stakeholder	Guidance for Development of Actions	Example actions
Authorities	Authorities should produce a policy position or statement (see actions S1 to S4), , relevant to existing or new INNS-focused legislation and regulation. This policy(s) should provide stakeholders with an improved understanding of how INNS legislation or regulation affects them. This needs to be communicated via an appropriate information cascade to include all relevant stakeholders. If legislation or regulation exists, but enforcement policy is undefined, it is recommended that stakeholders are still offered advice on this matter.	• Consult with relevant stakeholders on the implementation and feasibility of INNS focused policy. • Collaborate with industries to develop appropriate and achievable policy, without undue impact to Welsh blue growth and operators. • Ensure consistency with wider legislation and regulation (i.e. biosecurity with regards to animal health). • Establish a policy(s) for relevant regulation(s) and release a statement to provide stakeholders with a clear definition of what is expected under the legislation.

Responsible stakeholder	Guidance for Development of Actions	Example actions
National & local stakeholders	Official statements (as above) should be summarised and shared between relevant stakeholders, using plain, accessible language. Information could be included in newsletters or other communications to relevant stakeholders (e.g., updates from harbour authorities or from national recreational governing bodies) so that all stakeholders are aware of any legal responsibilities with regards to INNS. In cases where an authority-produced statement is unavailable, national and local stakeholders are encouraged to independently review the relevant regulation and provide advice to their members as appropriate.	• Issue a press-release that summarises current national policy, highlighting the requirements for compliance with the legislation or regulation • Include an overview of key INNS legislation and policy in e.g., public communications, employee information and club announcements.

2. Information, guidance and research on the slipper limpet

To ensure that information and guidance on the slipper limpet and relevant biosecurity within Welsh marine areas are consistent, high-quality and appropriate for all stakeholders and sectors.

PRIORITY ISSUE: Information resources for INNS and biosecurity awareness are abundant but can be fragmented, making it difficult for stakeholders to navigate and identify the most relevant and appropriate information, especially without a prior understanding of biosecurity.

Responsible stakeholder	Guidance for Development of Actions	Example actions
Authorities	To improve INNS biosecurity in Welsh marine areas, authorities should consider creating/aligning a national-level marine INNS and biosecurity awareness raising campaign. This should provide common resources and consistent messaging for all marine stakeholders. Key highlights of the campaign could include: • A centralised location for biosecurity and INNS awareness-raising materials. While there is considerable existing material available for this action, ensuring a common repository and "endorsement" of primary materials will help stakeholders maintain consistency. • Publication of INNS alerts when a population is newly established or spreading. • Clear points of contact for stakeholders seeking support and advice. Factsheets should be created to raise awareness of the slipper limpet among key stakeholders. The factsheets should contain information on the impacts the species causes and what actions can be / are being undertaken to minimise it's further spread. Existing species factsheets from the GB NNSS could be used as a basis for any Wales-specific resources. Factsheets should be developed in co-ordination with sector representatives to ensure that the information is relevant and outlines best practice. Language and writing style should be considered for different stakeholder groups / audiences – it is critical that information is presented appropriately and accessibly.	• Develop and update sector-specific factsheets on the slipper limpet. Identification sheets of several marine species can be found on the GB NNSS website. • Produce training resources on the slipper limpet that can be provided to other stakeholders. • Print (and disseminate) ID guides (such as the Welsh and English ID guide booklets produced by NRW) to as many relevant stakeholders as possible (e.g., local groups, aquaculture operations, points of sale). (see useful resources)

Responsible stakeholder	Guidance for Development of Actions	Example actions
Authorities continued	The fact sheets should be disseminated to key stakeholders in all parts of Wales, particularly to those undertaking any monitoring work. They should be made available on-line and in printed format to ensure consistency of messaging. A simple identification guide could also be included with instructions on how sightings (or suspected sightings) of the species should be reported. Species surveys and mapping of occurrence records should be undertaken to establish where populations currently are. Species distribution maps will provide insight into where the slipper limpet is present and absent, and therefore where it may be at risk of spreading from and to. Pathway analyses and risk assessments should be carried out to identify hot spots (see recent, related work above). This, in turn, will allow for effective prioritisation of resources for biosecurity and surveillance (either in relation to population management or prevention).	• Keep ID guides up to date, accounting for new and horizon INNS. • Map the distribution of slipper limpet and carry out pathway analyses to facilitate resource prioritisation.
All stakeholders	It is critical that authorities, as well as local and national stakeholders, take a holistic approach by integrating and co-ordinating their biosecurity activities. By doing so, they can ensure a cohesive and unified effort that builds on and enhances existing measures, maximising the effectiveness of INNS management across all marine pathways and action plans. All stakeholders should ensure that resources are appropriate for their sector, reviewing national guidance and tailoring outputs to reflect relevant operations and risk factors. Authorities could consider leading a consultation with other stakeholders on the production/review of these guidance documents. A simple presentation (e.g., PowerPoint slide pack) should be prepared and made openly available for all to use. The slide pack should contain a summary of key points on slipper limpet identification, how it's introduced and spread, the impacts it has, and how it should be reported. A simple script or recording should be included in the notes section to aid presenters.	• Refine existing biosecurity guidance to increase relevance for different sectors. • Provide identification training aids for the slipper limpet. • Undertake research to fill knowledge gaps in understanding of slipper limpet risk factors.

Responsible stakeholder	Guidance for Development of Actions	Example actions
All stakeholders continued	Use should also be made of the slipper limpet specimens that are included in the INNS kit from the National Museum of Wales, detailed in Useful Resources. Research councils (e.g. NERC, BBSRC) could be influenced to highlight this area of investigation as a priority programme. Investigations should be undertaken in collaboration with universities and researchers to provide scientific robustness. These evidence needs should be noted in NRWs marine evidence needs process and flagged as potential collaborative university student projects.	• Conduct investigations into the sources of existing and newly recorded slipper limpet populations. • Create an accessible central website to host biosecurity resources and information to make navigation to the most relevant information easier.

3. Raising awareness

To facilitate and encourage the active sharing of information and guidance on the slipper limpet among all stakeholders within Welsh marine areas.

PRIORITY ISSUE: Some stakeholders operating within Welsh marine areas are not aware of INNS (including the slipper limpet) and their impacts, or what biosecurity is. All stakeholders would benefit from more exposure to INNS awareness raising activities. All stakeholders could also facilitate the spread of information and awareness raising about INNS and biosecurity

Responsible stakeholder	Guidance for Development of Actions	Example actions
Authorities	Authorities should ideally be a primary source for INNS and biosecurity information in Wales. Messaging should ensure that stakeholders are aware of critical information, such as updates to policies (e.g. in-water cleaning rules) or species records/alerts.	• Issue regular updates/social media posts offering INNS and biosecurity advice. • Continue to engage with stakeholders • Include links or QR codes to online resources (including ID guides and factsheets) with communications. Where appropriate, stock/disseminate paper copies of resources.
All stakeholders	It should be noted that raising awareness actions are expected to overlap significantly across all marine PAPs, SAPs and BAPs. Therefore, it is critical that authorities, along with local and national stakeholders take a holistic approach by integrating/coordinating their biosecurity activities. By doing so, they can ensure a cohesive and unified effort that builds on and enhances existing measures, maximising the effectiveness of INNS management across all marine pathways and action plans. All stakeholders can have a role in raising awareness of INNS and biosecurity by promoting and disseminating existing information regarding INNS and key biosecurity messages, This could be achieved both digitally (e.g., through social media and relevant websites) and in print (e.g., in tackle shops, newsletters and magazines).	• Engage in any national awareness raising campaigns such as Invasive Species Week. Use approved or provided biosecurity resources in communications and training. A marine INNS workshop kit comprised of preserved specimens and information sheets can be borrowed from Amgueddfa Cymru (see Useful resources). • Become familiar with the existing slipper limpet guidance and resources.

Responsible stakeholder	Guidance for Development of Actions	Example actions
All stakeholders continued	There is no requirement for burdensome changes to current activities, but consideration of INNS within outwards facing communications or marketing can benefit the sustainability of all activities within Welsh marine areas. The useful resources within this SAP include links to existing high-quality information sources which can be used as the basis for awareness raising. However, it is hoped that as national awareness increases, stakeholders will expand their knowledge and activities in this area, eventually producing their own tailored resources (where they have not already done so), further amplifying awareness and engagement. Developing awareness raising materials that highlight the economic and environmental risks of the slipper limpet (based on the information provided in this SAP and the useful links) can provide targeted warnings where the slipper limpet is a particular problem (e.g. ports and marinas where the slipper limpet is resident); although, it is recommended that targeted awareness raising of individual species is created and disseminated in parallel with general INNS awareness raising. Biosecurity signage is known to be successful in raising awareness. Where appropriate (e.g. onshore aquaculture facilities, staging areas, recreational launches etc.) signage can be installed in visible (to employees or the public) areas. Information contained within signage can range from general actions and national guidance (e.g., the GB NNSS Check, Clean, Dry campaign), to site specific biosecurity protocols, depending on the intended audience (see Useful Resources for links to signage resources). Landowner permission should be considered (if applicable or required).	• Share information resources with other stakeholders as widely as possible. • Provide ad hoc information/facts on the slipper limpet and INNS in general to staff, colleagues, members of the public, customers etc. • Add in a link to biosecurity information on the GB NNSS website in staff updates. • Put up ID posters of the slipper limpet on notice boards or at the site office with a QR code to the iRecord web browser and/or to more information. Install Check Clean Dry signs at equipment stores. • Integrate slipper limpet information into education activities with schools or school-age groups (e.g., rockpooling trips)

Responsible stakeholder	Guidance for Development of Actions	Example actions
All stakeholders continued	Equipment cleaning guidance (e.g., the GB NNS Check, Clean, Dry campaign) should be shared by all relevant organisations and staff. For boats or submerged equipment, guidance should include information on cleaning all underwater surfaces (e.g., trestles, pontoons, buoys etc.) and removing standing/entrained water from bilges, as well as information on anti-fouling (e.g., the suitability of different coating types and how they should be maintained). It is important to educate and enthuse younger generations on issues relating to INNS and biosecurity. Engagement with local schools or school groups to explore the most suitable way in which the topic of INNS and biosecurity can be incorporated into national education. Materials and resources produced as part of component 2 should be shared with educators. Marine INNS and biosecurity could be integrated in the Ocean Literacy Strategy for Wales 2025 project “Y Môr a Ni”. This strategy should be promoted.	See actions above.

4. Biosecurity processes and procedures

To improve INNS biosecurity procedures, especially those which reduce the risk of introducing and spread the slipper limpet, being undertaken by stakeholders, ensuring consistency and efficacy.

PRIORITY ISSUE: Biosecurity may not be routinely undertaken by stakeholders and there is a perceived lack of appropriate guidance.

Responsible stakeholder	Guidance for Development of Actions	Example actions
All stakeholders	A pathway-based approach to biosecurity, rather than a species-based approach, is often taken preferentially as it means that all species associated with that pathway can be managed at the same time. This can improve efficiencies in cost, time and effort. In this way, all stakeholders operating within the Welsh marine environment are encouraged to implement or enhance biosecurity procedures. However, biosecurity could also be prioritised in areas where the slipper limpet is present. At the most basic, INNS biosecurity can be achieved simply through ‘Check Clean Dry’ procedures (see GB NNSS information). But stakeholders operating within areas where the slipper limpet is present should consider: • More frequent equipment/infrastructure cleaning and antifouling. • Cleaning equipment on land ensuring that waste is not allowed to re-enter the water. • <u>Do not attempt to remove the species from structures whilst still submerged</u> Stakeholders are encouraged to review and update their protocols and practical procedures to ensure that operational biosecurity comprehensively addresses INNS and is consistently applied. Continuous improvement should also be a priority. These updates do not need to be onerous or burdensome, particularly as many	• Authorities could define and provide support to national and local stakeholders for the implementation of improved biosecurity. • Review and update existing codes of good practice (e.g., for aquaculture) • Develop codes of good practice for all activities/operations in the Welsh marine environment. • Consult and collaborate with all sectors to ensure best practice is encouraged and enabled. The onus should be placed on pragmatic changes to procedures which do not negatively impact Welsh blue growth or individual operators.

Responsible stakeholder	Guidance for Development of Actions	Example actions
All stakeholders continued	stakeholders may already implement effective INNS biosecurity measures (e.g. aquaculture operators). Enhancements can leverage existing best practices, integrate example biosecurity/control actions (see Table 7), or adopt innovative approaches tailored by operators themselves. Best practice for marine sectors has been created as part of the RAPID LIFE project. Codes for good practice in aquaculture have already been developed, e.g., the Code of Good Practice for mussel seed movements from the Menai Strait Fishery Order Management Association (MSFOMA). Reviews and updates should be carried out with a process of consultation with stakeholders (e.g., aquaculture operators) to ensure that the code appropriately reflects practical and operational conditions as well as implementing improvements to biosecurity. <u>Appointment of Biosecurity Managers or Champions</u> For operations of varying scales, appointing a biosecurity manager or champion can be beneficial for the different sectors that are relevant to most pathways, keeping in mind the operational scale. This individual, equipped with relevant knowledge and a defined responsibility for biosecurity, can oversee and ensure that biosecurity actions are conducted appropriately and effectively for their site, business, or organisation. <u>Research and develop INNS management measures</u> Invest and participate in the development and testing of new methods and technologies to manage INNS. For example, working with a research body / professional.	• Regularly review emerging methods and technologies that offer INNS risk reduction. • Appoint a biosecurity manager or champion to act as a central point of contact for INNS related queries. • Consider collaborating with researchers to advance INNS management technologies. • Ensure innovative approaches and updated best practice is shared within the industry

5. Species management

To effectively manage (i.e. control or eradicate) the slipper limpet.

PRIORITY ISSUE: Removal of slipper limpet is challenging and may present an additional risk of spread. Coordination of control efforts and guidance for stakeholders could be improved, and efficacious methods for removal could be researched, developed and shared with stakeholders.

Responsible stakeholder	Guidance for Development of Actions	Example actions
All stakeholders	Removal of slipper limpets can be challenging and may carry a significant risk of damaging local ecosystems or of resulting in spread. Recommended control methods can be considered (see Table 7), but expert guidance with detailed planning and risk mitigation should be sought before any removal or population control efforts are undertaken. The potential environmental impacts, financial costs, and health and safety considerations must be factored into control strategies. Funding sources for further research should be considered and shared, with research councils like NERC and BBSRC prioritising invasive species management. Collaborative projects with universities will ensure scientific robustness, and NRW's marine evidence needs process should highlight invasive species as a research priority. University student projects should be encouraged to address knowledge gaps. Coordination and guidance for stakeholders must be improved to ensure best practices are followed in all management efforts. For example, clear guidance should be provided on how particular methods should be deployed, with any marine licencing or need for approvals identified. Guidance on how to monitor and assess efficacy and management endpoints should also be considered.	• Conduct investigations into the efficacy of current methods for the slipper limpet and into novel control methods. • Where feasible, develop control plans for known populations of the slipper limpet.

Responsible stakeholder	Guidance for Development of Actions	Example actions
All stakeholders continued	A structured plan should outline yearly objectives such as population reduction, containment, or eradication. It should define responsible stakeholders, control methods, agreed actions, milestones, success indicators, timelines, and funding strategies. Regular reviews should assess progress, refine strategies, and integrate new research findings. A structured and collaborative approach will help mitigate the impact of slipper limpet, protecting marine biodiversity and economic interests.	See actions above.

6. Monitoring and reporting

To establish a robust understanding of slipper limpet distribution in Welsh marine areas and facilitate the early detection of new introductions or spread.

To ensure that slipper limpet sightings are reported to an appropriate platform and records are included in national databases.

To ensure that up to date species distribution data is available to facilitate rapid responses to new carpet sea squirt introductions or spread events.

PRIORITY ISSUE: INNS monitoring and surveillance are insufficient in certain regions, with stakeholders often unaware of what to report or where to report sightings. Additionally, data flow is fragmented, data administration slow, and existing mechanisms for priority species reports reaching authorities are inconsistent, which may delay management response.

Responsible stakeholder	Guidance for Development of Actions	Example actions
All stakeholders	To understand the distribution of the slipper limpet within Wales, monitoring of both existing populations and locations where the slipper limpet is not currently known to have invaded is required. Existing populations should be monitored to understand population growth. To further the understand of rate of spread from known populations and facilitate rapid response high-risk (hot spot) locations may also be prioritised for monitoring. Surveillance of such high-risk locations where the species is yet to be detected will be essential in triggering rapid response processes. Ideally, monitoring should be of a consistent effort and persistent at a regional level for comparability between years. It is suggested that monitoring at locations considered as high risk should be funded to ensure quality and consistency. Citizen scientists, including individuals, NGOs, charities and local action groups should be engaged with and encouraged to report sightings of the slipper limpet. The NRW INNS identification guide (links in Useful resources) is clear and concise and includes information on how to report marine INNS.	• Promote and encourage the use of INNS reporting / recording platforms. • Check Welsh INNS biosecurity communications for opportunities to collaborate on monitoring efforts. • Consider proactive INNS monitoring through citizen science programmes.

Responsible stakeholder	Guidance for Development of Actions	Example actions
All stakeholders continued	This guide should be disseminated and maintained to facilitate effective reporting. However, surveillance and reporting should still generally target all INNS and be coordinated at a national level rather than focusing on individual species. Although, providing awareness materials and supplementary slipper limpet identification guides at high-risk locations, or in reference to high-risk operations, can support prioritised monitoring efforts. Although this component aims to increase the INNS monitoring and surveillance effort by stakeholders, it should be noted that INNS monitoring is multi-faceted and there is an expectation that authorities and local and national stakeholders should take an integrated approach to monitoring. By doing so, they can ensure a cohesive and unified effort that builds on and enhances existing programmes, maximising the effectiveness of monitoring across all marine pathways and action plans. Stakeholders who own or manage assets (e.g. aquaculture operators, marina and harbour operators, local authority managed assets etc.) should consider implementing regular monitoring for INNS/priority species. Monitoring can either be undertaken and reported by stakeholders individually or could be through a collaborative effort with other stakeholders, for example those in academia. It is best to use standard procedures for monitoring high-risk INNS. Procedures may be directed from a new national approach or from existing monitoring. The best approach to monitoring for current and horizon INNS is to employ multiple methods in tandem to achieve maximum coverage of habitat and species detection.	• Borrow the marine INNS workshop kit to run training in identification. The kit is comprised of preserved specimens and information sheets and can be borrowed from Amgueddfa Cymru (see Useful resources). • Promote opportunities for integrated or collaborative INNS monitoring efforts. • Conduct regular monitoring for the slipper limpet

Responsible stakeholder	Guidance for Development of Actions	Example actions
All stakeholders continued	Some of the monitoring methods that could be employed include: • Rapid Assessment Surveys (optimal for detecting fouling organisms but not for planktonic or soft bottom habitat species); • Environmental DNA (eDNA) (used to ascertain which species are present at a site using the genetic material that can be obtained from an environmental sample such as water). • Reviewing footage from drop down camera surveys (limited in its use but useful for areas that are otherwise difficult to access). Confirmed or suspected INNS should be reported. This improves INNS distribution knowledge and the ability to reduce the spread. Information on how and where to report sightings should be included in all biosecurity materials and resources. NRW recommend that INNS sightings should be reported to: • iRecord online [www.irecord.org.uk/]; and • iRecord App [available on Google Play].  Potential INNS sightings can also be reported directly to NRW at: invasive.non.native@naturalresourceswales.gov.uk Reporters should take photos and make a note of the sighting location (ideally GPS coordinates). If possible, they should take some notes about the surroundings (e.g., substrate type, other species in the area, tidal height). The reporting platform should be mentioned / linked on educational materials, at workshops and in social media engagements (see Component 2).	See actions above.

Responsible stakeholder	Guidance for Development of Actions	Example actions
Authorities	It has been recognised that the reporting of INNS sightings is not as efficient as it could be. Authorities should therefore engage with local groups, citizen science surveying groups (e.g., Seasearch), Local Environmental Records Centres (LERCs) and non-governmental organisations (NGOs) (e.g., Wildlife Trusts) to set up or improve data-sharing links and ensure that sightings of high-risk species or new incursions of horizon species are passed to the relevant authority and acted on in a timely manner. This could involve establishing a list of National alert species and disseminating this list to all relevant parties (e.g., LERCs and NGOs). A critical analysis of the dataflow for national INNS records should be considered, with the primary aim to improve the consistency, accuracy and timeliness of reports. Making use of existing reporting channels used by operatives in key sectors is also encouraged. For example, the reporting of INNS, including the slipper limpet, could be facilitated on the commercial fishing reporting "Catch Recording App" to make it easier for fishers to log sightings. Records should be accurate, accessible, and up-to-date and be maintained regularly. Any records obtained from locations where the species has not previously been recorded should be verified and acted on rapidly, as prioritised nationally. While the method by which information is gathered will depend on reporting processes, it may be beneficial to maintain a shared species-specific database /dataset containing, as a minimum, the location, date and nature of the record.	• Undertake a critical analysis of the data-flow for national INNS reports. • Ensure that priority INNS reports are flagged with relevant stakeholders (e.g. iRecord species alert notifications).

7. Collaborative working

To improve the collaboration between all stakeholders within Welsh marine areas and foster open communication, build trust, and align on shared goals to drive effective outcomes.

To cooperate in decision-making, share resources, and leverage the experience and knowledge of stakeholders to address challenges and achieve success together.

PRIORITY ISSUE 1: Stakeholders remain uncertain about advancing biosecurity implementation without clear guidance and support from regulators and authorities. Top-down leadership and inter-stakeholder collaboration are crucial. Mechanisms for sharing information, practical advice, and bespoke guidance tailored to both national and local stakeholder needs must be developed and prioritised.

PRIORITY ISSUE 2: Opportunities for coordinated and collaborative working can be missed due to limitations in communication, leading to duplicated effort and gaps.

Responsible stakeholder	Guidance for Development of Actions	Example actions
All stakeholders	All stakeholders should work to strengthen communication and collaboration mechanisms, ensuring that practical improvements, best practices and the expert knowledge of stakeholders are effectively shared and considered within national or regional biosecurity implementation. Open communication channels will facilitate the flow of information from authorities to stakeholders within key sectors (i.e., those whose operations may act as pathways of introduction and spread). Open channels will also facilitate the sharing of information from stakeholders to authorities. For example, slipper limpet sightings in new areas.	- Engage in the biosecurity framework for Welsh marine areas in some capacity. - Consider mechanisms for collaboration and integration with other stakeholders and projects.

Responsible stakeholder	Guidance for Development of Actions	Example actions
Authorities	Authorities could consider taking a leadership/coordinating role in this process by setting clear frameworks, facilitating dialogue, and ensuring that all voices are heard. Impartial guidance is critical in driving coordinated efforts, updates to national policy, maintaining transparency, and promoting a proportional approach.	• Ongoing stakeholder engagement to keep INNS at the forefront of stakeholders' activities and awareness. • Establish/task an existing working group with coordinating collaborative working. • Engage and coordinate with stakeholders to monitor progress and assess future support needs

Control and management methods

Table 7 contains a list of control methods for the slipper limpet that have been used elsewhere and identified from available literature. These methods may be employed to prevent the spread and reduce the abundance of INNS populations. **Inclusion in this table is by no means an endorsement of any of these methods as some methods listed below could have detrimental effects on the surrounding environment and wildlife. Any control action that is taken for the slipper limpet should be done so following the direction, advice and approval from the relevant authorities.** There may be limitations to the application of any of these methods if being undertaken in a protected site (e.g., SSSI, SAC or MCZ) and appropriate disposal of slipper limpet material and treatment waste should always be considered. Marine licenses and Habitat Regulations Assessments may also be required to undertake any of the following control methods.

Table 7. A list of control methods for the slipper limpet that have been utilised elsewhere and are reported in scientific literature. The references used can be found in the [control and management table's references](#) section of the bibliography.

ID	Action	Information
C-CF-1	Chain harrowing	This process can break up clusters of slipper limpets which can cause them to die, but there are no empirical data available on this technique as it has not yet been quantitatively investigated. This mechanism is relatively untested and could potentially lead to further spread of the species. The process is indiscriminate and may damage any native species present. Traditionally used in oyster management, it removes soft sediment from the oyster beds to expose the hard substrate for oyster spat settlement by towing chains behind a powered vessel over the beds which resuspends the surface layer of sediment.

ID	Action	Information
C-CF-2	Collection by fishers for a reward (dredging)	This is essentially the provision of a financial reward to fishers for landing slipper limpets (either intentionally or unintentionally). A process by which potentially large number of slipper limpets could be removed from specific locations, limiting spread and impact. Bounty systems have had some limited success in the management of INNS elsewhere. An example of this is the recapture of American lobsters in the south of England following a mass release in 2015. Incentivising fishers to land the slipper limpet could provide a valuable means to target populations intensively over a short period. How the species is collected however would need to be considered along with the longevity and funding sources of any such programme. There is also the potential to abuse such a system if it is not policed carefully.
C-CF-3	Collection by Harbour Authority (dredging)	A process by which potentially large number of slipper limpets could be removed from specific locations, limiting spread and impact. Harbour authority vessels can be used to collect the slipper limpets even when fisheries are closed to fishers. Ideally do this before spat settlement of commercially important shellfish to minimise the impact on fisheries. The slipper limpets must be disposed of appropriately following guidance from authorities.
C-CF-4	Collection using a suction dredge	A process by which potentially large numbers of slipper limpets could be removed from specific locations, limiting spread and impact. Remove slipper limpets using a suction dredge for a limited period each year via a modified 2m wide dredge head which removes the surface sediment along with the slipper limpet.
C-CF-5	Brine dipping	This method could be of use in removing the slipper limpet from encrusting commercial stock (most feasibly in bag and trestle aquaculture), especially bivalves, easily and effectively. Dip the slipper limpet in a strong salt solution until 100% mortality is reached. The treatment liquid must be disposed of appropriately.

ID	Action	Information
C-CF-6	Smothering and burying	A process by which potentially large number of the slipper limpet can be dispatched rapidly and effectively. The slipper limpet is poorly adapted to adjust its vertical in-sediment position. The slipper limpet does not survive burial deeper than 6cm. Dredge material, cultch, mussel stock or sediment could be used to smother areas effectively removing the population. This method (smothering by laying mussels) was used to address the accidental introduction of slipper limpets into the Menai Strait in 2007. No live or dead specimens were found in subsequent intertidal surveys in the following year.

Useful Resources

- [GB NNSS slipper limpet identification guide](#)
- [GB NNSS slipper limpet risk assessment](#)
- [GB NNSS slipper limpet information portal](#)
- [CABI Compendium slipper limpet information page](#)
- [Global Invasive Species Database slipper limpet fact sheet](#)
- [Marine Life Information Network \(MarLIN\) slipper limpet information page](#)
- [Nature Biodiversity Network \(NBN\) Atlas slipper limpet records](#)
- [Welsh marine INNS priority list](#)
- [Natural Resources Wales marine INNS guide in Welsh](#)
- [Natural Resources Wales marine INNS guide in English](#)
- **Links to Pathway Action Plans (PAPs) and other Species Action Plans (SAPs):**
Links to the action plans listed below can be found on the [Wild Seas Wales website](#):
 - Chinese mitten crab, *Eriocheir sinensis* SAP
 - American slipper limpet, *Crepidula fornicata* SAP
 - Trumpet tubeworm, *Ficopomatus enigmaticus* Species Action Plan
 - American oyster drill, *Urosalpinx cinerea*, & Japanese oyster drill, *Ocenebrellus inornatus* SAP
 - Recreational Boating (large boats) PAP
 - Recreational Boating (small boats) PAP
 - Recreational Activities PAP
 - Commercial Shipping PAP
 - Aquaculture PAP
 - On-shore Fishing PAP
 - Boat-based Fishing PAP

- **Marine Invasive Non-Native Species (INNS) Kit for Wales**

This kit was created with funding from European Maritime and Fisheries Fund and with support from NRW, Aberystwyth University and Wales Wildlife Trust. It is loosely based on the MBA's (Marine Biological Association, Plymouth) kit that was borrowed for an INNS workshop by the stakeholders in October 2022 and it was agreed that a kit for Wales would be useful. This kit can be borrowed as a whole or divided up into major groups and one part loaned out.

The kit consists of the following major groups:

- Algae (Seaweeds)
- Molluscs
- Sea squirts
- Bryozoans
- Crustaceans
- Other (Polychaetes, and anemone)

The kit may be borrowed by anyone who is running a supervised workshop for adults and it is an excellent way to train recorders who are looking out for Invasive Non-Native Species. It is free to borrow, but courier or transport costs, must be paid for.

It includes specimens, images, distribution data and species information that are included with each group of the kit. Images of the kit are included in the following pages along with approximate dimensions of it as a whole and divided into its separate subject groups.

To borrow the kit or any aspect of the kit please contact Anna Holmes (anna.holmes@museumwales.ac.uk).

**AMGUEDDFA
CYMRU**



With many thanks to Chloe Powell-Jennings (NRW), Morag Taite and Joe Ironside (Aberystwyth University), Dawn Thomas (N Wales Wildlife Trust) and Katherine Slade

(Amgueddfa Cymru) for their enthusiasm, knowledge, and teamwork. Financial support was provided by the European Maritime and Fisheries Fund.

Bibliography

General references

- Blanchard, M., 1997. Spread of the slipper limpet *Crepidula fornicata* (L. 1758) in Europe. Current state and consequences. *Scientia Marina*, **61**, 109-118.
- Bohn, K., 2014. The distribution and potential northwards spread of the invasive slipper limpet *Crepidula fornicata* in Wales, UK. NRW Evidence Report No: **40**, 43pp, Natural Resources Wales, Bangor.
- Bohn, K., Richardson, C.A. and Jenkins, S.R., 2015. The distribution of the invasive non-native gastropod *Crepidula fornicata* in the Milford Haven Waterway, its northernmost population along the west coast of Britain. *Helgoland Marine Research*, **69**: 313 - 325
- De Montaudouin, X. and Sauriau, P.G., 1999. The proliferating Gastropoda *Crepidula fornicata* may stimulate macrozoobenthic diversity. *Journal of the Marine Biological Association of the United Kingdom*, **79**, 1069-1077.
- Eschen, R., Kadzamira, M., Stutz, S., Ogunmodede, A., Djeddour, D., Shaw, R., Pratt, C., Varia, S., Constantine, K. and Williams, F., 2023. An updated assessment of the direct costs of invasive non-native species to the United Kingdom. *Biological Invasions*, **25**, 3265-3276
- FitzGerald, A., 2007. Slipper Limpet Utilisation and Management. *Report to Port of Truro Oyster Management Group*.
- McCabe, M., Ellis, M., Hatton-Ellis, T.W., Howe, E.A., Thorpe, D., Tucker, C., 2015. NRW Response to the Consultation on Revisions to Schedule 9 of the Wildlife & Countryside Act. NRW Staff Report No: Evidence Report No: **86**, 104pp, Natural Resources Wales, Bangor.
- Minchin, D., McGrath, D. & Duggan, C.B., 1995. The slipper limpet, *Crepidula fornicata* (L.), in Irish waters, with a review of its occurrence in the north-eastern Atlantic. *Journal of Conchology*, **35**, 247-254.
- Newell, R.C. and Kofoed, L.H., 1977. The energetics of suspension-feeding in the gastropod *Crepidula fornicata*, *Journal of the Marine Biological Association of the United Kingdom*. Cambridge University Press, **57**(1), pp. 161–180
- Richard, J., Huet, M., Thouzeau, G. and Paulet, Y.M., 2006. Reproduction of the invasive slipper limpet *Crepidula fornicata* in the bay of Brest, France. *Marine Biology*, **149**(4):789-801.
- Sewell J., Pearce S., Bishop J. and Evans, J.L., 2008. Investigations to determine the potential risk for certain non-native species to be introduced to North Wales with mussel seed dredged from wild seed beds. CCW Policy Research Report No. **06/3**. pp 82

- Sewell, J. and Sweet, N., 2011. GB Non-native Organism Risk Assessment for *Crepidula fornicata*. Accessible at [www.nonnativespecies.org]
- Thieltges, D.W., Strasser, M. and Reise, K., 2003. The American slipper limpet *Crepidula fornicata* (L.) in the northern Wadden Sea 70 years after its introduction. *Helgoland Marine Research*, **57**(1):27-33
- Thieltges, D., 2005. Benefit from an invader: American slipper limpet *Crepidula fornicata* reduces star fish predation on basibiont European mussels. *Hydrobiologia*, **541**: 241-244
- Thieltges, D.W., 2005. Impact of an invader: epizootic American slipper limpet *Crepidula fornicata* reduces survival and growth in European mussels. *Marine Ecology Progress Series*, **286**, 13-19
- Tillin, H.M., Kessel, C., Sewell, J., Wood, C.A., Bishop, J.D.D., 2020. Assessing the impact of key Marine Invasive Non-Native Species on Welsh MPA habitat features, fisheries and aquaculture. NRW Evidence Report. Report No: **454**, 260pp, Natural Resources Wales, Bangor.
- Walne, P.R., 1956. The biology and distribution of the slipper limpet *Crepidula fornicata* in Essex rivers. *Fishery Investigations*, series II, **20**, 1-50.

Control and management table's references

- FitzGerald, A., 2007. Slipper Limpet Utilisation and Management. *Report to Port of Truro Oyster Management Group*.
- Wilson, J., and Smith, K., 2008. Bangor Mussel Producers Association Code of Good Practice for mussel seed movement: Appendix E: Eradication measures for removing invasive non-native species from mussel lays. Available at <https://www.nw-ifca.gov.uk/app/uploads/Code-of-Good-Practice-seed-mussel-movement.pdf>
- RAPID LIFE, 2018. Good Practice Management Guide: Slipper limpet (*Crepidula fornicata*). Available at https://www.nonnativespecies.org/assets/Good_Practice_Management_-_Slipper_limpet.pdf

Data References

Table 8 Rightsholders and data providers for the open-source data downloaded from NBN Atlas for the purpose of this report.

Data Providers	Rights holders
Centre for Environmental Data and Recording	Agri-Food and Biosciences Institute
Environment Agency	CEDaR and Biological Records Centre
Joint Nature Conservation Committee	Centre for Environmental Data and Recording
Marine Biological Association	Department of Agriculture Environment and Rural Affairs
National Trust	Environment Agency
Natural England	iNaturalist & bernardpicton
Natural History Museum, London	iNaturalist & Ulster Wildlife
Natural Resources Wales	Joint Nature Conservation Committee
Porcupine Marine Natural History Society	Marine Biological Association
Seasearch	National Museums Northern Ireland
South East Wales Biodiversity Records Centre	National Trust
The Wildlife Trusts	Natural England
West Wales Biodiversity Information Centre	Natural Resources Wales
-	Porcupine Natural History Society
-	Seasearch
-	SEWBRc
-	The Wildlife Trusts
-	West Wales Biodiversity Information Centre

Data Set References:

© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right 2023
2004-2012 Bishop et al. Occurrence of non-native sessile invertebrates on the English coast by Marine Biological Association under licence CC BY. Conditions of use of dataset: No marina names (if deduced) should be published without the marinas explicit consent. Cite: Bishop, JDD, Wood, CA, Yunnice, ALE, Griffiths, CA. (2015) Unheralded arrivals: non-native sessile invertebrates in marinas on the English coast. *Aquatic Invasions*, 10.

2005 - Ongoing United Kingdom MarLIN Shore Thing timed search results by Marine Biological Association under licence CC BY. Released under DASSH terms and conditions – See

<http://www.dassh.ac.uk/terms-and-conditions>

Centre for Environmental Data and Recording (2023). Agri-Food and Biosciences Institute Marine Surveys. Occurrence dataset on the NBN Atlas

Centre for Environmental Data and Recording (2023). Centre for Environmental Data and Recording (CEDaR) Marine Species Data. Occurrence dataset on the NBN Atlas

Centre for Environmental Data and Recording (2023). Coastwatch Marine Species Records from Northern Ireland. Occurrence dataset on the NBN Atlas

Centre for Environmental Data and Recording (2023). Department of Agriculture Environment and Rural Affairs (DAERA) Marine and Fisheries Division Marine Survey Data. Occurrence dataset on the NBN Atlas

Centre for Environmental Data and Recording (2023). iNaturalist records from Northern Ireland. Occurrence dataset on the NBN Atlas

Centre for Environmental Data and Recording (2023). Ulster Museum Marine Surveys. Occurrence dataset on the NBN Atlas

DASSH Data Archive Centre - Statutory Surveys by Marine Biological Association under licence CC BY. Released under DASSH terms and conditions – See <http://www.dassh.ac.uk/terms-and-conditions>

DASSH Data Archive Centre Academic Surveys by Marine Biological Association under licence CC-BY. Released under DASSH terms and conditions – See <http://www.dassh.ac.uk/terms-and-conditions>

DASSH Data Archive Centre expert sightings records by Marine Biological Association under licence CC-BY. Released under DASSH terms and conditions – See <http://www.dassh.ac.uk/terms-and-conditions>

DASSH Data Archive Centre volunteer survey data by Marine Biological Association under licence CC BY. Released under DASSH terms and conditions – See <http://www.dassh.ac.uk/terms-and-conditions>

DASSH Data Archive Centre volunteer survey data by Marine Biological Association under licence CC BY. Released under DASSH terms and conditions – See <http://www.dassh.ac.uk/terms-and-conditions>

Environment Agency (2023). England Non Native Species records 1965 to 2017. Occurrence dataset on the NBN Atlas

Environment Agency (2023). Protected and Invasive Species Records Collected Through Environment Agency Survey 1995 - 2021. Occurrence dataset on the NBN Atlas

Joint Nature Conservation Committee (2023). Marine Nature Conservation Review (MNCR) and associated benthic marine data held and managed by JNCC. Occurrence dataset on the NBN Atlas

Joint Nature Conservation Committee (2023). Marine Offshore Seabed Survey data held by JNCC. Occurrence dataset on the NBN Atlas

Marine Biological Association (2023). 2014 Marine Biological Association of the UK (MBA) Noss Mayo Yealm Estuary Transect Survey of *Crassostrea gigas*. Occurrence dataset on the NBN Atlas

Marine Biological Association (2023). 2014 Marine Biological Association (MBA) Yealm River non-native species timed search. Occurrence dataset on the NBN Atlas

Marine Data from The Wildlife Trusts (TWT) Dive Team; 2014-2018

National Trust (2023). National Trust Species Records. Occurrence dataset on the NBN Atlas

Natural England (2023). Natural England Marine Monitoring surveys. Occurrence dataset on the NBN Atlas

Natural History Museum (2023). Data Portal query on 1 resources <https://doi.org/10.5519/qd.i4tk4lrk>

Natural Resources Wales. (2023) Marine data from Natural Resources Wales (NRW) Technical Support (Research & Monitoring) Contracts, Wales. Occurrence dataset accessed through the NBNAtlas

Natural Resources Wales. (2023) Marine Intertidal Phase 1 Species Dataset from the Countryside Council for Wales 1996-2005. Occurrence dataset accessed through the NBNAtlas

Natural Resources Wales. (2023) Marine Records from Pembrokeshire Marine Species Atlas. Occurrence dataset accessed through the NBNAtlas

Porcupine Marine Natural History Society (2020): Porcupine Marine Natural History Society Dataset. v2.2. Marine Biological Association. Dataset/Samplingevent. Occurrence dataset on the NBN Atlas. <https://doi.org/10.17031/zay9rc>

Records provided by CEDaR Online Recording, accessed through NBN Atlas website. (Creative Commons with Attribution 4.0 (CC-BY) CC BY Creative Commons Attribution). For more information: <https://registry.nbnatlas.org/public/show/dr1954>

Records provided by Marine Recorder Snapshot extract of surveys entered by Sussex Wildlife Trust, accessed through NBN Atlas website. (Creative Commons with Attribution 4.0 (CC-BY)). For more information: <https://registry.nbnatlas.org/public/show/dr2613>

Rees et al (2020). Macrobenthos Data from Shoreham, the Tyne and the Thames Estuaries, UK, 2000 to 2006. Cefas, UK. V1. doi: <https://doi.org/10.14466/CefasDataHub.45>

Seasearch (2023). Seasearch Marine Surveys in England. Occurrence dataset on the NBN Atlas

Seasearch (2023). Seasearch Marine Surveys in Scotland. Occurrence dataset on the NBN Atlas

Seasearch (2023). Seasearch Marine Surveys in the Channel Islands. Occurrence dataset on the NBN Atlas

Seasearch (2023). Seasearch Marine Surveys in Wales. Occurrence dataset on the NBN Atlas

SEWBrEC (2023). INNS Data: All Taxa (South East Wales). Occurrence dataset on the NBN Atlas

Ulster Wildlife (2023). Ulster Wildlife ShoreNI iNaturalist records. Occurrence dataset on the NBN Atlas

West Wales Biodiversity Information Centre (2023). INNS Records: All Taxa (West Wales). Occurrence dataset on the NBN Atlas