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Cyfoeth Naturiol Cymru
Natural Resources Wales

# Invasive Non-native Species Action Plan for Wales:

## Trumpet tubeworm
## (*Ficopomatus enigmaticus*)

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

With contributions from Holly Peek and Chloe Powell-Jennings

APEM Ltd. And Natural Resources Wales

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# 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 trumpet tubeworm, *Ficopomatus enigmaticus,* by putting forward actions that can be applied at national (Welsh), regional and local levels.
- This SAP provides an overview of the invasive trumpet tubeworm, 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 trumpet tubeworm include impacts on biodiversity, alteration of marine habitats and the fouling of vessel hulls, equipment, or infrastructure. These issues lead to costly management and repairs, as well as direct harm to the natural marine environment.
- The actions outlined within this SAP provide stakeholders of the Welsh marine environment a series of actions that could be implemented where the trumpet tubeworm 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 trumpet tubeworm within Welsh marine areas.

    1. Understanding roles and legal responsibilities
    2. Information and guidance on the trumpet tubeworm
    3. Raising awareness
    4. Biosecurity processes and procedures
    5. Species management
    6. Monitoring 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 trumpet tubeworm 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 trumpet tubeworm 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.

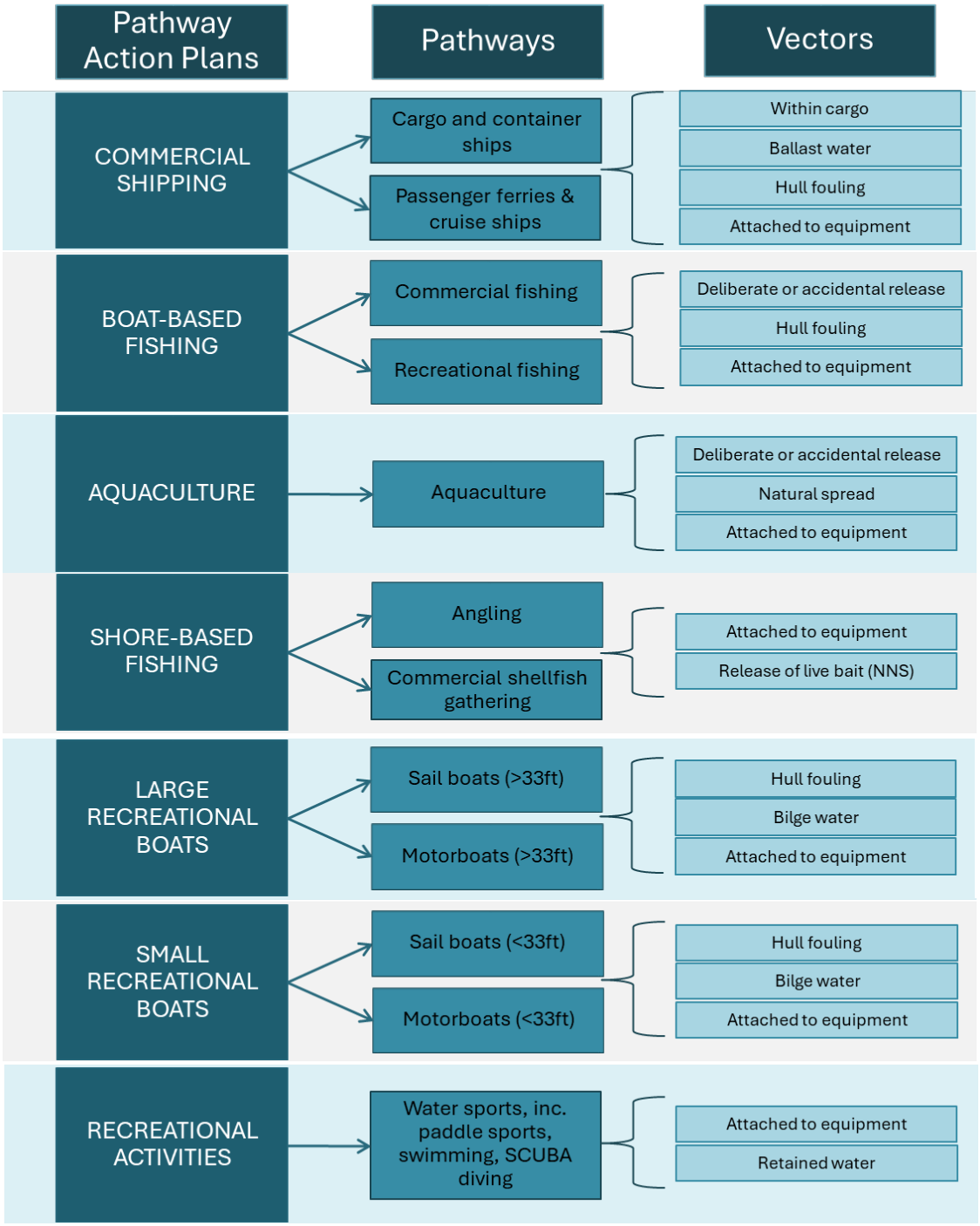


**Figure 1. An overview of the Pathway Action Plans that have been developed for Wales, and the vectors associated with the pathways. Note that the list of vectors is not exhaustive.**

# 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.

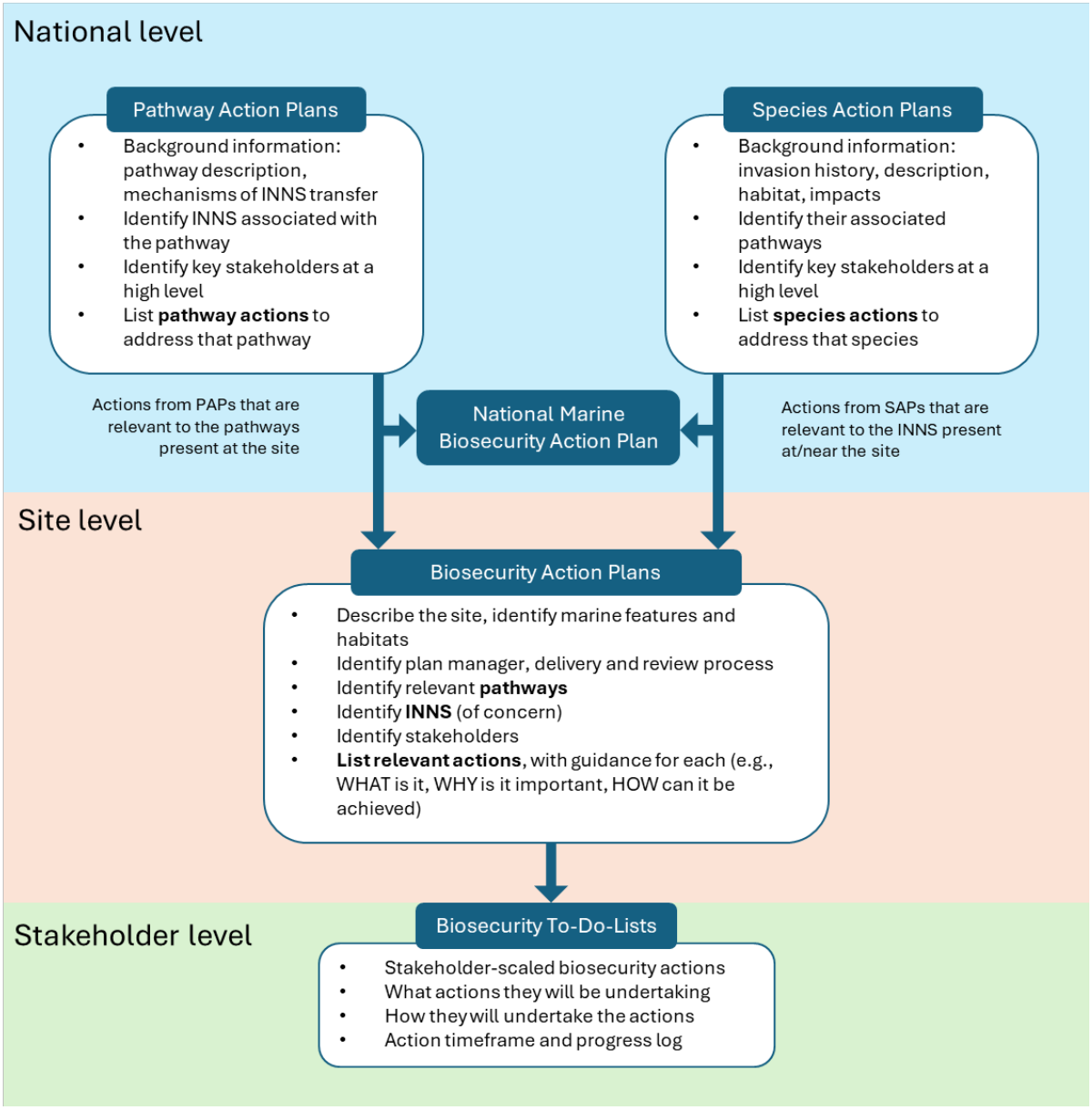


**Figure 2. A flowchart showing the relationships between the Pathway Action Plans, Species Action Plans and the Biosecurity Action Plans created for the Natural Resources Wales Biosecurity Planning Project with APEM Ltd.**

# 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 Australian tubeworm or trumpet tubeworm, *Ficopomatus enigmaticus* (referred to as the trumpet tubeworm 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 trumpet tubeworm, 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 trumpet tubeworm by putting forward actions that can be applied at national (Welsh), regional and local levels. The goal is to use existing INNS and trumpet tubeworm 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 trumpet tubeworm and the risks it poses.
- Put forward recommendations for actions that aim to reduce the further introduction and spread of the trumpet tubeworm into and around Wales and improve surveillance and reporting of new individuals.
- Outline possible control methods for the trumpet tubeworm that have previously been employed elsewhere.

# The trumpet tubeworm: Background

**Table 1. A summary of the trumpet tubeworm (*Ficopomatus enigmaticus*) background information**

| Attribute | Details |
|---|---|
| Native range | Unknown, likely Australasia |
| Appearance | The tubes of individual worms form clumps of varying shapes. Fresh tube growth calcareous (chalky) and white. Turns pale yellowish-brown colour with age. Tubes typically end in a flared collar and have banded transverse rings. Feathery appendages (tentacles) protrude from the tubes when the worm is feeding. The worm is greenish or reddish-orange and up to 25 mm in length. |
| Substrate | Low resistance to waves, therefore usually found in calmer waters such as creeks, channels, estuaries, inland waterbodies, and harbours. |
| Depth | 0.5-2 m but has been recorded at 40 m depth. |
| Temperature tolerance | 0-30°C. |
| Salinity tolerance | 1psu to 50psu. Optimum 10psu to 30psu. |
| Feeding method | Filter-feeder |
| Reproduction/Propagation | Sexual (cross-fertilisation). Hermaphrodites have been reported. Free-swimming larvae. Reefs can regenerate from small fragments. |
| Predators | Predation by crabs and fishes. |
| Pathways and vectors | Ballast and bilge water, fouling (on vessels and infrastructure), hitchhiking (on aquaculture stock and equipment), dredging and hopper water and natural spread. |
| Impacts | Competition, habitat alteration, impacts on biodiversity and socioeconomic. |

# Where did it come from?

The true native range of the trumpet tubeworm is unknown but is probably the Australasian region.

### Non-native range

The trumpet tubeworm was first described in 1923 from Caen, France, on the coast of the English Channel. Around the same time, it was recorded in Spain, England, Australia and California. In later years it was recorded from Hawaii, the East and Gulf coasts of the US, the Baltic Sea, the Mediterranean, the Caspian Sea, the Irish sea, Africa, South America, New Zealand, Japan and Taiwan.

# What does it look like?

The trumpet tubeworm lives in a hard, calcareous tube which it creates itself (see Figure 3). The tubes of multiple individuals can often become intertwined and form clumps (see Figure 4). These clumps, of varying shapes, can be relatively small, or they can be large enough to form reefs up to 0.5 m in height and 7 m across. Fresh tube growth (at the top of the tube) is calcareous (chalky) and white, but tubes turn a pale yellowish-brown colour with age. The tubes typically end in a flared collar; however, this collar is not always present. Tubes are 1-3 mm in diameter, and can vary greatly in length, sometimes reaching 80-100 mm. Tubes have banded transverse rings (across the width of the tube) that reflect periods of growth. Feathery appendages (tentacles) protrude from the tubes when the worm is feeding. The tentacles are greenish and darkly banded, about 30 mm long and arranged in a semi-circle. When disturbed, or taken out of the water, the tentacles retract into the tube and a spiny, dark-brown cap (operculum) forms a seal. The worm that resides inside the tube is greenish or reddish-orange and up to 25 mm in length.

Identification guides have been developed by several organisations and links can be found linked in Useful Resources.

# What habitat does it live in?

Due to its low resistance to waves, the trumpet tubeworm is usually found in calmer waters such as creeks, channels, estuaries, inland waterbodies, and harbours. The trumpet tubeworm is particularly abundant in brackish water (salinities between 10 and 30 psu (practical salinity units)). The trumpet tubeworm generally prefers warm, high nutrient (eutrophic) waters. It can, however, tolerate a wide range of salinities (1-50 psu), temperatures (0-30°C), dissolved oxygen levels (1-14 mg/l) and food (phytoplankton) abundance, as well as environments with poor water clarity and pollution. For example, colonies have been observed in Swansea estuary where the dock was polluted with waste oil. The trumpet tubeworm is typically found at depths of between 0.5-2 m but has been recorded at 40 m depth.

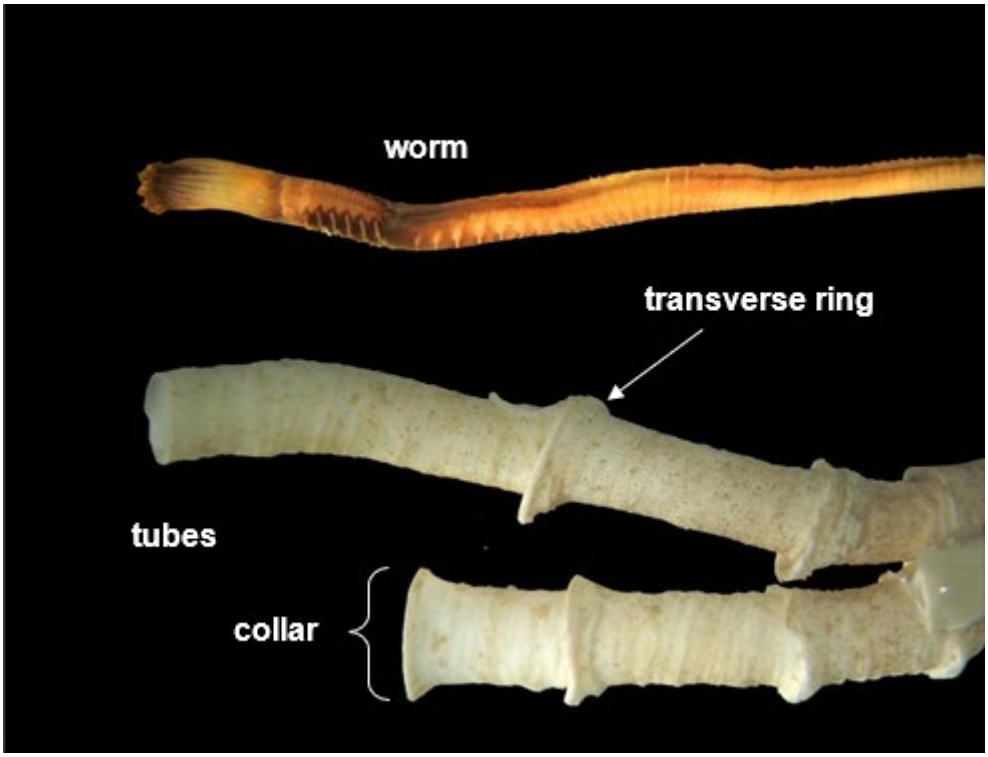


**Figure 3. Trumpet tubeworm: individual worm and tubes. © Duane Cox, Museum Victoria, CC BY 3.0 AU. Obtained via Wikimedia Commons.**

**Figure 4. Trumpet tubeworm found on ropes in Swansea Marina © Paul Brazier, NRW.**

## Behaviour and life cycle

The trumpet tubeworm mainly feeds on phytoplankton and other detritus that is suspended in the water (a process known as filter feeding), using its tentacles to capture food. At low tide when the trumpet tubeworm is exposed to air, the worm can survive for several hours by closing a seal (the operculum) at the top of its tube.

The trumpet tubeworm has a high growth rate, with tubes growing up to 20 mm per month. The rate at which reefs expand is highly variable, but monthly growth rate has been recorded as, on average, 10.6 mm, with growth being faster in the summer than winter. In general, growth rates, and the biomass of the trumpet tubeworm, are also greater in brackish water than they are in seawater.

Individual trumpet tubeworm are usually separate sexes, although hermaphrodites have been reported. There are generally two periods of spawning and population growth (recruitment), one in spring-summer and one in autumn. Recruitment in southeastern England starts in June and continues through to October. Eggs (between 1,000 and 10,000 per individual) and sperm are released into the water column and fertilisation takes place. Temperatures typically need to be higher than 15-18°C for reproduction to be successful (although successful reproduction at 10°C has been recorded), and phytoplankton levels (their food source) need to be above a certain threshold. The resulting larvae are free-swimming and, may take between 45 and 90 days to develop. As the larvae mature, they move to the sessile (fixed) stage of their life cycle and require a hard substrate to settle on, such as stones, empty shells, marina infrastructure, ship hulls and human litter. After settling, sexual maturity is reached at about four months of age. Additionally, trumpet tubeworm reefs can regenerate from small fragments, which poses a significant risk or spreading when trying to remove/manage the species.

## Does it have any predators?

There are few known predators of the trumpet tubeworm. Some that have been identified include the European eel (*Anguilla Anguilla*) and the European shore crab (*Carcinus maenas*).

## 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 specific, discrete parts within a pathway that facilitate the movement of INNS from one location to another. The pathways and vectors for the trumpet tubeworm are described below.

### Ballast and bilge water

This is one of the most likely pathways of introduction of this species into its non-native range. Ballast water is taken up by some vessels (e.g., cargo ships and some ferries) to aid stability while underway. Larvae of the trumpet tubeworm can be taken up in the ballast water of large, transoceanic ships and transported over long distances before being released at the

destination port. The UK merchant shipping (control and management of ships' ballast water and sediments) regulations 2022, which implement the requirements of the international convention for the control and management of ships' ballast water and sediments (2004), 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 discharged. If this legislation is enforced, this would decrease the risk that this pathway poses as a primary introduction pathway for the trumpet tubeworm.

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 secondary pathways of spread within the UK.

## Fouling on hulls and infrastructure

This is also a likely pathway of introduction of this species into its non-native range. The introduction of the trumpet tubeworm to the Caspian Sea probably resulted from hull fouling on ships. Hull fouling, of both commercial ships and recreational boats, 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 trumpet tubeworm, and therefore of spreading INNS. If the biofouling is not cleaned off and the vessel departs to a new location, the organisms might release eggs, larvae or propagules or individuals from a reef may fragment off the vessel into the water at the new location, resulting in potential introduction of new species to an area.

## Aquaculture and commercial fishing

Transport with aquaculture species is likely. 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.

## Dredging and hopper water

The trumpet tubeworm could be transferred during dredging operations via ballast water carried on the vessels and fouling on vessel hulls. 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

trumpet tubeworm that could facilitate its survival include its relatively broad environmental tolerances. However, the trumpet tubeworm could be damaged or buried during the dredging process. More research is needed to understand if the trumpet tubeworm 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 trumpet tubeworm) 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.

## Marine litter

The trumpet tubeworm can grow on a wide variety of surfaces, including plastics. Therefore, colonies or colony fragments attached to floating marine litter could be carried to new locations. For more information, see the 2024 González-Ortegón paper on floating plastics as a vector.

## A note on natural spread

Although not a human-mediated pathway, natural movement by currents can facilitate the secondary spread of a species once it has been introduced into its non-native environment. Trumpet tubeworm larvae can be carried in the water during their 1-3 month pelagic stage, potentially travelling several kilometres per day depending on the currents. However, larval dispersal distances are usually short due to the trumpet tubeworm's preference for colonising areas with low wave activity and the restricted swimming capability of larvae. Adults and juveniles, once settled, are non-mobile. They may, however, settle on floating material, for example on driftwood or vegetation, or alternatively colonies may become fragmented, and then be moved by wind or currents to new locations.

# What are its impacts?

## Environmental

### Habitat alteration

The trumpet tubeworm is referred to as an ecosystem engineer because it can structurally alter the environment in which it lives. This can have both positive and negative impacts. Large reefs can stabilise the seabed by retaining (or entraining) sediment. This can then reduce the impacts that sedimentation (i.e., smothering by sediment) may have on other seabed organisms in the vicinity. However, large reefs can also entrain organic matter, including the faeces and other excreted material from the worms, which collect at the reef base, potentially leading to the smothering of some species locally (i.e. living among the tubes). This creates a nutrient-rich, anoxic (i.e., without oxygen), muddy layer which may contribute to the formation of harmful or nuisance algal blooms. Contaminants can also be concentrated here and ultimately be passed up the food chain. The reef structures can also reduce water circulation.

The trumpet tubeworm can influence the biochemistry of a habitat by both providing a hard surface on which photosynthetic organisms, like algae, can grow and improving the clarity of the water by extracting fine sediments and detritus as it feeds, allowing more sunlight to reach the algae. The algae, as primary producers, can oxygenate the water and form the basis of the food web. However, it is important to note that the presence of the trumpet tubeworm may not guarantee that the clarity of the water improves, for example, decay of the increased algae could lead to hypoxic conditions (i.e. low or no oxygen) around the reef. Additionally, the trumpet tubeworm can support nuisance species, like some green algae, and other INNS which may negatively impact the water quality and wider ecosystem.

### Competition

In enclosed or semi-enclosed waters, the retention of trumpet tubeworm larvae can be high, resulting in surfaces becoming dominated by the species. For example, in Argentina, the trumpet tubeworm has covered 86% of the Mar Chiquita coastal lagoon's surfaces (see the 2004 Schwindt paper for more information). As such, with its high growth rate, the trumpet tubeworm is able to compete with other seafloor (or surface fouling) species for space. For instance, in Italy, the trumpet tubeworm outcompeted another non-native tubeworm (*Hydroides dianthus*) that produces thicker and longer tubes but grows more slowly. The trumpet tubeworm may also outcompete other filter feeding species such as bivalves (e.g., oysters and mussels) by depleting the food (phytoplankton and detritus) in the water column, especially if the density of the population is particularly high.

### Impacts to biodiversity

As mentioned above, the habitat alteration capabilities of the trumpet tubeworm can have profound impacts on biodiversity, this can favour some species and disadvantage others.

Reefs can provide resting sites for birds during low tides and feeding sites for migratory birds. They also provide a habitat for other benthic species like crabs, and a refuge from predation, and a surface for epibiotic species that live on other organisms. This can result in an increase in biodiversity. However, the resulting increase in the abundance of certain species can potentially imbalance the food web, disadvantaging other species. For example, increased numbers of crabs could result in the decreased abundance of their prey species which, in turn, could impact other species in that ecosystem. The tubeworm reefs can also provide a habitat for other invasive species.

### Socio-economic

The trumpet tubeworm can colonise a wide variety of surfaces which include important coastal and marine infrastructure. Aggregations of the trumpet tubeworm can impact the proper functioning of this infrastructure. For example, the trumpet tubeworm can block lock gates and the intake pipes of power stations, oil refineries and other industrial plants. The required removal of the trumpet tubeworm from such infrastructure is costly. Colonies can also grow on the hulls of boats, causing drag as they move through the water and decreasing fuel efficiency, as well as on boat propellers and other moving parts, restricting their use.

The fouling of fishing gear (e.g., nets and lines) by the trumpet tubeworm can increase drag in the water, making equipment difficult to use and potentially causing damage to mechanisms and to the equipment itself. Nets can also become entangled or snagged in trumpet tubeworm reefs. In shallow areas, the trumpet tubeworm can block access for boats or for people on foot to fishing areas. In the Mar Chiquita, Argentina this issue of access has led to a decrease in recreational fishing. The trumpet tubeworm can also compete for space and food with commercial shellfish species.

Additionally, the reefs that trumpet tubeworms form can create a safety hazard for people, as they can graze or cut themselves on the hard tubes.

# Trumpet tubeworm in Wales: National context

## Distribution of the trumpet tubeworm

In the UK, the trumpet tubeworm was first reported from docks in the Thames estuary in London, England in 1923, and was later recorded in Plymouth in 1939. Figure 5(A) shows the distribution of trumpet tubeworm records in the UK on the NBN Atlas database as of July 2023. An up-to-date map of trumpet tubeworm records in the UK can be found on the NBN Atlas. The trumpet tubeworm's current distribution mainly comprises the south of England

and the south of Wales, however detections have also been made on the east and west coasts of England and off the coast of County Galway, Ireland. Additionally, although not included in the map, recent sightings have been made of the trumpet tubeworm on boat hulls in the Isle of Man.

Figure 5(B) shows the distribution of trumpet tubeworm records in Wales. In the 1950s, the trumpet tubeworm was observed in the dock in Swansea. In 2014, it was recorded as being superabundant in Swansea Marina. The trumpet tubeworm has been reported from the south of Wales, in Abereiddy Bay (Blue Lagoon), Milford Haven, Pembroke (Mill Pond), Cardiff Bay and the Bristol Channel and more recently confirmed in north Wales, in Caernarfon and Y Felinheli (awaiting publication at time of writing).

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 tube/reef 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.

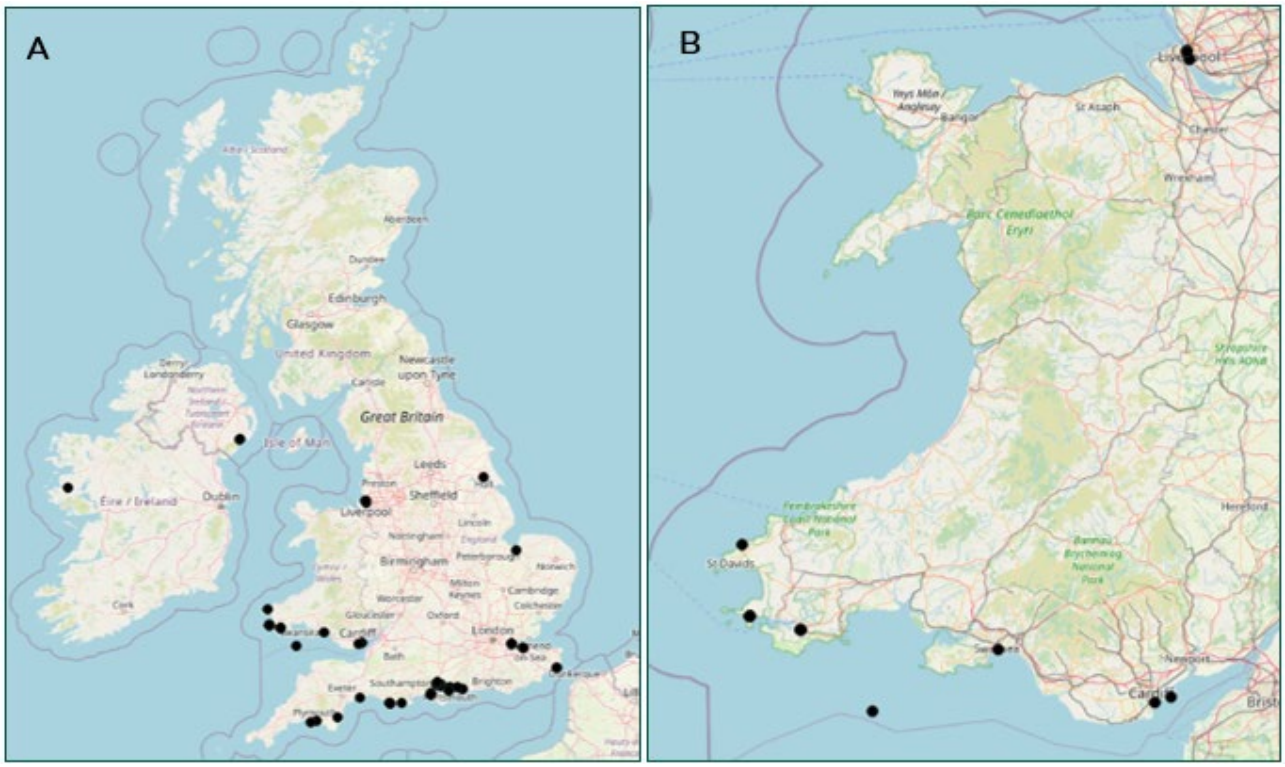


**Figure 5. Map of recorded and confirmed trumpet tubeworm occurrences in (A) the UK and (B) Wales from open source NBN Atlas data as of July 2023.** **Contains public sector information licensed under the Open Government Licence (OGL) v3.0, Public Domain Dedication (CC0) v1.0, Creative commons with attribution v4.0 (CC-BY). Data rightsholders, data providers, and dataset references are provided in Data References.**

# 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. Specific species, such as the trumpet tubeworm, are not mentioned within the Regulations, but measures should be appropriate to their management. A UK Marine INNS Priority List was developed to support delivery of the MSFD and to specifically focus monitoring efforts. The trumpet tubeworm is on this list as a priority species.
- 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. The trumpet tubeworm is recognised as being of high impact and therefore will affect the possibility of achieving or maintaining good ecological status. 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.

Where the trumpet tubeworm is not specifically mentioned by legislation or supporting documents (species lists), appropriate measures should still be taken in keeping with general guidance provided by the legislation. 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, the trumpet tubeworm has been assessed for the risks and impacts it poses to UK marine ecosystems. The outcomes of these assessments are listed in Table 2 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 not yet present but are likely to arrive in the future). The document also includes an assessment of the risk posed by INNS in Wales (in terms of invasiveness, spread and impact), which draws upon risk assessments developed by the GBNNSS.

**Table 2. Species impact and risk assessments for the trumpet tubeworm.**

| Assessment | Legislative driver | Trumpet tubeworm 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 |
| Marine Invasive Non-native Species Priority Monitoring and Surveillance List for Wales | Marine Strategy Regulations 2010 | Medium Risk |

# Challenges to INNS management

1. As described above, the trumpet tubeworm has high fecundity (i.e., produces many offspring) and its larvae has a long planktonic stage (approximately 1-3 months) during which time it 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 trumpet tubeworm to new locations, as much as is possible, and reducing or controlling existing populations. By decreasing population size, the propagule pressure is reduced as, if there are fewer spawning adults there will be fewer larvae, limiting the opportunity to disperse.

2. Trumpet tubeworm's ability to spread through fragmentation creates challenges to any removal attempts. Dislodged fragments can be carried by currents and settle in new areas, potentially accelerating its spread, which makes management of trumpet tubeworm extremely challenging.

3. Trumpet tubeworm demonstrates considerable tolerance to conventional antifouling paints—including copper-based and CCA-treated surfaces. Studies show that while early larval stages were susceptible to some historic paint formulations, the species often thrives on panels treated with copper–chromium–arsenic (CCA), with higher

settlement rates on CCA-treated wood compared to untreated controls (Dittmann et al 2009)

4. 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 Risk Assessments (HRAs) may be required.

5. Feasibility studies should be undertaken for potential control and eradication programs to assess the efficacy and impacts of different methodologies (see Table 4). However, accessing funding for these studies can be a potential barrier.

6. There are limitations and challenges for the enforcement, regulation and monitoring of national legislation, e.g., the Ballast Water Convention.

# Biosecurity to manage the trumpet tubeworm

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 trumpet tubeworm.

## 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 trumpet tubeworm 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

Table 3 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 3. 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<br>• Set out the position of the Welsh Government on pathway management and lay out a national approach for addressing key marine INNS.<br>• 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.<br>• 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.<br>• Aim to clearly state what is expected of all stakeholders and provide realistic, measurable and agreed targets.<br>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.<br>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 in Wales and the wider UK 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).<br>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.<br>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. |
| **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. |

| ID | Strategic action | Purpose |
|---|---|---|
| **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. |
| **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:<br>1. Regular meetings and workshops;<br>2. Agreements for data sharing and data integration;<br>3. Collaborative research, leveraging the expertise and experience of the industry;<br>4. Capacity building; and<br>5. Research and monitoring priorities communicated between stakeholders.<br><br>Promote the Natural Resources Wales list of high priority evidence needs and research ideas page: Natural Resources Wales / Marine and coastal evidence priorities. |

| ID | Strategic action | Purpose |
|---|---|---|
| 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.<br>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 trumpet tubeworm 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 trumpet tubeworm 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 trumpet tubeworm
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. 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.<br><br>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.<br><br>• Collaborate with industries to develop appropriate and achievable policy, without undue impact to Welsh blue growth and operators.<br><br>• Ensure consistency with wider legislation and regulation (i.e. biosecurity with regards to animal health).<br><br>• 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.<br><br>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<br><br>• 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 trumpet tubeworm

To ensure that information and guidance on the trumpet tubeworm 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.<br>Key highlights of the campaign could include:<br>• 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<br>• A defined list of priority INNS of concern.<br>• Publication of INNS alerts when a population is newly established or spreading.<br>• Clear points of contact for stakeholders seeking support and advice.<br><br>Factsheets should be created to raise awareness of the trumpet tubeworm 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.<br><br>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 trumpet tubeworm. Identification sheets of several marine species can be found on the GB NNSS website.<br><br>• Produce training resources on the trumpet tubeworm that can be provided to other stakeholders.<br><br>• 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)<br><br>• Keep ID guides up to date, accounting for new and horizon INNS. |

| Responsible stakeholder | Guidance for Development of Actions | Example actions |
|---|---|---|
| Authorities | 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.<br><br>A simple identification guide could also be included with instructions on how sightings (or suspected sightings) of the species should be reported.<br><br>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 trumpet tubeworm is present and absent, and therefore where it may be at risk of spreading from and to (and where impact to valuable assets may be great). Pathway analyses and risk assessments should be carried out to identify hot spots. This, in turn, will allow for effective prioritisation of resources for biosecurity and surveillance (either in relation to population management or prevention). | • Map the distribution of trumpet tubeworm 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.<br><br>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.<br><br>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 trumpet tubeworm 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 | • Refine existing biosecurity guidance to increase relevance for different sectors.<br><br>• Provide identification training aids for the trumpet tubeworm.<br><br>• Undertake research to fill knowledge gaps in understanding of trumpet tubeworm risk factors. |

| Responsible stakeholder | Guidance for Development of Actions | Example actions |
|---|---|---|
| All Stakeholders continued | presenters. Use should also be made of the trumpet tubeworm specimens that are included in the INNS kit from the National Museum of Wales, detailed in Useful Resources.<br><br>Investigations into the sources of trumpet tubeworm populations should also be prioritised. 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 trumpet tubeworm populations.<br><br>• 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 trumpet tubeworm among all stakeholders within Welsh marine areas.

PRIORITY ISSUE: Some stakeholders operating within Welsh marine areas are not aware of INNS (including the trumpet tubeworm) 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.<br><br>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.<br><br>• Continue to engage with stakeholders<br><br>• 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.<br>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 | • 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).<br><br>• Become familiar with the existing trumpet tubeworm guidance and resources.<br>• Share information resources with other stakeholders as widely as possible. |

| Responsible stakeholder | Guidance for Development of Actions | Example actions |
|---|---|---|
| All Stakeholders continued | shops, newsletters and magazines). 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.<br>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.<br><br>Developing awareness raising materials that highlight the economic and environmental risks of the trumpet tubeworm (based on the information provided in this SAP and the useful links) can provide targeted warnings where the trumpet tubeworm is a particular problem (e.g. ports and marinas where the trumpet tubeworm is resident); although, it is recommended that targeted awareness raising of individual species is created and disseminated in parallel with general INNS awareness raising.<br><br>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). | • Provide ad hoc information/facts on the trumpet tubeworm and INNS in general to staff, colleagues, members of the public, customers etc.<br><br>• Add in a link to biosecurity information on the GB NNSS website in staff updates.<br><br>• Put up ID posters of the trumpet tubeworm 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. If creating a poster information on the species can be found on the GB NNSS website .<br><br>• Integrate trumpet tubeworm 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 NNSS 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).<br><br>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.<br><br>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 trumpet tubeworm, 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 trumpet tubeworm is present.<br><br>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 trumpet tubeworm is present should consider:<br>• More frequent hull and equipment cleaning and antifouling.<br>• Cleaning equipment on land ensuring that waste is not allowed to re-enter the water.<br>• Refrain from removing the species from structures whilst still submerged.<br><br>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 stakeholders may already implement effective INNS biosecurity measures (e.g. aquaculture operators). Enhancements can leverage existing best practices, integrate example practical biosecurity / control | • Authorities could define and provide support to national and local stakeholders for the implementation of improved biosecurity.<br><br>• Review and update existing codes of good practice (e.g., for aquaculture)<br><br>• Develop codes of good practice for all activities/operations in the Welsh marine environment. |

| Responsible stakeholder | Guidance for Development of Actions | Example actions |
|---|---|---|
| All Stakeholders continued | actions (see Table 4), or adopt innovative approaches tailored by operators themselves.<br><br>Best practice for marine sectors has been created as part of the RAPID LIFE project. Additionally, codes for good practice in aquaculture have been developed, e.g., the Code of Good Practice for mussel seed movements from the Menai Strait Fishery Order Management Association (MSFOMA). Any reviews and updates to codes should be carried out with a process of consultation with relevant sector representatives to ensure that the code appropriately reflects practical and operational conditions as well as implementing improvements to biosecurity. Information should be included in codes on which INNS to look out for, how to report sightings and communication protocols<br><br>Appointment of Biosecurity Managers or Champions<br>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.<br><br>Research and develop INNS management measures<br>Invest and participate in the development and testing of new methods and technologies to manage INNS. For example, working with a research body / professional. | • 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.<br><br>• Regularly review emerging methods and technologies that offer INNS risk reduction.<br><br>• Appoint a biosecurity manager or champion to act as a central point of contact for INNS related queries.<br><br>• Consider collaborating with researchers to advance INNS management technologies.<br><br>• Ensure innovative approaches and updated best practice is shared within the industry |

## 5. Species management

To effectively manage (i.e. control or eradicate) the trumpet tubeworm.

PRIORITY ISSUE: Removal of trumpet tubeworm is challenging and presents a considerable 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 trumpet tubeworm is challenging and carries a significant risk of causing further spread. This INNS can regrow from small fragments or spawn when disturbed. Manual removal from in-water structures should not be attempted without ensuring the use of an appropriate method. Recommended control methods can be considered (see Table 4), but expert guidance with detailed planning and risk mitigation should be sought before any removal efforts are undertaken. The potential environmental impacts, financial costs, and health and safety considerations must be factored into all plans for programmes of control measures.<br><br>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.<br><br>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 | • Conduct investigations into novel control methods and the efficacy of current methods for the trumpet tubeworm<br><br>• Where feasible, develop control plans for known populations of the trumpet tubeworm |

| Responsible stakeholder | Guidance for Development of Actions | Example actions |
|---|---|---|
| All Stakeholders continued | approvals identified. Guidance on how to monitor and assess efficacy and management endpoints should also be considered.<br><br>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.<br><br>Regular reviews should assess progress, refine strategies, and integrate new research findings. A structured and collaborative approach will help mitigate the impact of trumpet tubeworm, protecting marine biodiversity and economic interests. | See actions above. |

## 6. Monitoring and reporting

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

To ensure that trumpet tubeworm 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 trumpet tubeworm within Wales, monitoring of both existing populations and locations where the trumpet tubeworm is not currently known to have invaded is required. Existing populations should be identified, prioritised and consistently 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.<br><br>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 | • Promote and encourage the use of INNS reporting / recording platforms.<br><br>• Check Welsh INNS biosecurity communications for opportunities to collaborate on monitoring efforts.<br><br>• Consider proactive INNS monitoring through citizen science programmes.<br><br>• 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). |

| Responsible stakeholder | Guidance for Development of Actions | Example actions |
|---|---|---|
| All Stakeholders continued | engaged with and encouraged to report sightings of the trumpet tubeworm.<br><br>As the trumpet tubeworm may be difficult for citizen scientists (i.e. non-experts) to definitively identify, it is important to ensure that ID guidance highlighting key distinguishing features is widely shared. Additionally, a robust monitoring strategy should include the training of more ID specialists and the creation of a network of specialists or DNA analysis services.<br><br>The NRW INNS identification guide (links in Useful resources) is clear and concise and includes information on how to report marine INNS. This guide should be disseminated and maintained to facilitate effective reporting.<br><br>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 trumpet tubeworm identification guides at high-risk locations, or in reference to high-risk operations, can support prioritised monitoring efforts.<br><br>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.<br><br>Stakeholders who own or manage assets (e.g. aquaculture operators, marina and harbour operators, local authority managed assets etc.) | • Promote opportunities for integrated or collaborative INNS monitoring efforts.<br><br>• Conduct regular monitoring for the trumpet tubeworm |

| Responsible stakeholder | Guidance for Development of Actions | Example actions |
|---|---|---|
| All Stakeholders continued | 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. For regular trumpet tubeworm monitoring, it is important to also have records of negative results so that a clear understanding of absence of the species as well as monitoring effort can be gathered.<br><br>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. Some of the monitoring methods that could be employed include:<br><br>• Rapid Assessment Surveys (optimal for detecting fouling organisms but not for planktonic or soft bottom habitat species);<br>• Settlement plates/panels (panels placed in key areas for a pre-determined amount of time and checked periodically for marine growth or analysed in a lab); and<br>• 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).<br>Stakeholders can contact NRW for guidance on monitoring INNS at their site at: **invasive.non.native@naturalresourceswales.gov.uk**<br><br>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.<br><br>NRW recommend that INNS sightings should be reported to:<br>• iRecord online [www.irecord.org.uk/]; and<br>• iRecord App [available on Google Play]. | See actions above. |

| Responsible stakeholder | Guidance for Development of Actions | Example actions |
|---|---|---|
| All Stakeholders continued | Potential INNS sightings can also be reported directly to NRW at: **invasive.non.native@naturalresourceswales.gov.uk**<br><br>Reporters should take photos and make a note of the sighting location (ideally GPS coordinates). If possible, they should take 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. |
| 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).<br><br>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.<br><br>The ID and reporting of the trumpet tubeworm should be requested from any marine benthic and coastal sampling conducted in Welsh | • Undertake a critical analysis of the data-flow for national INNS reports.<br><br>• Ensure that priority INNS reports are flagged with relevant stakeholders (e.g. iRecord species alert notifications). |

| Responsible stakeholder | Guidance for Development of Actions | Example actions |
|---|---|---|
| Authorities continued | waters (i.e., it should be a standing requirement to report trumpet tubeworms recorded during sampling).<br><br>Making use of existing reporting channels used by operatives in key sectors is also encouraged. For example, the reporting of INNS, including the trumpet tubeworm, could be facilitated on the commercial fishing reporting "Catch Recording App" to make it easier for fishers to log sightings.<br><br>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.<br><br>While the method by which information is gathered will depend on reporting processes, it may be beneficial for authorities and key stakeholders to maintain a shared species-specific database/dataset containing, as a minimum, the NGR (or latitude and longitude), date and nature of the record. | See actions above. |

## 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.<br><br>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, trumpet tubeworm sightings in new areas. | • Engage in the biosecurity framework for Welsh marine areas in some capacity.<br><br>• 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.<br>Authorities should ensure close working and collaboration with relevant authorities (and other stakeholders) in England (e.g., the Environment Agency) | • Ongoing stakeholder engagement to keep INNS at the forefront of stakeholders' activities and awareness.<br>• Establish/task an existing working group with coordinating collaborative working.<br>• Engage and coordinate with stakeholders to monitor progress and assess future support needs |

# Control and management methods

Table 4 contains a list of control methods for the trumpet tubeworm 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 trumpet tubeworm 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 trumpet tubeworm 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 4. A list of control methods for the trumpet tubeworm 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-FE-1** | **Osmotic stress** | This process involves immersing the trumpet tubeworm in water that has a salinity outside of the limits it can tolerate. Hypo- and hyper-saline (i.e., freshwater and brine water) environments prevent establishment or reduce trumpet tubeworm abundance.<br><br>One method of achieving this is to temporarily move floating colonised infrastructure that is in brackish or saline water into hyposaline water/freshwater (salinity <3 ppt, ideally 0 ppt) or into hypersaline water (salinity >40 ppt).<br><br>An example could be to use freshwater in power station cooling systems instead of brackish or saline water. Seawater should not be allowed to enter freshwater bodies during trumpet tubeworm spawning periods (keep sluice gates or other temporary barriers closed during this time). |

| ID | Action | Information |
|---|---|---|
| **C-FE-2** | **Manually scrape populations from hard surfaces** | This process involves the removal of colonised surfaces from the water (where possible) and the scraping off of trumpet tubeworm colonies by hand, using a hand scraper. All fragments should be captured and disposed of on land. They should not be allowed to re-enter the water, since fragments can create new populations. Physical stress can also cause INNS to spawn.<br><br>Where colonised surfaces cannot be removed from the water (i.e. a diver is required), this may be subject to marine licensing and Natural Resources Wales should be contacted for further advice.<br><br>Where the trumpet tubeworm has been killed, either naturally or due to treatment, tubes should be removed from structures as they can act as a settlement substrate, facilitating recolonisation. If not removed, the tubes can persist for years. |
| **C-FE-3** | **Mechanically scrape populations from seabed / hard structures** | This process involves the large-scale removal of the trumpet tubeworm from the seabed using a digger or a dredger.<br><br>Be aware that fragments that disperse into the water during removal could form new populations and that physical stress can cause INNS to spawn. |
| **C-FE-4** | **Apply anti-fouling paints** | This process involves the application of anti-fouling paint to vessels and other infrastructure to prevent the establishment of the fouling species (e.g., trumpet tubeworm), although control of the trumpet tubeworm using this method has been proven as relatively unsuccessful to date.<br><br>The trumpet tubeworm has proven resistant to an anti-marine borer timber preservative that comprised a solution of copper, chromium and arsenic compounds (CCA). In a study, their abundance was higher on treated timber than untreated. |
| **C-FE-5** | **Deoxygenation of water in contained areas (i.e., ballast water)** | This process involves lowering oxygen levels to that beyond the tolerance limit of the trumpet tubeworm. Deoxygenation has proven relatively effective for larvae of the trumpet tubeworm in ballast water. Deoxygenation of ballast water tanks to oxygen levels <0.8 mg/l using nitrogen gas killed 80% of trumpet tubeworm larvae after two days of exposure. |

| ID | Action | Information |
|---|---|---|
| **C-FE-6** | **Environmental restoration** | This process involves the restoration of polluted environments that are favoured by the trumpet tubeworm.<br><br>The trumpet tubeworm generally prefers warm eutrophic waters. In Tunisia, populations were observed to disappear after the restoration of a lagoon from a eutrophic to an oligotrophic state (i.e., normal nutrient levels). Other influential factors may have been decreases in water temperature, increases in water circulation and depth, and a shift from a brackish to a marine environment after restoration. |
| **C-FE-7** | **Desiccation** | This process involves drying the trumpet tubeworm to cause death.<br><br>Infrastructure should be removed from the water to dry the trumpet tubeworm.<br>This may not be particularly effective unless the trumpet tubeworm is left to dry for multiple weeks since the trumpet tubeworm can seal its tube to prevent it drying. Desiccation of other INNS (e.g., *Didemnum vexillum*) has not been proven effective. |
| **C-FE-8** | **Encapsulation / containment** | This process involves wrapping infrastructure that is colonised by the trumpet tubeworm in plastic. Complete encapsulation lowers oxygen levels and can cause mortality. Additionally, adding a biocide to the enclosed water such as chlorine (in the form of liquid sodium hypochlorite or chlorine releasing tablets) or acetic acid will accelerate and maximise the impact of encapsulation. An alternative is for boats or other floating infrastructure can be taken into a specialised pontoon containing enclosed seawater. A biocide can then be added to the water.<br><br>Other potential biocides are calcium (hydro)oxide, bromine, ferrate, hydrogen peroxide, peracetic acid, disinfectants, descalers. However, no evidence could be found that they have been used to successfully treat trumpet tubeworm populations. The period over which the treatment is carried out for it to be effective may have to be longer for the trumpet tubeworm than for other INNS, since the calcareous tube of the trumpet tubeworm can be sealed by the worm, protecting it from exposure to adverse conditions. |

| ID | Action | Information |
|---|---|---|
| **C-FE-9** | **Heat treatment** | This process involves the use of high temperatures to kill the trumpet tubeworm.<br>Heat elements contained in wooden boxes or underwater flame torches could be used to treat specific areas of infrastructure underwater. Heat treatment could also be considered for water used in cooling systems in power plants.<br>This may only be effective for larvae, as the calcareous tubes of the trumpet tubeworm may offer some protection from heat. |

More information on all of the above control options can be found in the 2023 Cawthron Report 3936 by Floerl and Lovett.

# Useful Resources

- **GB NNSS trumpet tubeworm information page**
- **CABI Compendium trumpet tubeworm information page**
- **Marine Life Information Network (MarLIN) trumpet tubeworm information page**
- **Nature Biodiversity Network (NBN) Atlas trumpet tubeworm records**
- **RYA The Green Blue Invasive Species Prevention guidance**
- **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, *Ocinebrellus 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).

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# Data References

*Table 5 Rightsholders and data providers for the open-source data downloaded from NBN Atlas for the purpose of this report.*

| Data Providers | Rights holders |
|---|---|
| Environment Agency | Environment Agency |
| Joint Nature Conservation Committee | Joint Nature Conservation Committee |
| Marine Biological Association | Marine Biological Association |
| National Trust | Marine Biological Association, and Biological Records Centre |
| Natural England | National Trust |
| Natural History Museum, London | Natural England |
| Natural Resources Wales | Natural Resources Wales |
| Seasearch | Seasearch |
| West Wales Biodiversity Information Centre | West Wales Biodiversity Information Centre |

**Data Set References:**

2004-2012 Bishop et al. Occurrence of non-native sessile invertebrates on the English coast by Marine Biological Association under licence CC BY.
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