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STATE OF KNOWLEDGE

Marine and Coastal non-indigenous and invasive species in Ireland

An Roinn Comhshaoil,
Aeráide agus Cumarsáide
Department of the Environment,
Climate and Communications

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More information can be found at http://invasives.ie

National Biodiversity Data Centre
Beechfield House,
South East Technological University West Campus,
Carriganore, Co. Waterford,
Ireland. X91 PE03

An Roinn Comhshaoil, Aeráide agus Cumarsáide
Department of the Environment, Climate and Communications

Executive Summary

The Marine Strategy Framework Directive (MSFD) provides the overarching European policy framework for achieving Good Environmental Status (GES) in marine waters, including Descriptor 2 which addresses non-indigenous and invasive species (NIIS). Under this descriptor, Good Environmental Status is achieved when human-mediated introductions of NIIS do not adversely alter ecosystems. Irelands Marine Strategy Part 1 (2020) identified the status of Ireland's marine environment and the gaps to achieving and/or maintaining GES. To close these gaps Ireland revised its Marine Strategy Part 3 (2022): Programme of Measures (PoMs), during which a measure was identified to develop a management strategy for coastal and marine areas. In 2023, funding was approved under the MSFD Unit of the Department of Housing, Local Government and Heritage (now the Department of Climate, Energy and Environment) to support a national programme delivered by the National Biodiversity Data Centreto develop this measure. In 2025 it was decided, with support from the programme's steering committee, to develop this into an all-island strategy. This report consolidates existing research and monitoring to establish a baseline understanding to inform an all-island strategy.

Current evidence shows that some marine non-indigenous and invasive species are well established in Irish waters, with 139 species recorded across multiple data sources. Species continue to be detected through targeted monitoring, while further taxa are identified as potential future invaders through horizon scanning. The majority of species originate from Indo-Pacific regions, with molluscs and arthropods among the most frequently recorded groups. Horizon scanning studies consistently demonstrate time-lagged species arrival from mainland Europe, supporting predictive monitoring based on neighbouring country datasets. New introductions continue to occur, with recent records confirming ongoing arrivals despite existing biosecurity measures.

Monitoring systems across Ireland and Northern Ireland are extensive but fragmented, combining targeted surveillance and wider environmental monitoring programmes. Aquaculture sites have been monitored in Ireland since 2013 using structured Shellfish Associated Species Inventory (SASI). These surveys are supported by Dutch shellfish importers, and more recently, since 2018 further supported by Bord Iascaigh Mhara (BIM). In Northern Ireland, the Department of Agriculture, Environment and Rural Affairs (DAERA) has expanded monitoring to shellfish production areas using comparable methodologies. Marinas are another key surveillance focus due to their role as high-risk introduction hubs, with Rapid Assessment Surveys (RAS) commissioned by the National Parks and Wildlife Service (NPWS) in Ireland and DAERA in Northern Ireland identifying repeated introductions and new records over time. Commercial ports, particularly Dublin, represent major entry points due to high vessel traffic and associated ballast water and hull fouling risks, yet are a monitoring gap.

Broader environmental monitoring programmes, including those undertaken under the Water Framework Directive, generate valuable records of marine invasive species. However, these records are often dispersed across organisations and monitoring programmes, limiting their accessibility and wider use. Establishing the National Biodiversity Data Centre as a central repository for marine invasive species records would provide a significant benefit by collating observations collected through existing monitoring activities. This would improve data integration, facilitate information sharing across agencies and sectors, and strengthen national surveillance and early detection efforts. In Northern Ireland, the Centre for Environmental Data and Recording (CEDaR) manages species data. Despite these existing data management structures, gaps remain in the integration of records from scientific, regulatory, and sector-specific monitoring programmes.

Pathways and vectors of introduction are dominated by maritime transport mechanisms, including ballast water discharge, hull fouling, aquaculture movements, and recreational boating. The Ballast Water Management Convention (BWMC), adopted in 2004 and brought into force in Ireland in 2023, provides a legally binding global framework for controlling the introduction of invasive aquatic species via ships' ballast water. Compliance is mandatory for ships, and it remains the only pathway of introduction that is currently subject to an IMO convention. Analysis consistently highlights shipping as the primary driver of introductions (European Environment Agency, 2024), with secondary spread facilitated by marinas and coastal connectivity. Risk assessments show that Ireland's south and east coasts are most exposed to incoming and secondary spread risks, with areas such as Waterford identified as high-risk convergence zones due to overlapping maritime activities and proximity to external source populations.

These bridgehead sites — locations where multiple pathways converge — play a critical role in facilitating further spread. These include marinas co-located with aquaculture activities and high-traffic ports.

Risk assessment frameworks underpin management decision-making but remain constrained by data gaps and methodological variability. A two-stage national framework developed under Invasive Species Ireland supports species prioritisation and detailed assessment, while recent initiatives such as the Shared Island Biosecurity and Invasive Species Initiative aim to standardise approaches through a unified risk register and GIS-based screening tools. Despite progress, only a fraction of known marine invasive species have been formally assessed.

In the Republic of Ireland, aquaculture-specific biosecurity systems are among the most developed sectoral responses, incorporating risk assessments, biosecurity protocols, and controls. These systems are supported by a national working group of marine invasive species experts spanning science, policy and management.

Management responses include international ballast water regulations and biofouling guidelines under the International Maritime Organization (IMO), alongside regional cooperation through OSPAR and related frameworks. However, eradication of marine invasive species in the marine environment remains rare globally, reinforcing prevention as the most effective and cost-efficient strategy. Rapid response is most successful when invasions are detected early and remain spatially limited, though containment is more realistic in most marine contexts.

Public awareness and engagement are supported through coordinated campaigns such as "Check, Clean, Dry" and Invasive Species Week, alongside national and regional education programmes. These initiatives target key user groups including boaters, anglers, aquaculture operators, and the wider public.

Species identification training, citizen science platforms, and sector-specific guidance further strengthen early detection capacity and compliance with biosecurity measures.

Marine invasive species generate significant environmental, economic, and potential human health impacts, including habitat alteration, biodiversity loss, infrastructure fouling, and costs associated with management and control. However, economic impact data for the island of Ireland remains limited, highlighting a major evidence gap.

Overall, while Ireland and Northern Ireland have developed a comprehensive suite of monitoring programmes, risk assessments, and policy tools, significant fragmentation remains across data systems and implementation structures. The evidence strongly supports the need for a coordinated all-island strategy underpinned by improved data integration, systematic gap analysis, harmonised monitoring, and strengthened pathway management. Prevention, early detection, and rapid response remain the most effective approaches for reducing the long-term ecological and economic impacts of marine invasive species.



Watersipora subatra © Ann Haigh

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Abbreviations and Acronyms

AFBI	Agri-Food and Biosciences Institute
AIS	Automatic Identification System
BIM	Bord Iascaigh Mhara
BWMC	Ballast Water Management Convention
CBD	Convention on Biological Diversity
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CIS	Common Implementation Strategy
DAERA	Department of Agriculture, Environment and Rural Affairs
DAFM	Department of Agriculture, Food and the Marine
DCEE	Department of Climate, Energy and the Environment
DFI	Department for Infrastructure
EIA	Environmental Impact Assessment
EMFAF	European Maritime Fisheries and Aquaculture Fund
EMFF	European Maritime and Fisheries Fund
EPA	Environmental Protection Agency
GES	Good Environmental Status
HELCOM	Baltic Marine Environment Protection Commission also known as the Helsinki Commission
IAS	Invasive Alien Species
IFI	Inland Fisheries Ireland
IMO	International Maritime Organization
IMREC	Marine Recreational Fishery in Ireland
JRC	Joint Regional Council
MARA	Maritime Area Regulatory Authority
MEPC	Marine Environment Protection Committee
MI	Marine Institute
MINNSMP	Marine Invasive Non-Native Species Management Plan
MMO	Marine Management Organisation
MSFD	Marine Strategy Framework Directive
NBAP	National Biodiversity Action Plan
NIEA	Northern Ireland Environment Agency
NIIS	Non-Indigenous and Invasive Species
NPWS	National Parks and Wildlife Service
OSPAR	Oslo Paris Convention
PAP	Pathway Action Plan
RAS	Rapid Assessment Survey
SAC	Special Areas of Conservation
SASI	Shellfish Associated Species Inventory
SPA	Special Protection Areas
WFD	Water Framework Directive

1. Introduction

The Marine Strategy Framework Directive [2008/56/EC] (MSFD) came into force in 2008. Under the Directive, 11 descriptors define what the marine environment will look like when good environmental status is achieved. Under MSFD Descriptor 2, Good Environmental Status (GES) is achieved where:

> *"Non-indigenous species (NIS) introduced by human activities are at levels that do not adversely alter the ecosystems"*

Ireland's MSFD Assessment (2024 described the GES for Descriptor 2 as:

> *"The number of non-indigenous species which are newly introduced via human activity into the wild, per assessment period is minimised and where possible reduced to zero".*

In that assessment and in the recent (December 2022) update on the Article 13 Programme of Measures to tackle the pressures associated with Descriptor 2, a non-indigenous species and invasive species management strategy for marine and coastal areas was proposed, hereafter referred to as the **Marine and Coastal Non-Native Species Strategy.**

In late 2023, government funding was provided to deliver a to what is known in Ireland's Marine Strategy Part 3 (2022): Programme of Measures (PoMs) M232; A Management Strategy for Coastal and Marine Areas. This programme of work will be delivered by The National Biodiversity Data Centre.

A number of detailed studies have been carried out in recent years on the introduction, presence, spread, horizon scanning, and recommendations for surveillance and monitoring of, marine non-indigenous and invasive species in Ireland. This report summarises these elements to help build a picture of our current State of Knowledge and serve as baseline information upon which to build . Following a decision to expand the Management Strategy to an all-island approach in 2025, this report provides context in both jurisdictions.

It should be noted that the terms "non-indigenous", "non-native", and "alien" are synonymous and are used interchangeably throughout the literature on this topic globally, including their use in relevant legislation and policy.



Sargassum muticum © Victoria Poppleton

An alien (non-indigenous/non-native) species is any live organism introduced by human activity outside its natural range. This includes viable parts, gametes, seeds, eggs, propagules, hybrids, varieties and breeds capable of survival or reproduction, as defined in CBD Decision VI/23 and Regulation (EU) No 1143/2014. The inclusion of these life stages does not imply that all introduced organisms must be capable of survival or reproduction; an organism transported beyond its natural range is considered alien regardless of whether it subsequently survives.

Throughout this document, NIIS is used to refer to non-indigenous and invasive species.

Legally, the concept of introduction includes both transport and release. In practice, however, the movement of a species outside its native range is often sufficient for it to be regarded as alien, irrespective of whether it is released into the wild. A species is considered invasive once it establishes self-sustaining populations and spreads, causing or having the potential to cause adverse impacts.

The term cryptogenic species refers to species whose native biogeographic origin is unknown, making it difficult to determine whether they are native or alien. While some cryptogenic species may be inferred to be non-indigenous based on their sudden appearance and rapid spread, in many cases their status cannot be determined with certainty.

1. Legal policy and framework

Table 1.1: Domestic (Northern Ireland and Ireland), EU, Regional and global Frameworks which regulate the protection of the marine environment which regulates the protection of the marine environment.

Legal Policy and Framework	Description	National Legislation
Marine Strategy Framework Directive (MSFD) [DIRECTIVE 2008/56/EC]	Descriptor 2 (D2) of the MSFD focuses on Non-Indigenous Species. Good Environmental Status (GES) for D2 describes GES as where "*Non-indigenous species (NIS) introduced by human activities are at levels that do not adversely alter the ecosystems*". It includes one primary criterion (D2C1: number of new NIS introductions) and two secondary criteria (D2C2: abundance and spatial distribution of established non-indigenous species and D2C3: the proportion of a species group or the spatial extent of a habitat that is adversely altered by invasive non-indigenous species). At an EU level, the MSFD Common Implementation Strategy Working Group on GES has the mandate to develop common approaches for assessing the environmental status of marine waters, in order to ensure coherence and consistency of GES across all marine regions/subregions. The work relevant to D2 is carried by national appointed experts under the coordination of the Joint Research Centre	**The European Communities (Marine Strategy Framework) Regulations 2011 (S.I. No. 249/2011)**) in Ireland **The UK Marine Strategy Regulations (2010**) in Northern Ireland
European Union (Invasive Alien Species) Regulations 2024 (1143/2014)	Stipulates rules to prevent, minimise and mitigate the adverse impacts on biodiversity from the introduction and spread (both intentional and unintentional) of Invasive Alien Species. Under this legal framework, species listed are banned from being imported, kept, sold, bred, grown or released into natural environments. The Regulation also requires systems for early detection and rapid eradication of Species of Union Concern during the initial stages of invasion, as well as ongoing management measures for IAS that are already extensively established.	**European Union (Invasive Alien Species) Regulations 2024 (SI 374/2024)** function to give effect to 1143/2014 in Ireland, with provisions to deal with IAS of national concern. This regulation makes provisions to enact Regulations 49 and 50 (in reference to third schedule species) of the European Communities (Birds and Natural Habitats) Regulations 2011. **The Invasive Alien Species (Enforcement and Permitting) Order (Northern Ireland) 2019.**
The Birds Directive (2009/147/EC) & **The Habitats Directive (92/43/EEC)**	These complementary pieces of legislation are aimed at protecting nature. Under the Birds Directive, Special Protection Areas (SPAs) must be designated to conserve naturally occurring wild bird species and their habitats. The Habitats Directive similarly requires the designation of Special Areas of Conservation (SACs) to safeguard natural habitats along with wild plant and animal species. Although invasive species are not specifically mentioned, their monitoring is implicitly required at these sites due to the threat they pose.	**European Communities (Birds and Natural Habitats) Regulations 2011**(S.I. No. 477/2011) in Ireland. **Conservation (Natural Habitats, etc.) Regulations (Northern Ireland) 1995 (as amended**) in Northern Ireland.

Legal Policy and Framework	Description	National Legislation
Water Framework Directive 2000/60/EC	The Water Framework Directive (WFD) acts as a framework for the development of integrated water management plans which address the issues of water use, water quality, river morphology, and the ecological value of waterbodies and their surrounding areas	**Water Framework Directive (2000/60/EC) European Communities (Water Policy) Regulations 2003 (S.I. No. 722/2003)** in Ireland **Water Environment (Water Framework Directive) Regulations (Northern Ireland) 2017** in Northern Ireland
Council Regulation (EC) No. 708/ 2007 concerning the use of alien and locally absent species in aquaculture	The Regulations require the translocation/ introduction of Alien and Locally Absent Species to be authorised by the Competent Authority, and to be recorded in a publicly available register. It allows exceptions for specific cases such as closed recirculation systems, where the risks of interactions with the external environment are minimal. It also recognises that some alien species have commonly been used in aquaculture for a long time in certain parts of the EU – for example, Carp and Pacific Oyster. These species, listed in Annex IV to the Regulation, are exempt from most provisions of the Regulation	**Council Regulation (EC) No. 708/ 2007 concerning the use of alien and locally absent species in aquaculture** in Ireland. **The Alien and Locally Absent Species (Aquaculture) (Amendment) (EU Exit) Regulations (Northern Ireland) 2020,** in Northern Ireland.
Nature Restoration Law (regulation (EU) 2024/1991)	Sets legally binding targets to restore degraded ecosystems across land and sea, including **marine habitats.** It applies to both coastal and offshore marine environments and aims to improve biodiversity and ecosystem condition in these areas. The Nature Restoration Law is a core component of the EU Biodiversity Strategy, a policy framework that acts as a roadmap for nature objectives.	**Nature Restoration Law (regulation (EU) 2024/1991)** in Ireland **Marine Spatial Planning (MSP) Directive 2014/89/EU** Not directly transposed into UK law but similar nature recovery goals are addressed through **the Environment Act 2021** and **Northern Ireland's Nature Recovery Strategy** **The Marine Act (Northern Ireland) 2013** Marine and Coastal Access Act 2009
Common Fisheries Policy (CPF) Regulation (EU) No 1380/2013	A set of rules and regulations for managing European fishing fleets and conserving fish stocks within the European Union. The CFP relates to marine invasive species by aiming to integrate environmental protection into fisheries management, specifically targeting the reduction of accidental introductions via fishing activities and supporting initiatives to manage the impact of these species on marine ecosystems	**Fisheries (Amendment) Act 1997 (No. 23 of 1997)** in Ireland provides a framework for regulating the movement and introduction of organisms via aquaculture **Wildlife Act 1976 & Wildlife (Amendment) Act 2000** in Ireland **Fisheries Act (Northern Ireland) 1966** The Wildlife and Natural Environment Act (Northern Ireland) 2011.
Ireland's 4th National Biodiversity Action Plan (NBAP)	A statutory, government-wide framework designed to halt and reverse biodiversity loss. It includes 194 actions, including tackling invasive species	Focused on Ireland, but includes all-island initiatives and aims for enhanced cross-border cooperation with Northern Ireland on shared ecological issues such as invasive species management.

Table1.2: International Agreements and Conventions

Legal Policy and Framework	Description	National Legislation
Convention on Biological Diversity	A global agreement aimed at reversing biodiversity loss. The Kunming-Montreal Global Biodiversity Framework was adopted for action over the decade to 2030, of which, Target 6 is focused on invasive alien species; Eliminate, minimize, reduce and or mitigate the impacts of invasive alien species on biodiversity and ecosystem services by identifying and managing pathways of the introduction of alien species, preventing the introduction and establishment of priority invasive alien species, reducing the rates of introduction and establishment of other known or potential invasive alien species by at least 50 per cent, by 2030, eradicating or controlling invasive alien species especially in priority sites, such as islands	**EU Invasive Alien Species Regulations (1143/214)** **European Communities (Birds and Natural Habitats) Regulations 2011** **Ireland's 4th National Biodiversity Action Plan**
The International Convention for the Control and Management of Ship' Ballast Water and Sediments (BWMC) 2004	Its purpose is to introduce global regulations to control the transfer of potentially invasive species via ship ballast water. The Convention requires ships to manage their ballast water to remove, render harmless, or avoid the uptake or discharge of, aquatic organisms and pathogens within ballast water and sediments.	**Sea Pollution (Ballast Water Management Convention) (Amendment) Regulations 2023** in Ireland **The Merchant Shipping (Control and Management of Ships' Ballast Water and Sediments) Regulations 2022** in Northern Ireland
OSPAR Convention (The Oslo Paris Convention for the Protection of the Marine Environment of the North-East Atlantic)	A mechanism by which 15 Governments and the European Union cooperate to protect the marine environment of the North-east Atlantic, which includes targets for protection, conservation and restoration to achieve biologically diverse and healthy seas.	**OSPAR has an OSPAR AQUIS which are a set of legally binding Decisions, and then non-legally binding Recommendations and Agreements**
Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animals) 1979	The Convention establishes a legal framework requiring parties to protect endangered migratory species and their habitats from threats, including the introduction of invasive non-native species.	**European Communities (Birds and Natural Habitats) Regulations 2011**(S.I. No. 477/2011) in Ireland. **Conservation (Natural Habitats, etc.) Regulations (Northern Ireland) 1995 (as amended)** in Northern Ireland. **ASCOBANS Agreement** **Natura 2000 network**
Convention on International Trade in Endangered Species (CITES) 1973	The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an international treaty, that protects over 40,000 species of animals and plants by regulating their international trade. It ensures that commercial trade in live specimens, products, and parts does not threaten their survival in the wild. IT acts as a regulatory tool that helps prevent the accidental or intentional introduction of non-native marine species into new ecosystems.	**Wildlife Act 1976 & Wildlife (Amendment) Act 2000 in Ireland** **The Invasive Alien Species (Enforcement and Permitting) Order (Northern Ireland) 2019.**

2. Marine Non-Indigenous and Invasive Species in Ireland

The most recent total for Ireland listed 110 marine non-indigenous and invasive species (Gittenberger *et al.*, 2023). For the purpose of the MSFD assessment, the number of newly-introduced species to Ireland within each reporting cycle (6 years) was compiled. The number of new non-indigenous species was summed for three periods 2003-2008, 2009-2014 and 2015-2020 corresponding to MSFD reporting periods. The total number of newly arrived non-indigenous species reported for the period 2003-2020 was 39 and the rate of observed new species introductions for the latest assessment period (2015-2020) appears to have declined since the previous period (2009-2014), with estimates of 14, 15 and 13 new introductions in each reporting period. The Gittenberger paper presents an analysis of those recorded in Ireland up to the year 2020, if their spread was deemed likely to be connected with anthropogenic activities. Inclusion criterion in the study were macrofauna and macroflora greater than 2mm in marine and brackish waters, originating from outside the north-east Atlantic region within the last three decades.

A 2019 report from Miramin *et al.* listed 122 marine non-indigenous and invasive species in Irish waters. The report included some species associated with estuarine and brackish environments, as well as some coastal species (e.g. smooth cord-grass, *Spartina anglica*) not included in Gittenberger *et al.*, (2023). Of the 122 listed, some species were ranked according to their potential impacts; 25 species were identified as moderate risk, 20 as high risk, and 6 as low risk. The remaining 71 species were not risk assessed.

A further four new species for Ireland were recorded between 2023-2025 during targeted monitoring at aquaculture sites and marinas (Tidbury *et al.*, 2026).

In Northern Ireland there are an additional three species listed as present on marine invasive species lists held by the Department of Agriculture, Environment and Rural Affairs and on the Marine Biodiversity Data Portal NI, which are not recorded as present in the Republic of Ireland;

Anotrichium furcellatum, Bispora polyomma and *Ensis leei.* An amalgamation of these reports provides a combined list of 139 species (Annex 1).

An additional 94 species were identified by Miramin *et al*(2019) as potential future invaders, based on being established in areas directly linked to Ireland by recognised pathways. In the six years since publication, some species listed have been recorded as present in Ireland.

The majority of non-indigenous and invasive species in Ireland, originate from Indo-Pacific regions (Gittenberger *et al.*, 2023). 75% of new species records spanning the last 30 years originate in these regions (Cook *et al.*, 2016), with similar statistics reported for both France (Massé *et al.*, 2023) and the Netherlands (Gittenberger *et al.*, 2023). Molluscs and arthropods are the most prevalent non-indigenous and invasive species currently recorded in Ireland (Miramin *et al.*, 2019).

Regulation (EU) No 1143/2014 on the prevention and management of the introduction and spread of invasive alien species is a binding legal instrument across the European Union. The core of the Regulation is the list of Invasive Alien Species of Union concern, which currently contains 114 species, including seven associated with marine or estuarine environments. The Regulation also continues to apply in Northern Ireland under the Windsor Framework.

Table 2.1: Marine and coastal species on the First Schedule list of Invasive Alien Species of Union concern.

Species	Common Name	Present on the island of Ireland
Eriochier sinensis	Chinese mitten crab	**Y**
Asterias amurensis	Northern Pacific sea star	**N**
Mulina lateralis	Dwarf surf clam	**N**
Nanozostera japonica	Dwarf eelgrass	**N**
Rugulopteryx okamurae	An alga	**N**
Fundulus heteroclitus	Mummichog	**N**
Plotosus lineatus	Striped eel catfish	**N**

The First Schedule list of Invasive Alien Species of national concern in the European Union (Invasive Alien Species) Regulations 2023 (S.I.No.374 of 2024) includes 13 marine and coastal species, 10 of which are present in the Republic of Ireland (Table 2).

Table 2.2: Marine and coastal species on the First Schedule list of Invasive Alien Species of National concern.

Species	Common Name	Present on the island of Ireland
Undaria pinnatifida	Wakame	**Y**
Sargassum muticum	Wireweed	**Y**
Didemnum spp	Carpet sea squirt	**Y**
Perophora japonica	Colonial sea squirt	**Y**
Balanus improvises	Bay barnacle	**Y**
Eriochier sinensis	Chinese mitten crab	**Y**
Caprella mutica	Japanese skeleton shrimp	**Y**
Crepidula fornicata	Slipper limpet	**Y**
Styela clava	Leathery sea squirt	**Y**
Spartina (all species)	Cord grass	**Y**
Ceratostoma inornatum	Asian oyster drill	**N**
Urosalpinx cinerea	American oyster drill	**N**
Grateloupia doryphora	Red alga	**N**



Sargassum muticum Wireweed ©Shutterstock ChWeiss

3. Monitoring and Early Detection

3.1 Targeted marine invasive species monitoring

3.1.1 Aquaculture Sites

Monitoring for non-indigenous and invasive species has been ongoing within the aquaculture sector since 2013 (Devine *et al.*, 2023). Surveys were initially implemented by the Dutch government via specialist consultants GiMaRIS, to reduce the introduction of non-indigenous and invasive species through shellfish transports from Ireland into Dutch aquaculture export sites. Legislation required these surveys to follow the Shellfish Associated Species Inventory (SASI) methodology and were originally organised directly between Irish operators and the Dutch importers they were selling to.

Bord Iascaigh Mhara (BIM), Ireland's Seafood Development Agency have commissioned these surveys since 2018 which has developed into an ongoing Invasive Alien Species work programme. They have also expanded their scope to cover all the majority of aquaculture growing bays and some non-aquaculture areas (Devine *et al.*, 2023). During a SASI, 70-90 5kg samples of shellfish are collected in a shellfish production area and all animal and algal species found in these samples are scored. Each species is photographed at least once and those which cannot be identified in the field, are preserved and sent for identification in the lab, sometimes with the assistance of DNA analysis. A species accumulation curve analysis is performed to assess survey comprehensiveness (GiMaRIS, no date).

Between 2010 and 2022, 151 SASIs have been carried out in Ireland, covering 40 shellfish production areas (Devine *et al.*, 2023). Survey data are available to view via the National Biodiversity Data Centre, Biodiversity Maps Data Portal. These sites have included bottom culture, rope culture, and trestles in areas of both oyster and mussel production. Areas are surveyed every three years, however an area may be visited for mussel culture one year and oyster culture on another (Devine *et al.*, 2023).

It is worth noting that as well as the SASI, test sampling is carried out when imported shellfish arrive in the Netherlands (Smoulders and Gittenberger, 2014). These Dutch legislative measure are collectively known as the Shellfish Import Monitoring and action Protocol (SIMP) (GiMaRIS, no date).

BIM also conduct biomass surveys of ephemeral seed mussel beds annually. Seed bed sites are located along both the east and southwest coasts of Ireland. In County Wexford these include Rusk Channel, Wexford Harbour, Blackwater Estuary, Rosslare Harbour, Long Bank, Cahore, and Glassgorman while Wicklow Head lies further north in County Wicklow. Sites on the southwest coast in County Kerry are Castlemaine Harbour and Cromane.

When a seed bed is determined to be viable, a seed mussel stock assessment and Invasive Alien Species screening survey is carried out. Should an invasive species be detected, further surveys are commissioned to determine the extent and spread of the species.

In 2016, BIM established the Invasive Alien Species and Aquaculture Working Group to oversee the development of the Risk Assessment and Biosecurity Planning template for the sector and to advise on issues of concern. The IAS Working Group is made up of marine invasive species experts spanning science, policy and management. BIM is responsible for preparing a Risk Assessment and convening the IAS Working Group to make recommendations to the Department of Agriculture, Food and the Marine.

Monitoring for marine NIIS at shellfish aquaculture sites in Northern Ireland is carried out by the Department of Agriculture, Environment and Rural Affairs (DAERA). Methods used closely follow those developed for marina surveys (see below) and commenced in 2025 at 6 locations (Carlingford Lough, Dundrum Bay, Killough and Strangford Lough all located in County Down, as well as Larne Lough in County Antrim). Samples are taken from 30 locations within each site, chosen based on their association with marine NIIS species (e.g. trestle tables, underside of oyster bags and adjacent sediment). SACFOR abundance (a standardized semi-quantitative scale used to assess the relative abundance of benthic flora and fauna) recording is used for each marine NIIS detected and those for which positive identification can be obtained in the field are preserved and analysed in the lab, potentially including DNA barcoding (Tidbury *et al.*, 2026).

3.1.2 Marinas

Monitoring for marine NIIS at marinas is common worldwide as they can provide an abundance of artificial structures which can act as a habitat for fouling species (Ferrario *et al.*, 2017; Gittenberger *et al.*, 2023; O'Shaughnessy *et al.*, 2023).

The Rapid Assessment Survey (RAS) is a widely used technique for efficiently examining extensive geographic areas within limited timeframes. It is a qualitative survey method that involves timed searches of defined habitats, during which focal species are recorded using an abundance scale (Arenas *et al.*, 2006; O'Shaughnessy *et al.*, 2023). The methodology requires surveyors to carry out timed, visual assessments of non-native and invasive species from a predetermined target list, as well as scrape samples, which are taken to the lab for microscopic identification (O'Shaunessy *et al.*, 2023). When applied to recreational marinas, RAS enables the evaluation of species abundance across broad expanses of submerged and intertidal hard substrates, such as pontoons and harbour walls. This approach has been implemented internationally to detect, map, and monitor the presence, distribution, and abundance of non-native species, as well as to identify newly introduced taxa.

RAS for marine non-indigenous and invasive species in marinas was carried out across 29 floating pontoons sites across the island of Ireland in 2005 and 2006 (Minchin, 2007). Twelve NIIS species were found and 25 new locality records were identified. Four of the recorded NIIS species were new to Ireland.

Since then, the National Parks and Wildlife Service (NPWS) have commissioned RAS in the Republic of Ireland detailed in Table 3.

Table 3.1 Rapid Assessment of Marinas for marine NIIS targeted monitoring in Ireland

Year	Number of marinas surveyed	Number of marine NIIS recorded	Number of new NIIS to Ireland	Reference
2021	22	25	4	O'Shaughnessy *et al.*, 2021
2025	23	32	4	Tidbury *et al.*, 2026

Additionally, BIM have carried out surveys at 11 marinas and ports between 2019-2021 (Dun Laoghaire Harbour, Kilmore Quay, Dunmore East, Waterford Marina, Roaringwater Bay dock, Port of Cork, Royal Cork Yacht Club, Cork Harbour Marina, East Ferry Marina Killybegs floating dock and Donegal Bay dock). These were carried out by specialist consultancy GiMaRIS to help develop a more comprehensive baseline of marine NIIS in areas along the coast of Ireland (Devine *et al.*, 2023).

In Northern Ireland, RAS were carried were carried out at 27 sites in 2012 (comprising of large marinas, smaller marinas or sites where there was a single floating boardwalk) by the Northern Ireland Environment Agency (NIEA) (Minchin & Nunn, 2013). A marked change in spread was reported in the six-year period since the all-island RAS surveys were carried out in 2006 and 6 new species were recorded for the Northern Irish coast.

Since 2015, DAERA has carried out annual Rapid Assessment Surveys (RAS) at six major, high-activity marinas: In Northern Ireland Bangor, Carrickfergus, Belfast, Ballycastle, Glenarm, and Rathlin. In addition, DAERA undertakes RAS at a further 18 marinas on a regular basis. These sites are surveyed less frequently, usually at intervals of two to three years, with the timing influenced by available resources and competing survey priorities (Tidbury *et al.*, 2026).

3.1.3 Species Specific Surveys

Species-specific targeted monitoring of marine non-indigenous species has been undertaken in Ireland, although this has generally been conducted through individual projects or targeted surveys rather than as part of a comprehensive, long-term national monitoring programme.

Pacific oyster (Magallana gigas) cultivation began in Ireland in the 1970s, initially based on the assumption that environmental conditions would prevent successful reproduction in the wild (Steele & Mulcahy, 1999). Although feral oysters were reported anecdotally from the 1980s onwards, the first national targeted survey in 2009 confirmed widespread recruitment, particularly in Lough Swilly and Lough Foyle. Further expansion was identified during surveys in 2012–2013, including the establishment of populations in additional bays and increased recruitment at previously recorded sites; Lough Foyle was the main exception, showing a decline in abundance (Zwerschke et al., 2017).

In 2024-2025, the Marine Institute commissioned a comprehensive national survey of feral Pacific oysters across the Republic of Ireland (Gittenberger et al., 2025), building on the previous surveys (Marine Institute, 2023). This included previously surveyed locations alongside additional sites covering sheltered bays, estuaries and selected exposed coastal areas, with the aim of assessing the current distribution of feral oysters and identifying factors associated with their establishment, including proximity to oyster cultivation, artificial structures and suitable settlement habitats.

A total of 171 intertidal locations, covering approximately 125 km of coastline, were surveyed. The results indicate that feral Pacific oysters have become well established and more widely distributed around the Irish coastline, with particularly high abundances along the western coast (Gittenberger et al., 2025) At many locations, populations have increased in abundance over time and several sites contained multiple size classes, indicating ongoing reproduction and recruitment. The main exception was Lough Foyle, where oyster abundance has declined since 2009. This monitoring work demonstrates the value of targeted, repeat national monitoring and provides evidence of how the distribution and abundance of an established marine NIS can be tracked over time.

3.1.3.1 Water Framework Directive Monitoring

The Water Framework Directive establishes a comprehensive legislative framework to protect and restore the health of all water bodies, including rivers, lakes, groundwater, and coastal waters.

Marine monitoring surveys are carried out under the remit of the WFD, which are not directed at NIS, but incidentally record marine NIS. In the Republic of Ireland, the EPA is responsible for the WFD monitoring and assessment programme with other agencies providing data as appropriate.

In Northern Ireland, DAERA are the overarching competent authority responsible for the remit of the WFD. These surveys include those listed in table 3.2.

Table 3.2: Marine environmental monitoring programmes carried out under the Water Framework Directive (WFD) across the island of Ireland

Organisation EPA in Ireland, DAERA in Northern Ireland	Monitoring Programme Intertidal seagrass surveys	Details Assessment of the species composition, spatial extend and cover on intertidal seagrass species	Frequency Waterbodies assessed twice in each 6-year cycle
EPA in Ireland. DAERA in Northern Ireland	Rocky Shore Macroalgae Survey	An assessment of the proportions of red, green , brown and opportunistic macroalgae communities, where surveys are carried out for the presence of specimens against a prescribed list of species.	Each waterbody is assessed twice in each six-year cycle.
EPA (with some data provided by the MI) in Ireland, AFBI in Northern Ireland	Phytoplankton Monitoring Programme	The phytoplankton species in each sample are identified and counted using a microscope and overall phytoplankton abundance is measured	Sampling is carried out three times during the summer and once during the winter in estuaries and coastal waters around Ireland.
EPA (in collaboration with NPWS) in Ireland. DAERA in Northern Ireland	Saltmarsh Surveys	Surveys typically involve a combination of habitat mapping, collecting vegetation data (e.g., typical species present), and recording details on human impacts and other threats to the site. This data helps determine if changes have occurred since previous monitoring periods.	Carried out in 2008, 2017-2018 and repeated again in 2022-2024

Organisation EPA in Ireland, DAERA in Northern Ireland	Monitoring Programme Intertidal seagrass surveys	Details Assessment of the species composition, spatial extend and cover on intertidal seagrass species	Frequency Waterbodies assessed twice in each 6-year cycle
IFI in Ireland, DAERA (in collaboration with AFBI) in Northern Ireland	Transitional Waters Fish Surveys	Conducted to determine the status of fish populations in Ireland's estuaries. Over 300 sites (which include rivers and lakes as well as estuaries) are examined. Sampling of fish is conducted using a variety of methods, including electric fishing and many forms of netting under standardised sampling methods, and provides information on abundance, species composition and age structure of all fish present in a water body.	Over 300 sites are examined in a 3-year rolling programme between June and October.
MI	Benthic Macro-invertebrate Surveys	Biological quality monitoring of transitional and coastal waters through a comprehensive benthic sampling programme. Samples are analysed using an index of invertebrate quality (IQI) developed jointly by the UK and Ireland and reported to the EPA for national assessment. This dataset has previously been interrogated for non-indigenous species	60 waterbodies are sampled once every 3 years
MI	National Crayfish Plague Surveillance Programme	Screening of water samples from 34 catchments using eDNA technology. While this is predominantly a freshwater monitoring programme, targeted sampling is also carried out at Waterford Harbour and Carlingford Lough and all samples are tested for Chinese Mitten Crab (*Eriochier sinensis*).	Annually since 2015
NPWS	Marine Benthic Monitoring	Monitoring with the primary aim of collecting data on protected sites and species	Data is collected and reported every 6 years since 2010
NPWS	Coastal Lagoon Monitoring	Monitoring with the primary aim of collecting data on protected sites and species	Data is collected and reported every 6 years since 2010
DAERA	Benthic Grab Sampling	Grab sampling at 19 sites for benthic analysis. Collabortive sites between WFD monitoring and Clean and Safe Sea Evidence Group CSSEG	Annually

3.1.3.2 Other Scientific Research and Recording

Table 3.3. Monitoring programmes associated with other scientific research, recording or environmental monitoring programmes

Organisation	Monitoring Programme	Details	Frequency
IFI	National Bass Programme	Surveys are conducted in the lower sections of New Ross Port, Lower Suir and Barrow Suir Nore estuaries for juvenile bass. Survey methods include seine netting and beam trawling	Surveys are conducted annually in August or September
AFBI	Crepidula Survey	This survey monitors the extent of the breeding population of *Crepidula fornicata*, the invasive Slipper limpet in Belfast Lough, using a small oyster dredge. This survey is to provide an evidence base to enable policies to be put in place to minimise the spread of NIIS	Annually in August and September

Organisation	Monitoring Programme	Details	Frequency
MI	Galway Bay SmartBay Observatory	As a cabled underwater observatory SmartBay streams real time oceanographic data (including underwater video footage and a range of sensor measurements), that provide insights into the local marine environment and its resident species. Researchers from the Galway-Mayo Institute of Technology have eDNA sampling and metabarcoding techniques at SmartBay to capture trace genetic material shed by organisms in the water, enabling the detection of a broad spectrum of biodiversity, including rare or cryptic organisms	Ongoing
MI & AFBI	Groundfish Survey	Independent estimate of abundance for commercially exploited fish stocks, in particular their reproductive success for that year	Ongoing annual survey
Commissioned by National Trust and NIEA	*Spartina anglica* Survey	Surveys of common cord-grass (*Spartina anglica*) are conducted across selected coastal estuaries in Northern Ireland. Monitoring is carried out through a mix of landowner walkover inspections and drone surveys	Annually since 2021

Species-specific surveys may also be carried out, particularly for high-priority invasive species, when their presence is suspected or confirmed. For instance, following detections in 2020 and 2021, targeted surveys for the Chinese mitten crab - listed as a Species of Union Concern under the IAS Regulations and classified as an alert species in both Ireland and Northern Ireland - were undertaken at several sites across Ireland between 2020 and 2022. These surveys were commissioned by the NBDC and BIM and used a range of monitoring approaches, including environmental DNA (eDNA) techniques (Tidbury *et al.*, 2026).

3.1.3.3 Citizen Science Projects

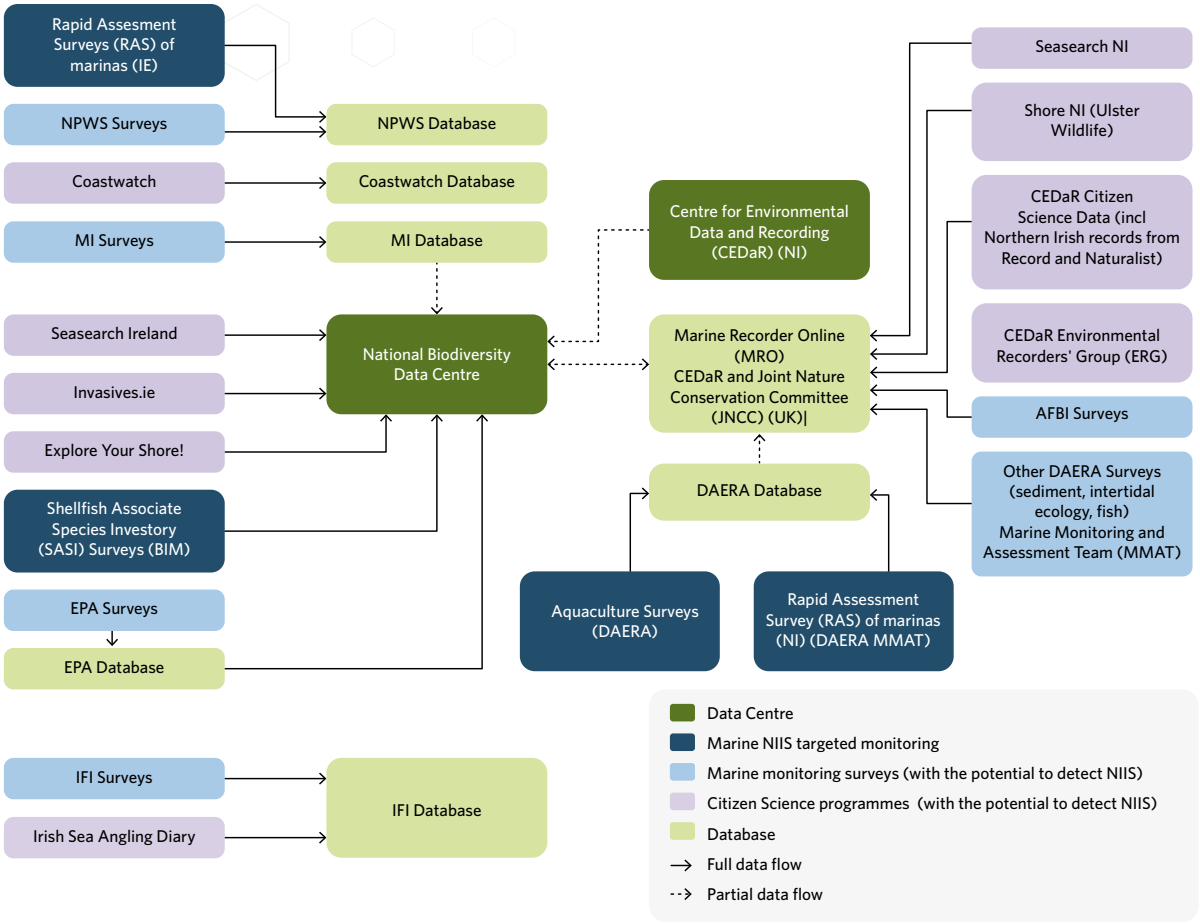
Table 3.4. Citizen Science Recording Programmes with the potential to report marine NIIS.

Organisation	Monitoring Programme	Details
IFI	Irish Marine Recreational Angling Survey	As most marine recreational fishing in Ireland is done from shore or private charter boats, this programme is designed to examine the recreational component of marine fishing for important species including cod, pollack and other highly migratory fishes. Anglers function as observers and may report unusual sightings and possibly NIS
National Biodiversity Data Centre	Explore Your Shore!	A marine biodiversity Citizen Science project run by the National Biodiversity Data Centre. The objective is to build our knowledge of the occurrence of marine species around the Irish coast, and what they tell us about climate change and water quality. It has four surveys aimed at intertidal species recording
National Biodiversity Data Centre	Citizen Science Portal and invasives.ie	Incidental sightings of marine NIS by members of the public are reported through the National Biodiversity Data Centre, including the the Citizen Science Portal, the invasives.ie portal and bioblitzes. These are validated by experts before being added to Biodiversity Maps.
Ulster Wildlife	Shore NI	A project led by Ulster Wildlife that encourages people to take part in shore surveys to monitor marine life, track environmental changes and contribute to conservation efforts.
Seasearch	Seasearch in Ireland and Northern Ireland	Citizen science biodiversity recording schemes for divers and snorkelers. The schemes utilise volunteer recreational divers to record sub-tidal species at dive sites around the island of Ireland. The schemes record a broad range of species including NIS

4. Data Flow and Reporting

4.1 Data Flow

Figure 4.1. Data flow diagram of marine NIIS data collected across Ireland



> *There is no single repository for all marine NIIS data in either jurisdiction. Data flow in both Ireland and Northern Ireland is complex, with a number of organisations involved.*

In Ireland, the National Biodiversity Data Centre could act as a central national repository for all non-indigenous and invasive species data records in Ireland. Channelling all data collection efforts into a central repository is widely accepted as a positive and necessary step to streamline data for reporting, research and management purposes.

The development of a central repository would require the design of a data flow protocol and agreement on adoption of the protocol from those responsible for the various monitoring programmes mentioned above. Currently data collected by BIM and citizen science data collected through Explore Your Shore! are the only consistent stream of marine NIIS data to the National Biodiversity Data Centre. Some, but not all EPA datasets are accessible through Biodiversity Maps and the data from the target marine NIIS Rapid Assessment of Marinas in Ireland is currently stored within a local NPWS database.

In Northern Ireland the Centre for Environmental Data and Recording (CEDaR) is established to collect, manage and share data on terrestrial, freshwater and marine species. The Northern Ireland Marine Recorder Database, which CEDaR maintains, receives data from various sources (DAERA, Loughs Agency, researchers and citizen science).

This includes data collected in Northern Ireland during the Rapid Assessment Marinas surveys targeted at marine NIIS and any aquaculture site surveys, however there are some data flow gaps such as scientific surveys carried out by AFBI.

The National Biodiversity Data Centre and CEDaR collaborate and share data to create all-Ireland datasets for some research, mapping and invasive species tracking. Data sharing occurs annually.

4.2 MSFD Monitoring Data

To assess environmental status for non-indigenous species, the primary criterion under the MSFD is the number which are newly introduced via human activity into the wild per assessment period (which runs in 6-year cycles). To collate the data for Ireland, which is subsequently submitted to the OSPAR Convention, two data sets are currently utilised; systematic surveys which are carried out through a Shellfish Associated Species Inventory (SASI) programme facilitated by BIMand citizen science records collated by the National Biodiversity Data Centre.

The SASI surveys are targeted surveys focusing on detecting marine non-indigenous and invasive species in areas of shellfish aquaculture (every three years) and/or wild fisheries and in marinas (ad-hoc). This work is funded by the Government of Ireland and the EU under the European Maritime and Fisheries Fund (EMFF) and most recently the European Maritime Fisheries and Aquaculture Fund (EMFAF). The NPWS also carry out marine NIIS surveying at marinas (RAS) but this data currently isn't utilised for the MSFD assessment.

Data is also collated from the National Biodiversity Data Centre. The Centre hosts records from incidental sightings and Citizen Science initiatives, including the marine programme Explore Your Shore!

Northern Ireland contributes marine monitoring data to the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) for UK-wide MSFD reporting, rather than submitting independent reports to the European Commission. The UK Marine Strategy, including Northern Ireland's data, is coordinated nationally to meet requirements.



Corella eumyota © Ann Haigh

5. Pathways and Vectors

Pathways and vectors refer to the ways marine invasive species are introduced and spread in new environments. Pathways are the processes through which species travel, such as shipping, aquaculture, or the aquarium trade. Vectors are the specific agents that carry the species along these pathways, for example, the ship ballast tank (with the water), a ship hull or a live seafood shipment (Miramin *et al.*, 2019, Massé *et al*, 2023).

An initial introduction from a distant biogeographical region typically occurs through a single pathway, whereas once the species becomes established, its secondary spread may involve multiple pathways (Minchin, 2014). Understanding pathways and vectors is crucial for managing and preventing the arrival of non-native species, because as a species expands its range, additional opportunities for further spread arise, making effective management increasingly challenging over time (Minchin, 2014; Nunes *et al.*, 2014).

The Convention on Biological Diversity (CBD) categorises introduction pathways of non-indigenous species into six main groups: Release, Escape, Transport-Contaminants, Transport-Stowaway, Corridors, and Unaided. These pathways are further subdivided into 44 categories. This classification is based on three shared attributes; degree of human involvement, means of transport, and means of subsequent introduction. The CBD framework is a global standard for classifying introduction pathways (Figure 2).

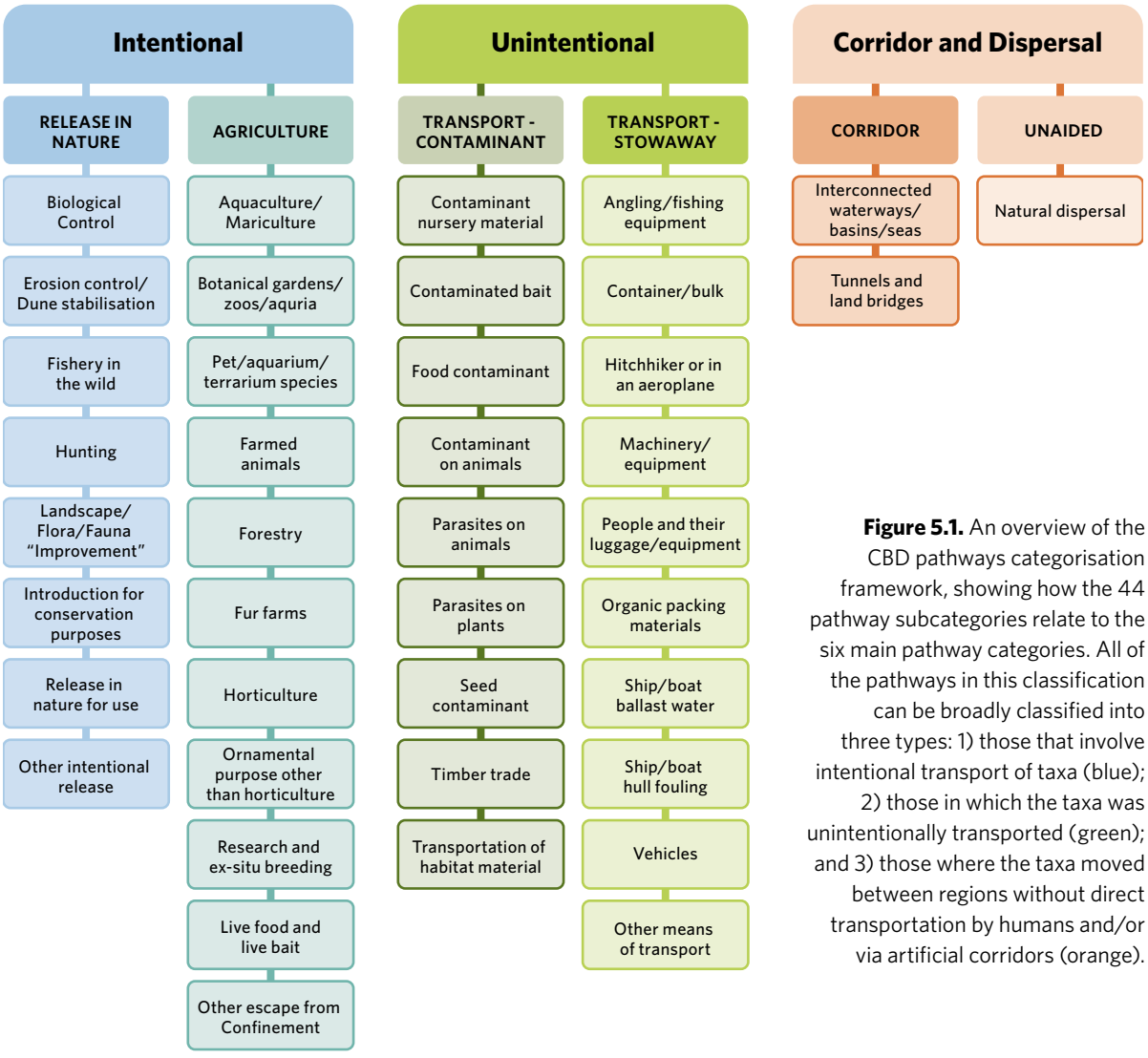


Figure 5.1. An overview of the CBD pathways categorisation framework, showing how the 44 pathway subcategories relate to the six main pathway categories. All of the pathways in this classification can be broadly classified into three types: 1) those that involve intentional transport of taxa (blue); 2) those in which the taxa was unintentionally transported (green); and 3) those where the taxa moved between regions without direct transportation by humans and/or via artificial corridors (orange).

The increase in global shipping and trade has been a major driver of the introduction and spread of marine and coastal non-native species (Katsanevakis *et al.*, 2013, Nunes *et al.*, 2014). Key pathways include ballast water discharge (Bailey 2015), organisms attached to vessel hulls (Gollasch, 2002), and those associated with aquaculture activities. As a result, international ports typically host higher numbers of non-native species than areas experiencing less shipping traffic (Costello *et al.*, 2022). Secondary pathways, such as recreational boating, contribute to the movement of species from these major hubs to smaller harbours, marinas, and natural coastal areas. Marinas, in particular, are increasingly recognised as "stepping stones" that facilitate species dispersal, with "spillover" into nearby natural habitats (including protected sites) becoming more frequent (Floerl *et al.*, 2009).

Some taxa, for example marine crustaceans, have multiple pathways of introduction, increasing their risk of arrival and subsequent establishment (Lucy *et al.*, 2020). Therefore, assessing the potential pathways of introduction for high-impact horizon scanning species is essential to enable targeted biosecurity measures.

Article 13 of Regulation (EU) No 1143/2014 obliges Member States to carry out a detailed assessment of the pathways responsible for the unintentional introduction and spread of invasive alien species of Union concern in both terrestrial and marine environments. They must also determine which pathways need priority action, considering either the volume of species or the potential impacts associated with them.

In 2019, Ireland conducted its first data-driven analysis and prioritisation exercise of pathways under Article 13 (O'Flynn, 2019), which resulted in the identification (and therefore prioritisation) of three unintentional pathways of introduction and spread for the (at the time) 49 IAS of Union concern;

- **Transport - stowaway: Angling/fishing equipment**
- **Transport - stowaway: Recreational boating and watercraft**
- **Transport - contaminant: Movement of soil and stone**

A comprehensive analysis of terrestrial, freshwater and marine pathways was carried out in the UK in 2019, to comply with the EU Invasive Alien Species Regulation (1143/2014), which is binding in Northern Ireland under the Windsor Framework (formerly the Northern Ireland Protocol). This resulted in six prioritised pathways, five of which are relevant to the marine environment;

- **Transport – stowaway: Ship/boat hull fouling**
- **Escape from confinement: Horticulture**
- **Transport – stowaway: Ship/boat ballast water**
- **Transport – stowaway: Angling/fishing equipment**
- **Escape from confinement: Botanical gardens/zoo/aquaria**

Building on this previous work, pathways were determined for the 187 priority species identified by Tidbury *et al.*, (2026) and subsequently counted and ranked. In many cases, more than one pathway was attributed to a single species, after which these pathway counts were summated. As only 24 of the 187 are associated with the marine environment, the pathway prioritisation cannot be interpreted for the marine environment in isolation. An analysis and prioritisation of the pathways associated with the marine species data from this study would be of benefit.

6. Identification of Geographical Hotspots

Monitoring effort for marine NIS in Ireland has not been equal around the entire coastline , however some studies have identified hotspots and/or areas of high potential risk for marine NIIS. Prioritising monitoring at sites with the highest risk of invasive species arrival enhances both the speed and likelihood of early detection, thereby supporting timely management responses (Canavan *et al.*, 2025). Concentrating monitoring efforts in areas where the probability of establishment is greatest further increases the chance of detection at a stage when containment or eradication might still be feasible.

Risk-based monitoring provides an efficient approach for directing limited resources toward activities that deliver the greatest impact. Preventing the introduction of invasive species, together with rapid intervention to eliminate propagules before they become established, is widely recognised as the most cost-effective strategy for reducing invasive species impacts (CBD, 1992; CBD, 2010).

6.1 Marinas

Marinas are widely recognised as key locations for the introduction and dispersal of invasive species, due to their close link with recreational boating and the movement of organisms transported on vessel hulls and within niche areas (Ferrario *et al.*, 2017; Gittenberger *et al.*, 2023; O'Shaughnessy *et al.*, 2023). A site prioritisation exercise for marine NIIS monitoring was undertaken by Tidbury *et al.*, in 2026, which included categorising marinas for risk. Marinas that are considered highest-risk for invasive species are also situated within protected sites, including Special Protection Areas (SPAs) under the EU Birds Directive and its national legislation, as well as Special Areas of Conservation (SACs) under the EU Habitats Directive and corresponding national laws. This overlap means that these locations not only face a heightened risk of invasive species introduction but also a greater potential for ecological impacts from any established species, underscoring the importance of regular and targeted monitoring. Ten marinas were categorised as "Very High Risk"; Dun Laoghaire, Bangor, Malahide, Carrickfergus, Howth, Kinsale Yacht Club, Carlingford, Royal Cork Yacht Club, Carlingford Marina and Kilrush Creek Marina.

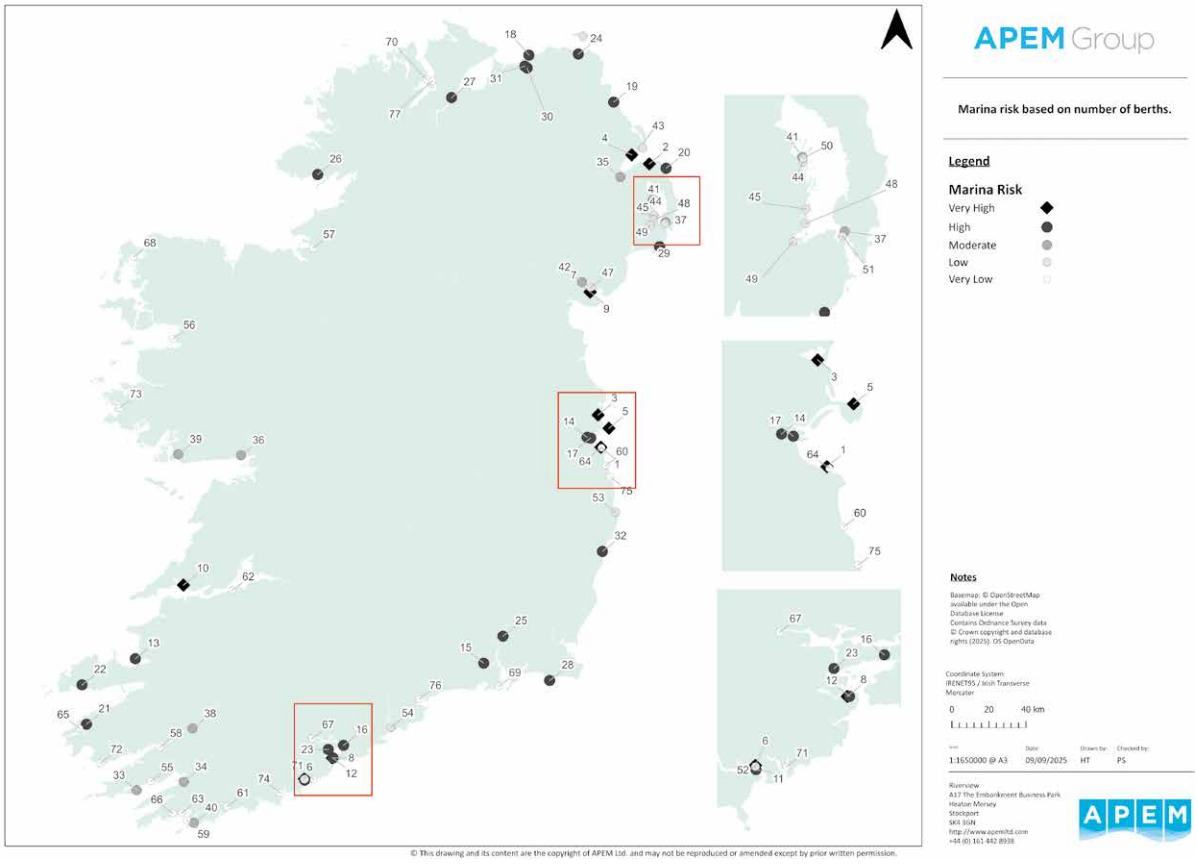


Figure 6.1. Marinas across the Island of Ireland, by invasive species risk estimated using the number of berths (Tidbury *et al.*, 2026).

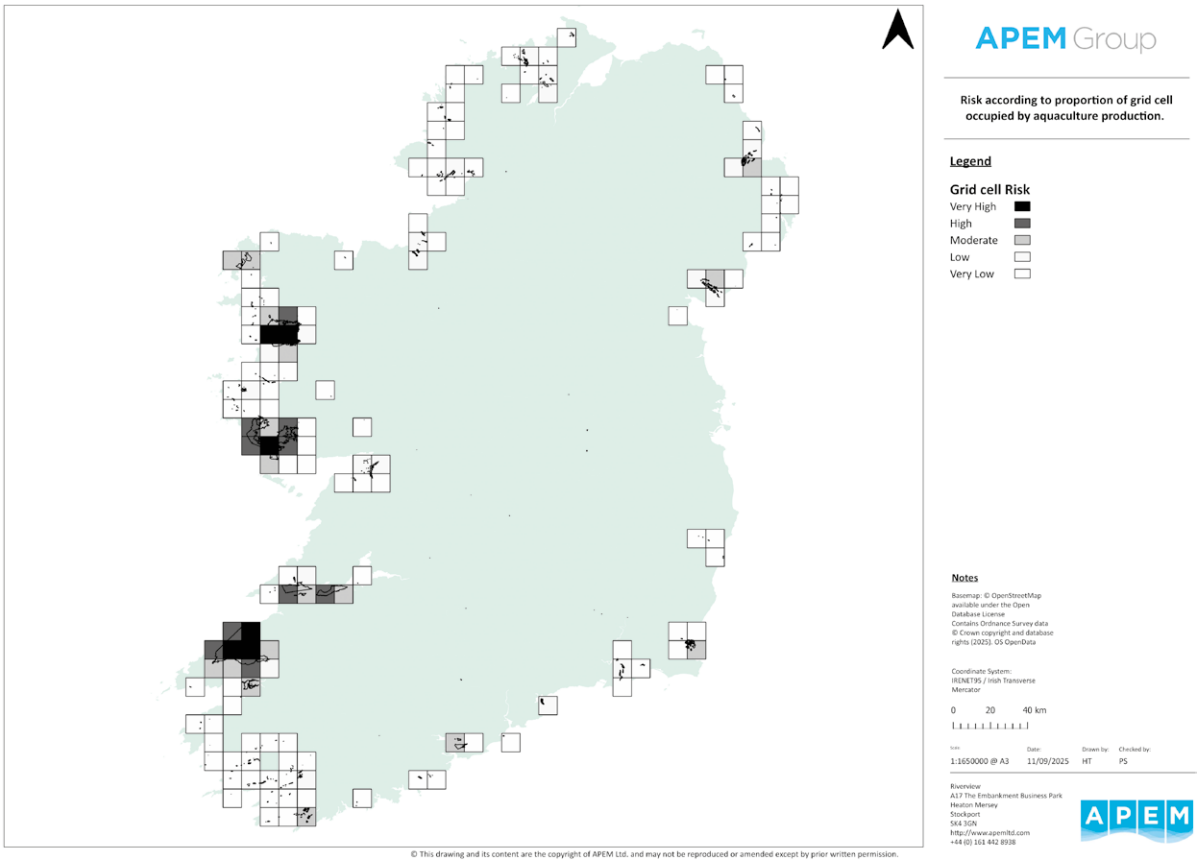


Figure 6.2. 10km² grid cells across the Island of Ireland by invasive species risk associated with aquaculture production, estimated using the proportion of the cell occupied by licensed aquaculture production sites. Note that inland sites have been excluded as this section focuses on marine invasive species monitoring (Tidbury *et al.*, 2026).

6.2 Aquaculture Sites

Aquaculture operations are recognised as key points for the potential introduction and spread of invasive species due to the movement of stock and equipment both within and between sites (Gittenberger *et al.*, 2023). These sites are also highly susceptible to the impacts of invasive species, which can cause substantial reductions in production and associated economic losses (Devine *et al.*, 2023). To identify higher-risk locations for more frequent monitoring, Tidbury *et al.*, conducted a risk assessment and site prioritisation in 2026. Because of the commercial sensitivity of the data, risk scores were calculated using predefined 10km² grid cells, based on the proportion of each grid occupied by licensed aquaculture production areas. It should be noted that aquaculture sites in Belfast Lough are not currently monitored but should be prioritised as it is considered a potential hotspot.

6.3 Commercial Ports

Commercial ports are also widely recognised as key hotspots for the introduction and spread of invasive species because of the potential for ships to transport organisms through ballast water discharge and biofouling on hulls (Nunes *et al.*, 2014). High vessel traffic increases propagule pressure in port environments ; Gollasch (2006) demonstrated the link between maritime traffic and NIS settlement in ports and Costello *et al.*, 2022 showed that ballast water and hull fouling are major vectors for NIS introductions.

Costello *et al.*2022, carried out an analysis of cargo shipping records to determine connectivity of shipping routes between ports in Ireland and international ports in order to facilitate horizon scanning for marine species likely to invade Ireland. Their analysis showed high connectivity between Ireland and the UK, eastern Europe and Scandinavia and found that Dublin was the primary destination port, with approximately 83% of incoming vessels using the Port of Dublin, followed by Cork Harbour (13%), New Ross (2.6%) and Rosslare (1.5%).

Risk scoring carried out by Tidbury *et al.*, in 2026, confirmed that Dublin is the port with the highest risk, exceeding the second-highest risk port more than threefold when assessed by vessel arrivals. These findings are consistent with earlier research by Tidbury *et al.* (2016) and that of Costello *et al.* (2022), which evaluated invasive species risk at selected Irish ports using Automatic Identification System (AIS) data. Following Dublin, Rosslare, Cork, Shannon Foynes, and Belfast were ranked as the second through fifth highest-risk ports, respectively.

A further risk scoring exercise using tonnage arrival data was carried out (Tidbury *et al.* 2026). Using gross tonnage is considered a robust way to analyse ports for the risk of invasive species because it acts as a proxy for propagule pressure, which is the total number of individuals and species introduced , and is directly correlated with the capacity for both ballast water discharge and hull fouling (Lo *et al.*, 2012; Soto-López *et al.*, 2025). Five ports categorised as "Very High" or High" risk for marine invasive species arrival (Table 7) (Tidbury *et al.*, 2026).

Table 6.1. Top five highest risk ports across Ireland for invasive species arrival (Tidbury *et al*, 2026).

Port	Risk Category
Dublin	Very high
Shannon Foynes	Very high
Cork	Very high
Belfast	High
Waterford	High

During a pathway analysis exercise, Tidbury *et al.*, (2026) found that a high proportion of the identified priority invasive species for the island of Ireland were associated with the CBD pathway subcategories "ship/boat ballast water" and "hitchhikers on ship/boat". These subcategories ranked as the sixth and eighth most common pathways for all priority species types, further emphasising ports in general as hotspots.

The south and east coasts of Ireland are exposed to the highest level of risk for secondary spread of species already present in adjacent UK and European seas (Miramin *et al.*, 2019). Secondary spread of marine invasive species refers to the movement and expansion of a non-native species after it has already been introduced and established in a new region. This phase is often responsible for the rapid geographic expansion of invasive species and can greatly amplify their ecological and economic impacts (Minchin *et al.* 2005). The Waterford coast is identified as the most likely recipient area, likely due to the culmination of multiple pathways; commercial and recreational watercraft, aquaculture, commercial fishing and geographical proximity to Great Britain.

6.4 Bridgehead sites

Locations where numerous pathways converge can be termed bridgehead sites and dispersal hubs. Sampling effort should reflect the distribution of these sites.

Increased risk is identified at several marinas which are in water bodies that also support oyster and mussel aquaculture sites. The RAS marina survey found that the sites with the greatest number of non-native species, outside Dublin port, support aquaculture activities (O'Shaughnessey *et al.* 2023).

7. Priority Species for monitoring

A range of legislative and policy frameworks shape the identification of priority invasive species for monitoring across the island of Ireland. The inclusion of species within relevant legislation or policy is supported by rigorous risk assessment processes that consider the likelihood of introduction, spread, establishment, and potential impacts. Consequently, species listed in legislation are considered to present a high level of risk.

Species designated under key legislation, prioritised through policy instruments (e.g. alert species), and recognised as high-risk horizon species (Lucy *et al.*, 2020) were compiled into a single, comprehensive list by Tidbury *et al.*, 2025 during commissioned work under the Shared Island Biosecurity and Invasive Species Initiative. The list comprised 187 species, 24 of which were marine (Table 7.1). The majority of marine species listed were classified as fouling/sessile species with minimal or no pelagic phase. The commissioned work included a monitoring methods manual, which details the key methods and explains how they can be applied depending on the environment, target species and seasonal conditions.

Table 7.1. Marine invasive species which are priorities for monitoring across the island of Ireland. Species associated with each priority type are denoted with a Y. The recording of each species with respect to IE and NI are also denoted with a Y. SoUc refers to Species of Union concern, IFSS refers to Ireland's First Schedule Species, Species on Schedule 9 of the Wildlife (Northern Ireland) Order 1985 (as amended) – 2020, are also highlighted though, there is no explicit requirement for monitoring under this Order. Summarized from Tidbury *et al.*, 2026.

Scientific Name	Common Name	Life History/Mobility and Dispersal	SoUc	IFSS	Schedule 9	Horizon	Alert NI	Alert IE	Recorded in NI	Recorded in IE
Amphibalanus improvisus	Bay barnacle	Sessile/Fouling - pelagic larvae		Y					Y	Y
Asterias amurensis	Northern Pacific seastar	Mobile benthic	Y							
Caprella mutica	Japanese skeleton shrimp	Sessile/Fouling - no or minimal pelagic stage		Y	Y				Y	Y
Caulacanthus okamurae	Pom-pom weed	Attached/Anchored				Y				Y
Celtodoryx ciocalyptoides	Sponge	Sessile/Fouling - no or minimal pelagic stage				Y				
Crepidula fornicata	Slipper limpet	Sessile/Fouling - pelagic larvae		Y	Y				Y	Y
Didemnum vexillum	Carpet sea squirt	Sessile/Fouling - no or minimal pelagic stage		Y	Y		Y	Y	Y	Y
Ensis leei	American razor-clam	Sessile/Fouling - pelagic larvae				Y			Y	
Eriocheir sinensis	Chinese mitten crab	Mobile benthic	Y	Y		Y	Y	Y		Y
Grateloupia doryphora	A red alga	Attached/Anchored		Y						
Hemigrapsus sanguineus	Asian shore crab	Mobile benthic				Y				
Hemigrapsus takanoi	Brush-clawed shorecrab	Mobile benthic				Y				
Hesperibalanus fallax	Warm-water barnacle	Sessile/Fouling - pelagic larvae				Y				
Homarus americanus	American Lobster	Mobile benthic					Y			Y
Mulinia lateralis	Dwarf surf clam	Sessile/Fouling - pelagic larvae	Y							
Nanozostera japonica	Dwarf eelgrass	Attached/Anchored	Y	Y	Y					
Ocinebrellus inornatus	Japanese oyster drill	Sessile/Fouling - no or minimal pelagic stage		Y						
Perophora japonica	Creeping sea squirt	Sessile/Fouling - no or minimal pelagic stage		Y					Y	Y
Plotosus lineatus	Striped eel catfish	Mobile benthic	Y							
Rapana venosa	Asian rapa whelk	Sessile/Fouling - pelagic larvae		Y						
Rugulopteryx okamurae	A brown seaweed	Attached/Anchored	Y							
Sargassum muticum	Wireweed; Japanese seaweed	Rafting		Y	Y				Y	Y
Styela clava	Stalked sea squirt	Sessile/Fouling - no or minimal pelagic stage		Y	Y				Y	Y
Undaria pinnatifida	Japanese kelp	Attached/Anchored			Y			Y	Y	Y
Urosalpinx cinerea	Atlantic oyster drill	Sessile/Fouling - no or minimal pelagic stage		Y						

8. Risk Assessment and Biosecurity Planning

Predicting which species will become invasive in a given environment is widely recognised as a complex challenge. Furthermore, addressing species that are already causing ecological harm in a coordinated and effective way requires well-informed policy measures that are transparent. Risk assessment provides one mechanism through which decisions can be made that are both transparent and clearly documented. However, risk assessment is not a straightforward or uniform process; its interpretation varies depending on perspective and context.

Miramin *et al.* (2019), collated a number of risk assessment frameworks that have been used for NIIS risk assessment in the Celtic Seas. Results generated by different impact assessment frameworks may vary. Turbé *et al.* (2017) argue that such discrepancies can be reduced by assessing invasive alien species (IAS) according to their most severe recorded impacts. Key limitations hindering comprehensive risk assessments include insufficient information on effects on ecosystem services, socio-economic factors, and the influence of climate change on assessed species. This highlights the need for a precautionary approach to risk assessment, whereby decisions are made in the absence of complete data by prioritising the prevention of the most serious documented impacts. Differences in pathway selectivity between taxa show that different indicators may be required to address NIS risk, which could focus on pathways (e.g., with higher number of introductions) and/or IAS' profiles (species with higher impacts) (Miramin *et al.*,2019).

In Ireland and Northern Ireland, a two-stage risk assessment framework was developed as part of Invasive Species Ireland (a collaborative initiative between NIEA and the NPWS) in 2013 (Kelly *et al.,* 2013a).

The first stage involved a prioritisation risk assessment, which is essential for evaluating the relative risks posed by a wide range of species. It was applied to 377 non-native species recorded in Ireland (across terrestrial, freshwater and marine environments), as well as 342 non-native species not currently known to occur there. Each species was evaluated, scored and ranked according to its potential impact, resulting in classifications of high, medium or low risk. From this exercise, 12% of species fell into the high-risk category, of which 5 were marine; *Didemnum vexillum*, *Crepidula forinicata, Styela clava, Spartina anglica* and *Sargassum muticum*.

The second stage consisted of a more detailed examination of the risks and uncertainties associated with a specific species, group of species or pathway of concern. This type of assessment is undertaken when additional information is required about a particular species and may, where necessary, inform decisions related to trade controls. However, conducting a detailed risk assessment does not automatically lead to trade restrictions. The proposed schema used during the Invasive Species Ireland exercise in 2013 was the same as the GB Non-native Species Secretariat, which detailed multiple benefits including ensuring consistency of approach across the entire UK and also consistency between the UK and Ireland (Kelly *et al.* 2013a).

The most recent risk assessment studies addressing marine NIIS and their introduction pathways in Irish waters were conducted by Minchin (2014) and Tidbury *et al.* (2016) . Minchin (2014) identified a range of species classified as high or moderate risk that are either already established in Irish waters or considered likely to be introduced due to their presence in British and northern European seas. All high risk NIIS fulfilled two or more of 16 predetermined criteria (also used by Hayes and Silwa in 2002). In contrast, Tidbury *et al.* (2016) adopted a risk-based approach that focused on identifying introduction hotspots and prioritising monitoring efforts for NIS across the UK and Ireland.

Miramin *et al.*(2019), collated information from multiple risk assessment frameworks to produce a list for Ireland. To date 51 of the known marine NIS in Ireland have been risk assessed (Annex 2). The remaining 71 species on the same report have not yet been assessed, nor have any future potential invaders of concern.

Currently, the Shared Island Biosecurity and Invasive Species Initiative is developing a Non-native Species Risk Register for the island of Ireland. This is an update to the work prioritisation assessment carried out by Invasive Species Ireland in 2013. This involves the development of a bespoke system that will be used to evaluate if a species should be prioritised for a Detailed Risk Assessment and/or other management measures. The Initiative has also developed a Detailed Risk Assessment template and review and approval framework which aims to be robust, effective, comprehensive and tailored for the island of Ireland. The process for this work can be reviewed in Figure 5. Pilot testing of both the Risk Register and the Detailed Risk Assessment is underway, supported by a panel of experts (National Biodiversity Data Centre, 2025).

This risk assessment work is part of a larger risk analysis framework under the same initiative (Figure 8.1). Risk analysis is a structured, science-based process that helps to provide the rationale for implementing management measures or policy decisions. It is also used to manage uncertainty, helping decisions to be made when scientific information is incomplete. Information used to undertake risk analysis can be qualitative or quantitative, ranging from published scientific literature, to grey literature, to expert judgement.

including those in marine environments. As the first centralised and standardised database of its kind in Ireland, CINS compiles information from diverse sources into a consistent framework aligned with international standards such as those of the Convention on Biological Diversity and the IUCN. This enables more effective analysis of introduction pathways, rates of spread, and potential impacts—key factors in assessing which non-native species may become invasive. The catalogue also highlights important knowledge gaps;

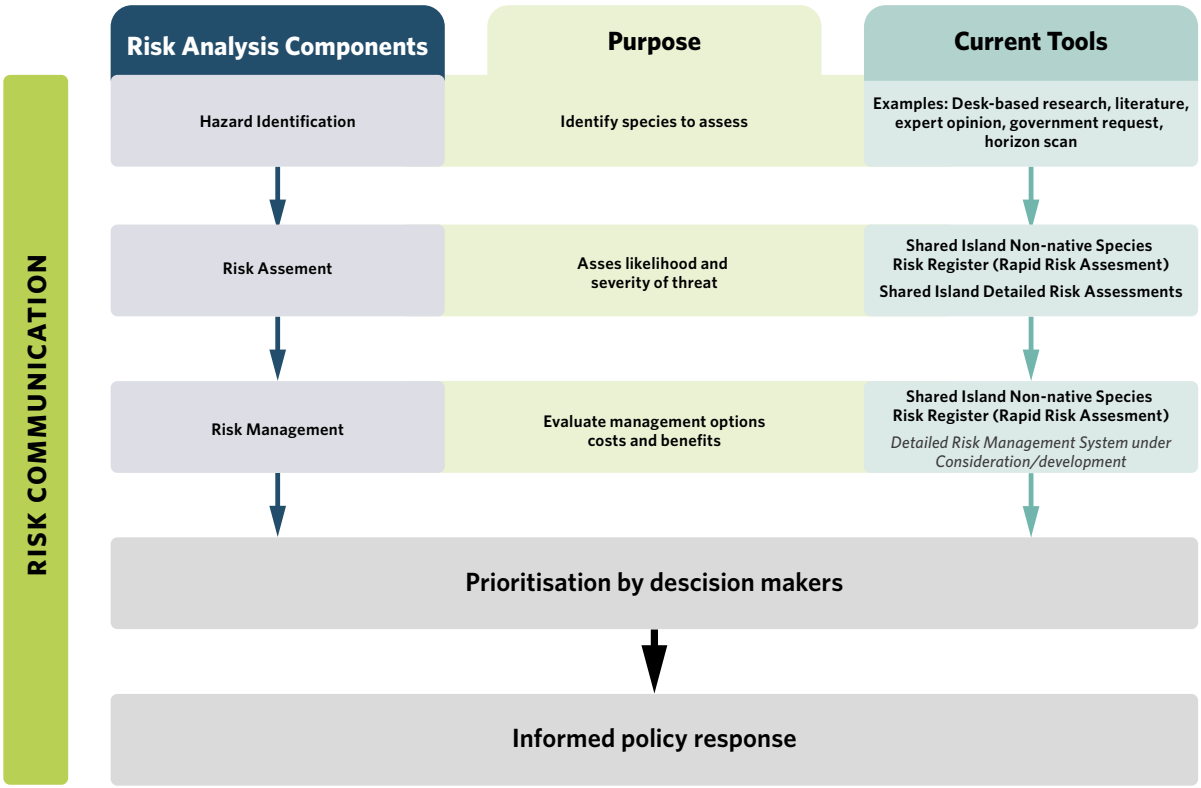


Figure 8.1. The elements of the current island of Ireland's risk analysis under the Shared island Biosecurity and Invasive Species Initiative

With respect to risk assessment of sites, modelled analyses indicate that continuous monitoring of locations with high or moderate exposure to introduction pathways is more effective than randomised approaches focussed on high impact species in early detection of NIS (Miramin *et al.* 2019).

The Shared Island Biosecurity and Invasive Species Initiative is also compiling a Catalogue of Ireland's Non-native Species (CINS). The development of the CINS represents a significant advancement in understanding and managing non-indigenous species, although 1,277 non-native species have been identified from a total of over 31,000 recorded species in Ireland, this is likely an underestimate due to incomplete data, particularly for less-studied groups. For marine NIIS, such structured and accessible information is essential for early detection, risk assessment, and prioritisation of management actions, supporting evidence-based policy and strengthening Ireland's capacity to respond to current and future biological invasions.

8.1 Aquaculture Specific Risk Assessments

There is a Risk Assessment and Biosecurity Protocol for the aquaculture sector (developed by the Invasive Alien Species and Aquaculture Working Group, alongside the industry). The Risk Assessment and Biosecurity Plan template is utilised nationwide (Devine *et al.*, 2023). The protocol is a six-step process, to direct management actions in relation to non-indigenous and invasive species. The plan defines measures to control and minimise risks, within the scope of business activities. Engagement with neighbouring aquaculture businesses and other sectors further enhances the impact of biosecurity plans.

Species specific risk assessments were developed for four key species of relevance to aquaculture in an Irish context following the international non-native organisms, risk assessments scheme; *Crepidula fornicata, Eriochier sinensis, Mulina lateralis* and *Undaria pinnatfida* (Devine *et al.*, 2023).

Permission for seed fishing to supply the bottom grown mussel sector, and retention of Marine Stewardship Council (MSC) certification requires risk assessment for the movement of mussel seed stocks from seed beds to licensed sites and between licenced sites. This is conducted annually following seed bed surveys and prior to opening of the fishery, (Devine *et al.*, 2023).

8.2 Horizon Scanning for new species of concern

A review study for the Netherlands revealed that most marine NIS were first introduced to mainland Europe and subsequently would take on average greater than 15 years to reach Ireland (Gittenberger *et al.*, 2023).

The same report detailed that of 28 marine NIIS newly introduced to the island of Ireland within the last 30 years with a known origin outside of NW Europe, 20 are also present in The Netherlands. Of these, 18 were first recorded in the Netherlands (Gittenberger *et al.* 2023). Since this report was published, a further 2 new species have been recorded in Ireland, both of which were recorded in the Netherlands around 15 years earlier, further supporting this reported trend.

The same report recommended that marine NIIS species lists from Great Britian and EU countries with an Atlantic coast should be the primary resource for horizon scanning for Ireland

Using information from neighbouring countries such as Great Britain, the Netherlands and France can allow predictions to be made on which species are more likely to be introduced in Ireland's waters. Analysis of the vectors and pathways associated with the identified species could assist with developing monitoring techniques such as DNA-based approaches

During the Kelly *et al.*, 2013 risk assessment exercise, seven horizon scanning marine species fell into the "High Risk" category, two of which have since been recorded in Ireland since; *Homarus americanus* and *Undaria pinnatifida*.

Miramin *et al.* 2019 identified an additional 94 species as potential future invaders, based on their establishment in areas directly connected to Ireland by recognised pathways. Of these, four were cited as present in Ireland by 2023.

In 2020, Lucy *et al.* established a list of 40 species of the most likely species to arrive on the island of Ireland between 2017-2027, 7 of which were marine. Since publication, two of the listed species have been recorded in Ireland's coastal waters.

9. Responding to marine NIIS incursions

Rapid response measures are widely regarded as the second tier of defence against non-indigenous species, following prevention as the primary safeguard. Management efforts are generally most effective when an invasion is detected at an early stage. Species that remain limited in distribution and occur at low population densities are far more likely to be successfully contained or eradicated than those that are already firmly established (Locke and Hanson, 2009). Once an invasive species has spread more widely, complete removal becomes increasingly difficult; however, actions at this stage may still help reduce harmful impacts. In most situations, timely rapid response actions aimed at eradication are both economically and environmentally more cost-effective than relying on prolonged management of an established nuisance species.

Eradication of invasive species in the marine environment is seldom successful (Locke and Hanson, 2009). Failed eradication attempts often go unreported, which removes the opportunity to learn from them.

Nonetheless, there are some viable options that should be investigated, including containment to geographical areas (Locke and Hanson, 2009). Species that have previously caused significant impacts in other regions—such as the seaweed *Caulerpa taxifolia* during its invasion in California and the black-striped mussel *Mytilopsis sallei* in Asia and Australia - tended to trigger faster and more decisive management responses. This is largely because prior experience reduced uncertainty in the risk assessment, increasing confidence in the threat posed and encouraging authorities to take prompt action.

9.1 Response to marine NIIS incursions in Ireland

In 2016, BIM established an Aquaculture and IAS Working Group to oversee the development of a Risk Assessment and Biosecurity Planning template for the sector and to advise on issues of concern. It has provided advice and made recommendations to the Department of Agriculture, Food and the Marine on listed species in the aquaculture sector. It has been rapidly convened in response to marine NIIS detections to provide expert opinion on next steps.

CASE STUDY 1:

Response to detection of the Chinese mitten crab (*Eriocheir sinensis*) in 2020

The highly invasive Chinese mitten crab (*E. sinensis*) was discovered in Morcombe Bay, Great Britain in 2020 after seed mussels had been transferred earlier in the year from there to Carlingford Lough. The transfer had been authorised under a Risk Assessment and Biosecurity Plan, ensuring a collaborative relationship with the UK was already in place. This response was coordinated by BIM and the IAS and Aquaculture Working Group. Despite the risk of transfer of Chinese mitten crab being considered low, a rapid response assessment was carried out in Carlingford Lough, followed by a more comprehensive survey of Ireland's East coast the following year. During this survey, the species was also detected independently in the Waterford Estuary. The finding was reported to the National Biodiversity Data Centre, which subsequently followed the EU notification procedures in accordance with legislative requirements, as the Chinese mitten crab is an IAS of Union Concern. In total the Chinese mitten crab has been recorded on seven occasions in the Waterford estuary since 2006, with the most recent verified records in 2022 and 2025. Since 2006 this has resulted in four periods of follow-up surveying and retainment of various specimens for further analysis. The National Biodiversity Data Centre facilitated multi-stakeholder meetings to investigate potential response and provided summary reports with recommended next steps.



Eriochier sinensis, Chinese mitten crab
©Shutterstock Erni

CASE STUDY 2:

Response to suspected detection of *Didemnum vexillum* in 2019

In 2019, the Invasive Alien Species and Aquaculture Working Group was convened following the detection of a small white ascidian colony suspected to be the invasive *Didemnum vexillum* during a routine mussel seed survey. Within a week, researchers carried out a follow-up investigation that included a repeat survey at the original site, a re-examination of the collected material, and several rapid assessments along Ireland's east coast. These activities aimed to determine the distribution of *Didemnum vexillum* at that time and to evaluate any potential risks associated with moving mussel seed. The assessments provided a clearer understanding of the species' distribution, ultimately confirming that the ascidian colony was a native species and posed no risk.

BIM, 2023

CASE STUDY 3:

Response to the detection of the Australian tube worm (*Ficopomatus enigmaticus*) in 2020

The Australian tube worm(*F. enigmaticus*) was discovered in the Tralee Ship Canal in 2020. AQUAFACT International Services were commissioned to investigate the extent of establishment, which was found to be very abundant. The investigation into controlling the species in the Tralee Ship Canal explored several management strategies, including physical removal, freshwater immersion, and air exposure. Physical removal was trialled in two heavily fouled canal areas, but its effectiveness was limited by the large surface area, difficult access, and potential for recolonisation. Trials exposing specimens to air and freshwater aimed to determine the duration needed to kill the worms, taking into account their tolerance for desiccation and brackish water. While resource constraints limited the scope of the study and prevented full-scale interventions, the trials provided baseline data for future management strategies along the 2.5 km canal. The study also noted the physical characteristics of the canal, including width, depth, and tidal influences, which are important considerations for any control measures.

Mulligan and O'Connor, 2021

CASE STUDY 4:

Response to the incursion of *Sargassum muticum* in 2003

Lough Hyne is a large coastal Special Area of Conservation (SAC) in County Cork. The site includes a variety of both marine and land-based habitats, among them three that are recognised under Annex I of the EU Habitats Directive. Lough Hyne has been the focus of extensive scientific research and is notable for its exceptionally high biodiversity and species richness despite its relatively small size (MERC Consultants, 2007) . Fishing activity in the area is limited, and the site is widely used for research by several academic institutions, many of which operate field stations in and around the lough.

After confirming the presence of *Sargassum muticum*, in Lough Hyne, Ireland's only Marine Nature Reserve in 2003. it was agreed through the NPWS that efforts should be made to remove the species. A thorough SCUBA survey was conducted in the 'Whirlpool' cliff area. A total of 40 individual plants were located at depths between 0-6 metres and subsequently removed. The specimens varied in size, ranging from 30 cm to 5.5 m in length.

Follow-up surveys were conducted through to 2006, including a survey of the benthic communities of the SAC commissioned by the NPWS which found "substantial" growth of the invasive wireweed *S. muticum* at the mouth of the Lough and that the species had become well established within the seagrass beds at the same location where "it was observed to be growing amongst seagrass beds to form very large plants that extended to the surface".

Simkanin, 2004; MERC Consultants, 2007, and Kraan, 2008

10. Impact

Rapid response measures are widely regarded as the second tier of defence against non-indigenous species, following prevention as the primary safeguard. Management efforts are generally most effective when an invasion is detected at an early stage. Species that remain limited in distribution and occur at low population densities are far more likely to be successfully contained or eradicated than those that are already firmly established (Locke and Hanson, 2009). Once an invasive species has spread more widely, complete removal becomes increasingly difficult; however, actions at this stage may still help reduce harmful impacts. In most situations, timely rapid response actions aimed at eradication are both economically and environmentally more cost-effective than relying on prolonged management of an established nuisance species.

Eradication of invasive species in the marine environment is seldom successful (Locke and Hanson, 2009). Failed eradication attempts often go unreported, which removes the opportunity to learn from them.

10.1 Environmental Impacts

Non-native species can become invasive and disrupt marine ecosystems by altering habitats and competing with native species. In Ireland, there have been case studies such as the freshwater Nuttall's pondweed in Lough Erne demonstrating how invasive species can significantly disrupt ecosystem services and native communities (O'Higgins *et al.*, 2018). However there is still limited evidence on the environmental impacts of many marine NIIS, particularly in relation to features of Marine Protected Areas (MPAs) and how their presence should be considered when assessing site condition, (MacLeod et-al, 2016, Salvaterra *et al.* 2013).

CASE STUDY 5:

Environmental impacts of *Sargassum muticum* in Irish coastal ecosystems

S. muticum is an invasive brown macroalga widely established along the Irish coastline. Its rapid rate of spread, estimated at approximately 2–3 km per year within individual bays and up to 54 km per year along the wider coastline (Kraan, 2008), has facilitated its colonisation of a range of coastal habitats.

The species is commonly found in ecologically sensitive environments, including seagrass beds and intertidal rock pools. Its presence in these habitats is associated with reductions in native biodiversity, as it competes with indigenous species for space and resources. In particular, the formation of dense surface canopies can significantly reduce light penetration to underlying benthic communities, negatively affecting photosynthetic organisms such as seagrasses (Vaz-Pinto, Olabarria and Arenas, 2014).

In addition to competitive effects, *S. muticum* can alter physical habitat structure. As a habitat-forming species, it introduces increased structural complexity, which may modify local ecological processes, including nutrient cycling and sediment dynamics (Vaz-Pinto, Olabarria and Arenas, 2014). These changes have the potential to influence associated faunal communities and disrupt existing trophic interactions.

An experiment was conducted in Lough Hyne by Salvaterra *et al.*, (2013), a marine reserve in Co. Cork, where *S.muticum* had become an established in 2003. The impacts were examined across various native marine algal communities. It was determined that presence of this species led to a significant decline in primary production, a key aspect of ecosystem functioning, while also increasing connectance within associated food webs, indicating changes in trophic interactions. Overall, the findings suggest that *S. muticum* not only directly disrupted native algal populations but also that these effects extended indirectly to the native fauna resulting in substantial alterations to the entire ecosystem

Overall, *S. muticum* demonstrates how a single invasive species can affect both biodiversity and ecosystem functioning in Irish coastal systems. However, further research is required to quantify the scale of these impacts and their implications for conservation features, particularly within Marine Protected Areas.

10.2 Economic Impacts

Economic impacts include economic losses suffered by society such as degradation of infrastructures, decreasing business activities, and loss of income etc. Invasive species may foul, block, or damage machinery and submerged infrastructure, which could negatively affect activities such as fishing, shipping, and aquaculture.

Also for consideration, are the cost of management efforts aimed at prevention, control and eradication of incursions represent additional, often substantial expenditures for human societies (McLeod *et al.* 2016). These costs are poorly understood.

The 2013 report by Invasive Species Ireland assessed the economic impacts invasive species, which cited a cost to the economies of Ireland and Northern Ireland to be a combined total of over €261 million per year (Kelly *et al.* 2013b). Eschen *et al.*, made updates to these estimated costs for Northern Ireland (and the rest of the United Kingdom) in 2023, using where available new information changes in distribution and impacts of species, new knowledge, changes in management and newly established NIIS. An inflation factor was applied to the remaining sectors and species and an annual cost to the Northern Ireland economy was estimated as £150 million (an equivalent of €173). While these figures cover all invasive species (terrestrial, freshwater, and marine) and require updating for Ireland, specific marine and aquaculture-related impacts are major known threats to biodiversity, infrastructure, and commercial industries.

Since 2014, a research team at Université Paris Saclay has developed the InvaCost database, which provides one of the most comprehensive and standardised collections of global economic cost estimates related to invasive alien species. Drawing on tens of thousands of sources, including peer-reviewed research and grey literature published in 14 languages, the database compiles more than 13,000 documented cost records. Each entry is also accompanied by over sixty descriptive variables to support detailed analysis of the economic impacts associated with IAS worldwide.

Ireland is included in the global InvaCost database however, very few cost records exist for Ireland compared to other countries. Specifically, only one aquatic invasive species in Ireland has clearly recorded cost (the freshwater curly waterweed), most other entries are non-specific or not well quantified in monetary terms (Lucy *et al.*, 2020a).

The UK (including Northern Ireland) has more entries in InvaCost than Ireland, but data are still patchy and uneven and costs are often reported at the UK-wide scale, not specifically for Northern Ireland.

Despite the global scope of the InvaCost database, cost data for Ireland remain extremely limited, highlighting a significant knowledge gap and reinforcing the importance of contributing national data to improve understanding and management of invasive species impacts.

10.3 Health Impacts

Marine invasive species can pose risks to human health through a range of pathways, including the transmission of parasites, exposure to toxins, and physical injury (Dolah, 2000). Some invasive species act as vectors for diseases; for example, the Chinese mitten crab (*Eriocheir sinensis*) can serve as an intermediate host for the lung fluke *Paragonimus westermani*, which can infect humans if contaminated seafood is consumed (Veilleux and de Lafontaine, 2007), although the primary host species is climatically unsuited to Ireland. In addition, harmful algal blooms caused by invasive phytoplankton species can produce toxins that accumulate in shellfish, leading to food poisoning in humans (Anderson *et al.*, 2012). Although these risks are often context-dependent, they highlight the importance of monitoring and managing marine invasive species to protect public health.

Research and evidence gathering are therefore critical to understanding both the ecological and socioeconomic impacts of invasive species and to informing risk assessment and management strategies (Simberloff *et al.*, 2013; MacLeod *et al.*, 2016).

11. Current Management Measures

11.1 Ballast water

In 2017, the International Convention for the Control and Management of Ship Ballast Water and Sediments Convention (BWM Convention) set new global standards for ballast water management, providing limitations on the allowable number and dimensions of organisms per cubic meter of water (IMO, 2017).

OSPAR developed guidance on voluntary ballast water exchange (Agreements 2010-07, 2014-11) and have established a joint task group with HELCOM to manage non-indigenous species in relation to ballast water management exemptions and to manage ballast water and biofouling (OSPAR, 2023). Ireland and the UK has national experts attending these groups.

11.2 Biofouling

The International Maritime Organization (IMO) through the Marine Environment Protection Committee (MEPC) set out "Guidelines for the control and management of ships' biofouling to minimise the transfer of invasive aquatic species"(IMO,2023).

These guidelines are further supplemented by the "Guidance for minimising the transfer of invasive aquatic species as biofouling (hull fouling) for recreational craft" (IMO, 2012).

11.3 Management measures within the aquaculture sector

The International Council for the Exploration of the Seas (ICES) Code of Practice on the Introduction and Transfers of Marine Organisms 2005 aims to reduce the ecological, environmental, economic and genetic impacts associated with the transfer of species utilised in aquaculture activities. While Government is responsible for some of the actions in this code others lie solely with the aquaculture sector for implementation.

In 2016, BIM established an Aquaculture and IAS Working Group to oversee the development of a Risk Assessment and Biosecurity Planning template for the sector and to advise on issues of concern. It has provided advice and made recommendations to the Department of Agriculture, Food and the Marine (DAFM) on listed species in the aquaculture sector (see Case studies 1 and 2 in this report).

In collaboration with this Working Group and representatives from industry, BIM produced a sector-specific risk assessment and biosecurity framework for aquaculture (BIM, 2023) The associated Risk Assessment and Biosecurity Plan template has since been applied across the country for multiple purposes. At an individual business level, it has supported the achievement of biodiversity objectives linked to environmental management and organic certification schemes. The framework has also been used to evaluate specific stock movements and to manage risks associated with particular non-native species. The protocol provides clear guidance for shellfish and aquatic plant aquaculture licence holders on identifying invasive alien species risks and designing appropriate biosecurity measures to reduce those risks. It is structured around a standard six-stage process and supports targeted management actions for species where shellfish movements are recognised as a high-risk pathway for introduction and spread.

In Northern Ireland, aquaculture managers are encouraged to introduce an Invasive Species Hazard Analysis and Critical Control Points (HACCP) system. This is to help identify risks, procedures to limit the opportunity of non-target species transfer and the appropriate time to take action when moving aquaculture species and equipment. This information is shared on the Invasive Species Northern Ireland webpage. The Fish Health Unit of DAERA require aquaculture operators to provide a Biosecurity Protocol for aquaculture transfers.

11.4 Biosecurity Awareness

11.4.1 *"Check, Clean, Dry"* Campaign

"Check, Clean Dry" is a biosecurity campaign, which promotes the need for inspection, thorough cleaning and drying of equipment to prevent the spread of aquatic non-indigenous and invasive species. Originally developed in New Zealand, to protect their freshwater ecosystems, the "Check, Clean Dry" campaign was later adopted by the British-Irish Council.

In Ireland, the Department of Housing, Local Government and Heritage have been promoting the campaign since 2018, with an official launch in January 2022 by Leave No Trace Ireland, the National Biodiversity Data Centre, and partners. In Northern Ireland the campaign is supported by a partnership including Invasive Species Northern Ireland, Waterways Ireland and DAERA.

Targeted education in the form of posters and leaflets, as well as digital resources are available from the *invasives.ie* and *invasivespeciesni.co.uk* websites. Resources provide tailored guidance for anglers, boaters and paddlers (Figure 7)

Some waterways display biosecurity awareness signage, such as angling locations, boat launching areas and protected waterways, e.g. Strangford Lough signage encourages water users to inspect, clean and dry equipment like fishing gear, boats and trailers.

The Shared Island Biosecurity and Invasive Species Initiative is a collaborative, all-island programme aimed at strengthening, coordinating, and managing invasive species threats across Ireland and Northern Ireland. It promotes initiatives such as "Check, Clean, Dry" at biosecurity awareness events across the island.

Both Invasives.ie and Invasive Species Northern Ireland share marine biosecurity awareness messages on their social media channels.

11.4.2 Invasive Species Week

This is an annual event primarily focused on Great Britain (also including the Isle of Man, Guernsey, and Jersey) and Ireland , coordinated by the GB Non-Native Species Secretariat. Organisations come together to raise awareness on invasive species and highlights actions to prevent their spread.

The specifics change each year but have included workshops, guided walks, biological recording sessions, webinars and social media campaigns. This is inclusive of terrestrial, freshwater and marine environments and there is active participation each year by both the National Biodiversity Data Centre in Ireland and the Northern Ireland Environment Agency.

11.4.3 Biosecurity Events

The Shared Island Biosecurity and Invasive Species Initiative has a Biosecurity and Engagement Officer, part of who's role it is to promote invasive species and biosecurity awareness across all environments. This is done by attending local and national events, as well as organising bespoke activities (webinars etc). Additionally, within the National Biodiversity Data Centre, there is both a Marine Invasive Species Officer and Invasive Species Officer (covering all environments) who attend awareness raising events as and when required.

The Northern Ireland Environment Agency has an Invasive Non-Native Species Team. Their primary role is to manage, monitor and control invasive species and this work is predominantly within the terrestrial and freshwater environment, however they promote aquatic biosecurity (encompassing marine) at local and national events.



Figure 11.1. Check, Clean, Dry campaign resource for water users, produced by the National Biodiversity Data Centre

11.4.4 Guidelines and Codes of Practice

A Code of Practice for "The Safe Operation of Recreational Craft" by the Department of Transport in Ireland details biosecurity measures for sail and motorboats to stop the spread of invasive species. (Department of Transport, 2024). This section of the Code is targeted at inland waterways, but the message is applicable to all waterbodies.

Invasives.ie and Leave No Trace Ireland provide Guidance for Boaters, Anglers, Paddle Sport Users and general Water Users (Figure 11.2).

Invasive Species Northern Ireland provide Biosecurity Guidelines and a Code of Practice for; Marina Operators, Aquaculture Operators, Anglers (Figure 11.3), Small Watercraft Users and Leisure and Industrial Craft Users. All published documents has information tailored to the specific stakeholders.



Figure 11.2. Targeted guidance resource for paddle sport enthusiasts produced by the National Biodiversity Data Centre.

11.4.5 Pathway Action Plans

Pathway Action Plans (PAPs) are tools developed to prevent or minimise the risk posed by the pathways using a series of measures. To date, Ireland has developed and finalised three Pathway Action Plans, two of which are of relevance to the marine environment.

- **Angling (Finalized April 2022) (NBDC, 2022a)**
- **Recreational Boating and Watercraft (Finalised May 2022) (NBDC, 2022b)**

Each plan was drafted by a Working Group chaired by the NPWS and were made available for public consultation.

Northern Ireland are actively developing Pathway Action Plans with those for Recreational Boating and Angling existing in draft at the pre-consultation phase (Invasive Species Northern Ireland, no date).



Figure 11.3. Targeted guidance resource for marine anglers produced by the Northern Ireland Environment Agency.

11.5 Species identification

11.5.1 Taxonomy Training

BIM is actively involved in raising awareness and providing training on invasive species management. BIM has been responsible for the delivery of six workshops for aquaculture operators, industry groups and officials on marine non-indigenous and invasive species identification, through the private consultancy GiMaRIS. Their approach is to improve the knowledge of those directly involved with the sector on species of concern including those already present in Ireland, and horizon scanning species predicted to arrive in the near future (Devine *et al.*, 2023).

Queens University Marine Laboratory delivered marine non-native species in NI workshops in 2023 and 2025. The delivery of these workshops to those involved with marine monitoring, marine environmental and academia as part of the Marine Environment and Fisheries funded project "Enhancing Blue Carbon baseline research capacity".

Explore Your Shore! Runs marine species identification and recording sessions, including marine NIIS, around the Irish Coast annually. Similar events are run by three Explore Your Shore! Hubs and via the Clean Coasts Observer programme. Additionally the National Biodiversity Data Centre has and online course on Marine Biodiversity Citizen Science which incorporates marine species identification training, including marine NIIS.

11.5.2 Species Identification Resources

Identification cards for some invasive species associated with aquaculture have been developed for Crabs, Tunicates, Molluscs and Bivalve Molluscs. These have been provided to industry as well as being made available online (BIM, 2024).

NIEA have produced non-native species identification guides for some marine species (Invasive Species Northern Ireland, 2026), as well as a printed booklet "Marine invasive non-native species in Northern Ireland" in collaboration with CEDaR for a selection of species (NIEA, 2020).

While not focused on marine NIIS, there are some marine biodiversity identification resources which include some of the established or widely spread NIIS found all around the coastline, including Explore Your Shore! ID posters and swatches produced by the National Biodiversity Data Centre (Explore Your Shore!, 2026) and resources produced by Coastwatch for their Shore Biodiversity surveys (Coastwatch, 2026)

Invasives.ie has an ongoing social media series called "Spotlight on Invasives" which provides species descriptions and key identification features on various marine, freshwater and terrestrial invasive species on a weekly basis.

11.6 Consideration of marine non-indigenous species within marine planning

A Marine Invasive Non-Native Species Management Plan (MINNSMP) is required by applicants as a supporting document to the Environmental Impact Assessment (EIA) of development proposals in the marine environment (DCEE, 2021). Management plans are reviewed by a specialist panel of experts.

The plan is further developed in advance of the construction phase, should incorporate relevant consent conditions and remain a "live" document throughout the lifetime of the project, with periodic updates. An Coimisiún Pleanála (The Planning Commission) is the independent statutory body responsible for determining planning applications for offshore renewable energy, including wind farms, in Ireland's maritime area. The Maritime Area Regulatory Authority (MARA) manages, regulates, and enforces permissions for development and activities within Ireland's maritime area. The Department for Infrastructure (DfI) – Rivers & Maritime / Marine Licensing Unit oversees licensing for works and developments in tidal waters, harbours, and other marine areas in Northern Ireland. The Marine Management Organisation (MMO) also gives regulatory oversight in UK waters.



Sargassum muticum Wireweed © Shutterstock Svetlana Zhukova

Conclusion

Marine NIIS will continue to arrive in Irish waters and impact our natural environment and seafood activities (Devine *et al.*, 2023). The 2013 report by Invasive Species Ireland assessed the economic impacts of invasive species, citing a cost to the economies of Ireland and Northern Ireland to be a combined total of over €261 million per year (Kelly *et al.* 2013b). While these figures cover all invasive species (terrestrial, freshwater, and marine) and require updating, specific marine impacts are major known threats to biodiversity, infrastructure, and commercial industries.

Marine NIIS are being recorded across an array of monitoring programmes. Some data collection programmes, such as those within the aquaculture sector in Ireland have been ongoing for some years and it is important these continue, but significant knowledge and data gaps remain regarding the distribution of marine invasive species along the Irish coastline, particularly in commercial ports, marinas, and adjacent protected sites. The implementation of a surveillance and monitoring programme which addresses gaps and focuses on known hotspot sites is needed. Improved data flow from all monitoring activities across the island of Ireland to allow this information to be utilised for assessment and reporting at local, regional and international level is also required. Ireland's marine environment is vast and complex, and without a unified strategy for surveillance, early detection, and rapid response, these monitoring gaps hinder the assessment of the true extent of invasions, the implementation of effective controls, and the quantification of ecological and economic impacts.

Overall, while risk assessment for non-indigenous invasive species remains inherently complex and subject to uncertainty, significant progress is being made across the island of Ireland to strengthen and harmonise approaches. The development of updated frameworks, such as the Shared Island Biosecurity and Invasive Species Initiative's Risk Register and detailed assessment tools, demonstrates a clear commitment to evidence-based and precautionary decision-making.

There is currently a range of management measures in place in the form of internationally aligned regulations on ballast water and biofouling, to sector-specific biosecurity frameworks within aquaculture, and widespread public awareness initiatives such as "Check, Clean, Dry". There is evidence of practical guidance, targeted training, and accessible identification resources ensuring that stakeholders—from industry professionals to recreational water users—are equipped to play an active role in recording, monitoring and biosecurity.

The continued advancement and implementation of these measures will be strengthened by strong cross-agency and cross-jurisdictional collaboration and sustained investment.

An all-island marine invasive species management plan is recommended as an effective and coherent approach to addressing the challenges. A coordinated plan would provide a structured framework for prevention, early detection, rapid response, and long-term management, ensuring that actions are prioritised and resources are used efficiently. It would also support compliance with international and European obligations, while strengthening Ireland's capacity to protect marine biodiversity and ecosystem services into the future.

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Annex 1

All 139 Marine NIIS recorded on the marine and coastal waters of the island of Ireland. Data records taken from Miramin et al., 2019; Gittenberger et al., 2023 and Tidbury et al., 2026.

Species	Common Name	Taxon Group
Caulacanthus okamurae	Pom-pom weed	Alga (Rhodophyta)
Agardhiella subulata	Agardh's red weed	Alga
Anotrichium furcellatum	Fork twig weed	Alga
Coscinodiscus wailesii	N/A	Algae (Bacillariophyta)
Labyrinthula zosterae	N/A	Algae (Bigyra)
Bonamia ostreae	Bonamia	Algae (Cercozoa)
Haplosporidium nelsoni	N/A	Algae (Cercozoa)
Codium fragile subsp. atlanticum	Dead man's fingers	Algae (Chlorophyta)
Codium fragile subsp. fragile	N/A	Algae (Chlorophyta)
Ulva australis	N/A	Algae (Chlorophyta)
Ulva californica	N/A	Algae (Chlorophyta)
Ulva rhacodes	N/A	Algae (Chlorophyta)
Isochrysis galbana	N/A	Algae (Haptophyta)
Alexandrium tamarense	Toxic Dinoflagellate	Algae (Myzozoa)
Gymnodinium aureolum/Gyrodinium aureolum	Dinoflagellate	Algae (Myzozoa)
Karenia mikimotoi	N/A	Algae (Myzozoa)
Biddulphia sinensis/ Odontella sinensis	N/A	Algae (Ochrophyta)
Colpomenia peregrina	Oyster thief	Algae (Ochrophyta)
Sargassum muticum	Wireweed	Algae (Ochrophyta)
Undaria pinnatifida	Japanese kelp/ Wakame	Algae (Ochrophyta)
Aphanomyces astaci	N/A	Algae (Oomycota)
Antithamnion densum	N/A	Algae (Rhodophyta)
Antithamnionella spirographidis	N/A	Algae (Rhodophyta)
Antithamnionella ternifolia	N/A	Algae (Rhodophyta)
Asparagopsis armata	Harpoon weed	Algae (Rhodophyta)
Bonnemaisonia hamifera	N/A	Algae (Rhodophyta)
Cryptonemia hibernica	N/A	Algae (Rhodophyta)
Dasysiphonia japonica/Heterosiphonia japonica	Red seaweed	Algae (Rhodophyta)
Gracilaria multipartita	Gracilaria	Algae (Rhodophyta)
Gracilaria vermiculophylla/ Agarophyton vermiculophyllum	Gracilaria	Algae (Rhodophyta)
Grateloupia turuturu	Devil's tongue weed	Algae (Rhodophyta)
Laurencia brongniartii	N/A	Algae (Rhodophyta)

Species	Common Name	Taxon Group
Lomentaria hakodatensis	N/A	Algae (Rhodophyta)
Melanothamnus harveyi/ Neosiphonia harveyi/Polysiphonia harveyi	Harvey's siphon weed	Algae (Rhodophyta)
Polysiphonia subtilissima	N/A	Algae (Rhodophyta)
Codium fragile subsp. Tomentosoides	Green sea fingers	Algae
Iridaea sp.	N/A	Algae
Bispora polyomma	Purple fan worm	Annelida
Clymenella torquata	Bamboo worm	Annelida
Ficopomatus enigmaticus	Australian tubeworm	Annelida
Goniadella gracilis	N/A	Annelida
Paralaeospira malardi	N/A	Annelida
Pileolaria militaris	N/A	Annelida
Pseudopolydora cf paucibranchiata (possibly P. nordica)	N/A	Annelida
Streblospio benedicti	N/A	Annelida
Terebella lapidaria	N/A	Annelida
Taeniastrotos sp.	N/A	Arthopod
Aplidium glabrum	N/A	Ascidiacea
Asterocarpa humilis	Compass sea squirt	Ascidiacea
Botrylloides diegensis	N/A	Ascidiacea
Botrylloides violaceus	Orange cloak sea squirt	Ascidiacea
Corella eumyota	Orange tipped sea squirt	Ascidiacea
Didemnum spp.(non-native)	N/A	Ascidiacea
Didemnum vexillum	Carpet sea squirt	Ascidiacea
Molgula manhattensis	Sea grape	Ascidiacea
Perophora japonica	Sea squirt	Ascidiacea
Phallusia mammillata	N/A	Ascidiacea
Styela clava	Leathery sea squirt	Ascidiacea
Aerococcus viridans	Bacteria	Bacteria
Bugula neritina	N/A	Bryozoa
Bugulina fulva	N/A	Bryozoa
Bugulina simplex	N/A	Bryozoa
Bugulina stolonifera	N/A	Bryozoa
Schizoporella japonica	Bryozoan	Bryozoa
Smittoidea prolifica	N/A	Bryozoa
Tricellaria inopinata	N/A	Bryozoa
Watersipora subatra	Red-rust bryozoan	Bryozoa
Cordylophora caspia	Freshwater hydroid	Cnidaria
Diadumene lineata	Orange-striped anemone	Cnidaria

Species	Common Name	Taxon Group
Amphibalanus amphitrite/ Balanus amphitrite	Striped barnacle	Crustacea
Amphibalanus improvisus/Balanus improvisus	Bay barnacle	Crustacea
Arcitalitrus dorrieni	New Zealand land hopper	Crustacea
Austrominius modestus	n/a	Crustacea
Caligus pageti	N/A	Crustacea
Caprella mutica	Japanese skeleton shrimp	Crustacea
Chelicorophium curvispinum	Caspian mud shrimp	Crustacea
Critomolgus actiniae	N/A	Crustacea
Eriocheir sinensis	Chinese mitten crab	Crustacea
Gammarus tigrinus	N/A	Crustacea
Herrmannella duggani	Copepod	Crustacea
Heterolaophonte hamondi	N/A	Crustacea
Heterolaophonte hamondi	Copepod	Crustacea
Homarus americanus	American lobster	Crustacea
Jassa marmorata	Marbled tube-maker/Marbled scud	Crustacea
Limnoria quadripunctata	N/A	Crustacea
Megabalanus tintinnabulum	N/A	Crustacea
Monocorophium acherusicum	N/A	Crustacea
Monocorophium insidiosum	N/A	Crustacea
Monocorophium sextonae/Corophium sextonae	Mud shrimp	Crustacea
Muceddina multispinosa	N/A	Crustacea
Myicola ostreae	Copepod	Crustacea
Mytilicola intestinalis	Mussel red worm	Crustacea
Mytilicola orientalis	Parasitic copepod	Crustacea
Paradoxostoma angliorum	N/A	Crustacea
Penaeus japonicus/Marsupenaeus japonicus	Karuma shrimp	Crustacea
Pilumnoides inglei	N/A	Crustacea
Pollicipes pollicipes	Goose barnacle	Crustacea
Porcellidium ovatum/Porcellidium tenuicauda	N/A	Crustacea
Porcelloides tenuicaudus	N/A	Crustacea
Spartina anglica	Smooth cordgrass	Flowering Plant
Spartina townsendii var. anglica	Common cordgrass	Flowering Plant
Spartina x townsendii	Townsend's cordgrass	Flowering Plant
Claviceps purpurea	N/A	Fungi
Ostracoblabe implexa	N/A	Fungi
Isochrysis spp. (Isocrysis galbana?)	N/A	Haptophyta
Craspedacusta sowerbii	Peach blossom jellyfish	Hydrozoa

Species	Common Name	Taxon Group
Gonionemus vertens	Clinging jellyfish	Hydrozoa
Telmatogeton japonicus	N/A	Insecta
Bankia fimbriatula	N/A	Mollusca
Brachidontes exustus	N/A	Mollusca
Calyptraea chinensis	Chinaman's hat	Mollusca
Cerithium litteratum	N/A	Mollusca
Chama sp.	N/A	Mollusca
Corbicula fluminea	N/A	Mollusca
Crepidula fornicata	Slipper limpet	Mollusca
Dendostrea frons	Frond oyster	Mollusca
Dreissena polymorpha	Zebra mussel	Mollusca
Ensis leei	Jack knife clam/American razor clam	Mollusca
Haliotis discus hannai	Japanese abalone	Mollusca
Haliotis tuberculata	European abalone	Mollusca
Isognomon radiatus	Radial purse-oyster	Mollusca
Magallana gigas	Pacific oyster	Mollusca
Martesia striata	N/A	Mollusca
Mercenaria mercenaria	N/A	Mollusca
Mizuhopecten yessoensis	N/A	Mollusca
Mya arenaria	N/A	Mollusca
Ocinebrellus inornatus	Japanese oyster drill	Mollusca
Ostrea equestris	Crested oyster	Mollusca
Potamopyrgus antipodarum	New Zealand mud snail	Mollusca
Ruditapes philippinarum	Manila clam	Mollusca
Teredo navalis	Naval shipworm	Mollusca
Anguillicola crassus	Eel bladder nematode	Nematoda
Oncorhynchus gorbuscha	Pink salmon/ Humpback salmon	Pisces
Oncorhynchus mykiss	N/A	Pisces
Poecilopsetta beanii	N/A	Pisces
Alexandrium minutum	Red tide dinoflagellate	Protozoan
Heterosigma akashiwo	Red tide microalgae	Raphidophyceae
Ostreid herpesvirus OsHV-1	Oyster herpesvirus	Virus
Ceratophyllum submersum	Soft hornwort	Wildflowers

Annex 2

List of the 56 marine NIIS recorded across the island of Ireland which have undergone a form of risk assessment. This list was compiled using a dataset from Miramin et al. (2019), which integrates multiple risk assessment frameworks, alongside the Marine Invasive Non-Native Species List for Northern Ireland produced by DAERA.

Risk Category	Species	Common Name	Taxon Group
High	*Alexandrium tamarense*	Toxic dinoflagellate	Algae (Myzozoa)
	Amphibalanus improvisus/Balanus improvisus	Bay barnacle	Crustacea
	Anguillicola crassus	Eel bladder nematode	Nematoda
	Aphanomyces astaci	N/A	Algae (Oomycota)
	Biddulphia sinensis/ Odontella sinensis	N/A	Algae (Ochrophyta)
	Bonamia ostreae	Bonamia	Algae (Cercozoa)
	Bonnemaisonia hamifera	N/A	Algae (Rhodophyta)
	Caprella mutica	Japanese skeleton shrimp	Crustacea
	Chelicorophium curvispinum	Caspian mud shrimp	Crustacea
	Corbicula fluminea	N/A	Mollusca
	Corella eumyota	Orange tipped sea squirt	Ascidiacea
	Coscinodiscus wailesii	N/A	Algae (Bacillariophyta)
	Crepidula fornicata	Slipper limpet	Mollusca
	Didemnum vexillum	Carpet sea squirt	Ascidiacea
	Eriocheir sinensis	Chinese mitten crab	Crustacea
	Homarus americanus	American lobster	Crustacea
	Sargassum muticum	Wireweed	Algae (Ochrophyta)
	Spartina anglica	Smooth cordgrass	Flowering Plant
	Styela clava	Leathery sea squirt	Ascidiacea
	Undaria pinnatifida	Japanese kelp/Wakame	Algae (Ochrophyta)
	Asterocarpa humilis	Compass sea squirt	Ascidiacea
	Didemnum spp.(non-native)	N/A	Ascidiacea
	Grateloupia turuturu	Devil's tongue weed	Algae (Rhodophyta)

Risk Category	Species	Common Name	Taxon Group
Medium	*Antithamnionella spirographidis*	N/A	Algae (Rhodophyta)
	Antithamnionella ternifolia	N/A	Algae (Rhodophyta)
	Arcitalitrus dorrieni	New Zealand land hopper	Crustacea
	Austrominius modestus	N/A	Crustacea
	Botrylloides violaceus	Orange cloak sea squirt	Ascidiacea
	Calyptraea chinensis	Chinaman's hat	Mollusca
	Codium fragile subsp. atlanticum	Dead man's fingers	Algae (Chlorophyta)
	Codium fragile subsp. Tomentosoides	Green sea fingers	Algae
	Cordylophora caspia	Freshwater hydroid	Cnidaria
	Dasysiphonia japonica/Heterosiphonia japonica	Red seaweed	Algae (Rhodophyta)
	Diadumene lineata	Orange-striped anemone	Cnidaria
	Dreissena polymorpha	Zebra mussel	Mollusca
	Ficopomatus enigmaticus	Australian tubeworm	Annelida
	Gammarus tigrinus	N/A	Crustacea
	Gracilaria vermiculophylla/Agarophyton vermiculophyllum	Gracilaria	Algae (Rhodophyta)
	Magallana gigas	Pacific oyster	Mollusca
	Melanothamnus harveyi/Neosiphonia harveyi/ Polysiphonia harveyi	Harvey's siphon weed	Algae (Rhodophyta)
	Myicola ostreae	Copepod	Crustacea
	Mytilicola intestinalis	Mussel red worm	Crustacea
	Mytilicola orientalis	Parasitic copepod	Crustacea
	Ostreid herpesvirus OsHV-1	Oyster herpesvirus	Virus
	Potamopyrgus antipodarum	New Zealand mud snail	Mollusca
	Schizoporella japonica	Bryozoan	Bryozoa
	Tricellaria inopinata	N/A	Bryozoa
	Watersipora subatra	Red-rust bryozoan	Bryozoa
	Ensis leei	Jack knife clam/American razor clam	Mollusca
	Ruditapes philippinarum	Manila clam	Mollusca
Low	*Amphibalanus amphitrite/ Balanus amphitrite*	Striped barnacle	Crustacea
	Antithamnion densum	N/A	Algae (Rhodophyta)
	Aplidium glabrum	N/A	Ascidiacea
	Asparagopsis armata	Harpoon weed	Algae (Rhodophyta)
	Bugula neritina	N/A	Bryozoa
	Colpomenia peregrina	Oyster thief	Algae (Ochrophyta)

An tIonad Náisiúnta Sonraí Bithéagsúlachta
National Biodiversity Data Centre

National Biodiversity Data Centre,
Beechfield House,
South East Technological University,
West Campus, Carriganore,
Co. Waterford, Ireland. X91 PE03

+353 (0)51 306 240
info@biodiversityireland.ie
biodiversityireland.ie

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