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Coherence of marine alien species biosecurity legislation: A study of England and Wales

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ABSTRACT

The marine environment is particularly at risk from the intentional and unintentional introduction and spread of invasive alien species (IAS); preventing their introduction and spread from occurring is therefore, a key component in the on-going management of marine IAS. Ensuring legislation is coherent and consistent is essential to the success of managing the existing and future impacts of marine IAS. We explore the coherence (determined as consistency and interaction) of marine biosecurity legislation for IAS at different geopolitical scales. There was consistency between both the Bern Convention and Convention on Biological Diversity and European and national legislation that had been created in response. There was a lack of interaction evidenced by the Ballast Water Management Convention, which had not yet been transposed into regional (mainly European) or national legislation. Implementation measures such as legislation should be coherent as any failure in the chain could potentially weaken the overall effort to establish and maintain biosecurity and achieve behaviour change.

1. Introduction

Whilst most non-native species do not have impacts post introduction, a minority have the potential to become invasive and have negative environmental, social and economic impacts (Ricciardi and MacIsaac, 2010; IMO, 2011; Sambrook et al., 2014); hereafter referred to as invasive alien species (IAS). The cost of post introduction management measures in remedial action to counter the impacts and/or control species can be huge. The cost to the United States, United Kingdom, Australia, South Africa, India and Brazil combined has been estimated at over $314 billion per annum (Pimentel et al., 2005), in the European Union (EU) IAS are estimated to cost approximately €12.5 billion a year (£11 billion) (Kettunen et al., 2009), and in Great Britain £1.7 billion per year ($2.2 billion) (Williams et al., 2010).

Preventing the introduction of IAS is considered the most cost effective and efficient means to reduce economic, ecological, and economic costs in the future. This is particularly relevant to the marine environment where species are especially difficult to removed once established (Katsanevakis et al., 2013; Tidbury et al., 2016). Prevention has, therefore, become part of a common policy in the management of IAS and forms the primary action in policy instruments such as conventions, regulations, directives, and legislation. However, implementing legislation, is extremely challenging, as it relies on the cooperation of stakeholders, in addition to the development of the policy instruments and reaching binding agreements (Hulme et al., 2008; Williams and Grosholz, 2008). The coherence of policy is becoming an increasingly important objective in governance in the EU. Policy coherence is defined as the ability of multiple policy goals to coexist and support each other in the achievement of the goals (Howlett, 2018). Coherence is pursued to enhance synergies and reduce conflicts between other interacting policies to achieve the outcomes (Nilsson et al., 2012). Policy coherence is essential for successful implementation of policies to achieve international and national goals and objectives (Howlett and Rayner, 2007). Coherence should achieve consistency (the ability of multiple policy tools to reinforce rather than undermine each other in the pursuit of policy goal) and positively interact (Howlett, 2018). It is assumed that policy consistency has a positive result, where inconsistency has a negative impact (ineffective) (Howlett and Rayner, 2007). Similarly, where there are positive interactions between policies, a positive result will occur.

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Understanding the coherence of policies, their consistency and how they interact is considered to be one of the most important issues in environmental governance and can help to identify synergies and conflicts between existing policies and how they influence each other's effectiveness (Carter, 2007; Nilsson et al., 2012; Strambo et al., 2015). Consistency can improve effectiveness, as having inconsistent and incoherent policies can send confusing or conflicting messages to stakeholders (Howlett and Rayner, 2007; Owens and Driffill, 2008). Incoherent and conflicting policies will ultimately limit the uptake and effectiveness of policy on the ground (Schillo et al., 2017).

Policy analysis can help assess how global policy instruments are introduced into national systems, and can provide insight into the relationship between policies for managing the pathways of marine non-native species (May et al., 2006; Nilsson et al., 2012; Kivimaa and Virkamäki, 2014). This process has been applied to climate policy, highlighting many inconsistencies (as well as synergies) between climate change mitigation and energy security policies instruments in the EU (Strambo et al., 2015). Höhne et al. (2017) argued that there were inconsistencies between current national actions to achieve the long-term goals of the Paris Agreement and identified factors that would strengthen national action to reduce emissions in order to be more consistent with the agreed global long-term goals. Therefore, having a coherent policy framework at an international and national level is key to the success of managing the existing and future impacts of IAS in the marine environment. Policy instruments set standards of what is acceptable behaviour for target groups (Carter, 2007). Policy instruments work at the group level to influence norms and a persons' intention to behave (Ajzen, 1991). Whilst there is a sizeable literature on coherence in other related topic areas (mainly climate policy), currently no policy analysis has been applied to the legislative/regulatory framework around IAS in the marine environment.

The overarching aim of this study is to explore the coherence of marine IAS legislation at an international and national scale. The objectives of the work are: a) investigate the consistency and, b) the interaction of policies at international, regional (European) and national levels.

2. Research design and methodology

2.1. Data collection and analysis

Legislation was identified at the international level, regional legislation at the European scale, and national legislation was for England and Wales. Wales falls under the same judicial system as England and much of the legislation considered applied to both England and Wales. The study excluded national policies from Northern Ireland and Scotland due to different political systems and policies dealing with non-native species at the national level.

Legislation was purposefully selected using a top down approach, as this approach is better suited to exploring the coherence between the written content of policies formulated internationally. This approach allows the researcher to track the consistency of legislation down through governance levels and study the interaction of these policies (Urwin and Jordan, 2008).

Three international conventions were identified by a literature review as the most relevant agreements for this study: the Convention on Biological Diversity (CBD) (1992) (https://www.cbd.int/), the Bern Convention (1982) (https://www.coe.int/en/web/bern-convention), and the Ballast Water Management (BWM) Convention (2017) (http://www.imo.org/en/OurWork/Environment/BallastWaterManagement/Pages/Default.aspx). The BWM Convention treaty was proposed by the IMO which is the United Nations agency for shipping. Unlike the other two international legislative documents, the convention is pathway specific, directed at the risk of moving hazardous substances in ballast water and sediment. The convention entered into force in September 2017, and to date (December 2019) 81 parties have ratified excluding the UK, which has yet to ratify the convention. One reason given by the UK for not ratifying the convention is that it has yet to be placed into a national legislation.

The online search was conducted from March 2017 to October 2019. The researchers only included legally binding conventions, therefore other conventions such as OSPAR, RAMSAR or the Bonn convention have not been included in this study as they are not legally binding. The internet was searched for relevant regional and national legislation, related to the three conventions. The regional (European) and national legislation that was identified from the international convention websites and included legislation, directives, and regulations. Websites for European and national legislation included European law (Europa.eu) and the National Archive (Legislation.gov). Additional legislation were identified through a search of IAS legislation, using the Great Britain Non-Native Species (GBNNS) Secretariat webpage on 'Legislation and Regulation' relevant for Great Britain (http://www.nonnativespecies.org//index.cfm?pageid=67). These included legislation on the use of IAS in aquaculture.

It should be noted that the selected legislation were not intended to be an exhaustive list of all of the Government's legislative efforts for England and Wales, rather they were chosen as they relate specifically to the marine environment and/or overarching IAS management. As the aim of the paper was to look at how items of legislation relate, a limited number of legislative instruments were considered rather than a more expansive approach to keep the analysis focussed on the marine environment. Therefore, legislative frameworks such as the Birds Directive were not included in the analysis as these do not relate specifically to the marine environment or IAS. Legislation implemented for the control of specific species (e.g American lobster (Stebbing et al., 2012)) has also been omitted.

2.2. Consistency

The 14 international and national legislation identified were analysed using iterative qualitative content analysis which is widely used in policy analysis (Schreier, 2012; Kalaba et al., 2014). The coding was performed by the primary researcher and checked by the remaining three authors.

Vertical policy consistency (top down compatibility of legislative aims/actions without conflict) was determined by analysing legislation using the following pre-determined categories: i) aims of legislation; ii) relevance to international legislation (conventions); iii) primary interest and iv) terminology. Each category included codes and search terms that were used to search each legislation (Table 1). Samples of text for each category and code were put into a combined matrix (Supporting information 1).

An iterative process was used to search all the legislation for their general or IAS related aim(s). The term 'aim' was not always used consistently in legislation and therefore search terms included 'aim', 'goal', 'objective' and 'target' (Table 1). All terms were combined and from here forward are referred to as 'aim'. The identified aims were then used to evaluate the interaction of legislation. European and national legislation were also searched for reference among the three conventions to track their implementation.

Each legislative document was coded as either environmental, economic, social, travel or trade according to the code description and search terms, and more than one code could be used to identify the broad primary interest. The primary interest of each instrument was again used to evaluate interactions.

Because of the debate concerning terminology used in IAS science and how the choice of terminology or lack of common terminology can heavily determine the implementation of policy objectives (Larson, 2005), each legislative document was coded to determine the type of terminology used, and highlighted where and if the terminology was defined. The terminology from the Bern Convention, CBD and BWM Convention were tracked down through European and national

Table 1
Pre-determined categories, codes and search terms for content analysis.

Category	Code	Search terms
Aims of legislation	Aim	Aim, goal, objectives, target
Relevance to conventions	Bern Convention	Convention on the Conservation of European Wildlife and Natural Habitats/ Bern Convention
	CBD	Convention on Biological Diversity/ CBD
	BWM Convention	Ballast Water Management Convention/ BWM Convention
Primary interest	Environmental	Nature conservation, marine conservation, biodiversity, sustainability, environment, plants, and animals
	Economic	Economic, economy, production, cost, finance, income, output
	Social	Sustainability, development, health, society, welfare, economy
	Trade	Trade, economy, transport, deal, agreement, goods, services, business, sell
	Travel	Transport, location, air, land, sea, shipping, vehicle
Terminology	Prevention	Prevention Biosecurity
	Invasive	Non-native, invasive non-native, alien, non-indigenous, introduced

legislation to determine whether the terminology and definitions were linear from a top down perspective.

2.3. Interaction

Both vertical (e.g. international and European) and horizontal (e.g. European and European) interactions between legislation and their aims (identified in the previous section), were assessed to determine how the aims of one legislation impacted the effectiveness of achieving the aims in another, specifically in relation to IAS and biosecurity. Interaction was assessed as either positive, negative or neutral. Positive interactions were determined when one aim supported the aims of another, for example if two policies shared the same aims or if one aim enhanced that of another. Negative interactions were determined when one aim had the potential to, or evidently conflicted (or prevented) that of another aim being achieved. For example, if one legislative instrument allowed a certain activity whilst another prohibited it. Neutral interactions were identified when aims of either legislation had any relevance to that of another, for example it neither enhanced nor discouraged an aim.

3. Results

3.1. Consistency

3.1.1. General aim(s) of legislation and relevance to IAS

The general aims of the international, European and national legislation and their relevance to IAS can be found in Table 2. All three international legislation state that IAS are damaging to the environment, economy and society and need to be controlled and managed, therefore there are no conflicts between the aims of the conventions. The Bern Convention covers the whole of Europe and is a binding legal instrument that sets out aims and objectives to conserve European wildlife and habitats. According to the Bern Convention (Article 11(2b)) all parties should strictly control the introduction of non-native species. On a global scale, the CBD is an international legally binding treaty (ratified agreement between states) that aims to develop regional and national strategies for the conservation and sustainable use of biological diversity. The CBD has adopted a three-tier hierarchal approach to IAS management: i) prevention; ii) early detection and rapid response and iii) long-term management. The CBD identifies IAS as one of the biggest threats to biodiversity and therefore recognises that there is an urgent need to address the impact of IAS.

3.1.2. Relevant European and national legislation

Both the CBD and the Bern Convention have been transposed into European and national legislation (Table 2; Fig. 1).

Regionally the Council Regulation concerning the use of alien and locally absent species in aquaculture, the EU Regulation on IAS and the MSFD were created to implement the goals agreed in the CBD. The Marine Strategy Regulations and the Alien and Locally Absent Species in Aquaculture Regulations both transpose the requirements of the name sake European legislation into national legislation. Legally, Regulations are automatically binding throughout the EU and therefore it does not need to be incorporated into the national law of Member States. Therefore the EU Regulation is directly applicable and binding in its entirety, however the Invasive Alien Species (Enforcement and Permitting) Order 2019 allows for the enforcement of the EU Regulation in England and Wales, including the relevant licenses, permits and rules for keeping invasive alien species.

As a signatory, the EU meets the obligations of the Bern Convention through the Habitats Directive, the WFD and the MSFD. The obligations of the Bern Convention have been transposed from European legislation to national (England and Wales) legislation by means of the WCA, the Conservation of Offshore Marine Habitats and Species Regulations.

The BWM Convention is relatively new and in early stages of implementation, therefore there are currently no regional or national legal instruments that implement the aims of the convention.

3.1.3. Primary interest

All three international legislative instruments were concerned with environmental protection and achieving conservation and sustainability targets (Table 2). Within European legislation, the Habitats Directive, WFD and MSFD are all conservation focussed and aim to protect biodiversity within the marine environment. The Council Regulation concerning the use of alien and locally absent species in aquaculture and the IAS Regulation are also environmentally focussed, specifically on addressing the impacts of IAS.

Not all international legislation examined were solely focussed on environmental issues. For example, the BWM Convention also includes travel, trade and economic interests as the Convention targets the shipping industry in relation to IAS. Although not a primary focus, Council Regulation concerning the use of alien and locally absent species in aquaculture and the national counterpart are also focused on social and economic issues as the industry is concerned with risks to businesses.

3.1.4. Terminology

The term ‘non-native species’ is used by the Bern Convention. The term ‘non-native species’ could be tracked down to the European level within the Habitats Directive and on a national level in the WCA and the Conservation of Offshore Marine Habitats and Species Regulations (Table 3). However, there is other European (WFD, MSFD) and national (the Water Environment Regulation, the Marine Strategy Regulation) legislation that do not use the Bern Convention terminology. The Ballast Water Convention uses terms synonymous with the Bern Convention, referring to ‘harmful aquatic organisms’ and ‘invasive aquatic species’. The MSFD uses the term ‘non-indigenous species’ which is not found in any other legislative document. No synonymous terms to ‘non-native’ was used within the Water Environment Regulations. The Marine Strategy Regulation used terms synonymous with the MSFS.

The Bern Convention itself does not refer to prevention or biosecurity. On both a European level and national level, policies reference ‘prevention’ but this is in the context of water pollution and deterioration of the water body or ‘crops, livestock, forests, fisheries and water and other types of property’ (Habitats Directive).

The CBD uses the term ‘alien species’. Both European (Council Regulation concerning the use of alien and locally absent species in aquaculture, IAS Regulation) and national (Alien and Locally Absent Species in Aquaculture Regulations) legislation use the same

Table 2
General aims, relevance to IAS and primary interest of international, European and national legislation.

Scale	Document	General aim(s)	Relevance to IAS	Primary interest(s)
International legislation	The Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) 1982	The principle aims of the Convention are to ensure conservation and protection of wild plant and animal species and their natural habitats, to increase cooperation between contracting parties, and to regulate the exploitation of those species listed (including migratory species).	The Bern Convention is a binding international legal instrument in the field of nature conservation. The Convention recognises that IAS pose a significant threat to the aims of conserving wild flora and fauna and their natural habitats within Europe and therefore the introduction of IAS must be controlled.	Environmental
	The Convention on Biological Diversity (CBD) 1992	As the first global treaty to provide a legal framework for biodiversity conservation, the Convention established three principle goals. (1) the conservation of biological diversity, (2) the sustainable use of its components, (3) the fair and equitable sharing of the benefits arising from the use of genetic resources.	Article 8(h) of the CBD states that Parties should "prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species".	Environmental
	Ballast Water Management Convention (BWM) 2017	The principle aim of the BWM Convention is to prevent the spread of harmful aquatic organisms, by establishing standards and procedures for the management and control of ships' ballast water and sediments.	Introduces a global framework to control the transfer of potential IAS in ships' ballast water.	Environmental Economic Travel Trade
European legislation	Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)	The principle aim of the Habitats Directive is to promote the maintenance of biodiversity by requiring Member States to take measures to maintain or restore natural habitats and wild species listed on the Annexes to the Directive at a favourable conservation status, introducing robust protection for those habitats and species of European importance.	Article 22 of the Directive requires Member States to "ensure that the deliberate introduction into the wild of any species which is not native to their territory is regulated so as not to prejudice natural habitats within their natural range or the wild native fauna and flora and, if they consider it necessary, prohibit such introduction."	Environmental
	Water Framework Directive (WFD) 2000/60/EC	The purpose of the Directive is to establish a framework for the protection of inland surface waters (rivers and lakes), transitional waters (estuaries), coastal waters and groundwater. It will ensure that all aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands meet 'good status'.	Aim to achieve or maintain a good ecological status for European inland, transitional and coastal waters and prevent their further deterioration. Non-native species are one of the significant pressures that could result in a water body failing to meet environmental objectives (such as failing to achieve good ecological status).	Environmental
	Marine Strategy Framework Directive (MSFD) 2008/56/EC	The MSFD outlines a legislative framework for an ecosystem-based approach to the management of human activities which supports the sustainable use of marine goods and services. The overarching goal of the Directive is to achieve 'Good Environmental Status' (GES) by 2020 across Europe's marine environment.	IAS are considered to prevent good environmental status being achieved. Descriptor 2 states that "non-indigenous species introduced by human activities are at levels that not adversely alter the ecosystem".	Environmental Social Economic
	Council Regulation (EC) No. 708/2007 concerning the use of alien and locally absent species in aquaculture	The principle aim is to ensure there is adequate protection of aquatic habitats.	Establishes a dedicated framework to assess and minimise the possible impact of alien and locally absent species used in aquaculture in the aquatic environment.	Environmental Economic
	Regulation (EU) No 1143/2014 on the prevention and management of the introduction and spread of IAS	The principle aim is to set three distinct types of measures which follow an internationally agreed hierarchical approach to combatting IAS: Prevention, Early detection and rapid eradication and Management. These actions are focused on a list of IAS of particular concern to the EU.	This imposes restrictions on a list of species known as 'species of Union concern'. These are species whose potential adverse effects across the EU are such that concerted action across Europe is required. The list is then managed by Member States using risk assessments and scientific evidence.	Environmental Social Economic
National legislation	The Wildlife and Countryside Act (WCA) 1981	The WCA 1981 is the primary legislation which protects animals, plants and habitats in the UK.	Section 14(1) of the Act makes it illegal to release or allow to escape into the wild any animal which is not ordinarily resident in Great Britain and is not a regular visitor to Great Britain in a wild state or is listed in Schedule 9 to the Act.	Environmental
	The Conservation of Offshore Marine Habitats and Species Regulations 2017	The Conservation of Offshore Marine Habitats and Species Regulations 2017 form the legal basis for the implementation of the Habitats and Birds Directives in terrestrial areas and territorial waters out to 12 nm in England and Wales (including the inshore marine area) and to a limited extent in Scotland and Northern Ireland.	The regulation makes it an offence to deliberately introduce any live non-native animal or plant which would give rise to a risk of prejudice to natural habitats within their natural range or a risk of prejudice to wild native flora or fauna.	Environmental
	The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017	This Regulation transposes the Water Framework Directive into national law in the UK. The Regulations outline the duties of regulators in relation to environmental permitting, abstraction and impoundment of water in order to achieve "good status" (or good ecological potential for artificial or heavily modified water bodies).	Non-native species are one of the significant pressures that could result in a water body failing to meet environmental objectives (such as failing to achieve good ecological status).	Environmental
	Marine Strategy Regulations 2010			Environmental

(*continued on next page*)

Table 2 (*continued*)

Scale	Document	General aim(s)	Relevance to IAS	Primary interest(s)
		This statutory instrument transposes the requirements of the MSFD into UK legislation and requires the UK to take necessary measures to achieve or maintain a good environmental status in the marine environment by 2020.	Achievement of GES will be assessed against eleven descriptors which include descriptor 2: Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems.	
	The Alien and Locally Absent Species in Aquaculture (England and Wales) Regulations 2011	This Regulation implements Council Regulation (EC) 708/2007. It makes provision with respect to permits issued by the competent authority under the Regulation, notifying movement of Annex IV species or locally absent species, environmental risk assessments, contingency plans and monitoring.	Establishes a dedicated framework to assess and minimise the possible impact of alien and locally absent species used in aquaculture in the aquatic environment. A risk assessment is needed to import a new species into the UK or to relocate.	Environmental Economic
	The Invasive Alien Species (Enforcement and Permitting) Order 2019	The policy instrument which embeds Regulation (EU) No 1143/2014 on the prevention and management of the introduction and spread of IAS into UK law, providing detail of the enforcement powers.	Provides detail of how enforcement activities relevant to the Regulation will be carried out, the relevant fines and what constitutes a criminal act.	Environmental Social Economic

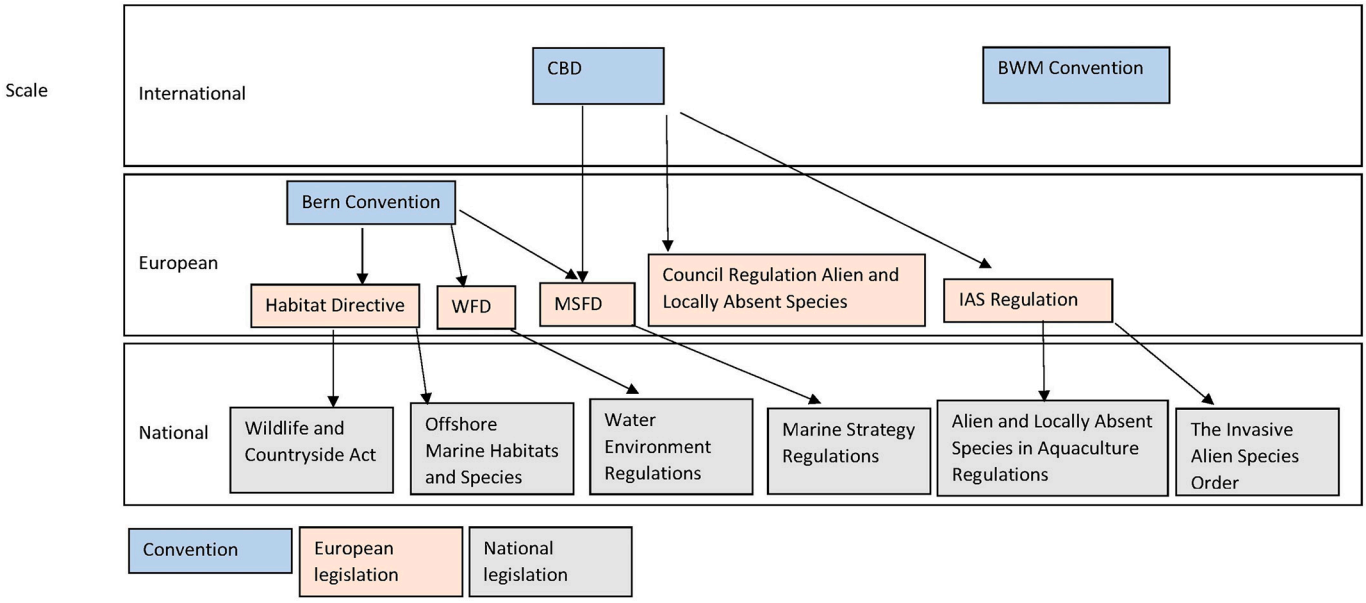

Fig. 1. International agreements and relevant European and national law. Arrows indicate related national and European legislation to illustrate flow.

terminology. Prevention is one of the three guiding principles recommended in the CBD in dealing with IAS. The term 'prevention' is used at a European level by the IAS Regulation and Regulation concerning the use of alien and locally absent species in aquaculture. The term 'prevention' is also used within the Invasive Alien Species (Enforcement and Permitting) Order 2019, the national legislation related to the CBD. The Marine Strategy Regulations, which relates to both the CBD and Bern Convention refers to prevention, but in the context of chemical based pollution from shipping rather than specifically IAS.

The BWM Convention refers to 'prevention' with a goal to 'reduce, or eliminate the transfer of Harmful Aquatic Organisms and Pathogens through ships' Ballast Water and Sediments' (BWM Convention, 2017). There is currently no existing national legislation that implements the BWM Convention and therefore the terminology could not be tracked.

3.2. Interaction

3.2.1. Vertical interaction

There is evidence of positive vertical interaction between the aims of the three international legislative instruments, and the aims of European and national legislative instruments (Supporting information 2). There is evidence that both the Bern Convention and CBD have been transposed into European and national legislation, of which highlight the impact of IAS on the environment, economy and in society. For example, the EU IAS Regulation uses the same three-stage approach to addressing IAS as the CBD. Similarly, the Regulation concerning the use of alien and locally absent species in aquaculture establishes a framework using the same approach as the CBD, and the EU IAS Regulation. Whilst there is no negative interaction between the BWM Convention and national legislation, there are areas of neutral interaction. For example, there was no negative nor positive interaction between the BWM Convention and the Habitats Directive, the Regulation concerning the use of alien and locally absent species in aquaculture (European), the WCA and the Alien and Locally Absent Species in Aquaculture Regulations (national). This was because the aims of the BWM convention neither supported nor conflicted with the aims of these regulations as they focused on different habitats and activities.

Whilst most interactions from European to national legislation were positive, there was evidence of some negative vertical interaction between Council Regulation concerning use of alien and locally absent species in aquaculture and the WCA. The WCA aims to protect animals, plants and habitats in the UK and makes it illegal to release or allow

Table 3
Terminology used in international, regional and national legislation in relation to IAS and biosecurity, in addition to their relevance to international legislation.

Scale	Document	Relevant international agreements	Terminology used in relation to IAS and biosecurity
International legislation	The Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) 1982		Non-native species
	The Convention on Biological Diversity (CBD) 1992		Prevent Alien species
	Ballast Water Management Convention (BWM) 2017		Invasive aquatic species Harmful aquatic organisms
European legislation	Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)	Bern Convention	Non-native species
	Water Framework Directive (WFD) 2000/60/EC	Bern Convention	(Pollution) prevention and control
	Marine Strategy Framework Directive (MSFD) 2008/56/EC	Bern Convention CBD	Non-indigenous species
	Council Regulation (EC) No. 708/2007 concerning the use of alien and locally absent species in aquaculture	CBD	Alien species Locally absent species Prevent the introduction
	Regulation (EU) No 1143/2014 on the prevention and management of the introduction and spread of IAS	CBD	Alien species Invasive alien species Invasive alien species of Union concern Invasive alien species of Member State concern Prevention
National legislation	The Wildlife and Countryside Act 1981	Bern Convention	Preventing serious damage (to livestock) Invasive non-native species of animal or plant
	The Conservation of Offshore Marine Habitats and Species Regulations 2017	Bern Convention	Prevention (of deterioration of habitats and disturbance of species and the spread of disease) Non-native species
	The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017	Bern Convention	Prevent (deterioration of the status of each body of surface water)
	Marine Strategy Regulations 2010	Bern Convention CBD	Prevent (inputs into the marine environment)
	The Alien and Locally Absent Species in Aquaculture (England and Wales) Regulations 2011	CBD	Alien Locally absent species
	The Invasive Alien Species (Enforcement and Permitting) Order 2019	CBD	Alien Species Non-native species Invasive non-native species Invasive alien species Prevention

escape into the wild of any animal which is not ordinarily resident in England and Wales and is not a regular visitor in a wild state or is listed in Schedule 9 to the Act. This conflicts with the Regulation concerning use of alien and locally absent species in aquaculture which permits the use of IAS for farming which would not normally be permitted under the WCA.

There was linear terminology used for European and national documents related to each international Convention. There was no cross over between the Bern Convention and CBD related legislation (i.e Bern Convention documents related to non-native species whilst the CBD documents referred to the term 'alien'). However, both the Bern Convention and CBD documents used the term 'invasive' to describe alien/non-native species with a negative environmental, social or economic impact.

3.2.2. *Horizontal interaction*

There was evidence of positive horizontal interactions between legislation. This occurred between all three international conventions (as all had a primary aim to protect the environment from IAS) as well as between the regional legislation. The EU IAS Regulation for example had positive horizontal interactions with all European legislation. There was potential conflict between the Council Regulation concerning the use of alien and locally absent species in aquaculture, and European nature conservation legislation such as the Habitats Directive and the MSFD which recognise that IAS could prevent good environmental status being achieved. However, the Council Regulation only allows for alien species to be introduced or translocated after a series of applications, permits and monitoring which satisfies the aims of both Directives. Similar positive, neutral and negative horizontal interactions were found on a national scale between legislation – with neutral interactions between marine and terrestrial legislation.

4. Discussion

This study is the first to review the coherence of IAS legislation in the marine environment and demonstrates positive linear consistency of legislation from the three international conventions reviewed (Bern Convention, CBD and BWM Convention), and many positive interactions between legislative instruments, both horizontally and vertically, at the regional (EU) and national (England and Wales) level. Our results illustrate that both the Bern Convention and CBD had been transposed into European and national law. However, just because there may be vertical links between legislative frameworks, does not guarantee consistency; therefore, the design of the legislation must be fully considered. National legislation that is put in place to reach an international commitment should have positive interaction/alignment by nature of the fact it is designed to meet an international commitment. There should be more guidance produced by the government illustrating how legislation works together (Scalera et al., 2020). The BWM Convention has not yet been transposed and is relatively new in comparison therefore any analysis for consistency was limited. In order to successfully manage IAS in the marine environment, legislation must be coherent as any failure in the chain could potentially weaken the overall effectiveness of the control and management of non-native species (Lehtiniemi et al., 2015).

Having a harmonised approach makes it easier for organisations that operate in multiple EU member states, to comply with one regulation as opposed to many. Unlike the other international legislation reviewed, the BWM convention needs to be implemented at the state level and will therefore not be implemented at the regional level. Co-ordination of implementation is however likely to occur within Regional Sea Conventions, such as OSPAR and HELCOM.

The specific terminology used by each Convention was consistently tracked within relevant European and national legislation. Whilst all three conventions used different terminology for IAS they were used synonymously. When exploring the definitions for each term, the term

'invasive' was used to illustrate negative impacts, whilst the terms 'non-native' and 'alien' were used synonymously. However, there is a shift in term from using the term 'IAS' on an international and European scale to using 'non-native' on a national level. Although not used within this analysis, the Great Britain Non-Native Species Strategy instead uses the term 'invasive non-native species' (INNS). This was in response to a study in 2008 conducted by Defra that found stakeholders (anglers, boaters etc.) preferred the term 'INNS' as the term 'alien species' was less familiar and deemed a less appropriate term (Defra, 2009). However, concerns around the definitions applied within international conventions have been raised by Richardson et al. (2000) who highlighted that whilst issues around definitions would unlikely be resolved, it would be imperative that international legislation be consistent with the use of terminology, or if different terminology is preferred then definitions should be provided. Additionally, Larson (2005) argues that the type of terminology used to reference IAS can influence the management of a species or issues on the ground. Definitions were not always used within the legislation included in this study, which could lead to confusion and misinterpretation. Where definitions were provided, there were no conflicts between the terms 'IAS' and 'INNS' which both implied negative impacts.

Sector specific IAS legislation are considered to have a greater potential to be more effective than general regulation/directives, as they potentially increase the uptake of behaviours to achieve the objectives (Ajzen, 1991; Jacob and Volkery, 2004). Sector specific policies must however be used consistently and coherently with existing legislative documents on the same or similar issues. Our results highlight a lack of positive vertical interaction between the BWM Convention and other legislation. Therefore, we suggest that if the BWM Convention were transposed into a national legislation, it would be beneficial to analyse the vertical and horizontal interaction of these documents. Having a coherent horizontal framework (as well as vertical), is instrumental for the creation of a long-term holistic biosecurity model which will prioritise knowledge gaps within relevant sectors and contribute to the improvement of the reduction of IAS introductions (Hoey et al., 2016). Policy makers need to proactively engage the relevant commercial industries as part of the solution, as biosecurity can only occur with collaboration and cooperation from key high risk pathway industries (i.e. trade) (Reaser et al., 2008).

Many national legislation, including the EU IAS Regulations, have only recently (2019) been introduced. Before this, the UK had created non-binding policy instruments which also implement the goals of international conventions and support regulatory instruments by setting out the values, standards of behaviour and expectations of stakeholders in order to achieve the aims of legislation. For example, the Great Britain Non-Native Species Strategy is a national plan for Great Britain. In many cases, voluntary agreements come into play where regulation not yet in place to try to provide some form of management. There are examples of voluntary agreements that are supported by governments and regulatory bodies; for example, in global climate change governance, voluntary agreements are officially endorsed by the United Nations Framework Convention on Climate Change (Gulbrandsen and Christensen, 2014). In the case of IAS, voluntary codes of conduct and best practices are considered as fundamental flexible 'implementation' tools which intend to mobilise a number of professionals linked to trade, exhibition, or sale of wild plants and animals (plus hunters, anglers and managers of protected areas) (Tollington et al., 2015; Genovesi et al., 2015). These voluntary codes are created to support public bodies, industry federations, user groups and/or NGOs in the hope that (due to existing interest) they will be the first to change behaviours to prevent the introduction and spread of IAS (Tollington et al., 2015; Genovesi et al., 2015). In the case of IAS legislation, there seemed to be a recent shift to sector specific codes of conduct, guidelines, strategies to address IAS. For example, existing non-binding instruments include strategies (e.g. European Union Biodiversity Strategy, European Strategy on IAS) and codes of conduct (e.g. the European Code of Conduct on Zoological Gardens and Aquaria and IAS, the European Union Code of Conduct on Recreational Boating and IAS). Since biosecurity is voluntary, some authors have measured the existing levels of biosecurity among field workers (Shannon et al., 2019), anglers and canoeists (Anderson et al., 2014). Other more recent studies have measured the effectiveness of voluntary instruments such as e-Learning to provide environmental training (Shannon et al., 2020). In a recent review by Defra, efforts have been made to understand how to enable co-ordination between sectors through public consultation (Defra, 2020; House of Commons Environmental Audit Committee, 2020).

The combination of regulatory and voluntary instruments presents challenges to the coherence of IAS legislation. Voluntary codes of conduct or best practice guidance should complement existing regulatory instruments and provide activity specific advice and incentives to stakeholders (Genovesi et al., 2015). The recent surge of voluntary instruments could suggest that top-down methods are inadequate and voluntary measures may be better suited for gaining acceptance and support (Tollington et al., 2015; Crowley et al., 2017). It will be necessary to measure the effectiveness of these instruments in relation to behaviour change to help policy makers understand what drives and motivates stakeholders to change behaviours in relation to IAS.

The UK government recognises that IAS pose a constant threat to international ecology and economy and that ensuring effective biosecurity measures are in place is therefore of great and lasting importance. However much of the UK's biosecurity currently depends upon cooperation with the EU. As the UK is set to leave the EU in 2019, this will create challenges for policy but there are also some opportunities for national measures (e.g. tailoring lists of restricted species to better reflect the risks posed to the UK, or increasing checks at ports and airports). Brexit therefore provides an opportunity for the Government to consider fundamentally altering its approach to managing biosecurity, moving away from a system based on a list of restricted items (which does not protect against unknown risks) and towards a unified biosecurity policy across all sectors. It is a requirement under the EU Regulation for management measures to be put in place for widespread IAS. In October 2019, the IAS (Enforcement and Permitting) Order 2019 was implemented in order to tighten rules around releasing IAS which threaten the UK environment and to tackle future IAS. The effectiveness of this Act is currently unknown, however policy makers should make sure that there are no conflicts between the new Act and existing environmental, social or economic policy, as any conflicts can reduce the effectiveness of policy on the ground. In addition to this, similar to Australia and New Zealand, the UK is an island which should be capitalised on and should consider creating a Biosecurity Act, which can be an effective approach to maintain biosecurity on an island, in combination with biosecurity campaigns. Leaving the EU could therefore offer the UK the opportunity to improve its biosecurity.

5. Conclusion

International conventions are part of and form global efforts to protect biodiversity and natural environments. IAS are a global problem that can pose a significant threat to the marine environment and therefore require a collaborative approach to manage. It is assumed that international policies set explicit aims and objectives which are then directly translated into action 'on the ground' through regional (European) and national instruments. It is important to evaluate the consistency of legislation at each scale and understand the interactions between these policies, which will highlight any implications for their effectiveness. Through application of a top down policy analysis we were able to demonstrate that whilst regional and national instruments related to the same conventions were consistent, horizontal consistency and interaction was lacking between legislation, especially new emerging pathway specific legislation. There is an opportunity for a more consistent approach to UK biosecurity across introductory pathways. Voluntary agreements should continue to work side by side of

legislation however, the UK could learn from New Zealand's ambitious Biosecurity 2025 plan and adopt a Biosecurity Act or similar piece of legislation, which brings different sector instruments together to provide coherence and prevent any duplication of work. However, this will depend on more interaction and collaboration between sectors and industries and equally important is the existence of a specific central authority, an identifiable and responsible institution, to oversee and administer the process of strategic integration (Lafferty and Hovden, 2003). Responsibility of these sectors to implement legislation will increase coherence and create a stronger approach to manage the impacts of IAS.

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CRediT authorship contribution statement

Caitriona Shannon: Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft. **Claire H. Quinn:** Conceptualization, Methodology, Writing - review & editing, Supervision, Funding acquisition. **Alison M. Dunn:** Conceptualization, Methodology, Writing - review & editing, Supervision, Funding acquisition. **Paul D. Stebbing:** Conceptualization, Methodology, Writing - review & editing, Supervision, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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