Audit, review and prioritisation for marine invasive non-native species biosecurity planning in England

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Executive summary

The impact of invasive and non-native species (INNS) is recognised as a major driver of global biodiversity loss world-wide. INNS can have detrimental impacts on the recipient environment through predation of, and competition with, native species, introduction of new diseases and parasites, hybridisation and species extinctions and are known to impact negatively on local economies through direct effects but also through high costs associated with treatment, management and control.

The spread of marine and coastal INNS has been attributed to the rise in global shipping and trade, with ballast water exchange, hull fouling and aquaculture identified as major pathways of introduction and spread. Secondary pathways, such as recreational boating, facilitate the spread of species away from these initial introduction points to smaller harbours and bays. There are growing concerns that there may be spread from these initial points of introduction to natural areas, particularly areas containing protected species and habitats such as Marine Protected Areas (MPAs). In fact, marine INNS have been identified as having negative impacts on the protected features of Marine Protected Areas (MPAs) and have recently been highlighted as a condition threat in several sites in England.

Preventing the introduction of INNS is recognised as the most effective and least environmentally damaging management intervention, especially in the marine environment where eradication and containment are often not possible. Biosecurity plans present pragmatic, ‘best practice’ measures to reduce the risk of INNS movement via pathways identified as high risk.

Currently, there are several existing marine biosecurity plans that have been developed as part of past projects or by different organisations, effectively creating a patchwork of biosecurity coverage across England. The exact extent of geographic coverage, status of plans and pathways addressed, as well as effectiveness of plans, however, was not fully understood.

This project aimed to address this gap in knowledge by auditing and reviewing all available marine biosecurity plans in England; this information will inform priorities for biosecurity planning in the future. The ultimate aim is to have effective marine biosecurity plans in place covering MPAs in England which are located in sites of high risk. Specific objectives to meet this aim include:

- Carrying out an audit of existing marine biosecurity plans in England;
- reviewing the effectiveness of existing marine biosecurity plans; and
- identifying a priority list for future marine biosecurity planning in England.

This project identified 31 marine biosecurity plans in England: three plans were not made available, 14 plans were current, three plans were out of date, eight plans were in the draft stage, two were in the process of updating and one plan’s status was unknown. The spatial distribution of plans around England was inconsistent, with more plans located

along the south coast (particularly in southwest England) than any other coast. Twenty-four biosecurity plans were reviewed, and 15 interviews were conducted with owners of these plans.

Hotspots of INNS introduction for England were identified and hotspots without any biosecurity coverage were highlighted, which included: London, Dover, Felixstowe, Southport/Blackpool and Bristol, although Southampton and Portsmouth only have localised marina-level plans in place (i.e. planning is not estuary-wide).

Several common messages emerged from interviews with plan owners:

- There is a lack of support for development and management of plans
- There is a lack of stakeholder interest
- There is a lack of dedicated staff to put time to biosecurity planning
- INNS expertise is needed to develop and manage plans
- There is a lack of clarity around responsible parties and enforcement
- There is a lack of legal obligation
- Support for and interest in plans diminish significantly over time
- There is concern that plans are a box-ticking exercise
- There is concern over new and emerging pathways
- A top-down approach for biosecurity planning is needed

A selection of international biosecurity plans was reviewed. Three key messages emerged during the review of these plans:

- High scoring plans are backed by legislative frameworks;
- High scoring plans have full support (e.g. funding, staffing, training) from government bodies; and
- High scoring plans lay out responsible parties.

From the audit and review of plans, geographic gaps were identified and presented as priority areas for future biosecurity planning, which included:

- Bristol
- Dover
- Felixstowe
- Immingham and the Wash
- Liverpool and the Northwest (including Southport and Blackpool)
- London and the Thames Estuary
- Portsmouth (including Chichester and Langstone Harbours)
- Southampton and The Solent

From the interviews and assessment of the data, key priority actions for marine biosecurity planning in England were identified and included:

- Implement coordinated national level guidance for standardised marine biosecurity planning
- Implement biosecurity plans in geographic locations where they are missing
- Work with current biosecurity plan owners to finalise, improve or enhance existing biosecurity plans
- Develop sector-specific step-by-step instructions for how to write and manage biosecurity plans
- Provide technical expertise for development, implementation and management of biosecurity plans
- Provide real UK case studies of invasions that have caused economic losses
- Identify plans with low stakeholder engagement and identify opportunities to engage with existing stakeholders

The future of biosecurity planning may necessarily need to take a comprehensive area-wide (i.e. MPA-wide or estuary-wide) approach where all pathways and species of concern are considered in order to maximise biosecurity efforts thereby reducing the risk of introduction and spread of INNS.

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Introduction

The impact of invasive and non-native species (INNS) is recognised as a major driver of global biodiversity loss world-wide. Invasive species can have detrimental impacts on the recipient environment through predation of, and competition with, native species, introduction of new diseases and parasites, hybridisation and ultimately species extinctions (Blossey and Notzold, 1995; Mooney and Cleland, 2001; Peeler et al., 2011). INNS are known to impact negatively on local economies through direct effects on recreation and tourism, public utilities and infrastructure, aquaculture and fisheries, as well as indirectly through costs associated with treatment, management and control. In the marine environment alone, the cost to industry in Great Britain has been estimated at £40 million/year (Williams et al., 2010).

INNS are moved via various pathways, which are human mediated means and routes by which species are spread into new areas. In the marine environment, pathways include aquaculture operations, vessel and mobile infrastructure fouling, ballast water exchange and biofouling of rafting litter. Understanding how these pathways facilitate the movement of species informs development of relevant means to help reduce the introduction and spread of INNS. Processes and measures implemented to reduce this risk of INNS transfer is generally referred to as biosecurity.

Preventing the introduction of INNS is recognised as the most effective and least environmentally damaging management intervention. This is especially important in the marine environment as once INNS are established in a new area, they are considered nearly impossible to eradicate or control. Biosecurity plans present pragmatic, ‘best practice’ measures to reduce the risk of INNS movement via relevant pathways. Implementation of robust biosecurity plans prevent or reduce the adverse impacts and costs associated with managing established INNS, protecting both local biodiversity and economies.

As INNS can have negative impacts on native habitat and biota, areas where biosecurity may be especially needed in the marine environment are Marine Protected Areas (MPAs). Biosecurity can reduce the risk of INNS introduction and spread on MPAs and will help preserve protected features. MPAs located in the vicinity of high-risk areas, such as international ports and harbours, are at particularly high risk of INNS introduction, and thus, should be considered for biosecurity planning.

Throughout England, there are several existing marine biosecurity plans that have been developed by a variety of projects and/or by different authorities. There is not, however, a full overview of their current status or a robust review of the effectiveness of these plans. Reviewing existing plans is vital to understand lessons learnt which will facilitate the development of innovative and bespoke marine biosecurity plans in the future in order to reduce the risk of INNS movement in the marine environment.

Aim and objectives

The aim of this project was to conduct a review of existing marine biosecurity plans for their potential to be effective in reducing the movement of INNS and to inform development of and identify priorities for future biosecurity planning.

Objectives to meet this aim included:

- Carrying out an audit of existing marine biosecurity plans in England;
- reviewing the effectiveness of existing marine biosecurity plans; and
- identifying a priority list for future marine biosecurity planning in England.

Methods

Audit of existing marine biosecurity plans

Using a list of known marine biosecurity plans in England as a foundation, a search for additional plans was conducted and included searches for estuary wide, individual operator, authority level and any other biosecurity plans publicly available. As some organisations do not have a dedicated biosecurity plan, INNS management plans and other environmental plans were also opportunistically reviewed for embedded INNS related biosecurity content.

Each biosecurity plan was audited for essential identifying content which included:

- Location and geographic coverage;
- Plan period;
- Status of the plan (e.g. draft, current, out of date);
- Main point of contact for the plan; and
- Pathways addressed by the plan.

Information for each plan was collated and stored as a database of plans in Microsoft Excel (Supplementary Information 1).

Location and geographic coverage of biosecurity plans were mapped in relation to protected and designated sites with a marine element (hereafter referred to generally as ‘MPAs’), which for the purpose of this project included:

- Marine Conservation Zones (MCZ)
- Special Area of Conservation (SAC)
- Special Protection Areas (SPA)

As INNS have been identified as impacting protected features of MPAs, it is important to understand if any MPAs have biosecurity planning in place. Thus, MPAs with biosecurity

plans in place were identified and MPAs with geographic gaps in biosecurity were highlighted.

Additionally, locations of biosecurity plans were mapped in relation to INNS introduction 'hotspots' identified by Tidbury et al. (2016), who highlighted high risk areas in the UK using shipping as the vector of INNS introduction (hereafter, 'introduction hotspots'). Areas where biosecurity planning was missing with regards to introduction hotspots were identified.

Review of existing marine biosecurity plans

A review of effectiveness of each plan identified during the audit was conducted to gather information along three major themes:

- How well the plan has been developed and maintained;
- How well the plan has been implemented; and
- How effective the plan has been.

In order to answer these questions, the review consisted of two information gathering processes using semi-quantitative and qualitative approaches:

- A scoring process for each plan (semi-quantitative approach); and
- A discussion with those involved in the development and/or the delivery of the plan (qualitative approach).

Semi-quantitative approach

The review process consisted of evaluating plans against the Marine Biosecurity Planning Guidance for Estuary Wide Plan Development template[1]. This was achieved by identifying essential criteria within the template and assessing content from each plan against those criteria (Appendix 1). A simple biosecurity plan scoring tool was used to review the plans by scoring content on a scale of 1-3 or 1-5 depending on the criterion. Plans were assessed against criteria in the template for 'effectiveness' and 'potential to be effective'. 'Effectiveness' was assessed based on responses gathered from semi-structured interviews (see Qualitative approach below), as questions in these interviews addressed what actions have been implemented since plans had been written. 'Potential to be effective' was used in addition to 'effectiveness' because several of the plans reviewed had not yet been fully implemented, did not have a review process in place to evaluate effectiveness and/or an interview was not able to be conducted to learn of effectiveness of

[1] Marine Biosecurity Planning Guidance for Estuary Wide Plan Development. Natural England, Marine Pathways Group and C2W.

biosecurity actions. This meant that plans could not be evaluated for actual effectiveness. An overall plan score was also calculated based on ‘effectiveness’ and ‘potential to be effective’ scores. Overall plan scores were not calculated for plans that were not able to be assessed for ‘effectiveness’. In order to compare scores across all plans, when plans are presented, they have been listed in rank order according to the ‘potential to be effective’ scores throughout this report and in the supporting Supplemental Information.

Qualitative approach

Further information to determine how well the plan has been implemented, including what has worked well and what has not, if any monitoring has been implemented and feedback from stakeholders was gathered by conducting semi-structured interviews with relevant individuals (hereafter referred to as ‘interviewees’). A semi-structured interview is a meeting in which the interviewer does not strictly follow a formalised list of questions; instead, the interviewer develops and uses an ‘interview guide’, which is a list of questions and topics that need to be covered during the conversation, usually in a particular order. The questions are open-ended, allowing for a discussion with the interviewee rather than a straightforward question and answer format. The interviewer follows the guide but is able to follow topical trajectories in the conversation that may stray from the guide.

For this project, 15 general question areas were discussed, with questions mainly focussing on uptake and implementation of plans and continuous review and improvement of plans and were compiled in consultation with Natural England. A full list of questions covered during interviews is included in Appendix 2. Main points of contact for all plans reviewed were contacted for interviews and as many interviews as possible were carried out.

Responses from the semi-structured interviews were used to feed into the semi-quantitative review in order to assess effectiveness of each plan. Additionally, all interviews were assessed for common responses to highlight key messages.

A selection of international biosecurity plans was also reviewed using the same biosecurity plan scoring tool as described above where possible (e.g. some plans did not include much of the same criteria used to evaluate the English plans). As interviews were not able to be conducted for most of these plans, only their “potential effectiveness” was able to be evaluated.

Priorities for future marine biosecurity planning

The list of priority sites for consideration for biosecurity planning was developed by overlaying locations of biosecurity plans (i.e. geographic coverage of plans) and introduction hotspots over MPA boundaries in England using QGIS v. 3.16.7. In QGIS, a 10-km buffer was applied around each introduction hotspot point and then intersected with locations of biosecurity plans and MPAs. From this, the following lists were generated: i)

priority geographical areas for future biosecurity planning, ii) MPAs without biosecurity coverage and iii) MPAs within or near introduction hotspots.

Knowledge gaps in marine biosecurity planning in England were identified through assessment of existing biosecurity plans and via semi-structured interviews. Knowledge gaps were identified by:

- Highlighting criteria within the biosecurity planning review in which plans consistently scored low;
- Identifying content extracted from common messages from the semi-quantitative review; and
- Highlighting suggestions that would facilitate biosecurity planning put forth by interviewees.

Results

Audit of existing marine biosecurity plans

Overall, 31 marine biosecurity plans in England were identified, of which three plans were not made available. Of the 28 plans available, 14 were current, three plans were out of date, eight plans were in the draft stage, two were in the process of updating and one plan's status was unknown (Supplementary Information 1). The spatial distribution of plans around England was inconsistent, with more plans located along the south coast (particularly in southwest England) than any other coast (**Figure 1**). This does, to a degree reflect those areas where INNS are most likely to be introduced in general terms.

Figure 1 shows biosecurity plan locations- there are 15 in the Southwest and Solent, 8 spread along the East and North East coast and 6 in the Northwest.

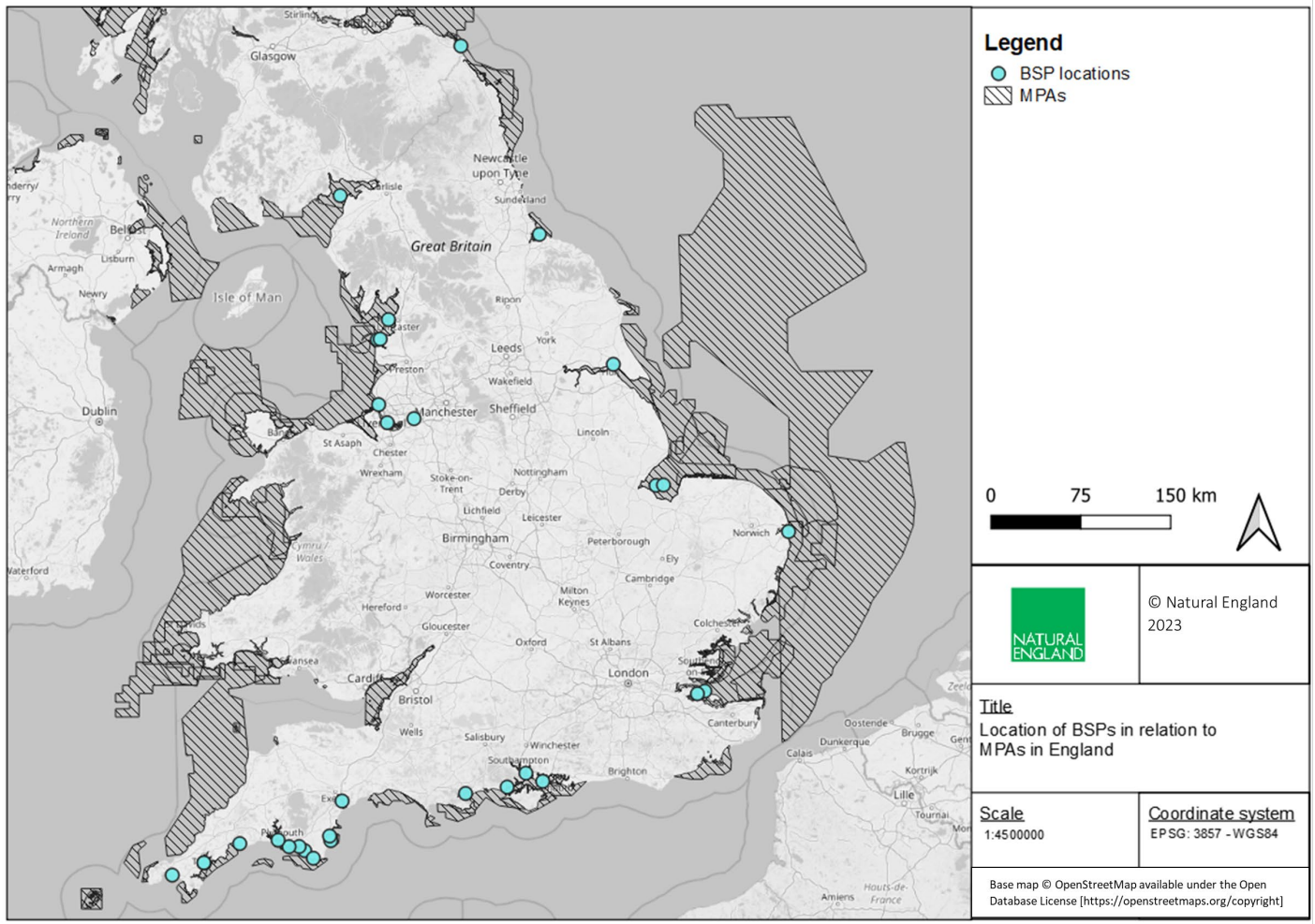

Figure 1. Locations in England identified as having marine biosecurity plans (BSP) mapped with MPAs. See Supplementary Information 2 for site-specific maps. See Appendix 9 for data sources.

Hotspots of INNS introduction into England, as identified by Tidbury et al. (2016), include Poole, Bristol, Felixstowe, Plymouth, Southport/Blackpool, Portsmouth, London, Immingham, Southampton, Liverpool, Dover and Tees (Figure 2). Only Plymouth, Poole, Southampton and Portsmouth have current biosecurity plans, but within Poole, the biosecurity plan is operated by the Southern IFCA, which addresses only the aquaculture pathway, while Southampton and Portsmouth have plans that are localised to marinas only. Locations considered to be hotspots in which biosecurity plans are in development (draft stage) include Tees (Teesport Biosecurity Plan) and Liverpool (Peel Ports Liverpool and RAPID LIFE Mersey) (Supplementary Information 2).

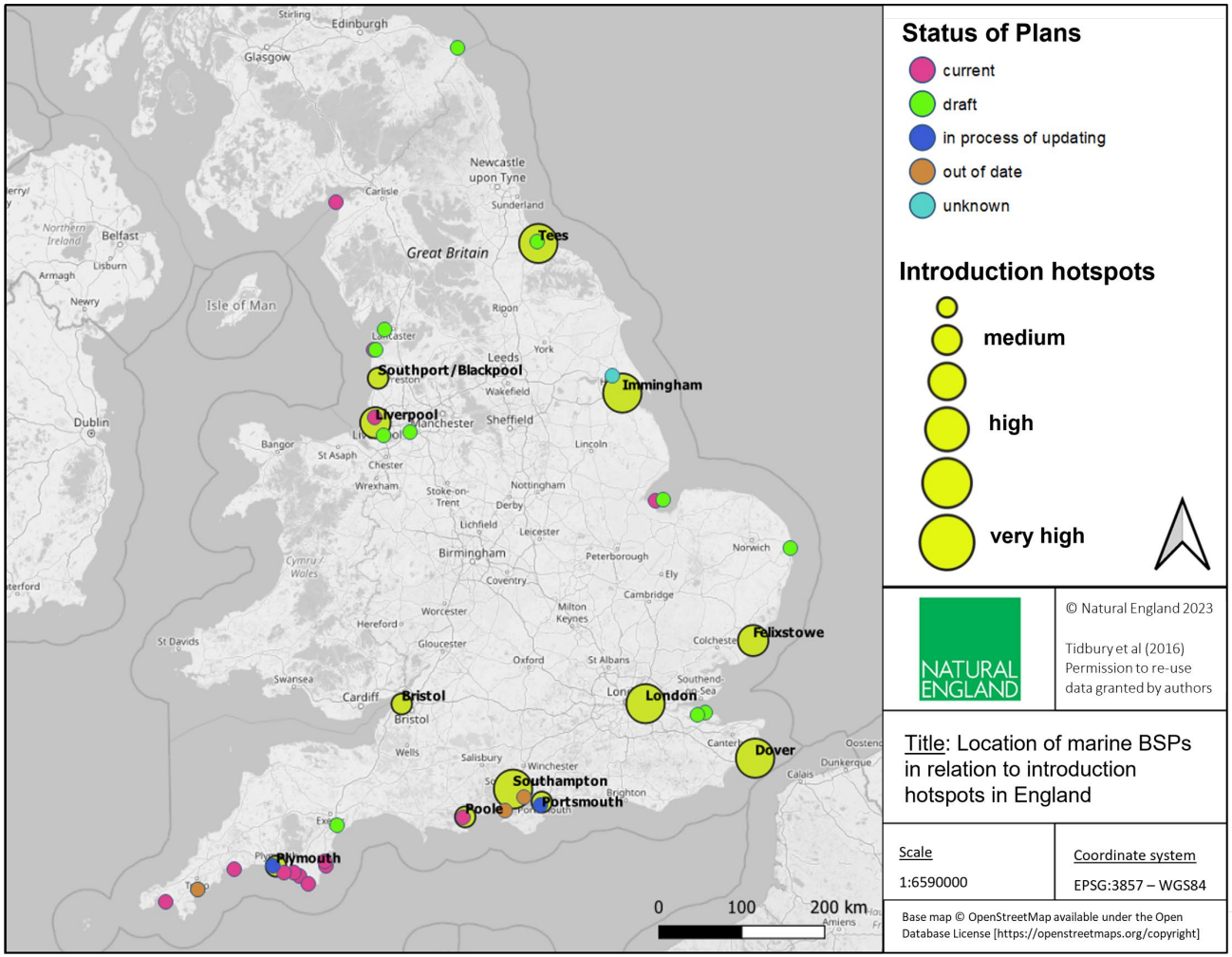

Figure 2. Locations in England identified as having marine biosecurity plans (shown by status of plans) mapped with introduction hotspots (Tidbury et al., 2016). Size of introduction hotspot circles relates to shipping intensity (i.e. medium, high, very high intensity). 'BSPs' = biosecurity plans. See Supplementary Information 2 for site-specific maps. See Appendix 9 for data sources.

Hotspots without any biosecurity planning coverage (current or draft) include London, Dover, Felixstowe, Southport/Blackpool and Bristol, although Southampton and Portsmouth only have localised marina-level plans in place (i.e. planning is not estuary-wide). These areas – particularly the areas adjacent to MPAs – should be urgently considered for future biosecurity planning (Appendix 3, 4) (Supplementary Information 2, 3).

Review of existing marine biosecurity plans

Semi-quantitative approach

Overall, 24 marine biosecurity plans in England were reviewed, with the mean 'overall plan score' being 70.0% (± 0.03 standard error (SE)), the mean 'potential to be effective' score being 70.4% (± 0.03 SE) and the mean 'effectiveness' score being 59.2% (± 0.05 SE) (Appendix 5). The highest scoring plan for 'potential to be effective' was the Tamar Estuaries Marine Biosecurity Plan and the Fal and Helford SAC Recreational Boating Biosecurity Plan (both scoring 94%), whereas the lowest scoring Plan for 'potential to be effective' was RAPID LIFE: Wyre at 53% (Table 1). The lowest scoring categories were 'overall supporting work' and 'overall review', which covered monitoring and rapid response planning and review and evaluation, respectively (Table 2). These areas should receive extra consideration for future biosecurity planning to ensure they are developed to the highest standard.

Qualitative approach

Fifteen semi-structured interviews were conducted by three interviewers between July - August 2022, with each interview lasting between 30 - 90 minutes. Seven of these plans have implemented at least one of the biosecurity actions put forth in their plans[2], while there were no plans that implemented all actions. Two plans – Eastern and Northwestern IFCA Plans – have some form of high-risk INNS monitoring in place, but this is due to the need to preserve fisheries. One plan has implemented the monitoring of settlement panels that are checked once per year (Solway Firth Biosecurity Plan).

Of the plans that do have at least one biosecurity action in place (excluding monitoring), all of these actions are some form of awareness-raising. These actions include: creating 'top 10 most unwanted species' guides or lists with images; displaying INNS posters and distributing leaflets in key areas; posting INNS signage at key locations including at water

[2] NB: Five of these seven plans are the South Devon AONB Estuaries Partnership Biosecurity Plans

entry points; and including INNS information in newsletters, on websites and on social media.

Table 1. Biosecurity Plans with the highest and lowest scores for 'Potential to be effective', 'Overall score' and 'Effectiveness'.

Scores	Potential to be effective	Overall score	Effectiveness
Highest score	Tamar Estuaries Marine Biosecurity Plan (94%), Fal and Helford SAC Biosecurity Plan (94%)	Tamar Estuaries Marine Biosecurity Plan (85%)	Solway Firth Partnership (80%)
Lowest score	RAPID LIFE: Wyre (53%)	Eastern IFCA (50%)	Eastern IFCA (30%), MDL Hamble Point Marina (30%), Haslar Marina (30%)

Table 2. Summary of scores for each of the criterion used in the review of English biosecurity plans. Standard error (SE) for the means has been included.

Score criteria	Maximum possible	Minimum possible	Highest score	Lowest score	Median score	Mean score (± SE)	Mean score - % (± SE)
Background Information	18	6	18	11	14	14.38 ± 0.08	**80% ± 0.5%**
Identification of Risks	3	1	3	2	3	2.63 ± 0.02	**88% ± 0.7%**
Biosecurity Actions	12	4	12	6	9	8.96 ± 0.07	**75% ± 0.6%**
Supporting Work	6	2	6	2	3	3.58 ± 0.05	**60% ± 0.8%**
Additional Information	6	2	6	2	4	3.79 ± 0.05	**63% ± 0.8%**
Review	3	1	3	1	1	1.71 ± 0.04	**57% ± 1.2%**
Implementation	10	2	8	3	6.5	5.71 ± 0.07	**57% ± 0.7%**

Common messages

Common messages gathered from the semi-structured interviews are described below. Relevant suggestions from interviewees that address the issues raised are included. Messages are not presented in any specific order. See Appendix 6 for illustration of common messages.

- **Message #1 Lack of support:** There is a significant lack of funding available for development, implementation and management of plans. There is preference for an INNS expert to be brought in to facilitate the development and implementation of plans; but if this is not possible, step-by-step and user-friendly instructions for how to write biosecurity actions in detail is needed so implementation of actions and success of plans can be realised and could build upon existing guidance[3]. Furthermore, there is the perception that a coordinated and strategic national approach to marine INNS biosecurity is lacking. Provision of national guidance with a more coordinated effort and supportive atmosphere is desired. Although several plan owners used the Marine Biosecurity Planning Guidance for Estuary Wide Plan Development template[1], there was still desire for further support, mostly in the form of INNS experts. Further questions were not asked specifically about the existing guidance and this could be subject for further investigation. Moreover, there is an assumption that national bodies such as Natural England and the GB Non-Native Species Secretariat should have some hand in helping to develop, implement and manage biosecurity plans, especially given lack of resources at the local level.
- **Message #2 Lack of stakeholder interest:** It was highlighted that some stakeholders do not consider INNS and biosecurity to be relevant to them. Moreover, there is concern that plans lack the necessary stakeholder support and that all of the relevant stakeholders have not been reached. Furthermore, it is perceived that guidance on how to engage with stakeholders for implementation of biosecurity actions is lacking. In order to gain stakeholder interest and start interacting with relevant users, consistent stakeholder workshops, events, consultations, etc. are needed, with these events tailored specifically to each user group. To do so, substantial resources, such as training material, INNS expertise, staff time, etc. are desired.
- **Message #3 Lack of dedicated staff:** There is a strong desire to implement actions and engage actively with stakeholders on-the-ground. However, due to high staff turnover and general lack of dedicated staff, this is rarely possible. Moreover, when temporary staff are involved, their knowledge is lost when they leave the organisation. Provision of funding to support a permanent INNS biosecurity officer is highly desired.

[3] https://www.nonnativespecies.org/biosecurity/marine-biosecurity/

- **Message #4 INNS expertise is needed:** There is desire for INNS experts to be brought in to lead the development of plans, as well as be available for consulting during implementation of actions and future work regarding plans (i.e. management of the plan). There is a need for taxonomic experts to lead on monitoring efforts and taxonomic identification. Whilst many plans have been developed by organisations' environment officers or someone with a similar role, and this person is knowledgeable about their site and the environmental issues within it, there is concern that their knowledge is limited concerning INNS and biosecurity issues.
- **Message #5 Lack of clarity around responsible parties and enforcement:** There is a desire for guidance regarding who is responsible for all stages of the plans. In particular, there was confusion over who is responsible for implementation and maintenance/management of the plans, with several respondents indicating they believed government bodies are or should be responsible for support, implementation and maintenance of plans. Additionally, there is no clear instruction or guidance regarding enforcement of actions, with owners of plans indicating hesitation around enforcement.
- **Message #6 Lack of legal obligation:** Implementation of biosecurity actions relies on groups, agencies and organisations voluntarily adopting these actions due to lack of legal obligation to carry out actions. There is a real need for effective legislation in combination with a dedicated member of staff embedded in relevant government with some real influence. Due to this lack of legislation, most biosecurity actions are ultimately not implemented. The difficulty in getting support from stakeholders in implementing actions has resulted in only the very low-cost and simple measures – such as supplying posters, leaflets and identification guides and posting on social media and websites – being implemented. Furthermore, because there are no statutory requirements, enforcement is not in place.
- **Message #7 Support and interest diminish significantly over time:** Stakeholders who were involved at initial stages of plans have since become less engaged and interested. Thus, there is a desire for guidance on how to keep stakeholders involved and interested in INNS and biosecurity. There is interest in discussing this with other plan owners to learn how others have approached the topic, particularly with those who consider themselves successful in retaining stakeholder interest.
- **Message #8 Concern that the plan is a box-ticking exercise, and it has done little to reduce the spread of INNS:** Biosecurity plans need to be viewed as living documents that evolve over time and that are permanent parts of the areas for which they were written (i.e. plans should not be written as having a limited lifetime). It is clear that many plans have been written as an isolated exercise with an end date as evidenced by the considerable concern that these plans, once written, simply reside on the shelves of the organisations that developed them, and they are rarely seen again. There is concern that the time and effort put into developing plans is not paying off. Several respondents indicated the plans are too long and not created in such a way in which they can be shared with stakeholders. Furthermore, and perhaps the most concerning, is that some respondents indicated

that they did not believe their plans were helping to reduce the introduction and spread of INNS.

- **Message #9 Concern over new and emerging pathways:** It is evident that owners of plans are concerned about new and emerging uses of their sites, meaning they must re-assess risks and evaluate effectiveness of current biosecurity actions. Of particular concern is the need to reach individual ('solo') users who are not members of water sports clubs or marinas (e.g. portable and inflatable watercraft users such as SUPs and kayaks who launch at undesignated points of entry).
- **Message #10 Need a top-down approach:** The UK has approached biosecurity planning with a 'light touch' (i.e. voluntary commitments from non-experts with little support), and it is now clear that this approach needs to be evaluated and perhaps come from a different perspective. With a top-down approach, senior management buys-in, a biosecurity manager is appointed, followed by training of staff, thus creating an organisation-wide approach and providing on-the-ground staff will full support. Currently, it seems many owners of plans feel they have been 'thrown into the deep end' and are essentially working alone on the issue.

International Biosecurity Plans

Several international biosecurity plans were reviewed to gain lessons learnt and understand best practice around plans that are considered successful. International plans scored between 70 - 94% for potential to be effective (Appendix 7, Supplementary Information 4). Generally, the plans that scored highly had high scores within the Biosecurity Actions, Supporting Work (Monitoring and RRP) and Review and Evaluation categories (Table 3). Three key messages emerged during the review of international plans:

- High scoring plans are backed by legislative frameworks;
- High scoring plans have full support (e.g. funding, staffing, training) from government bodies; and
- High scoring plans lay out responsible parties.

In New Zealand, the creation and implementation of national and regional pest management plans has been **guided by several key acts of legislation** which include:

- The Biosecurity Act 1993, which underpins the New Zealand approach to non-native species, lays out the process for the 'preparation, implementation and review of pest and pathway management plans' and is frequently amended and updated
- The Resource Management Act 1991, which sets out the functions of regional councils for ecosystem management
- The Local Government Act 2002, which provides a framework and powers for local authorities to decide how to undertake biosecurity activities

Here, INNS biosecurity is overseen by the Ministry for Primary Industries and the Ministry of Agriculture and Forestry which have formed partnerships with councils and key departments, such as the Department of Conservation, allowing them to develop strategies for surveillance and INNS population management. Some councils have also formed partnerships with other councils, creating management groups to facilitate coordinated strategies to meet the legislative requirements. This has allowed for the creation of consistent management plans, like the small-scale programmes enacted by the Marlborough, Nelson and Tasman districts to manage the impacts of the Mediterranean fanworm (*Sabella spallanzani*). Regional councils have their own rules and requirements for marine biosecurity, but it is stipulated that they must not be inconsistent with the national or regional plan, any regulations or any pathway management plans; in fact, the legislation requires that if one plan might affect another, they must state how they will coordinate the implementation of the plans.

In the Netherlands, **governmental ministries are directly involved** with facilitating and carrying out monitoring, surveillance and early warning activities and provide support for research (e.g. Gittenberger et al., 2015, 2017, 2019). Several of their relevant ministries (e.g. Netherlands Food and Consumer Product Safety in the Ministry of Agriculture, Ministry of Infrastructure and Water Management) hold information and provide guidance regarding INNS in general, survey and monitoring and pathways of introduction. The ministries are currently evaluating existing international and EU guidance and management strategies (e.g. BWC, IMO biofouling guidance, Marine Strategic Framework Directive D2) to develop best-practice protocols specific to the Netherlands.

In California (US), **state-wide regulations on mandatory biofouling management regulations**, which are modelled after the IMO Biofouling Guidelines, are written into the California Code of Regulations, which supports the Marine Invasive Species Program in the California State Lands Commission. Funding is partially via fees charged to vessels arriving in California ports. Because of this, the programme has funding in perpetuity to support several scientists and inspectors to educate vessel operators on state regulations and perform enforcement actions where regulations are not adhered to. Under these regulations, vessel operators are required to provide the programme with a Biofouling Management Plan and a Biofouling Record Book. When the new regulations came into action, the programme disseminated a standard template for a Biofouling Management Plan to vessel operators. The funding also supports continuous monitoring by researchers at the Smithsonian Environmental Research Center, with researchers having conducted baseline surveys in California ports in the early 2000s.

Identifying the administrative level at which an action must be taken and who the responsible party is in planning or implementing biosecurity measures or responding to an event can provide clarity and reassurance to plan owners and allow for decisive and coordinated action delivery. This is seen within the New Zealand National Plan of Action in which the lead intervention and decision maker is identified for different circumstances of pests in the marine environment who is then responsible for bringing together parties with the necessary powers, functions and resources. Similarly, in Australia, the North Burnet Regional Council Plan identified all responsible parties at different administrative levels

involved in the delivery of the plan, from individual businesses to local, state and federal government, and outlined their role in the plan and the actions they needed to take.

In Wales, Natural Resources Wales (NRW) has taken a **SAC-wide approach to biosecurity planning**, with seven SACs planning to be covered by area-wide biosecurity plans. The development and roll-out of the Pen Llŷn a'r Sarnau (PLAS) Special Area of Conservation biosecurity plan has been recently completed. Significant planning and stakeholder engagement had been done prior to writing this plan by gathering sufficient evidence to underpin biosecurity planning so that biosecurity measures could be achievable and would be applicable to and feasible for all users of the SAC. Engagement was done through distribution of questionnaires to relevant users and holding stakeholder workshops to gain local knowledge, as well as partnering with the Royal Yachting Association (RYA) for a boating event to raise awareness of INNS and biosecurity. Significant research around current records of INNS in the SAC and horizon INNS had also been done prior to writing the plan. Additionally, prior to the writing of the plan, formal assessments of high-risk activities and areas were conducted. Importantly, NRW focused efforts on effectively disseminating information upon completion of the plan. This included creating social media posts and INNS fact sheets, developing a marine INNS identification guide (amended from the Marine Biological Associations' INNS identification guide) and INNS kit and holding a stakeholder workshop. They also developed pathway and species action plans as a result of the pathway and species assessments. These actions were able to be carried out due to a dedicated staff member being assigned to the role of Biosecurity Project Officer.

Table 3. Summary of scores for each of the criterion used in the review of international biosecurity plans. Standard error for the means has been included.

Score criteria	Maximum possible	Minimum possible	Highest score	Lowest score	Median score	Average score (± SE)	Percent Average score (± SE)
Background Information	18	6	18	13	15	15.15 ± 0.11	**84% ± 0.6**
Identification of Risks	3	1	3	1	2	2.38 ± 0.05	**88% ± 1.6**
Biosecurity Actions	12	4	12	8	11	11.15 ± 0.08	**93% ± 0.7**
Supporting Work	6	2	6	2	5	4.69 ± 0.12	**78% ± 2.0**
Additional Information	3	1	3	2	3	2.54 ± 0.04	**85% ± 1.3**
Review	3	1	3	1	3	2.77 ± 0.04	**92% ± 1.5**

Priorities for future marine biosecurity planning

Priority sites

From the audit and review of plans, geographic gaps were identified and presented as priority areas for future biosecurity planning, which were developed based on: i) MPAs without biosecurity coverage (Appendix 3), ii) MPAs within or near introduction hotspots (Appendix 4) and iii) a gap analysis of MPAs that currently have biosecurity plans (Appendix 8). The following geographic areas have been identified as high priority for future biosecurity planning (Supplementary Information 2):

- Bristol
- Dover
- Felixstowe
- Immingham and the Wash
- Liverpool and the Northwest (including Southport and Blackpool)
- London and the Thames Estuary
- Portsmouth (including Chichester and Langstone Harbours)
- Southampton and The Solent

There was a total of 96 MPAs without any biosecurity coverage, consisting of 20 SACs, 22 SPAs, 54 MCZs (Supplementary Information 3)

Priority actions

From semi-structured interviews and assessment of the data, key priority actions for marine biosecurity planning in England have been identified. Priority actions are listed in

no particular order but the suggested year of implementation (Year 1, 2, 3) is provided in the text.

Implement coordinated national level guidance for standardised marine biosecurity planning

Coordinate a strategic national approach specific to marine INNS biosecurity so as to direct effort and resources to the needs of highest priority and the areas of greatest risk. This should be the central resource for all marine biosecurity planning across England from which local biosecurity planning can be based and adapted from. This may entail organisation of a Marine Biosecurity Planning Steering Committee, or similar group, composed of key INNS and biosecurity players in England such as national, regional and local players, as well as INNS practitioners, research organisations and non-government organisations. As it is likely that full adoption of biosecurity will only come with legislation, enforcement and the proactive, continuing involvement of government agencies, this group should consider, as much as possible, influencing policy and regulations as a major aim of the group. Organising individuals from key agencies and organisations to create a Marine Biosecurity Planning Steering Committee (or similar), identifying the main aims and objectives of the group and setting out initial actions should be done in Year 1.

As part of this approach, there should be consideration for developing a national framework and support system for existing and new plan owners. This may entail developing a national database of marine biosecurity plans that could include relevant information on each plan such as status of plan (e.g. draft, current, out of date), date of review and evaluation, information on which biosecurity actions have been implemented and main point of contact, as well as a list of relevant taxonomic and INNS experts. Development of this framework/national database of plans should be one of the initial actions set out to being in Year 1 with its completion and dissemination set for Year 2. Review and evaluation of the steering committee and national database should be done in Year 3 and then subsequently at regular intervals. Inclusion of Scotland and Wales should be considered for a GB-wide approach.

Implement biosecurity plans in geographic locations where they are missing

Geographic areas identified as high priority in this report should be immediately considered for biosecurity planning (see Supplementary Information 2). Before any new plans are developed, a list of priority sites for plans should be identified and should necessarily take an MPA- or estuary-wide approach. Importantly, ensure there is an annual review of priority areas and pathways in place at a national level. Where possible, ensure these new plans follow a coordinated national level guidance for standardised marine biosecurity planning.

In Year 1, develop plans for high priority areas that contain MPAs, are within or near to introduction hotspots and have no plans in place. These areas include:

- Bristol
- Dover

- Felixstowe

Plans for these high priority areas should be developed in tandem and led by one agency or organisation to facilitate sharing of information and lessons learned.

In Year 2, develop new plans and enhance current plans for high priority areas that contain MPAs and are also within or near to introduction hotspots, but which already have some sort of biosecurity planning in place (e.g. plans are in draft, plans only cover one pathway or plans cover a small discrete area). These areas include:

- Immingham and The Wash
- Liverpool and the Northwest (including Southport and Blackpool)
- London and the Thames Estuary
- Southport and Blackpool
- Portsmouth (including Chichester and Langstone Harbours)
- Southampton and The Solent)

In Year 3, develop plans for areas listed as 'medium priority' (see Supplementary Information 2). These areas include:

- Poole
- Teesport

For the areas being addressed in Years 2 and 3, utilise any existing plans, conservation forums and contacts as a foundation from which to build comprehensive, MPA- or estuary-wide plans.

Work with current biosecurity plan owners to finalise, improve or enhance existing biosecurity plans

In Year 1, contact all biosecurity plan owners whose plans are in the 'draft', 'out of date' and 'unknown' stages (Supplementary Information 1) and identify obstacles they are facing which are preventing them from finalising plans. Of these plans, prioritise the ones that cover areas in or near introduction hotspots. These plans include:

- ABP Humber
- Lymington Yacht Haven
- MDL Point Hamble Marina
- Peel Ports
- RAPID LIFE Medway
- RAPID LIFE Mersey

In Year 2, review scores from the biosecurity plan review (Supplementary Information 1) to identify low-scoring plans, with particular attention to plans that scored low in categories essential for successful biosecurity planning such as identification of risks, biosecurity actions and stakeholder identification. These plans should be targeted for improvement actions. Plans that scored lowest for the 'potential to be effective' include:

- Eastern IFCA (56%)
- RAPID LIFE – Medway (56%)
- RAPID LIFE – Wash (56%)
- RAPID LIFE – Wyre (53%)

As several of the IFCA plans cover entire estuaries and/or large geographic areas, in Year 3, explore the possibility of building off these plans to cover additional pathways or work in collaboration with these owners to develop additional plans that address remaining pathways. In this way, site-specific and other relevant information might be shared, effectively reducing the likelihood of duplicating efforts.

Develop sector-specific step-by-step instructions for how to write and manage biosecurity plans

Although there are guides currently in existence for writing plans[3], the previous roll-out of these guides was perceived as falling short of fully understanding the different requirements of the wide range of stakeholders and not delivering tailored approaches to specific sectors (e.g. large commercial operators will have different legislative and operational requirements compared to smaller marinas or watercraft clubs). Thus, there is a need to understand the requirements of the full range of stakeholders first, and second, explore the development of detailed, step-by-step instructions/decision support tools or user guides for development of biosecurity plans for specific scenarios, pathways and sectors. As such, a review of requirements of relevant stakeholders and sectors across England should be conducted beginning in Year 1. Results from this review should feed into the creation of detailed instructions and user guides for how to write and manage plans, which should be initiated in Year 2. As part of this approach, relevant case studies and templates for specific scenarios, pathways and sectors should be provided.

Provide technical expertise for development, implementation and management of biosecurity plans

Facilitate the sourcing of funds for allocation to sites of high priority to support INNS experts to assist with or lead the development (and perhaps implementation) of biosecurity plans (ideally in Year 1 and ongoing). Given limited funding, experts might be consulted only at key milestones throughout the development and implementation of the plan or only for monitoring and surveillance work or taxonomic identification and horizon scanning. In Year 1, coordinate the gathering of contacts for relevant INNS and taxonomic experts to share with plan owners if desired, and keep the list current over time.

Provide real UK case studies of invasions that have caused economic losses

There is sometimes hesitation from stakeholders and users of the area to buy-in to implementing biosecurity actions as they may not fully understand the consequences of doing nothing. Providing real, tangible case studies demonstrating the negative effects of INNS in the marine environment in Great Britain (i.e. do not use examples from freshwater environments or from other countries) will illustrate realistic threat levels in the UK. Case

studies could build upon examples put forth in the report, “Investigating the Impacts of Marine Invasive Non-Native Species – NECR223”[4]. As such, in Year 1, information on UK examples should begin to be gathered, with information being conveyed in useable ways (e.g. through in-person messaging such as posting information plaques marinas) to stakeholders and users beginning in Year 2.

Identify plans with low stakeholder engagement and identify opportunities to engage with existing stakeholders

Engage with owners of plans where stakeholder engagement was identified as lacking to determine the challenges faced (Year 1). Prioritise plans with low stakeholder engagement that are located in high-risk priority areas (Supplementary Information 2). In Years 2 and 3, conduct a nation-wide, large-scale stakeholder engagement exercise with various stakeholders across England via questionnaires and workshops to gain an understanding of general concerns around INNS and biosecurity and gain insight on how to approach stakeholders for their buy-in. To facilitate this process, consult with plan owners where stakeholder engagement was high. With information gained from this exercise, develop a coordinated national approach to advise on how to engage with different user groups and explore development of a funding scheme to support resources to facilitate stakeholder engagement and direct the allocation of that funding to high-risk areas. Moreover, it is not uncommon for stakeholders to be invested and interested at the commencement of plan development, but their interest diminishes over time as the plan loses ‘momentum’. This can be problematic as plans should be permanent and on-going fixtures (i.e. plans should not be written as having a limited lifetime). This issue needs consideration when gathering information from stakeholders and advising plan owners on stakeholder engagement. Stakeholder scores can be found in Supplementary Information 1.

A first approach could be to engage with areas/plans that already have existing stakeholder frameworks in place, such as MPA management groups and conservation forums. Any opportunities to build on these existing opportunities/relationships and INNS work should be included in determining priorities. Groups that could be considered for initial stakeholder engagement include: the Fal and Helford SAC Management Forum, the Solent Forum, the North West Coastal Forum, the Cumbria Forum, the Tamar Estuaries Consultative Forum, the Wash and North Norfolk Marine Partnership and the South Devon AONB Estuaries Partnership.

[4] http://publications.naturalengland.org.uk/publication/5091100843311104

Future biosecurity planning

In order to maximise biosecurity efforts thereby reducing the risk of introduction and spread of INNS, future biosecurity planning may necessarily have to take a comprehensive area-wide approach where all pathways and species of concern are considered. This should, as much as possible, provide maximum biosecurity coverage for the area. As such, prior to any biosecurity plan being developed, relevant MPA management groups and conservation forums should be consulted. These groups provide readymade estuary-wide stakeholder groups which can facilitate implementation and management of plans across a range of sectors and could include the Fal and Helford SAC Management Forum, the Solent Forum, the North West Coastal Forum, the Cumbria Forum, the Tamar Estuaries Consultative Forum, the Wash and North Norfolk Marine Partnership and the South Devon AONB Estuaries Partnership.

Prior to biosecurity plan development, **pathway risk assessments** to analyse risk of INNS introduction and spread should be conducted. These assessments compare the physical and environmental conditions on either end of the pathway (i.e. source and receptor) as well as investigate conditions of the pathway itself (e.g. ballast water tanks) to determine risk level of the pathway. Pathway risk assessments also involve identification of relevant stakeholders for consultation to gain a comprehensive understanding of each pathway. This is a vital first step for developing biosecurity plans, as biosecurity actions should be intrinsically linked and tailored to the specific pathways in the area.

Pathway risk assessments should be supported by **species risk assessments**, which involve investigating INNS currently present and horizon species that are likely to arrive and establish in the area. Understanding the suit of species already present in the area will help in understanding what horizon species may survive if introduced. Assessing likelihood of horizon species arriving and establishing will facilitate the development of early detection and rapid response plans. If current species data are not available for the area, **baseline surveys** should be conducted. These data are essential for pathway and species risks assessments and will feed into biosecurity plans. Surveys should continue to be done over time to monitor current INNS and surveil for new arrivals. Detection of a new arrival is vital for triggering a timely rapid response and implementing subsequent management actions (i.e. eradication, containment, control) which should be laid out in the biosecurity plan.

Appendices

Appendix 1 – Review of biosecurity plans: semi-quantitative approach

Table A1. Essential criteria and associated descriptions presented by category for the semi-quantitative review of plans.

	Criteria	Description of criteria	Description of scores	Scores
Background Information	Title information	Are authors of the Plan identified? | Is the year of development or publication provided? | Is the Plan period provided (i.e. period over which the Plan is active)?	Author(s), year of publication and Plan period included	3
			Only author(s) OR year of publication OR Plan period included (i.e. one or two included but not all three)	2
			Neither author(s) nor year of publication included	1
	Scene setting	Is there information regarding: What are INNS? | What is biosecurity? | What are pathways?	Definition/description of INNS, biosecurity and pathways included	3
			Definition/description of INNS OR biosecurity OR pathways included (i.e. one or two included but not all three)	2
			Definition/description of INNS, biosecurity or pathways not included	1
	Ownership of Plan	Is responsible person(s) or organisation(s)/group(s) identified or is there an indication that a Biosecurity Manager/Officer will be responsible? i.e. who will ensure Plan is carried out?	Owner of the Plan explicitly identified	3
			Owner of the Plan not explicitly identified but implied	2
			It is not clear who the owner of the Plan is	1
	Scope	Is the purpose of Plan and/or overall aim(s) identified? | Are	Purpose of Plan and/or overall aim(s)	3

	Criteria	Description of criteria	Description of scores	Scores
		objectives for meeting the purpose(s)/aim(s) laid out?	and objectives included	
			Purpose of Plan and/or overall aim(s) included but objectives not laid out	2
			Purpose of Plan and/or overall aim(s) and objectives not included	1
	Site information	Are site location, site description and asset owners identified? e.g. map provided, size of area covered, tide-salinity, marine features, environmental management measures, conditions assessments (if available), designated and/or sensitive site, protected habitats or features, protected species, who owns/manages/leases land and/or assets?	Location, description and ownership of site fully described	3
			Some but not all site details included (i.e. one or two included but not all three)	2
			No location, description and ownership information provided	1
	INNS	Does the plan identify INNS present? | Does the Plan identify Horizon INNS?	INNS present on-site listed and horizon INNS identified	3
			INNS present on-site listed OR horizon INNS identified (i.e. one or the other identified but not both)	2
			Neither INNS present on-site listed nor horizon INNS identified	1
ID of Risks	Use of the area	How well does the Plan identify risky pathways/activities? | Does the Plan assign risk level to each activity/pathway? (e.g. high, medium, low)	Risky pathways/actions identified and associated level of risk assigned to each	3
			Risky pathways/actions identified without associated level of risk assigned to each	2

	Criteria	Description of criteria	Description of scores	Scores
			Risky pathways/activities not identified	1
Biosecurity Actions	Identification and description of actions	Are actions identified and described?	Actions identified and described in detail	3
			Actions identified but not described in detail	2
			Actions not identified	1
	Who implements actions?	Are owners of each action identified? i.e. who is responsible for each action?	Owner for each action identified	3
			Owner for some but not all actions identified	2
			No owners of actions identified	1
	When are action implemented?	When should an action be implemented? Actions may be indicated by priority (low, medium, high).	Indication of when all actions should be implemented or a specific timeframe provided (e.g. 'Year 1', 'immediately')	3
			Some actions but not all include indication of when they should be implemented	2
			No indication of when actions should be implemented or a specific timeframe included for any actions	1
	Applicability of actions to identified risks	Are all risks identified addressed by the biosecurity actions put forth?	Actions fully address all risks identified	3
			Actions cover only some of the risks identified	2
			Actions do not cover all risks identified OR actions not identified (as above)	1
Support Work	Monitoring	Is there any INNS monitoring in place (e.g. regular INNS surveys, horizon INNS surveillance)?	Dedicated INNS and or horizon species monitoring in place	3
			General monitoring in place	2

	Criteria	Description of criteria	Description of scores	Scores
			no monitoring in place	1
	Contingency / Rapid Response Plan	Is there a contingency / rapid response plan (RRP) in place for when a new INNS is detected (ideally one that defines the process for reporting new INNS)?	Dedicated contingency/RRP in place and bespoke to the site	3
			A reference or link to a general or external contingency/RRP included but no dedicated plan bespoke to the site	2
			No contingency plan/RRP in place, no reference or link to an external contingency/RRP included	1
Additional Information	Stakeholders identified	Are key stakeholders relevant to the Plan, such as local action groups, conservation organisations, local governing bodies, marinas, watercraft clubs, INNS experts, etc. identified?	Key stakeholders identified and main contact provided	3
			Key stakeholders identified but no contact provided	2
			Key stakeholders not identified	1
	Events identified	Is a list of risky events provided? Ideally, this list would be reviewed and updated annually.	Not applicable, e.g. aquaculture designation	3
			A list of risky events is provided and a procedure for annual review of events is in place	3
			A list of risky events is provided but a procedure for annual review of events is not in place	2
			A list of risky events is not provided	1
Review	Review and evaluation	Is there a plan or procedure in place to review general progress and evaluate outcomes of any actions that have been implemented? e.g. yearly review with full evaluation at the end of the Plan period.	Review of progress and evaluation of biosecurity action outcomes in place	3
			Review of progress OR evaluation of biosecurity action outcomes in place	2

	Criteria	Description of criteria	Description of scores	Scores
			No review of progress nor evaluation of biosecurity action outcomes in place	1
Implementation	Stakeholders Title information	Are all stakeholders (SHs) aware of the Plan (i.e. has Plan been disseminated to SHs)?	Plan has been disseminated to all relevant stakeholders and have had feedback	5
			Plan has been disseminated and actively promoted/displayed (i.e. SH engagement or harbour signage)	4
			Plan has been disseminated to all/most stakeholders	3
			Plan has been disseminated to some but not all relevant stakeholders	2
			Plan has not been disseminated to any stakeholders	1
			No interview	N/A
	Scene setting Implementation of actions	Have any biosecurity actions been implemented?	Many biosecurity actions have been implemented/High confidence (success monitoring?)	5
			Many biosecurity actions have been implemented/Some confidence	4
			Some actions have been implemented/Some confidence	3
			Some actions implemented/Limited confidence	2
			None of the biosecurity actions have been	1

	Criteria	Description of criteria	Description of scores	Scores
			implemented/No confidence	
			No interview	N/A

Appendix 2 – Review of biosecurity plans: qualitative approach – List of questions covered during the semi-structured interviews

1. What responsibility do you have in relation to the implementation of the plan?
2. Are others also responsible for the implementation of the plan? (i.e. other stakeholders. Can you define each stakeholder's role or are they all responsible for a particular area?). Ask for contact details if others are involved.
3. Is the plan regularly reviewed and updated? (What is the mechanism for that review?)
4. What is the review process for the plan (e.g. 5-yearly review by creators of the plan and relevant stakeholders), and has the plan been reviewed yet?
5. Who has the plan been disseminated to / are stakeholders aware of the plan?
6. Has there been any feedback from stakeholders who were involved in writing the plan and/or use (or should be using) the plan? Or public/users of the area? If so, can you share that feedback?
7. Overall, do you think the plan has been implemented and do you think it has achieved its objective to take a proactive approach to biosecurity? i.e. are people/stakeholders actively engaged in it?
8. What parts of the plan do you think are most useful? Is there anything missing from the plan?
9. Which parts of the plan do you think could be improved?
10. What has worked well with the implementation of the plan?
11. Where could implementation of the plan be improved?
12. Have all/any of the actions presented in the plan been implemented/are there plans for implementation?
13. If actions have not been implemented what has prevented or slowed their implementation?
14. If actions have been implemented, has there been any monitoring carried out to track plan actions?
15. Do you feel that the plan has been effective at reducing the spread of INNS? If so, how do you know this/how are new introductions and spread measured? i.e. would you know if there was a new introduction?

Appendix 3 – MPAs without Biosecurity Plans

Table A4. Site names and identifying codes of MPAs not covered by biosecurity plans.

SiteCode	SiteName	Designation	Nationality	Primary AT Name
UKMCZ0051	Albert Field	MCZ	English Inshore	Wessex
UK0030076	Alde, Ore and Butley Estuaries	SAC	English Inshore	Norfolk and Suffolk
UK9009112	Alde-Ore Estuary	SPA	English Inshore	Norfolk and Suffolk
UKMCZ0052	Axe Estuary	MCZ	English Inshore	Devon, Cornwall and Isles of Scilly
UKMCZ0053	Beachy Head East	MCZ	English Inshore	Sussex and Kent
UKMCZ0002	Beachy Head West	MCZ	English Inshore	Sussex and Kent
UKMCZ0054	Bembridge	MCZ	English Inshore	Thames Solent
UK0013104	Benacre to Easton Bavents Lagoons	SAC	English Inshore	Norfolk and Suffolk
UK9009171	Benfleet and Southend Marshes	SPA	English Inshore	West Anglia
UK9009245	Blackwater Estuary (Mid-Essex Coast Phase 4)	SPA	English Inshore	West Anglia
UKMCZ0003	Blackwater, Crouch, Roach and Colne Estuaries	MCZ	English Inshore	West Anglia
UK0012570	Braunton Burrows	SAC	English Inshore	Devon, Cornwall and Isles of Scilly
UK9009181	Breydon Water	SPA	English Inshore	Norfolk and Suffolk
UKMCZ0076	Cape Bank	MCZ	English Inshore/Offshore	Devon, Cornwall and Isles of Scilly
UK0017076	Chesil and the Fleet	SAC	English Inshore	Wessex
UKMCZ0004	Chesil Beach and Stennis Ledges	MCZ	English Inshore	Wessex
UK9010091	Chesil Beach and The Fleet	SPA	English Inshore	Wessex
UK9011011	Chichester and Langstone Harbours	SPA	English Inshore	Thames Solent

SiteCode	SiteName	Designation	Nationality	Primary AT Name
UK9009243	Colne Estuary (Mid-Essex Coast Phase 2)	SPA	English Inshore	West Anglia
UKMCZ0031	Cromer Shoal Chalk Beds	MCZ	English Inshore	Norfolk and Suffolk
UK9009244	Crouch and Roach Estuaries (Mid-Essex Coast Phase 3)	SPA	English Inshore	West Anglia
UK9009261	Deben Estuary	SPA	English Inshore	Norfolk and Suffolk
UK9009242	Dengie (Mid-Essex Coast Phase 1)	SPA	English Inshore	West Anglia
UKMCZ0032	Dover to Deal	MCZ	English Inshore	Sussex and Kent
UKMCZ0033	Dover to Folkestone	MCZ	English Inshore	Sussex and Kent
UK9012091	Dungeness, Romney Marsh and Rye Bay	SPA	English Inshore	Sussex and Kent
UKMCZ0077	East of Start Point	MCZ	English Inshore/Offshore	Devon, Cornwall and Isles of Scilly
UK0013690	Essex Estuaries	SAC	English Inshore	West Anglia
UKMCZ0043	Farnes East	MCZ	English Inshore/Offshore	Northumbria
UK9006101	Flamborough and Filey Coast	SPA	English Inshore	Yorkshire and northern Lincolnshire
UK0013036	Flamborough Head	SAC	English Inshore	Yorkshire and northern Lincolnshire
UKMCZ0006	Folkestone Pomerania	MCZ	English Inshore	Sussex and Kent
UKMCZ0060	Foreland	MCZ	English Inshore	Sussex and Kent
UK9009246	Foulness (Mid-Essex Coast Phase 5)	SPA	English Inshore	West Anglia
UKMCZ0061	Goodwin Sands	MCZ	English Inshore	Sussex and Kent
UK9009271	Great Yarmouth North Denes	SPA	English Inshore	Norfolk and Suffolk
UK0030369	Haisborough, Hammond and Winterton	SAC	English Inshore/Offshore	Norfolk and Suffolk
UK9009131	Hamford Water	SPA	English Inshore	West Anglia

SiteCode	SiteName	Designation	Nationality	Primary AT Name
UKMCZ0078	Holderness Offshore	MCZ	English Inshore/Offshore	Yorkshire and northern Lincolnshire
UKMCZ0079	Inner Bank	MCZ	English Inshore/Offshore	Sussex and Kent
UK0030370	Inner Dowsing, Race Bank and North Ridge	SAC	English Inshore/Offshore	Norfolk and Suffolk
UK9020288	Isles of Scilly	SPA	English Inshore	Devon, Cornwall and Isles of Scilly
UK0013694	Isles of Scilly Complex	SAC	English Inshore	Devon, Cornwall and Isles of Scilly
UKMCZ0008-01	Isles of Scilly: Bishop to Crim	MCZ	English Inshore	Devon, Cornwall and Isles of Scilly
UKMCZ0008-02	Isles of Scilly: Bristows to the Stones	MCZ	English Inshore	Devon, Cornwall and Isles of Scilly
UKMCZ0008-03	Isles of Scilly: Gilstone to Gorregan	MCZ	English Inshore	Devon, Cornwall and Isles of Scilly
UKMCZ0008-04	Isles of Scilly: Hanjague to Deep Ledge	MCZ	English Inshore	Devon, Cornwall and Isles of Scilly
UKMCZ0008-05	Isles of Scilly: Higher Town	MCZ	English Inshore	Devon, Cornwall and Isles of Scilly
UKMCZ0008-06	Isles of Scilly: Lower Ridge to Innisvouls	MCZ	English Inshore	Devon, Cornwall and Isles of Scilly
UKMCZ0008-07	Isles of Scilly: Men a Vaur to White Island	MCZ	English Inshore	Devon, Cornwall and Isles of Scilly
UKMCZ0008-08	Isles of Scilly: Peninnis to Dry Ledge	MCZ	English Inshore	Devon, Cornwall and Isles of Scilly
UKMCZ0008-09	Isles of Scilly: Plympton to Spanish Ledge	MCZ	English Inshore	Devon, Cornwall and Isles of Scilly
UKMCZ0008-10	Isles of Scilly: Smith Sound Tide Swept Channel	MCZ	English Inshore	Devon, Cornwall and Isles of Scilly
UKMCZ0008-11	Isles of Scilly: Tean	MCZ	English Inshore	Devon, Cornwall and Isles of Scilly

SiteCode	SiteName	Designation	Nationality	Primary AT Name
UKMCZ0080	Kentish Knock East	MCZ	English Inshore/Offshore	West Anglia
UKMCZ0009	Kingmere	MCZ	English Inshore	Sussex and Kent
UKMCZ0010	Lundy	MCZ	English Inshore	Devon, Cornwall and Isles of Scilly
UK0013114	Lundy	SAC	English Inshore	Devon, Cornwall and Isles of Scilly
UK0030372	Lyme Bay and Torbay	SAC	English Inshore	Devon, Cornwall and Isles of Scilly
UK0030371	Margate and Long Sands	SAC	English Inshore	Sussex and Kent
UK9009101	Minsmere-Walberswick	SPA	English Inshore	Norfolk and Suffolk
UKMCZ0063	Morte Platform	MCZ	English Inshore	Devon, Cornwall and Isles of Scilly
UK0019838	North Norfolk Coast	SAC	English Inshore	Norfolk and Suffolk
UK9009031	North Norfolk Coast	SPA	English Inshore	Norfolk and Suffolk
UKMCZ0064	North West of Lundy	MCZ	English Inshore	Devon, Cornwall and Isles of Scilly
UKMCZ0044	Offshore Overfalls	MCZ	English Inshore/Offshore	Sussex and Kent
UKMCZ0081	Orford Inshore	MCZ	English Inshore/Offshore	Norfolk and Suffolk
UK0014780	Orfordness - Shingle Street	SAC	English Inshore	Norfolk and Suffolk
UKMCZ0065	Otter Estuary	MCZ	English Inshore	Devon, Cornwall and Isles of Scilly
UKMCZ0013	Pagham Harbour	MCZ	English Inshore	Sussex and Kent
UK9012041	Pagham Harbour	SPA	English Inshore	Sussex and Kent
UKMCZ0014	Poole Rocks	MCZ	English Inshore	Wessex
UKMCZ0066	Purbeck Coast	MCZ	English Inshore	Wessex
UKMCZ0039	Runswick Bay	MCZ	English Inshore	Yorkshire and northern Lincolnshire
UKMCZ0068	Selsey Bill and the Hounds	MCZ	English Inshore	Sussex and Kent
UK9015022	Severn Estuary	SPA	English Inshore/Welsh	Wessex

SiteCode	SiteName	Designation	Nationality	Primary AT Name
UK0013030	Severn Estuary/ Môr Hafren	SAC	English Inshore/Welsh	Wessex
UKMCZ0015	Skerries Bank and Surrounds	MCZ	English Inshore	Devon, Cornwall and Isles of Scilly
UK0017073	Solent and Isle of Wight Lagoons	SAC	English Inshore	Thames Solent
UKMCZ0022	South Dorset	MCZ	English Inshore/Offshore	Wessex
UKMCZ0070	South of Portland	MCZ	English Inshore	Wessex
UKMCZ0082	South of the Isles of Scilly	MCZ	English Inshore/Offshore	Devon, Cornwall and Isles of Scilly
UK0030061	South Wight Maritime	SAC	English Inshore	Thames Solent
UKMCZ0071	Southbourne Rough	MCZ	English Inshore	Wessex
UK0030373	Start Point to Plymouth Sound and Eddystone	SAC	English Inshore	Devon, Cornwall and Isles of Scilly
UK9009121	Stour and Orwell Estuaries	SPA	English Inshore	Norfolk and Suffolk
UKMCZ0072	Studland Bay	MCZ	English Inshore	Wessex
UK0030382	Studland to Portland	SAC	English Inshore	Wessex
UKMCZ0073	Swanscombe	MCZ	English Inshore	West Anglia
UKMCZ0017	Thanet Coast	MCZ	English Inshore	Sussex and Kent
UK0013107	Thanet Coast	SAC	English Inshore	Sussex and Kent
UK9012071	Thanet Coast and Sandwich Bay	SPA	English Inshore	Sussex and Kent
UKMCZ0040	The Needles	MCZ	English Inshore	Thames Solent
UKMCZ0019	Torbay	MCZ	English Inshore	Devon, Cornwall and Isles of Scilly
UKMCZ0042	Utopia	MCZ	English Inshore	Sussex and Kent
UKMCZ0075	Yarmouth to Cowes	MCZ	English Inshore	Thames Solent

Appendix 4 – Hotspots in or near MPAs

Table A5. Introduction hotspots within or near to MPAs with associated biosecurity plans within these areas.

Hotspot name	Intensity of shipping vector (score 1-3)	Intensity of shipping vector (rank)	Site Code	Site Name	Designation	Region	BSP
Bristol	1	medium	UK0013030; UK9015022	Severn Estuary; Severn Estuary	SAC; SPA	Western Channel and Celtic Sea	none
Dover	3	very high	UKMCZ0032; UKMCZ0061; UKMCZ0033; UKMCZ0006; UKMCZ0060; UK9012071	Dover to Deal; Goodwin Sands; Dover to Folkestone; Folkestone Pomerania; Foreland; Thanet Coast and Sandwich Bay	MCZ; MCZ; MCZ; MCZ; MCZ; SPA	Eastern Channel & Southern North Sea	none
Felixstowe	2	high	UK0014780; UK0030076; UK9009112; UK9009121; UK9009131; UK9009261; UK9020309	Orfordness - Shingle Street; Alde, Ore and Butley Estuaries; Alde-Ore Estuary; Stour and Orwell Estuaries; Hamford Water; Deben Estuary; Outer Thames Estuary	SAC; SAC; SPA; SPA; SPA; SPA; SPA	Southern North Sea	None

Hotspot name	Intensity of shipping vector (score 1-3)	Intensity of shipping vector (rank)	Site Code	Site Name	Designation	Region	BSP
Immingham	3	very high	UK0030170; UK9006111	Humber Estuary; Humber Estuary	SAC; SPA	Southern North Sea	ABP Humber (2017)
Liverpool	2	high	UK0030131; UK9005103; UK9005131; UK9013011; UK9020287; UK9020294	Dee Estuary/ Aber Dyfrdwy; Ribble and Alt Estuaries; Mersey Estuary; The Dee Estuary; Mersey Narrows and North Wirral Foreshore; Liverpool Bay / Bae Lerpwl	SAC; SPA; SPA; SPA; SPA; SPA	Irish Sea	RAPID LIFE (2020) - Mersey
London	3	very high	UKMCZ0073; UKMCZ0011-01; UKMCZ0011-02; UK9012031; UK9020309; UK9012021	Swanscombe; Medway Estuary - Zone 1; Medway Estuary - Zone 2; Medway Estuary and Marshes; Outer Thames Estuary; Thames Estuary and Marshes	MCZ; MCZ; MCZ; SPA; SPA; SPA	Southern North Sea	RAPID LIFE (2020) - Medway

Hotspot name	Intensity of shipping vector (score 1-3)	Intensity of shipping vector (rank)	Site Code	Site Name	Designation	Region	BSP
Plymouth	1	medium	UKMCZ0059; UKMCZ0016; UKMCZ0021; UK0013111; UK9010141	Erme Estuary; Tamar Estuary Sites; Whitsand and Looe Bay; Plymouth Sound and Estuaries; Tamar Estuaries Complex	MCZ; MCZ; MCZ; SAC; SPA	Western Channel and Celtic Sea	South Devon AONB (2017) – Erme Estuary; South Devon AONB (2017) – Yealm; Tamar Estuaries Marine Biosecurity Plan
Poole	1	medium	UKMCZ0014; UKMCZ0072; UKMCZ0071; UKMCZ0066; UK9010111	Poole Rocks; Studland Bay; Southbourne Rough; Purbeck Coast; Poole Harbour	MCZ; MCZ; MCZ; MCZ; SPA	Eastern Channel	Southern IFCA
Portsmouth	1	medium	UKMCZ0054; UK0017073; UK0030059; UK0030061; UK9011011; UK9011051; UK9011061	Bembridge; Solent and Isle of Wight Lagoons; Solent Maritime; South Wight Maritime; Chichester and Langstone Harbours; Portsmouth Harbour; Solent and Southampton Water	MCZ; SAC; SAC; SAC; SPA; SPA; SPA	Eastern Channel	Haslar Marina (2017); MDL Hamble Point Marina (2019)
Southampton	3	very high	UK0030059; UK9011061	Solent Maritime; Solent and Southampton Water	SAC; SPA	Eastern Channel	Haslar Marina (2017); MDL Hamble Point Marina (2019)

Hotspot name	Intensity of shipping vector (score 1-3)	Intensity of shipping vector (rank)	Site Code	Site Name	Designation	Region	BSP
Southport/ Blackpool	1	medium	UKMCZ0007; UKMCZ0067; UKMCZ0074; UK9005103; UK9020294; UK9020326	Fylde; Ribble Estuary; Wyre-Lune; Ribble and Alt Estuaries; Liverpool Bay / Bae Lerpwl; Morecambe Bay and Duddon Estuary	MCZ; MCZ; MCZ; SPA; SPA; SPA	Irish Sea	RAPID LIFE (2020) - Wyre
Tees	3	very high	UK9006061; UK9006131	Teesmouth and Cleveland Coast; Northumbria Coast	SPA; SPA	Northern North Sea	Berwickshire and Northumberland INNS Strategy

Appendix 5 – English Biosecurity Plan scores

Table A2. Percentage scores for international biosecurity plans reviewed indicating criteria where plans scored low ('red' or 'amber'). See Supplementary Information 1 for review of English plans.

Name of Plan	Potential to be effective%	Overall %	Effectiveness %	Red or Amber in 'Potential to be Effective' Scores
Fal and Helford SAC: Recreation Biosecurity Plan (2022)	94%	N/A	N/A	none
Tamar Estuaries Marine Biosecurity Plan	94%	85%	50%	Additional Information (Stakeholders & Events)
Northwest IFCA Biosecurity Plan (2014 to 2019)	86%	83%	70%	Risks
Northwest IFCA Biosecurity Plan (2022-2025)	86%	83%	70%	Risks
Solway Firth Partnership (2021-2024)	83%	83%	80%	Risks; Additional Information (Stakeholders & Events)
Cornwall IFCA Biosecurity Plan (2019)	81%	N/A	N/A	Risks; Review
Fowey Biosecurity Plan (2015)	78%	70%	40%	Supporting Work (Monitoring & RRP); Additional Information (Stakeholders & Events); Review

Name of Plan	Potential to be effective%	Overall %	Effectiveness %	Red or Amber in 'Potential to be Effective' Scores
Berwickshire and Northumberland INNS Strategy	75%	N/A	N/A	Background; Risks; Supporting Work (Monitoring & RRP); Additional Information (Stakeholders & Events)
Waddeton Fishery (shellfish) (2022)- Devon & Severn IFCA	72%	70%	60%	Background; Supporting Work (Monitoring & RRP); Review
RAPID LIFE (2020) - Mersey	72%	N/A	N/A	Risks; Biosecurity Actions; Supporting Work (Monitoring & RRP); Additional Information (Stakeholders & Events); Review
Lymington Yacht Haven	69%	N/A	N/A	Background; Biosecurity Actions; Supporting Work (Monitoring & RRP); Additional Information (Stakeholders & Events); Review
South Devon AONB Estuaries Partnership Salcombe Harbour & Kingsbridge Estuary Marine Biosecurity Plan 2017- 2020	67%	67%	70%	Background; Biosecurity Actions; Supporting Work (Monitoring & RRP); Additional Information (Stakeholders & Events); Review
Haslar Marina (2017)	67%	59%	30%	Supporting Work (Monitoring & RRP); Additional Information

Name of Plan	Potential to be effective%	Overall %	Effectiveness %	Red or Amber in 'Potential to be Effective' Scores
				(Stakeholders & Events); Review
South Devon AONB Estuaries Partnership Avon Estuary Marine Biosecurity Plan 2017- 2020	64%	65%	70%	Background; Biosecurity Actions; Supporting Work (Monitoring & RRP); Additional Information (Stakeholders & Events); Review
South Devon AONB Estuaries Partnership Erme Estuary Marine Biosecurity Plan 2017-2020	64%	65%	70%	Background; Biosecurity Actions; Supporting Work (Monitoring & RRP); Additional Information (Stakeholders & Events); Review
South Devon AONB Estuaries Partnership Dart Harbour & Estuary Marine Biosecurity Plan	64%	65%	70%	Background; Biosecurity Actions; Supporting Work (Monitoring & RRP); Additional Information (Stakeholders & Events); Review
South Devon AONB Estuaries Partnership Yealm Estuary Marine Biosecurity Plan 2017-2020	64%	63%	60%	Background; Biosecurity Actions; Supporting Work (Monitoring & RRP); Additional Information (Stakeholders & Events); Review
Falmouth Harbour Commissioners Biosecurity Plan	64%	N/A	N/A	Background; Biosecurity Actions; Supporting Work (Monitoring & RRP); Additional Information (Stakeholders & Events); Review

Name of Plan	Potential to be effective%	Overall %	Effectiveness %	Red or Amber in 'Potential to be Effective' Scores
Exe Estuary (2022)	64%	N/A	N/A	Background; Biosecurity Actions; Supporting Work (Monitoring & RRP); Additional Information (Stakeholders & Events); Review
MDL Hamble Point Marina (2019)	61%	54%	30%	Background; Supporting Work (Monitoring & RRP); Additional Information (Stakeholders & Events); Review
Eastern IFCA (2020-2025)	56%	50%	30%	Background; Risks; Biosecurity Actions; Supporting Work (Monitoring & RRP); Additional Information (Stakeholders & Events); Review
RAPID LIFE (2020) - Medway	56%	N/A	N/A	Background; Risks; Biosecurity Actions; Supporting Work (Monitoring & RRP); Additional Information (Stakeholders & Events); Review
RAPID LIFE (2020) - Wash	56%	N/A	N/A	Background; Biosecurity Actions; Supporting Work (Monitoring & RRP); Additional Information (Stakeholders & Events); Review
RAPID LIFE (2020) - Wyre	53%	N/A	N/A	Background; Risks; Biosecurity Actions; Supporting Work

Name of Plan	Potential to be effective%	Overall %	Effectiveness %	Red or Amber in 'Potential to be Effective' Scores
				(Monitoring & RRP); Additional Information (Stakeholders & Events); Review

Appendix 6 – Common messages

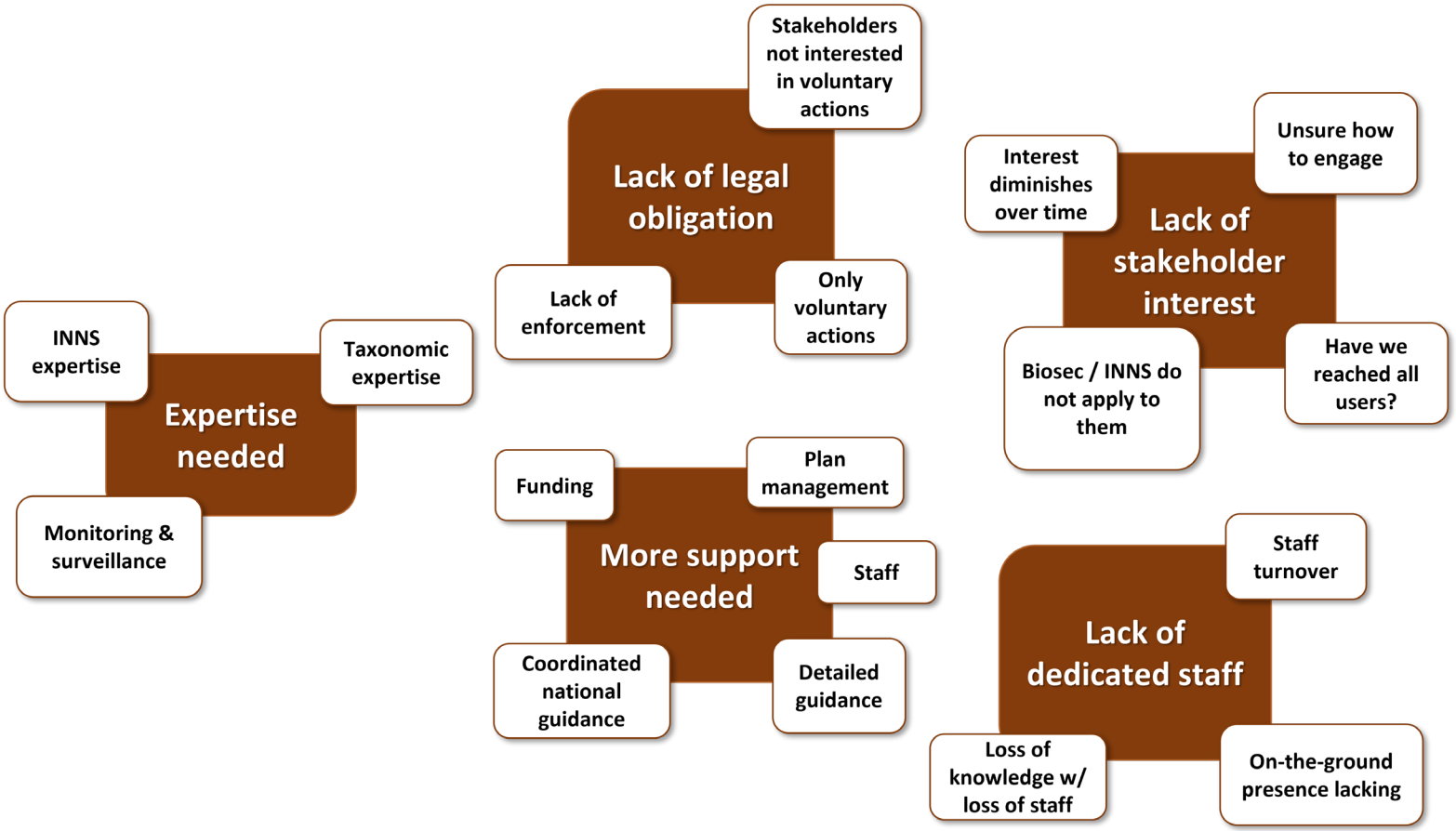

Figure 3. This is an illustration of common messages gathered from the semi-structured interviews along with suggestions to address the issues. This image was used in a PowerPoint presentation about the project to Natural England and NRW staff in September 2022. © APEM 2023

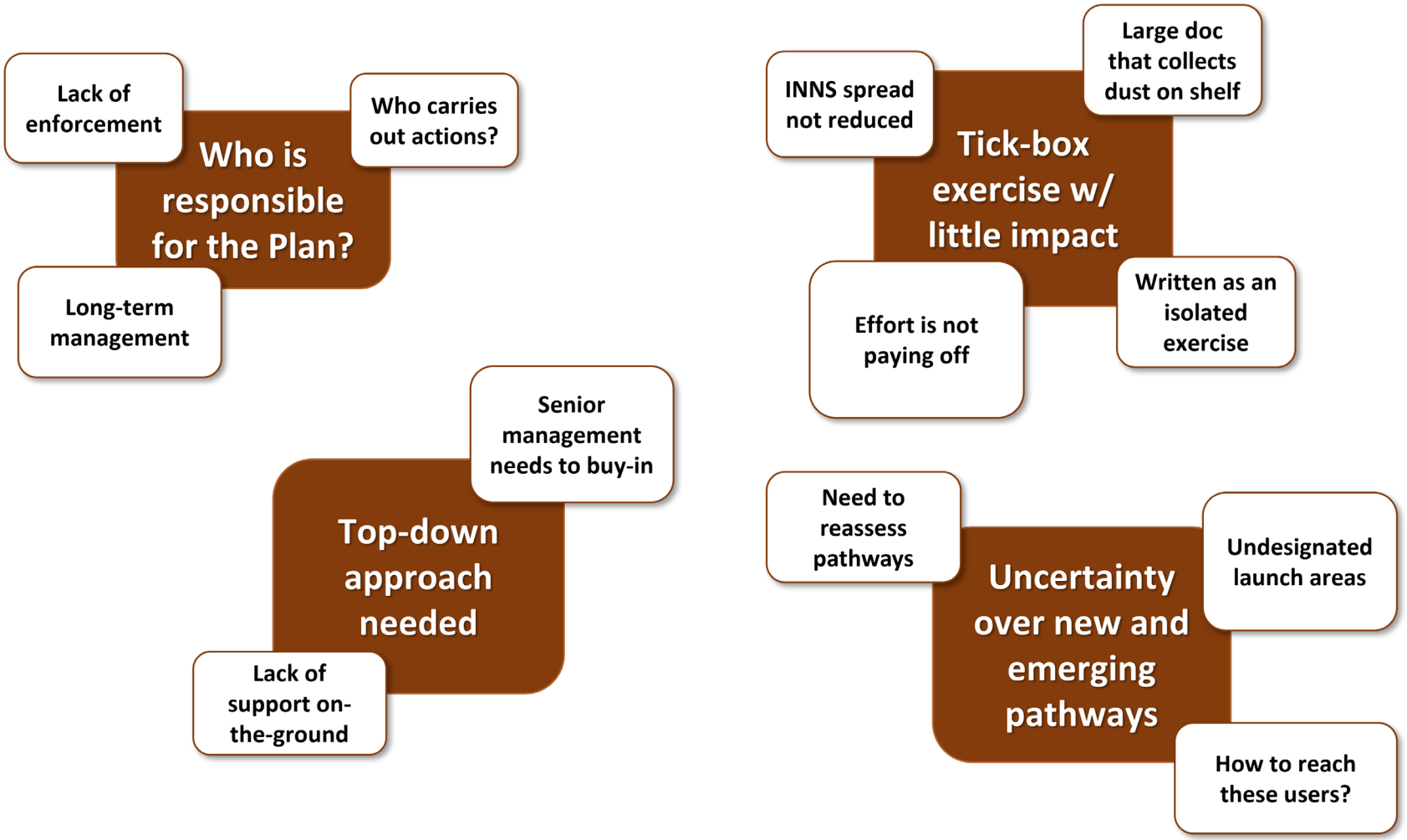

Figure 4. This is an illustration of common messages gathered from the semi-structured interviews along with suggestions to address the issues. This image was used in a PowerPoint presentation about the project to Natural England and NRW staff in September 2022. © APEM 2023

Appendix 7 – International Biosecurity Plan scores

Table A3. Percentage scores for international biosecurity plans reviewed indicating criteria where plans scored high ('green') and low ('red' or 'amber'). See Supplementary Information 3 for review of international plans.

Name of Plan	Potential to be effective %	Green in 'Potential to be Effective' scores	Red or Amber in 'Potential to be Effective' scores
Isle of Man Marine Biosecurity Plan - May 2018	94%	Background, Risks, Biosecurity Actions, Supporting Work, Review	Stakeholders
Fiordland Marine Biosecurity Plan	94%	Background, Risks, Biosecurity Actions, Supporting Work, Stakeholders, Review	None
Napier Port Biosecurity Management Plan, Wharf 6	91%	Background, Risks, Biosecurity Actions, Supporting Work, Review	Stakeholders
Port of Mackay Biosecurity Management Plan, NQBP	88%	Biosecurity Actions, Supporting Work, Stakeholders, Review	Background and Risks
Port of Hay Point Biosecurity Management Plan, NQBP	88%	Biosecurity Actions, Supporting Work, Stakeholders, Review	Background and Risks
Port of Weipa Biosecurity Management Plan, NQBP	88%	Biosecurity Actions, Supporting Work, Stakeholders, Review	Background and Risks
Port of Abbot Point Biosecurity Management Plan, NQBP	88%	Biosecurity Actions, Supporting Work, Stakeholders, Review	Background and Risks
Shetland Islands' Marine Spatial Plan: A biosecurity plan for the Shetland Islands	85%	Background, Risks, Biosecurity Actions, Supporting Work, Stakeholders	Review
North Burnett Regional Council Biosecurity Plan 2019-2024	85%	Background, Biosecurity Actions, Additional Information, Review	Risks and Supporting Work

Name of Plan	Potential to be effective %	Green in 'Potential to be Effective' scores	Red or Amber in 'Potential to be Effective' scores
Bay of Plenty Marine Biosecurity Management Plan	85%	Background, Risks, Supporting Work, Stakeholders, Review	Biosecurity Actions and Stakeholders
Northern Ireland INNS: Recreational Boating Pathway Action Plan (PAP)	79%	Risks, Biosecurity Actions, Stakeholders	Background, Supporting Work and Review
The Bahamas National Invasive Species Strategy (NISS)	73%	Background, Biosecurity Actions	Risks, Supporting Work, Stakeholders and Review
Australia: National Strategic Plan for Marine Pest Biosecurity 2018-2023	70%	Biosecurity Actions, Review	Background, Risks, Supporting Work and Stakeholders

Appendix 8 – Gap analysis of MPAs with Biosecurity Plans

Table A6. Designated sites that are within the geographic coverage of a biosecurity plan, the status of the biosecurity plan, the pathways covered by the biosecurity plan and the review score.

Designated Site Name	Designation	Identification code	Biosecurity Plan name	Location	Geographic coverage	Status	Pathways	Review score - Potential to be effective
Dart Estuary	MCZ	UKMCZ0057	Waddeton Fishery (shellfish) (2022) - Devon & Severn IFCA	Waddeton Shellfishery	Waddeton Shellfishery	current	aquaculture (Pacific oyster) - diseases	72%
Devon Avon Estuary	MCZ	UKMCZ0058	South Devon AONB (2017) - Avon	Avon	Avon Estuary	current	recreational vessels, commercial vessels, fishing vessels, aquaculture, movement of structures	65%
Erme Estuary	MCZ	UKMCZ0059	South Devon AONB (2017) - Erme Estuary	Erme Estuary	Erme Estuary	current	fishing vessels, recreational vessels, movement of structures	65%
Medway Estuary - Zone 1	MCZ	UKMCZ0011-01	Peel Ports Biosecurity Plan	London Medway	Peel Ports - London Medway	draft	unknown	N/A

Designated Site Name	Designation	Identification code	Biosecurity Plan name	Location	Geographic coverage	Status	Pathways	Review score - Potential to be effective
Medway Estuary - Zone 1	MCZ	UKMCZ0011-01	RAPID LIFE (2020) - Medway	Medway	Swale and Medway Estuary	draft	commercial vessels, recreational vessels	55%
Medway Estuary - Zone 2	MCZ	UKMCZ0011-02	Peel Ports Biosecurity Plan	London Medway	Peel Ports - London Medway	draft	unknown	n/a
Medway Estuary - Zone 2	MCZ	UKMCZ0011-02	RAPID LIFE (2020) - Medway	Medway	Swale and Medway Estuary	draft	commercial vessels, recreational vessels	55%
Wyre-Lune	MCZ	UKMCZ0074	RAPID LIFE (2020) - Wyre	Wyre	Wyre Estuary	draft	recreational vessels, recreational angling, fishing vessels, movement of structures and fishing equipment	53%

Designated Site Name	Designation	Identification code	Biosecurity Plan name	Location	Geographic coverage	Status	Pathways	Review score - Potential to be effective
Berwickshire and North Northumberland Coast	SAC	UK0017072	Berwickshire and Northumberland INNS Strategy	Berwickshire and Northumberland	Berwickshire and Northumberland coast	draft	aquaculture, attachment to marine debris?, ballast water? release, escape or release from aquaria and catering?, hull fouling?, maintenance of port and harbour infrastructure, recreational water sports and equipment?, relocation of structures and equipment?	74%
Fal and Helford	SAC	UK0013112	Fal and Helford Recreation Biosecurity Plan (2022)	Fal and Helford SAC	Falmouth Harbour and Helford River	draft	recreational vessels	94%
Fal and Helford	SAC	UK0013112	Falmouth Harbour Commissioners Biosecurity Plan	Falmouth Harbour	Falmouth Harbour	out of date	recreational vessels and assoicated equipment, commercial vessels and associated	64%

Designated Site Name	Designation	Identification code	Biosecurity Plan name	Location	Geographic coverage	Status	Pathways	Review score - Potential to be effective
							cleaning, ballast water	
Humber Estuary	SAC	UK0030170	ABP Humber (2017)	Humber Estuary	Humber Estuary	unknown	unknown	n/a
Morecambe Bay	SAC	UK0013027	Peel Ports Biosecurity Plan	Heysham	Peel Ports - Heysham	draft	unknown	n/a
Plymouth Sound and Estuaries	SAC	UK0013111	South Devon AONB (2017) - Yealm	Yealm	Yealm Estuary	current	cruise liners, recreational vessels, commercial vessels, fishing vessels, movement of structures, live fish and shellfish export, aquaculture	65%
Plymouth Sound and Estuaries	SAC	UK0013111	Tamar Estuaries	Tamar Estuaries	Tamar Estuary	in process of updating	naval vessels, recreational vessels, commercial vessels	93%
Solway Firth	SAC	UK0013025	Solway Firth Partnership (2021-2024)	Solway Firth	Solway Firth	current	recreational vessels, commercial vessels,	82%

Designated Site Name	Designation	Identification code	Biosecurity Plan name	Location	Geographic coverage	Status	Pathways	Review score - Potential to be effective
							movement of structures	
The Wash and North Norfolk Coast	SAC	UK0017075	Eastern IFCA (2020-2025)	Eastern IFCA	The Wash Estuary	current	aquaculture - diseases	56%
The Wash and North Norfolk Coast	SAC	UK0017075	RAPID LIFE (2020) - Wash	Wash	The Wash Estuary	draft	recreational vessels, fishing vessels, aquaculture, movement of structures, offshore windfarm structures	55%
Exe Estuary	SPA	UK9010081	Exe Estuary (2022)	Exe Estuary	Exe Estuary	draft	live fish and shellfish exports, aquaculture, fishing vessels, recreational vessels, commercial vessels	64%
Falmouth Bay to St Austell Bay	SPA	UK9020323	Fal and Helford Recreation Biosecurity Plan (2022)	Fal and Helford SAC	Falmouth Harbour and Helford River	draft	recreational vessels	94%

Designated Site Name	Designation	Identification code	Biosecurity Plan name	Location	Geographic coverage	Status	Pathways	Review score - Potential to be effective
Falmouth Bay to St Austell Bay	SPA	UK9020323	Falmouth Harbour Commissioners Biosecurity Plan	Falmouth Harbour	Falmouth Harbour	out of date	recreational vessels and assoicated equipment, commercial vessels and associated cleaning, ballast water	64%
Humber Estuary	SPA	UK9006111	ABP Humber (2017)	Humber Estuary	Humber Estuary	unknown	unknown	n/a
Mersey Estuary	SPA	UK9005131	RAPID LIFE (2020) - Mersey	Mersey	Mersey Estuary	draft	commercial vessels, fishing vessels, recreational vessels, recreational angling, dock operations, constrcution and development	71%
Morecambe Bay and Duddon Estuary	SPA	UK9020326	Peel Ports Biosecurity Plan	Heysham	Peel Ports - Heysham	draft	unknown	n/a
Poole Harbour	SPA	UK9010111	Southern IFCA	Southern IFCA	Poole Harbour	current	aquaculture - diseases	n/a

Designated Site Name	Designation	Identification code	Biosecurity Plan name	Location	Geographic coverage	Status	Pathways	Review score - Potential to be effective
Solway Firth	SPA	UK9005012	Solway Firth Partnership (2021-2024)	Solway Firth	Solway Firth	current	recreational vessels, commercial vessels, movement of structures	82%
Teesmouth and Cleveland Coast	SPA	UK9006061	Teesport	Teesport	Tees Estuary	draft	unknown	n/a
The Wash	SPA	UK9008021	Eastern IFCA (2020-2025)	Eastern IFCA	The Wash Estuary	current	aquaculture - diseases	56%
The Wash	SPA	UK9008021	RAPID LIFE (2020) - Wash	Wash	The Wash Estuary	draft	recreational vessels, fishing vessels, aquaculture, movement of structures, offshore windfarm structures	55%

Appendix 9 Data sources

Table A7. External data sources used for maps (figures 1 and 2) and Supplementary Information 2. Biosecurity Plan Points were created in QGIS as part of the project.

Dataset	Source	Designation
Water Framework Surface Water Operational Catchments Cycle 2	Environment Agency	Used to create the 'Biosecurity Plan Areas' polygon data in addition to polygons created in QGIS as part of the project. Available to use and download under the Open Government Licence. © Environment Agency copyright and/or database right 2014
Shipping Hotspots	Tidbury et al. (2016)	Permission to re-use the data granted by authors. Report can be downloaded from: Marine non-indigenous species monitoring and risk management - ME5215
MPA data	Natural England	Available to use and download under the Open Government Licence
Background maps	Open Street Map	© OpenStreetMap available under the Open Database License openstreetmap.org/copyright

The data in this report was produced by QGIS licensed under GNU GPLv2

Bibliography

BLOSSEY, B. AND NOTZOLD, R., 1995. Evolution of increased competitive ability in invasive nonindigenous plants: a hypothesis. Journal of Ecology, 83, 887-889.

GB Non-Native Species Secretariat: Marine biosecurity guidance www.nonnativespecies.org/biosecurity/marine-biosecurity/

GITTENBERGER, A., RENSING, M., DEKKER, R., NIEMANTSVERDRIET, P., SCHRIEKEN, N. AND STEGENGA, H., 2015. Native and non-native species of the Dutch Wadden Sea in 2014. Commissioned by Office for Risk Assessment and Research, The Netherlands Food and Customer Product Safety Authority of the Ministry of Agriculture, Nature and Food Quality. GiMaRIS report 2015_08.

GITTENBERGER, A., RENSING, M., VAN DER VEER, H.W., PHILIPPART, C.J.M., VAN DER HOORN, B., D'HONT, A., WESDORP, K.H., SCHRIEKEN, N., KLUNDER, L., KLEINE-SCHAARS, L., HOLTHUIJSEN, S. AND STEGENGA, H., 2019. Native and non-native species of the Dutch Wadden Sea in 2018. Commissioned by Office for Risk Assessment and Research, The Netherlands Food and Customer Product Safety Authority of the Ministry of Agriculture, Nature and Food Quality. GiMaRIS report 2019_09.

GITTENBERGER, A., WESDORP, K. H. AND RENSING, M., 2017. Biofouling as a transport vector of non-native marine species in the Dutch Delta, along the North Sea coast and in the Wadden Sea. Commissioned by Office for Risk Assessment and Research, The Netherlands Food and Customer Product Safety Authority of the Ministry of Agriculture, Nature and Food Quality. GiMaRIS report 2017_03.

MACLEOD, A., COOK, E.J., HUGHES, D. & ALLEN, C. 2016. Investigating the Impacts of Marine Invasive Non-Native Species. A report by Scottish Association for Marine Science Research Services Ltd for Natural England & Natural Resources Wales, pp. 59. Natural England Commissioned Reports, Number223. http://publications.naturalengland.org.uk/publication/5091100843311104

MOONEY, H. AND CLELAND, E., 2001. The evolutionary impact of invasive species. Proceedings of the National Academy of Sciences, 98(10), 5446-5451.

PEELER, E., OIDTMANN, B., MIDTLYNG, P., MIOSSEC, L. AND GOZLAN, R., 2011. Non-native aquatic animals introductions have driven disease emergence in Europe. Biological Invasions, 13, 1291-1303.

TIDBURY, H., TAYLOR, N., COPP, G., GARNACHO, E. AND STEBBING, P., 2016. Predicting and mapping the risk of introduction of marine non-indigenous species into Great Britain and Ireland. Biological Invasions, 18(11), 3277-3292.

WILLIAMS, F., ESCHEN, R., HARRIS, A., DJEDDOUR, D., PRATT, C., SHAW, R.S., VARIA, S., LAMONTAGNE-GODWIN, J., THOMAS, S.E. AND MURPHY, S.T., 2010. The

Economic Cost of Invasive Non-Native Species on Great Britain. DEFRA commissioned report from CABI.

List of abbreviations

AONB – Areas of Outstanding Natural Beauty

IFCA – Inshore Fisheries and Conservation Authority

INNS – invasive and non-native species

JNCC – Joint Nature Conservation Committee

MCZ – Marine Conservation Zone

MPA – Marine Protected Areas

NE – Natural England

NRW – Natural Resources Wales

SAC – Special Areas of Conservation

SPA – Special Protection Area

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