Rapid Risk Assessment for Marine Non-native Invasive Species in the Channel Islands

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Part One – Introduction

Non-native species are flora and fauna that are introduced outside of their natural geographic range, either as a direct or indirect consequence of human activities. Not all non-native species can successfully invade new habitats (States of Jersey 2017), however, those that do become invasive present a major threat to ecosystem functioning and biodiversity (Gallardo *et al.* 2016). Loss of native species, changes in community structure and altered processes including nutrient cycling as a consequence of invasive non-native species (INNS), can result in reduction of valuable ecosystem services delivered by affected habitats (Molnar *et al*. 2008; Walsh *et al*. 2016).

Preventing introductions of non-native species in the marine environment is particularly challenging due to high connectivity, that facilitates greater dispersion capacity (Giakoumi *et al*. 2019). This is exacerbated by anthropogenic movements and it is now understood that shipping is the main pathway for marine non-native species introductions at a European and on a global scale (Molnar *et al*. 2008; Katsanevakis *et al*. 2013).

The Channel Islands are situated in close proximity to one of the world's busiest shipping lanes in the central English Channel and are highly interconnected with regard to both commercial and leisure shipping activities (States of Jersey 2017). This places the Channel Islands at high risk for receiving non-native species via shipping, and for dispersal of such species between the Islands, as has been identified by overlap in non-native species recorded in St Helier and St Peter Port and those recorded in ports at Brittany and Southern England (States of Jersey 2017).

In the marine environment, it is not often feasible to aim for complete eradication, and the suppression of these species has been suggested to be an achievable and effective target to minimise impacts of marine non-native species on marine habitats (Green *et al*. 2014). In the Channel Islands, where prevention of receipt of marine non-native species is not feasible, monitoring and risk evaluation are key management tools to minimise the impacts of non-native species and potential introductions on local marine habitats (States of Jersey 2017).

Greater dispersal in the marine environment means that species statuses are likely to change quicker. Therefore, it is important that methodologies employed to evaluate marine INNS risks are rapid, to facilitate fast and more frequent determination of the greatest risks to the Channel Islands, enabling timely actions for those species that may require management. Additionally, monitoring should be conducted frequently to establish a baseline in an area, identify new arrivals and understand dispersal patterns.

Part Two – Rapid Risk Assessment

In 2017, a report was published by the States of Jersey that identified and risk assessed 134 marine INNS that were present in the Channel Islands and neighbouring regions. Six years following the States of Jersey (2017) assessment, it will be valuable to reassess all 134 species and additional species that have been identified post-2017. Further, it would be prudent to design a rapid and repeatable risk assessment methodology to enable frequent reassessments as a part of continued monitoring in the Channel Islands.

Aims and Objectives

The aim of this investigation is to design a repeatable, rapid risk assessment methodology to identify the spread and threat of marine non-native species in the Channel Islands. A further aim will be to use this risk assessment to assess the threat of marine non-native species present and the likelihood of introduction of those that are not yet established. The primary objectives of the study will be:

1. To design or adapt a rapid risk assessment method that determines the presence and extent of key non-native marine species in the Channel Islands and to predict the likelihood of their impacting established species.
2. To use the method to assess the presence and extent of key non-native marine species in the Channel Islands and to predict the likelihood of their impacting established species.

Methodology

Species List

All 134 species that were assessed by States of Jersey (2017) were reassessed in the present investigation. The following species were added because they are considered to present medium to high risk for Guernsey:

- *Asterias amurensis*
- *Eriocheir sinensis*
- *Gammarus tigrinus*
- *Neogobius melaostomus*
- *Styela plicata*

The following species that have been alerted as high-risk INNS, or are included in Channel Islands INNS lists were added to the species list:

- *Mulina lateralis*
- *Panulirus regius*
- *Pleurosigma simonsenii*
- *Umbraulva dangeardii*

Since the States of Jersey (2017) report was released, some species' names have changed. Currently accepted species names are used in this report and names used in States of Jersey (2017) are inserted in square brackets where it is deemed necessary for the purpose of clarity.

Threat Scoring

The rapid risk assessment was adapted from Molnar (2008), Roy *et al*. (2014) and States of Jersey (2017). The risk assessment used a threat scoring system, scoring the following criteria (see Box 1 for details):

- Impacts: Ecosystem
- Impacts: Socio-economic
- Invasive Potential (Dispersal or Horizon Scanning)

For each species, a score from 1 (little to no impact) to 4 (highest impact) was assigned for each criterion alongside a confidence score ranging from 1 (little to no confidence) to 3 (high confidence). Species that have positive impacts were scored at 1 and the positive impact was highlighted in the comments on the summary table and in the information sheet. In cases where the literature is scarce or unclear, scores were conservatively assigned under the assumption that species which pose greatest threat are the most well-documented and a confidence score of 1 was used to indicate scarce literature in support of the threat score.

The overall threat level was determined by multiplying the three criterion scores and the alert level used for information sheets was determined as follows:

- High threat: 48 – 64
- Medium threat: 9 – 36
- Low threat: 1 – 8.

Because only three scores were multiplied, the overall threat scores were limited to 16 possible output values. The medium threat range includes the largest set of possible output values and species with both 3,2,2 and 4,3,3 combinations, the latter being notably higher risk than the former. Ergo, the data analyses considered the following ranges to differentiate the data further:

- High threat: 48 – 64
- Medium – high threat: 32 – 36
- Medium threat: 18 – 27
- Low – medium threat: 9 – 16
- Low threat: 1 – 8.

Box 1. Threat scoring criteria defined for the rapid risk assessment. Criteria are adapted from Branquart (2007), Molnar (2008), Roy *et al*. (2014), States of Jersey (2017) and Tsiamis *et al*. (2020).

Here, each threat criterion used for the rapid risk assessment are defined. Threat is scored on a scale of 1 to 4, increasing in severity with 4 as the most severe impacts. Different parameters will be considered within each criterion and the threat score assigned should represent the highest score for any one of the parameters. Where literature is scarce, assign threat scores conservatively and provide a confidence score of 1.

Threat Criteria

Impacts: Ecosystem
Likelihood of species changing ecosystem functioning or changing habitats or biodiversity.

The following parameters should be considered when determining threat score:

- Colonisation of high conservation value habitats
- Adverse impacts on native species (considering predation / herbivory, competition, disease transmission and genetic effects)
- Alteration of ecosystem functions (considering nutrient cycling, physical modifications to the habitat and disruptions to food webs)

Scores
1 – No / low impact (includes positive impacts)
2 – Minor impacts e.g. one species or minor disruption to the ecosystem
3 – Moderate impacts e.g. multiple species or moderate disruption to ecosystem functioning
4 – Major impacts e.g. severe impacts to multiple species of important conservation value or major disruption to ecosystem functioning.

Impacts: Socio-economic
Likelihood of species impacting upon local economies or causing impacts to society including spread of disease to humans.

Assigned scores should include consideration of incurred costs through factors including fouling, predation and costs to industries such as tourism or commercial fishing.

Effects of parasites and pathogens on local industries and societal health should also be assessed.

Scores
1 – No / low impact
2 – Minor impacts
3 – Moderate impacts
4 – Major impacts

Invasive Potential
Measured differently dependent upon whether a species has been present in the Channel Islands or not.

Species that are present or historically recorded as present will be graded on rate and likelihood of dispersal.

Scores
1 – Not established
2 – Likely established but not dispersing
3 – Established and dispersing at a moderate rate
4 – Established and rapidly spreading

Species that are not yet recorded as present in the Channel Islands will be graded on likelihood of establishment. This will be determined using the Horizon Scanning method defined by Table 1 in Tsiamis *et al.* (2020).

Scores
1 – Highly unlikely to establish
2 – Unlikely to establish
3 – Likely to establish
4 – Likely to establish in the next five years or to be already established and unreported

Data Collection and Presentation

For each species, information on the species name, common name and taxonomic group (Table 1) was mandatory. In cases where species did not possess a common name, the taxonomic group was used in its place. The following are additional key information that were collected:

- Habitat type (selected from a pre-defined list, Table 2)
- Pathways for dispersal (selected from a pre-defined list, Table 3)
- Brief comment justifying each criterion score.

A minimum of two different references per species was required and each scored criterion was supported by a reference where information was available to ensure that all scores were justified and easily re-evaluated.

Table 1. Taxonomic group names defined by Phylum and Class.

Phylum: Class	Taxonomic Group
Annelida: Polychaeta	Worms
Arthropoda: Copepoda	Copepods
Arthropoda: Malacostraca	Amphipods, Isopods, Crabs, Prawns and Shrimp
Arthropoda: Ostracoda	Ostracods
Arthropoda: Pycnogonida	Sea spiders
Arthropoda: Thecostraca	Barnacles
Bacillariophyta: Bacillariophyceae	Diatom
Chlorophyta	Green seaweed
Chordata: Ascidiacae	Bryozoans and Sea squirts
Chordata: Teleostei	Teleost
Cnidaria: Anthozoa	Anemone
Cnidaria: Hydrozoa	Hydroids
Ctenophora: Tentaculata	Sea combs
Echinodermata: Stelleroidea	Sea star
Mollusca: Bivalvia	Bivalve
Mollusca: Gastropoda	Sea snails
Myzozoa: Dinophyceae	Dinoflagellate
Nematoda: Secementea	Nematodes
Ochrophyta: Phaeophyceae	Brown seaweed
Ochrophyta: Raphidophyceae	Ochrophyta
Paramyxea: Martellidea	Paramyxea
Platyhelminthes: Amplimatricata	Platyhelminthes
Porifera: Demospongiae	Sponges
Protozoa: Ascetospora	Protists
Rhodophyta: Florideophyeae	Red seaweed

Table 2. Defined habitat types (Fiona Fyfe Associates 2020).

Habitats
Intertidal
Intertidal: Biological substrate
Intertidal: Coastal
Intertidal: Estuary
Intertidal: Hard substrata
Intertidal: Oyster reef
Intertidal: Pebble beach
Intertidal: Rocky shore
Intertidal: Salt marsh
Intertidal: Sandy shore
Intertidal: Seagrass meadow
Intertidal: Wood
Intertidal: Mud flat
Shallow sea
Shallow sea: Biological substrata
Shallow sea: Hard substrata
Shallow sea: Hard benthos (bedrock / cobble)
Shallow sea: Hard benthos (pebbles / gravel)
Shallow sea: Kelp forest
Shallow sea: Maerl beds
Shallow sea: Muddy
Shallow sea: Open ocean (pelagic)
Shallow sea: Oyster reef
Shallow sea: Rock platform
Shallow sea: Rocky reef
Shallow sea: Sandy substrate
Shallow sea: Seagrass meadow
Deep sea
Deep sea: Maerl beds
Deep sea: Open ocean (pelagic)
Unknown

Table 3. Pathways for introduction as defined by UNEP/CBD/SBSTTA/18/9/Add.1.

Pathways
Release: Biological control
Release: Erosion control
Release: Fishery in wild
Release: Hunting
Release: Aesthetic release
Release: Conservation in wild
Release: Release in nature for use (other than above, e.g., fur, transport, medical use)
Release: Other release
Escape: Agriculture
Escape: Aquaculture / Mariculture
Escape: Botanical gardens / Zoos / Aquaria
Escape: Domestic Aquaria / Pet
Escape: Farmed animals
Escape: Forestry
Escape: Fur farms
Escape: Horticulture
Escape: Ornamental purpose excluding horticulture
Escape: Research and ex-situ breeding facilities
Escape: Live food & live bait
Escape: Other escape
Contaminant: Nursery material contaminant
Contaminant: Bait contaminant
Contaminant: Food contaminant (includes live food)
Contaminant: Contaminant of animals
Contaminant: Parasite of animals
Contaminant: Contaminant of plants
Contaminant: Parasite of plants
Contaminant: Seed contaminant
Contaminant: Timber trade contaminant
Contaminant: Habitat material contaminant
Contaminant: Other contaminant
Stowaway: Fishing equipment
Stowaway: Container & bulk cargo
Stowaway: Airplane
Stowaway: Ship excluding ballast water or hull fouling
Stowaway: Machinery & equipment
Stowaway: People & luggage
Stowaway: Packing material
Stowaway: Ballast water

Stowaway: Hull fouling
Stowaway: Land vehicles
Stowaway: Other stowaway
Corridor: Interconnected waterways / basins / seas
Corridor: Canals and artificial waterways
Corridor: Tunnels and bridges
Unaided: Natural dispersal
Unknown

Data were collected in comprehensive individual species spreadsheets and collated in a summary table containing all species' threat scores, confidence scores, primary habitats, primary vectors, key comments and references. Information sheets were created to display information stored in the individual species spreadsheets and the key overall findings are presented in the present report.

Results and Discussion

Application of the rapid risk assessment to all 143 species took under two months of full-time work conducted by a single researcher and produced a comprehensive dataset covering all species considered relevant to the Channel Islands. In this section, the data are presented with the aim to highlight key trends in the datasets and elucidate the important information derived from the risk assessment.

Taxonomic Diversity

The risk assessment showed that 39% of assessed species had at least one record of presence in the Channel Islands. This shows that ten additional species have been identified in the Channel Islands since the States of Jersey (2017) report, which is 6.5% greater than the percentage of species with records from the Channel Islands at the time of the 2017 assessment.

In total, there were 33 taxonomic groups, spanning 25 classes, and of the 33 taxonomic groups assessed, there were 15 with valid records from the Channel Islands. This shows that the taxonomic diversity of records from the Channel Islands is 45.5% of the taxonomic diversity from neighbouring waters. Lower diversity is partly because some species in neighbouring regions cannot settle in the Channel Islands due to differing habitat types. It is also feasible that sampling efforts in particular areas such as the intertidal zone will be greater compared to more difficult to access areas such as harbours and the open ocean.

Red seaweeds are the taxonomic group with the most occurrences in the risk assessment list and the highest number of species with valid records from the Channel Islands (Table 4, Figure 1, Figure 2). This group comprises 15.4% of all groups of the assessed species and 19.6% of the groups with records from the Channel Islands. Of the taxonomic groups with valid records from the Channel Islands, sea squirts, bivalves, worms, bryozoans and crabs comprised 10.7%, 10.7%, 8.9%, 7.1% and 7.1% of the list respectively. Of all species assessed, sea squirts and worms comprised 6.3%, bivalves comprised 7.7%, and bryozoans and crabs comprised 6%. A notable general pattern in these data is that the conspicuous, easily identifiable species are the most common in the Channel Islands data. This is congruent with expectation because smaller species and those that require expert identification such as dinoflagellates and copepods are historically underreported in the Channel Islands (States of Jersey 2017).

Table 4. Taxonomic diversity of all species included in the assessment and of species with at least one valid report from the Channel Islands (CI Species).

Phylum: Class	Taxonomic Group	All Species	CI Species
Arthropoda: Malacostraca	Amphipod	2	0
Cnidaria: Anthozoa	Anemone	2	2
Arthropoda: Thecostraca	Barnacles	10	3
Mollusca: Bivalvia	Bivalve	11	6
Ochrophyta: Phaeophyceae	Brown seaweed	3	3
Chordata: Ascidiacae	Bryozoan	8	4
Arthropoda: Copepoda	Copepods	5	0
Arthropoda: Malacostraca	Crabs	8	4
Bacillariophyta: Bacillariophyceae	Diatom	8	3
Myzozoa: Dinophyceae	Dinoflagellate	7	0
Chlorophyta	Green seaweed	3	2
Cnidaria: Hydrozoa	Hydroids	4	0
Arthropoda: Malacostraca	Isopod	3	1
Nematoda: Secementea	Nematodes	1	0
Ochrophyta: Raphidophyceae	Ochrophyta	1	0
Arthropoda: Ostracoda	Ostracods	2	0
Paramyxea: Martellidea	Paramyxea	1	0
Platyhelminthes: Amplimatricata	Platyhelminthes	2	0
Arthropoda: Malacostraca	Prawns	4	2
Protozoa: Ascetospora	Protists	1	0
Rhodophyta: Florideophyeae	Red seaweed	22	11
Ctenophora: Tentaculata	Sea combs	1	0
Mollusca: Gastropoda	Sea snails	9	3
Arthropoda: Pycnogonida	Sea spiders	1	0
Chordata: Ascidiacae	Sea squirts	9	6
Echinodermata: Stelleroidea	Sea star	1	0
Arthropoda: Malacostraca	Shrimp	2	0
Porifera: Demospongiae	Sponges	1	0
Chordata: Teleostei	Teleost	2	1
Annelida: Polychaeta	Worms	9	5

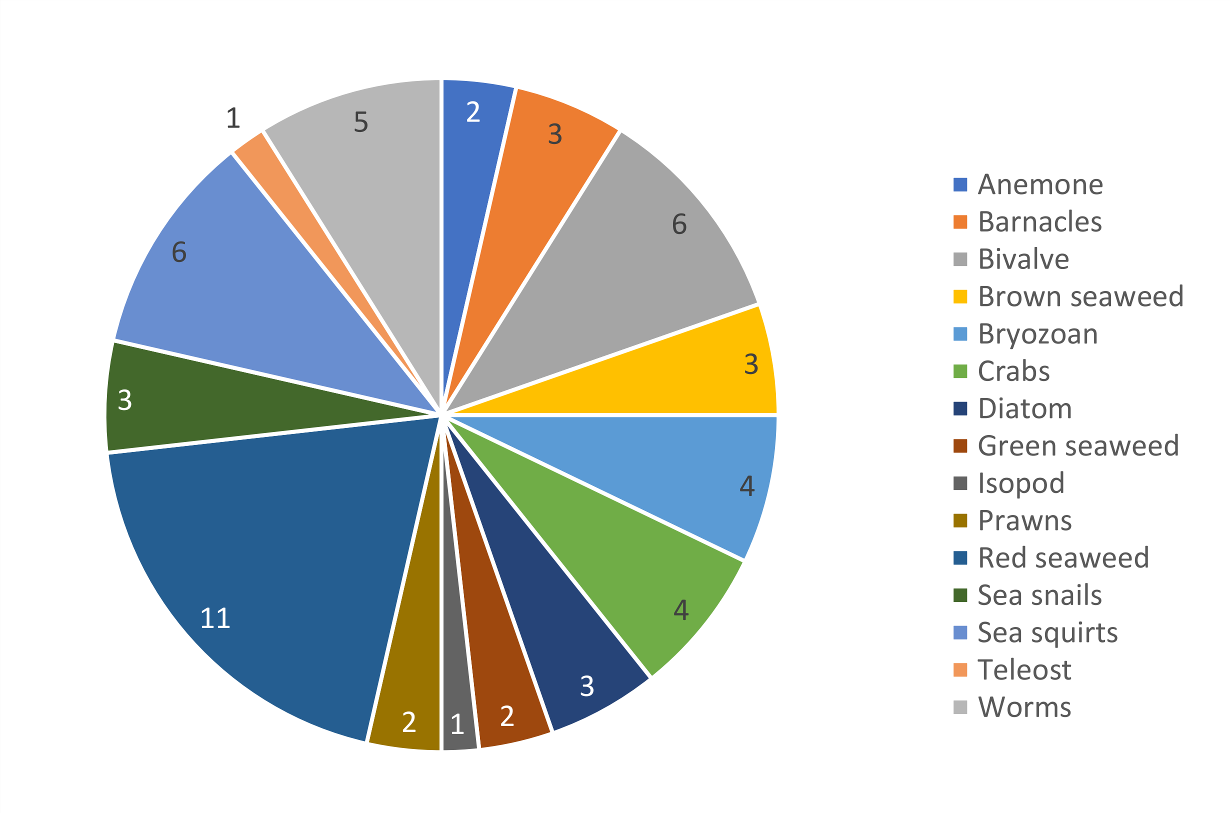

Figure 1. Taxonomic groups of the species with one or more valid reports from the Channel Islands.

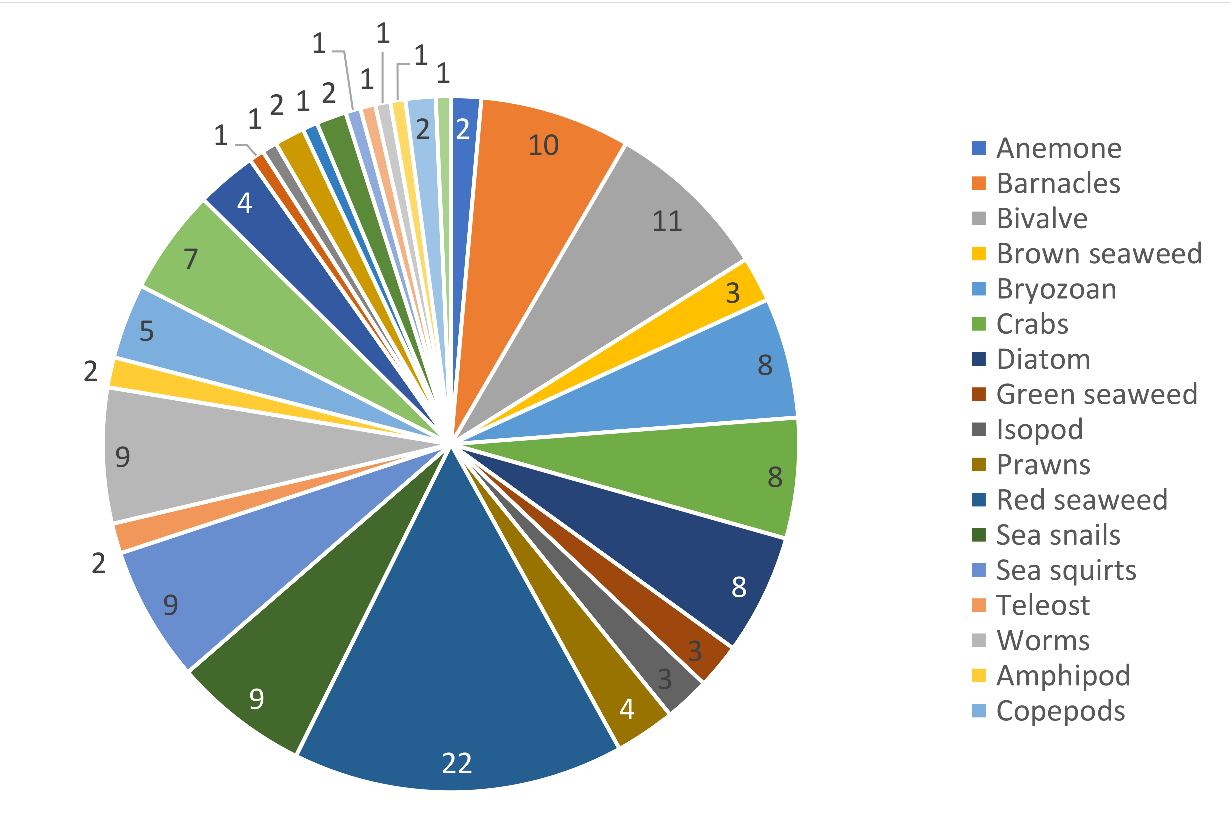

Figure 2. Taxonomic groups of all species assessed.

Pathways of Introduction

Analyses of the main pathways for introduction showed that shipping (transportation via ballast water, hulling fouling or other shipping activities) was the primary pathway for 45% of all assessed species (Figure 3). Aquaculture and mariculture (transportation of non-native species for aquaculture or non-native species on aquacultured species) was the second-most common main pathway for introduction, comprising 28% of all assessed species (Figure 3). These findings are congruent with Katsanevakis *et al*. (2013), which found that shipping comprised 51.9% of marine INNS introductions in Europe and that 16.4% were introduced via aquaculture. Notably, Katsanevakis *et al*. (2013) found that 'corridors' were the main pathway of introduction to Europe for 40.3% of marine INNS, which is consistent with the findings of States of Jersey (2017) which suggested that natural dispersal (introduction via corridors such as canals and water basins) is the primary cause for introduction of marine INNS to the Channel Islands.

The main modes of introduction for species with records from the Channel Islands are shipping (51.7%) and aquaculture and mariculture (30.4%), as is shown by Figure 4. Natural dispersal comprised only 5.4% of the main pathways for introduction of species with records from the Channel Islands, however this pathway was included in 37.5% of pathways lists for species with records from the Channel Islands. Furthermore, the natural dispersal pathway for introduction is included in only 16.1% of the pathways lists for horizon scanned species, suggesting that this mode of transportation is an important factor for introduction to the Channel Islands, in agreement with States of Jersey (2017) and Katsanevakis *et al*. (2013). It is especially likely that natural dispersal is a major pathway for introduction to the Channel Islands because of the strict biosecurity measures and ballast water regulations that act to prevent introductions via aquaculture and ballast water pathways. So, natural dispersal and hull fouling are the most likely modes of introduction to the Channel Islands, which is consistent with the finding that most taxonomic groups with valid records from the Channel Islands are those associated with fouling, and that natural dispersal is a more common pathway for those species that have been recorded from the Channel Islands.

Pathways for introduction will be discussed further in the context of the Channel Islands in 'Part Three' of this report, in which the impacts of recreational shipping and dispersal of marine INNS around Jersey are investigated.

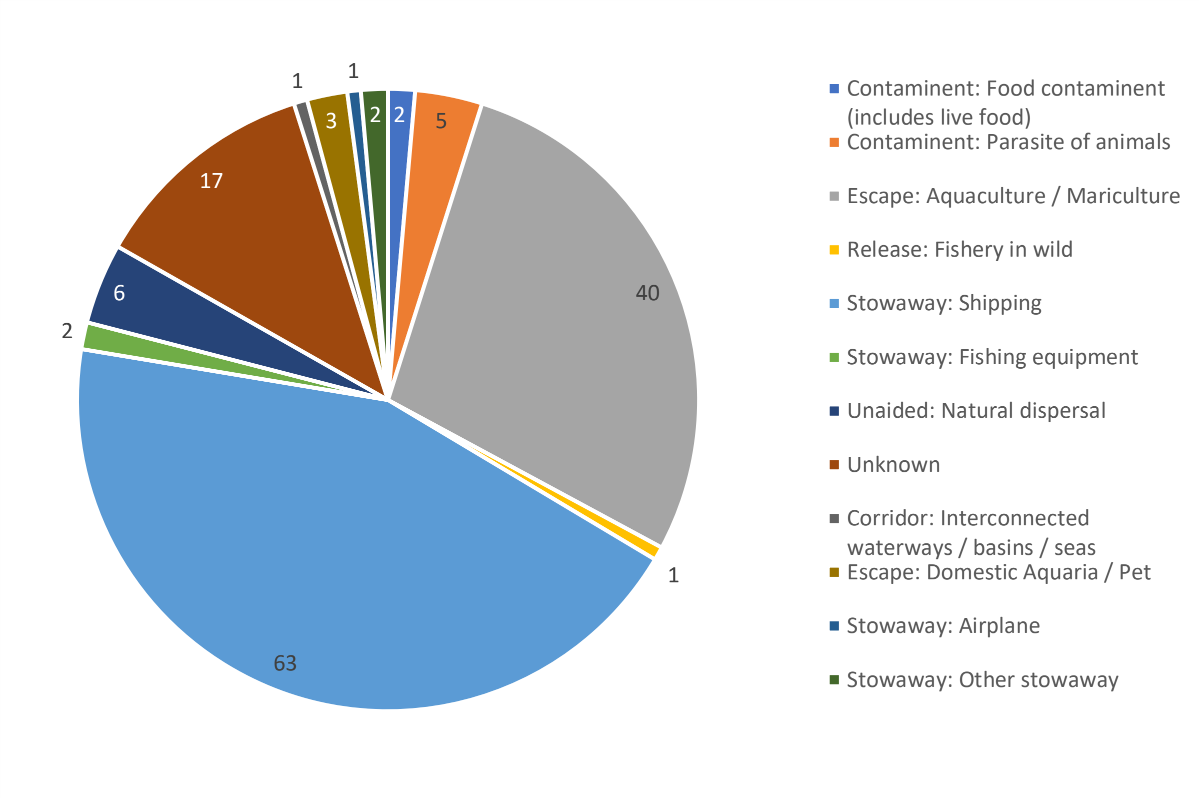

Figure 3. Main pathways for introduction for all assessed species.

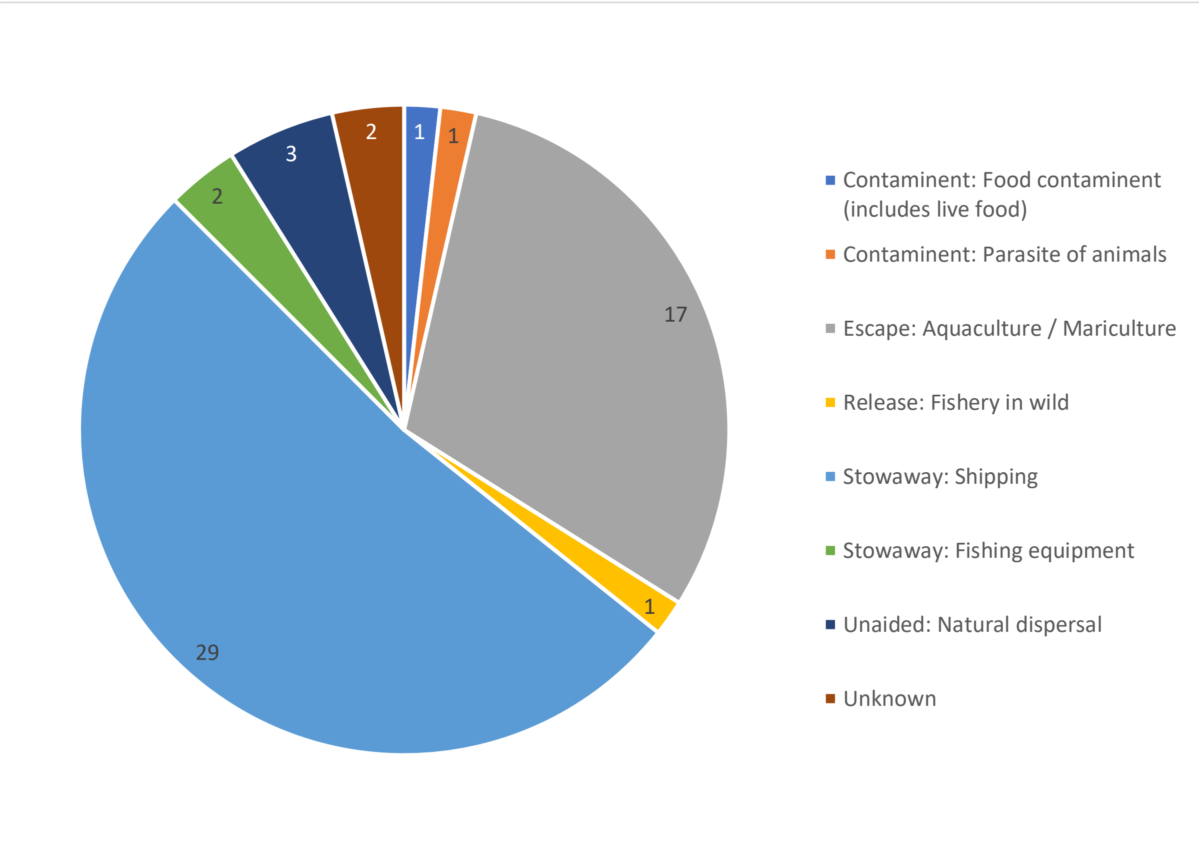

Figure 4. Main pathways for introduction for species with valid records from the Channel Islands.

Threat Scores

The threat scoring method for the risk assessment uses qualitative data to assign scores on a scale with a small range. This means that resulting scores are subjective and therefore their overall significance is open to debate. However, this method does enable the rapid assessment of marine INNS and highlights those key species that present the highest threats for consideration for management actions.

Threat scores range from 1 to 64 and 46.9% of species were assigned scores less than 8, indicating that they present negligible or low threat to the Channel Islands. Species characterised as low risk generally received lower confidence scores compared with higher scoring species, highlighting that some species scores were potentially reduced by limited literature availability (Appendix, Table 6). However, many species are understudied because they are low risk, so this general pattern was congruent with expectations for low scoring species.

A further 26 species (18.2% of species) were assigned scores between 9 and 16, meaning that these species were categorised as a low-medium threat to the Channel Islands. These species present minor risk to the Channel Island marine environments, but may not have high invasive potential or present serious risks to the environment nor economy.

There were 34 species, constituting 23.8% of all assessed species, scoring between 18 and 27 which means that they were categorised as medium threat to the Channel Islands (Table 5). Species characterised as medium threat generally received scores of '3' indicating moderate impacts for one or more of the three threat criteria.

Within the range of scores from 32 to 36, the medium-high threat scores, there were 9 species (6.3% of all assessed species), (Table 5). Medium-high scores indicate that the score of '4', major negative impacts has been assigned for at least one of the three threat criteria and generally that the species scored between 3 and 4 for all threat criteria.

There were 7 species (4.9%) that scored 48 or 64, meaning that these species are categorised as high threat and present a serious threat to the Channel Islands (Table 5). High scoring species scored entirely '4' or scored '4' in two threat criteria and '3' for one criterion, meaning that these species have the capacity to have severe negative impacts ecologically, socio-economically and have high invasive potentials. The highest scoring species may require further investigation to determine whether monitoring or management actions will be necessary and effective on an individual species basis.

The purpose of the rapid risk assessment methodology and scores assigned in this assessment is to enable fast identification of the species to investigate further and consider for management action. This assessment shows that *D. vexillum* and *C. fornicata*, both of which are present in the Channel Islands, present the greatest threat to the Channel Islands. This shows a rise in the rank of *D. vexillum* on the threat score list compared with the States of Jersey (2017) report. Since last assessed, *D. vexillum* has been reported from the Channel Islands, first reported from Elizabeth Marina, Jersey in 2023 and may disperse rapidly around the island. *D. vexillum* is not considered to be feasible to eradicate once established due to its capacity for natural dispersal. This highlights the importance of using a continuously updated, threat scored marine INNS list to guide actions to prevent the introduction of high scoring species in particular to the Channel Islands, to bar the need for costly and often unsuccessful management actions.

Table 5. Species with overall threat score between 18 (medium threat) and 64 (high threat), species names in bold are established in the Channel Islands, red overall threat score are high threat, orange is high-medium overall threat and yellow is medium overall threat score.

Name	Overall Score
Crepidula fornicata	64
Didemnum vexillum	64
Alexandrium minutum	48
Asterias amurensis	48
Mnemiopsis leidyi	48
Rapana venosa	48
Sargassum muticum	48
Caulerpa taxifolia	36
Corella eumyota	36
Ocinebrellus inornatus	36
Pachygrapsus marmoratus	36
Pseudodactylogyrus anguillae	36
Undaria pinnatifida	36
Watersipora subatra	36
Heterosigma akashiwo	32
Homarus americanus	32
Amphibalanus improvisus	27
Bugula neritina	27
Codium fragile fragile	27
Karenia brevisulcata	27
Karenia papilionacea	27
Karenia umbella	27
Molgula manhattensis	27
Pseudomyicola spinosus	27
Alexandrium affine	24
Amphibalanus amphitrite	24
Asparagopsis armata	24
Botrylloides violaceus	24
Dasysiphonia japonica	24
Gracilaria vermiculophylla	24
Hemigrapsus sanguineus	24
Hesperibalanus fallax	24
Magallana [Crassostrea] gigas	24
Perophora japonica	24

Alexandrium leei	18
Amphibalanus eburneus	18
Austrominius modestus	18
Caulacanthus ustulatus	18
Coscinodiscus wailesii	18
Eriocheir sinensis	18
Fibrocapsa japonica	18
Grateloupia subpectinata	18
Haplosporidium nelsoni	18
Hemigrapsus takanoi	18
Marteilia refringens	18
Megabalanus coccopoma	18
Megabalanus tintinnabulum	18
Melanothamnus [Neosiphonia] harveyi	18
Pseudo-nitzschia multistriata	18
Styela clava	18

Qualitative data and differences in methodology are responsible for some changes in species ranking compared with in the States of Jersey (2017) report. One such notable difference between the highest scoring species compared with the States of Jersey (2017) report was that barnacles (Arthropoda: Thecostraca) have scored more highly in the present report. This is because of their fouling impacts and impacts on multiple species, which are factors that often warrant a medium (3) rank in the ecological and socio-economic impact categories under the present methodology, meaning that their potential impacts have increased their rank higher than may be necessary for the Channel Islands specifically. Additionally, the number of possible output values are reduced in the present report, meaning that some species that may have had differentiated ranks in the States of Jersey (2017) report may have the same rank in the present report. While these differences are important considerations, they should not be over scrutinized because the purpose of this assessment is to inform further investigations into the higher scoring species. Subsequent further investigation will inherently address and resolve these differences.

Incorporation of high-medium ranked species relevant to Guernsey was advantageous because this has revealed species, most notably *Asterias amurensis*, that are ranked amongst the highest threat to the Channel Islands in the present investigation (Table 5). This elucidates the value of future collaborative efforts between the Channel Islands, especially within the marine environment because high connectivity and dispersal pathways between the islands means that most marine INNS between islands are the same. Threat assessments and monitoring in particular should be shared across the Channel Islands, as the high connectivity between Channel Islands means that communication and collaboration will be key preventative methods.

Conclusions and Recommendations

This section details and presents the results of a rapid methodology for risk assessment of marine INNS relevant to the Channel Islands. The risk assessment highlighted rise in the risk posed by *D. vexillum* following its recent introduction, this species is monitored in Jersey and is only known from one location at present. A key outcome arising from the incorporation of species from Guernsey lists was that some of the species added were high ranking in the risk assessment, emphasising the value of collaboration between Channel Islands. Therefore, continued collaboration between Channel Islands with regard to marine INNS is advocated.

Taxonomic diversity revealed that red seaweeds comprised the largest proportion of the INNS list and that sea squirts, bivalves, worms, bryozoans and crabs also comprised a large proportion of the list. This highlighted bias in favour of conspicuous, easily identifiable species in the current baseline data for Channel Islands INNS. Considering that diatoms and dinoflagellates comprise 14% of the INNS ranking between 64 (high) and 18 (medium) and some of which pose public health threats, future investigations into the presence of these diatom and dinoflagellate species will be beneficial for determining risks and devising mitigation strategies if necessary.

Strict regulations on key pathways for INNS introduction mean that natural dispersal plays a key role in INNS dispersal across the Channel Islands. However, hull fouling was found to be a major pathway for introduction and this is not regulated to the same extent as ballast water and aquaculture and mariculture. This finding formed the basis of the field survey that is described in and is discussed further in ‘Part Three’.

Part Three – Intertidal Rocky Shore INNS Field Survey

Shipping activities are key pathways for introduction of marine INNS and ports are hotspots for established marine INNS populations (Holland *et al*. 2021). Whilst strict regulations for ballast water management and biosecurity are in place, key pathways for introduction including hull fouling remain largely unregulated (Murray *et al*. 2011). Hull fouling on recreational and commercial ships has the potential to pose similar threat level to ballast water with regard to marine INNS introductions (Drake & Lodge 2007), and it would therefore be valuable to determine to what extent hull fouling is impacting upon marine INNS dispersal in the Channel Islands.

Aims

In this investigation intertidal rocky shore field surveys will be conducted in areas with differing levels of shipping activities across Jersey. The aim of these surveys will be to understand marine INNS community compositions and distributions in intertidal rocky shore habitats and to make inferences about the impact of hull fouling on the spread of marine INNS around the Island.

Methodology

Survey Sites

Seven survey sites (Figure 5) were selected based on the following criteria:

1. The sites should be evenly distributed around the North, South, East and West of the Island.
2. The site should have abundant and accessible rocky reef habitat.
3. A reasonable range of boat traffic levels (inferred by number of moorings at a site) should be represented by the sites selected.

Figure 5. Sampling sites.

Fieldwork Protocol

The method used for this investigation was based on a method used and kindly provided by Michael Clarke.

Surveys were conducted at low tide, with arrival at each site approximately one hour before low tide, dependent upon the distance and ease of access to the shoreline. At each site, nine $1m^2$ quadrats were randomly placed, three in each tidal zone. All low intertidal zone quadrats were conducted at the time of low tide and > 1 quadrat in the low intertidal zone was conducted during spring tide to ensure that data were representative of the zone.

For each quadrat, a survey sheet was completed, detailing the exact location of the quadrat, habitat type and species identified. The quadrat was photographed and rocks in the quadrat were turned over to identify all species in the quadrat.

Data analysis

Using the quadrat photographs and notes on the survey sheets, the abundance of marine INNS (per meter squared) was calculated. Photographs were used to determine the percentage cover of hard substratum per quadrat using Coral Point Count with Excel extension software (Kohler & Gill 2006). Number of moorings at each site was approximated using information provided by Ports of Jersey online resources and searching Google Maps images.

Correlations between the percentage of hard substratum and species abundances as well as between number of moorings and species abundances were calculated to determine whether there was a relationship between the two factors. Additionally, correlations between number of marine INNS and INNS abundance were calculated. Unpaired t-tests comparing species abundances between sampling sites were conducted to determine whether there was a significant difference comparing species abundances between sites.

Results

Correlation analyses revealed that the weak negative relationship between the hard substratum cover and total INNS abundance was not significant ($r = -0.30$, $p > 0.05$). As is shown in Figure 6(a), *Sargassum muticum* was dominant in six out of seven survey sites, so the correlation between hard substrate cover and INNS abundance sans *S. muticum* was investigated to determine whether dominance of this widespread, long established species skewed the results. Analysis found that there was no correlation between INNS abundance sans *S. muticum* and hard substrate cover ($r = -0.04$, $p > 0.05$), as is visualised in Figure 6(b). Additionally, it was found that seaweed cover was present in 75% of quadrats and comprised a major proportion to the entirety of 26.7% of quadrats, lowering percentage hard substratum cover.

Figure 6(b) shows that, when *S. muticum* was removed from the data, *Colpomenia peregrine* dominated INNS abundances in five out of seven survey sites. Additionally Figure 6(b) shows that in Belcroute Bay, *Grateloupia subpectinata* was the dominant INNS, and in Fliquet *Austrominius modestus* was the dominant INNS.

Correlation analysis revealed that the weak negative relationship between the approximate number of moorings at each survey site and total INNS abundance was not significant ($r = -0.42$, $p > 0.05$). Furthermore, there was no significant relationship between INNS abundance sans *S. muticum* and approximate number of moorings at each survey site ($r = -0.04$, $p > 0.05$). The absence of relationship between approximate number of moorings and the INNS abundances at each site are visualised in Figure 6(a,b).

Unpaired t-tests revealed that there were no significant differences comparing marine INNS abundances between all sampling sites ($p > 0.05$). The standard errors for abundance data were high for some survey sites and many overlap, as is highlighted by error bars in Figure 6(a,b). However, there was no significant difference between INNS abundances at sites where the error bars do not overlap, for example between total abundances at L'Étacq and Petit Port ($t = 1.07$, $p = 0.34$).

Correlation analyses revealed that there was no significant correlation comparing between the total number of INNS and total abundance of INNS ($r = 0.161$, $p > 0.05$). However, removal of *S. muticum* from INNS abundance data revealed a significant strong positive correlation comparing between total number of INNS and total abundance of INNS ($r = 0.794$, $p < 0.05$), indicating that *S. muticum* may impact the abundance and diversity of INNS (Figure 7).

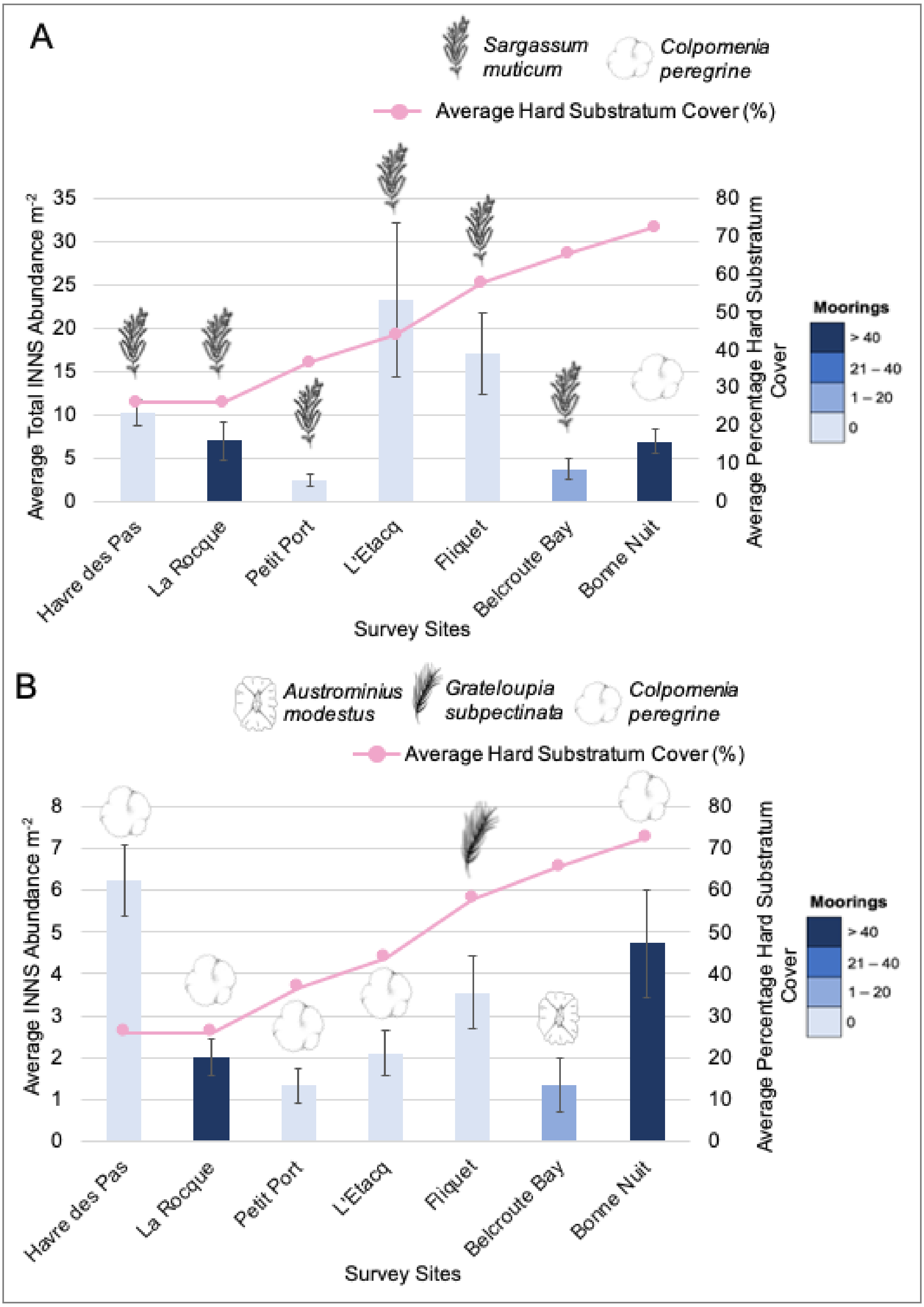

Figure 6. (A) Comparison of average total INNS abundance (m^{-2}) (bar chart) and the average percentage hard substratum cover (line graph) across all survey sites. Bar colours represent approximate number of moorings at each site, images indicate the dominant species at each site. (B) Comparison of average INNS abundance (m^{-2}) sans *Sargassum muticum* (barchart) and the average percentage hard substratum cover (line graph) across all survey sites. Bar colour is number of moorings, image is dominant species at each site.

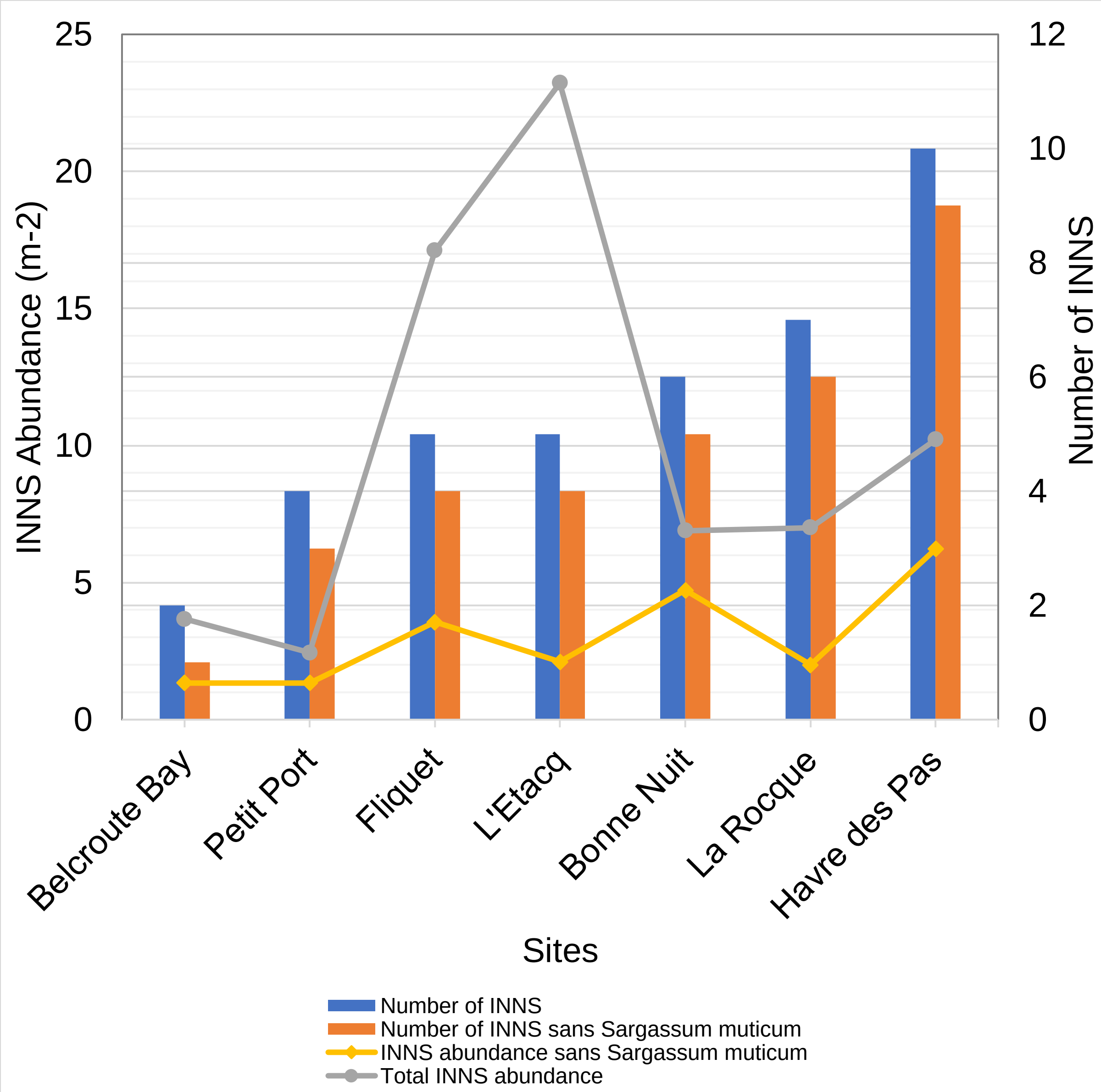

Figure 7. Comparison between the number of different invasive non-native species (INNS) at each site (blue bars), number of different INNS at each site with *Sargassum muticum* removed (orange bars), total abundance of INNS (m^{-2}) (grey line with circles) and the abundance of INNS (m^{-2}) (yellow line with diamonds) with *S. muticum* abundance removed from the data at each site.

Discussion

Presence of *G. subpectinata* at all sites except for Belcroute Bay and dominance of this species in the INNS community at Fliquet Bay (sans *S. muticum*) indicates that *G. subpectinata* has spread northwards since the States of Jersey (2017) report. Presence of *G. subpectinata* at Fliquest Bay, that has no boat moorings, and not at Belcroute, which has moored boats, suggests that natural dispersal may be the key pathway for the dispersal of species. However, Fliquet Bay is located next to St Catherine's Harbour, that has frequent and abundant boat traffic, so it is possible that *G. subpectinata* arrived at St Catherine's Harbour via hull fouling and naturally dispersed to Fliquet Bay.

The finding that *S. muticum* and *C. peregrine* were the dominant INNS in intertidal rocky shores across Jersey was congruent with expectations. Both species have been established across Jersey for many years, with first reports of *S. muticum* in Jersey in the 1970s and it is now known to be widespread (States of Jersey 2017). The identification of *A. modestus* was also consistent with expectations because this barnacle species has been present in Jersey since 1977 but is not common (States of Jersey 2017). Dominance of *A. modestus* at Belcroute Bay (sans *S. muticum*) was interesting because it has previously been reported that this species is not common and often occurs as single individuals in Jersey (States of Jersey 2017). This was true of the individuals identified at Belcroute Bay but it is notable that they were common in this bay, which has boat moorings and is in close proximity to Elizabeth Marina, suggesting that the dispersal of this fouling species across Jersey may be facilitated by hull fouling.

Watersipora subatra was abundant at Havre des Pas and in the low intertidal zone of Fliquet Bay and La Rocque. This is interesting because these are the sites closest to the harbours with the greatest numbers of moorings and is especially notable because the species was not found at L'Étacq or Petit Port, which are located furthest from boat moorings of all survey sites in this investigation. This is consistent with expectations for this species because the free-swimming larvae of *W. subatra* are only pelagic for a few hours before settlement, limiting capacity for natural dispersal (André & Limouzin 2021). Additionally, this species is known to have high tolerance to anti-fouling paints and is therefore more likely to be transported via hull fouling as well as to facilitate the transport of intolerant species (Floerl *et al*. 2004). Ergo, it could be inferred that the spread of species such as *W. subatra* may be most closely associated with hull fouling, dependent upon reproductive type.

The finding that with the removal of *S. muticum* from the data there was a strong relationship between the abundance of INNS and the number of different INNS between survey sites was interesting because this suggests that presence and dominance of *S. muticum* may suppress both the abundance and diversity of other INNS. This is consistent with expectation of competition and displacement by this long established invasive species (e.g. Harries *et al*. 2007) and it is notable that *S. muticum* may have similar impacts on other INNS in intertidal rocky shore communities.

Lack of significant results with regard to the relationship between number of moorings at each site and the abundance of INNS, was not congruent with the expectation that there would be a positive correlation if hull fouling plays a role in their dispersal across the Island. It is possible that few results were significant in this investigation were because Havre des Pas was used as it is closest to Elizabeth Marina, the largest harbour in Jersey, and Fliquet is located in close proximity to St Catherine's Harbour, which also has frequent boat traffic, so lack of moorings at these sites is somewhat misleading. Additionally, it is vital to highlight that heavily fouled but stationary boats are not a risk for dispersal of INNS, it is the frequency of travel that poses the greatest risk (Murray *et al*. 2011). Considering this, it would be valuable to investigate both the fouling communities on boat hulls and the frequency of boat movements in bays and harbours across Jersey to make confident conclusions about the threat posed by hull fouling as a vector for INNS dispersal across Jersey (Murray *et al*. 2011).

Percentage hard substratum cover was reduced by macroalgal cover in three quarters of the quadrats in this survey and was significantly reduced in over one quarter of quadrats. This likely skewed analyses comparing INNS abundances and hard substratum cover because macroalgae support an abundance of species. It would be useful to include a photograph of the quadrat with macroalgae lifted to reveal the substrate under the macroalgae to compare hard substratum and soft substratum specifically and this may negate the factors that possibly drove some of the insignificant results. Building on this, sampled bays varied in size and it is recommended that future investigations adjust the number of quadrats at each habitat proportionally, according to sampling site size, to ensure that data is representative of the habitat. This would reduce skew by factors including macroalgal cover and would improve confidence in results.

Conclusions and Recommendations

Investigation of fouling INNS communities in intertidal rocky shore habitats across Jersey explored the potential role of hull fouling as a pathway for INNS introduction. Northward dispersal of *G. subpectinata* since the States of Jersey (2017) report was a key finding that reinforced the importance of natural dispersal as a pathway for introduction in the Channel Islands. However, association of *W. subatra* with sites that have or are in close proximity to many boat moorings suggested that hull fouling is perhaps important for facilitating the dispersal of species with low natural dispersal capacity. Collection of data on the INNS present in fouling communities of boat hulls and the frequency of boat movements is recommended to inform inferences that can be made about the importance of hull fouling for facilitating dispersal across Jersey and therefore to determine whether regulatory actions on hull fouling should be pursued.

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Appendices

Table 6. Risk assessment results for all assessed species. 'IE' is Impacts: Ecosystem, 'ISE' is Impacts: Socio-economic, 'IP' is Invasive Potential and is either capacity to disperse (D) if the species is established or horizon scanning (HS) if species is not established. 'C' indicates the confidence score for each threat criterion and 'total' is the overall threat score.

Name	Phylum: Class	IE	C	ISE	C	IP:D	IP:HS	C	Total
Crepidula fornicata	Mollusca: Gastropoda	4	3	4	3	4	/	3	64
Didemnum vexillum	Chordata: Ascidiacae	4	3	4	3	4	/	3	64
Alexandrium minutum	Myzozoa: Dinophyceae	3	3	4	3	/	4	3	48
Asterias amurensis	Echinodermata: Stelleroidea	4	3	4	3	/	3	3	48
Mnemiopsis leidyi	Ctenophora: Tentaculata	4	3	3	3	/	4	3	48
Rapana venosa	Mollusca: Gastropoda	4	3	3	3	/	4	3	48
Sargassum muticum	Ochrophyta: Phaeophyceae	4	3	3	3	4	/	3	48
Caulerpa taxifolia	Chlorophyta	4	3	3	3	/	3	3	36
Corella eumyota	Chordata: Ascidiacae	3	3	3	3	4	/	3	36
Ocinebrellus inornatus	Mollusca: Gastropoda	3	3	4	3	/	3	2	36
Pachygrapsus marmoratus	Arthropoda: Malacostraca	3	2	3	2	4	/	3	36
Pseudodactylogyrus anguillae	Platyhelminthes: Amplimatricata	4	3	3	3	/	3	3	36
Undaria pinnatifida	Ochrophyta: Phaeophyceae	3	3	3	3	4	/	3	36
Watersipora subatra	Chordata: Ascidiacae	3	3	3	3	4	/	3	36
Heterosigma akashiwo	Arthropoda: Ostracoda	4	3	4	3	/	2	2	32
Homarus americanus	Arthropoda: Malacostraca	4	3	2	3	/	4	3	32
Amphibalanus improvisus	Arthropoda: Thecostraca	3	3	3	2	/	3	2	27
Bugula neritina	Chordata: Ascidiacae	3	3	3	3	3	/	3	27
Codium fragile fragile	Chlorophycota	3	3	3	3	3	/	2	27
Karenia brevisulcata	Myzozoa: Dinophyceae	3	3	3	3	/	3	3	27
Karenia papilionacea	Myzozoa: Dinophyceae	3	3	3	3	/	3	3	27
Karenia umbella	Myzozoa: Dinophyceae	3	3	3	3	/	3	2	27
Molgula manhattensis	Chordata: Ascidiacae	3	3	3	3	/	3	2	27

Pseudomyicola spinosus	Arthropoda: Copepoda	3	3	3	2	/	3	2	27
Alexandrium affine	Myzozoa: Dinophyceae	3	3	2	3	/	4	3	24
Amphibalanus amphitrite	Arthropoda: Thecostraca	2	3	3	2	4	/	2	24
Asparagopsis armata	Rhodophyta: Florideophyeae	3	3	2	3	4	/	3	24
Botrylloides violaceus	Chordata: Ascidiacae	4	3	3	3	2	/	3	24
Dasysiphonia japonica	Rhodophyta: Florideophyeae	4	3	2	3	3	/	3	24
Gracilaria vermiculophylla	Rhodophyta: Florideophyeae	4	3	2	3	3	/	3	24
Hemigrapsus sanguineus	Arthropoda: Malacostraca	3	3	2	3	4	/	3	24
Hesperibalanus fallax	Arthropoda: Thecostraca	4	3	2	3	3	/	2	24
Magallana [Crassostrea] gigas	Mollusca: Bivalvia	3	3	2	3	4	/	3	24
Perophora japonica	Chordata: Ascidiacae	3	2	2	2	4	/	2	24
Alexandrium leei	Myzozoa: Dinophyceae	3	2	3	3	/	2	1	18
Amphibalanus eburneus	Arthropoda: Thecostraca	3	2	3	2	/	2	3	18
Austrominius modestus	Arthropoda: Thecostraca	3	3	3	3	2	/	3	18
Caulacanthus ustulatus	Rhodophyta: Florideophyeae	3	3	2	1	/	3	3	18
Coscinodiscus wailesii	Bacillariophyta: Bacillariophyceae	3	3	3	3	2	/	2	18
Eriocheir sinensis	Arthropoda: Malacostraca	3	3	3	3	/	2	3	18
Fibrocapsa japonica	Ochrophyta: Raphidophyceae	3	3	2	2	/	3	2	18
Grateloupia subpectinata	Rhodophyta: Florideophyeae	3	2	2	3	3	/	2	18
Haplosporidium nelsoni	Protozoa: Ascetospora	3	3	3	3	/	2	2	18
Hemigrapsus takanoi	Arthropoda: Malacostraca	3	3	2	1	3	/	3	18
Marteilia refringens	Paramyxea: Martellidea	3	3	3	3	/	2	3	18
Megabalanus coccopoma	Arthropoda: Thecostraca	3	3	3	3	/	2	3	18
Megabalanus tintinnabulum	Arthropoda: Thecostraca	3	2	3	3	/	2	2	18
Melanothamnus [Neosiphonia] harveyi	Rhodophyta: Florideophyeae	3	3	2	1	3	/	3	18
Pseudo-nitzschia multistriata	Bacillariophyta: Bacillariophyceae	2	3	3	3	/	3	2	18

Styela clava	Chordata: Ascidiacae	3	3	2	3	3	/	2	18
Anguillicola crassus	Nematoda: Secementea	4	3	2	1	/	2	2	16
Bonamia ostreae	Protozoa: Ascetospora	4	3	4	3	1	/	3	16
Tricellaria inopinata	Chordata: Ascidiacae	2	3	2	3	4	/	3	16
Acartia (Acanthacartia) tonsa	Arthropoda: Copepoda	3	3	1	1	/	4	2	12
Blackfordia virginica	Cnidaria: Hydrozoa	3	3	2	2	/	2	2	12
Bugula stolonifera	Chordata: Ascidiacae	2	3	3	3	2	/	3	12
Ensis [directus] leei	Mollusca: Bivalvia	4	3	1	3	/	3	3	12
Gammarus tigrinus	Arthropoda: Malacostraca	3	3	2	3	/	2	3	12
Grateloupia turuturu	Rhodophyta: Florideophyeae	3	3	1	1	4	/	3	12
Harmioea japonica	Mollusca: Gastropoda	2	1	3	3	/	2	3	12
Hydroides dianthus	Annelida: Polychaeta	2	3	2	3	3	/	2	12
Hydroides elegans	Annelida: Polychaeta	2	3	2	3	3	/	2	12
Hydroides ezoensis	Annelida: Polychaeta	2	3	2	3	3	/	2	12
Lyrodus pedicellatus	Mollusca: Bivalvia	2	3	3	3	2	/	2	12
Mytilicola orientalis	Arthropoda: Copepoda	2	3	2	3	/	3	2	12
Potamopyrgus antipodarum	Mollusca: Gastropoda	3	3	2	3	2	/	3	12
Ruditapes philippinarum	Mollusca: Bivalvia	3	3	1	3	4	/	3	12
Schizoporella errata	Chordata: Ascidiacae	3	3	2	3	/	2	2	12
Schizoporella japonica	Chordata: Ascidiacae	3	3	2	3	/	2	2	12
Styela plicata	Chordata: Ascidiacae	2	3	2	3	/	3	3	12
Urosalpinx cinerea	Mollusca: Gastropoda	3	3	4	3	1	/	2	12
Asterocarpa humilis	Chordata: Ascidiacae	1	1	3	3	/	3	2	9
Botrylloides diegensis	Chordata: Ascidiacae	3	3	1	1	3	/	2	9
Celtodoryx ciocalyptoides	Porifera: Demospongiae	3	3	1	3	/	3	3	9
Gonionemus vertens	Cnidaria: Hydrozoa	1	3	3	3	/	3	3	9
Takayama tasmanica	Myzozoa: Dinophyceae	3	3	1	1	/	3	2	9
Aglaothamnion halliae	Rhodophyta: Florideophyeae	2	2	1	1	/	4	3	8
Antithamnionella ternifolia	Rhodophyta: Florideophyeae	2	2	1	3	4	/	3	8
Boccardia semibranchiata	Annelida: Polychaeta	2	3	2	2	/	2	2	8
Colpomenia peregrina	Ochrophyta: Phaeophyceae	2	3	2	3	2	/	3	8
Diadumene lineata	Cnidaria: Anthozoa	2	2	1	1	4	/	3	8
Ficopomatus enigmaticus	Annelida: Polychaeta	2	3	2	3	/	2	3	8

Koinostylochus ostreophagus	Platyhelminthes: Amplimatricata	2	2	2	1	/	2	2	8
Myicola ostreae	Arthropoda: Copepoda	2	3	2	3	/	2	2	8
Mytilicola intestinalis	Arthropoda: Copepoda	2	3	2	3	/	2	3	8
Ammothea hilgendorfi	Arthropoda: Pycnogonida	1	2	1	1	/	4	3	6
Amphibalanus reticulatus	Arthropoda: Thecostraca	1	1	3	2	/	2	2	6
Antithamnion nipponicum	Rhodophyta: Florideophyeae	2	1	1	1	/	3	2	6
Antithamnion pectinatum	Rhodophyta: Florideophyeae	2	1	1	1	/	3	2	6
Antithamnionella spirographidis	Rhodophyta: Florideophyeae	2	2	1	3	/	3	2	6
Balanus trigonus	Arthropoda: Thecostraca	1	2	2	2	/	3	2	6
Bonnemaisonia hamifera	Rhodophyta: Florideophyeae	2	3	1	2	3	/	2	6
Caprella mutica	Arthropoda: Malacostraca	2	3	1	3	/	3	2	6
Cordylophora caspia	Cnidaria: Hydrozoa	2	3	3	3	/	1	3	6
Grandidierella japonica	Arthropoda: Malacostraca	2	1	1	1	/	3	2	6
Limnoria quadripunctata	Arthropoda: Malacostraca	1	2	3	3	/	2	2	6
Limnoria tripunctata	Arthropoda: Malacostraca	1	2	3	2	/	2	2	6
Monocorophium sextonae	Arthropoda: Malacostraca	2	2	1	1	3	/	3	6
Neodexiospira brasiliensis	Annelida: Polychaeta	2	1	1	1	3	/	3	6
Neogobius melaostomus	Chordata: Teleostei	3	3	2	3	/	1	3	6
Odontella sinensis	Bacillariophyta: Bacillariophyceae	2	3	1	3	3	/	3	6
Penaeus japonicus	Arthropoda: Malacostraca	3	3	1	3	/	2	3	6
Solieria chordalis	Rhodophyta: Florideophyeae	2	2	1	3	3	/	3	6
Stephanopyxis palmeriana	Bacillariophyta: Bacillariophyceae	2	3	1	2	/	3	3	6
Teredo navalis	Mollusca: Bivalvia	1	3	3	3	2	/	3	6
Corethron pennatum	Bacillariophyta: Bacillariophyceae	2	2	2	2	1	/	2	4
Desdemona ornata	Annelida: Polychaeta	2	2	1	1	/	2	2	4
Diadumene cincta	Cnidaria: Anthozoa	1	2	2	2	2	/	2	4
Fusinus rostratus	Mollusca: Gastropoda	2	2	1	1	/	2	2	4

Lomentaria hakodatensis	Rhodophyta: Florideophyeae	1	1	2	1	/	2	2	4
Mercenaria mercenaria	Mollusca: Bivalvia	2	3	1	3	2	/	3	4
Mulinia lateralis	Mollusca: Bivalvia	2	2	1	1	/	2	2	4
Mya arenaria	Mollusca: Bivalvia	2	3	1	3	2	/	2	4
Palaemon macrodactylus	Arthropoda: Malacostraca	2	3	1	3	/	2	3	4
Polyopes lancifolius	Rhodophyta: Florideophyeae	2	3	1	1	2	/	3	4
Rhithropanopeus harrisii	Arthropoda: Malacostraca	2	2	2	3	/	1	3	4
Steromphala [Gibbula] albida	Mollusca: Gastropoda	2	2	1	1	/	2	2	4
Tritia neritea	Mollusca: Gastropoda	2	3	1	3	/	2	3	4
Victorella pavida	Chordata: Ascidiacae	2	2	2	2	/	1	3	4
Amphibalanus variegatus	Arthropoda: Thecostraca	1	1	3	2	/	1	1	3
Asthenognathus atlanticus	Arthropoda: Malacostraca	1	1	1	1	/	3	2	3
Laurencia brongniartii	Rhodophyta: Florideophyeae	1	1	1	3	/	3	2	3
Mytilopsis leucophaeata	Mollusca: Bivalvia	1	1	3	3	/	1	3	3
Nemopsis bachei	Cnidaria: Hydrozoa	1	2	1	1	/	3	2	3
Spongoclonium caribaeum	Rhodophyta: Florideophyeae	1	1	1	1	/	3	2	3
Anotrichium furcellatum	Rhodophyta: Florideophyeae	1	1	1	1	2	/	2	2
Antithamnion densum	Rhodophyta: Florideophyeae	1	1	1	1	/	2	2	2
Bopyrissa diogeni	Arthropoda: Malacostraca	2	3	1	1	1	/	1	2
Eusarsiella zostericola	Arthropoda: Ostracoda	1	2	1	1	/	2	3	2
Goniadella gracilis	Annelida: Polychaeta	1	2	1	1	/	2	2	2
Odontodactylus scyllarus	Arthropoda: Malacostraca	2	1	1	1	/	1	2	2
Oncorhynchus kisutch	Chordata: Teleostei	2	2	1	3	1	/	3	2
Panulirus regius	Arthropoda: Malacostraca	2	3	1	3	1	/	2	2
Pileolaria berkeleyana	Annelida: Polychaeta	1	1	1	1	2	/	3	2
Pleurosigma simonsenii	Bacillariophyta: Bacillariophyceae	1	1	1	1	/	2	2	2
Thalassiosira punctigera	Bacillariophyta: Bacillariophyceae	1	1	1	1	/	2	2	2
Thalassiosira tealata	Bacillariophyta: Bacillariophyceae	1	1	1	1	/	2	2	2
Umbraulva dangeardii	Chlorophycota	1	1	1	1	2	/	2	2

Caulibugula zanzibariensis	Chordata: Ascidiacae	1	1	1	1	/	1	1	1
Choromytilus chorus	Mollusca: Bivalvia	1	1	1	1	/	1	1	1
Mizuhopecten yessoensis	Mollusca: Bivalvia	1	1	1	2	/	1	3	1
Pikea californica	Rhodophyta: Florideophyeae	1	3	1	1	/	1	3	1
Sarcodiotheca gaudichaudii	Rhodophyta: Florideophyeae	1	1	1	3	/	1	2	1