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Research Article

The Influence of Marina Characteristics on Invasive Non-native Colonization

Marina Özelliklerinin İstilacı Yerli Olmayan Türlerin Kolonileşmesi Üzerindeki Etkisi

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Abstract

The marina properties, such as; salinity range, tidal fluctuations, depth, and ascidian presence influence the distribution of invasive non-natives. Transport vectors, aquaculture and fishery practices also have an important role in the distribution of invasive non-native species during the bioinvasion process. We focused on 10 invasive non-native species of marine invertebrates in the UK. This study explained the distribution and ecology of five invasive non-native species (*Styela clava* (Ascidia), *Didemnum vexillum* (Ascidia), *Caprella mutica* (Crustacea), *Crepidula fornicata* (Gastropoda), *Watersipora subtorquata* (Bryozoa)) and the marina characteristics of five invasive non-native species colonization (*Austrominius modestus* (Arthropoda), *Ciona intestinalis* (Ascidia), *Botrylloides violaceus* (Ascidia), *Tricellaria inopinata* (Bryozoa), *Bugula neritina* (Bryozoa)) in Wales coasts. The study site deployed settlement tiles in the inner and the outer tile as two positions in each marina: An equal number of vertical and horizontal tiles was deployed at each site with half-sampled at two weeks (very early colonization) and at eight weeks (later colonization). The results showed that some variations in marina characteristics affected the distribution of invasive non-native species. Invasive non-native species abundance, diversity and multivariate structure of the assemblages were very high. The colonization of tiles varied between locations at the entrance and within the marina, but not in any way, and the effect of tile orientation was surprisingly low.

Keywords: *distribution, invasive non-native species, marine invertebrates, transport vectors, Wales marinas*

Öz

Marinalarda tuzluluk aralığı, gelgit dalgalanmaları, derinlik, ve ascidan varlığı gibi faktörler istilacı yerli olmayan türlerin dağılımını etkiler. Ayrıca, taşıma vektörleri, su ürünleri yetiştiriciliği ve balıkçılık uygulamaları da tür istilası sürecinde istilacı yerli olmayan türlerin dağılımında önemli bir role sahiptir. Birleşik Krallıktaki 10 istilacı yerli olmayan deniz omurgasız türüne odaklandık. Bu çalışma, Büyük Britanya'daki beş istilacı yerli olmayan türün (*Styela clava* (Ascidia), *Didemnum vexillum* (Ascidia), *Caprella mutica* (Crustacea), *Crepidula fornicata* (Gastropoda), *Watersipora subtorquata*

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(Bryozoa)) dağılımını ve ekolojisini ayrıca, Galler kıyılarında beş istilacı yerli olmayan türün (*Austrominius modestus* (Arthropoda)*, Ciona intestinalis* (Ascidia)*, Botrylloides violaceus* (Ascidia)*, Tricellaria inopinata* (Bryozoa)*, Bugula neritina* (Bryozoa)) kolonileşmesi üzerinde marina karakterlerinin etkilerini açıklamaktadır. Çalışma bölgesindeki her bir marinanın girişi ve dışında belirlenen yüzeylere plakalar yerleştirdi. Örneklemeler iki haftada (çok erken kolonizasyon) ve sekiz haftada (sonraki kolonizasyon) alındı. Elde edilen sonuçlar, marina özelliklerindeki bazı değişikliklerin istilacı yerli olmayan türün dağılımını etkilediğini göstermiştir. Bu türlerin bolluğu, çeşitliliği ve çok değişkenli yapısının oldukça yüksek olduğu ve plakaların kolonizasyonu marina girişi ve içindeki konumlar arasında farklılık gösterdiği, fakat bu değişkenliğin tutarlı bir şekilde olmayıp marinalardaki plaka konumlarının etkisinin de şaşırtıcı derecede düşük olduğu belirlenmiştir.

Anahtar sözcükler: *dağılım, istilacı yerli olmayan türler, deniz omurgasızları, taşıyıcı vektörler, Galler marinaları*

Introduction

The Distribution of Invasive Non-Native Species

The Identification of Invasive Non-Natives and the Invasion Process

Invasive non-native species (INNS) are species that have been introduced to an area outside their previous natural distribution and have an adverse environmental, economic, or social impact on the new location (Corrales et al., 2020).

The stages of the invasion process include an introduction, colonization, and expansion phases. As the process mainly impacts invasive non-native biodiversity, so it is referred to as bioinvasion (Corrales et al., 2020), and bioinvasion is determined according to the features of invasive non-native species and the characteristics of the recipient community according to propagule pressure. The term 'propagule pressure' generally refers to the abundance or quantity of introduced species and the frequency that they arrive in the location (Ros et al., 2013). Invasive non-native species pass through all stages of the invasion process, from moving to a new environment to distribution after their establishment (Powell-Jennings & Callaway, 2018).

The Effects of Invasive Non-Natives on the Distribution of Marine Species

Invasive non-native species pose a significant threat to the world's oceans (Willis et al., 2009) because they may harm native species, through competition, predation or the transmission of viruses (Chan & Briski, 2017). These species can also affect the distribution of other invasive non-native species because of a damaged ecosystem. In this case, an invasive non-native species cannot spread around invasion areas, even though they are still considered invaders (Orlando-Bonaca et al., 2019).

The extreme density of invasive non-natives may have negative impacts on native and aquaculture species such as "cultured mussels" through competition for space and food. For example, *Didemnum vexillum* (Kott, 2002) can replace mussels as the dominant species in fouling communities. This event is a major functional habitat change because mussels provide a year-round substrate for the settlement of other organisms (National Estuarine and Marine Exotic Species Information System [NEMESIS], 2020). However, the ecological and economic impacts of *D. vexillum* on the biology of sea scallops and fishing are yet unknown (Commonwealth Agricultural Bureaux International [CABI], 2020). The solitary ascidian *Styela clava* (Herdman, 1882) is a sessile filter feeder, an abundant species, and often the dominant species fouling organisms in harbours. In English coasts, the growing population of *S. clava* is paralleled by a decrease in *Ciona intestinalis* because it excludes other organisms while also providing a secondary substrate for other fouling organisms (NEMESIS, 2020). *Crepidula fornicata* (Linnaeus, 1758) has been a very successful invader. They affect the growth of other bivalves by competing in a variety of ways as well as altering habitats in European waters (NEMESIS, 2020). For example, attached limpets increase the hydrodynamic stress on mussels; therefore, the mussels shift energy resources to increase the production of byssus threads (NEMESIS, 2020). *Watersipora subtorquata* (d'Orbigny, 1852) can form very large colonies (Global Invasive Species Database [GISD], 2020). Their colonies provide non-toxic points of attachment for other organisms by allowing a diverse fouling community to develop which can adversely affect the speed and efficiency of ships. Their colonies often develop elevated leaf-like folds rising above the substrate and create additional space for colonization by other organisms (NEMESIS, 2020).

The Ecological Features of Invasive Non-Native Species

The Characteristics of Invaders in Relation to Invasion Success

The adaptation of the species can influence their abundance and indicates the success of the invasion if they cannot successfully adapt to the new location due to their characteristics (Osman & Whitlatch, 2007). A growth layer of some invasive non-native species can serve to protect other invasive non-natives from predation, showing that they are opportunistic species (Foster et al., 2016). In addition, the invasion success of an invasive non-native species in experimental fouling communities is dependent on the presence of large amounts of unoccupied space (CABI, 2020). For example, the dense mats of *D. vexillum* are considered as physical barriers because this species influence the geochemical cycling of nutrients/elements and the circulation of dissolved oxygen, contributing to indirect shifts in benthic ecosystems (Zhan et al., 2015).

Invasive Non-Native Species Resistance to Stress Factors

The success of invasion in marine habitats is determined by the interaction between species-specific adaptations and site-specific environmental features (Lenz et al., 2011). Fluctuating habitats (i.e. intertidal habitats) are more likely to have successful invaders, as species growing in these environments are pre-adapted to variations in abiotic variables such as temperature, salinity, light intensity, and oxygen availability. Adaptation should be predestined by tolerating stressful situations during transport and after introduction to a new habitat (Lenz et al., 2011). Communities of invasive non-native species are less stress-tolerant in their area than in their introduced area. This difference can derive from another feature of successful invaders: the capacity to respond rapidly to new challenges (Lenz et al., 2011). As yet, however, it has not been possible to clarify how these factors on marine invasive non-native species impact the primary mechanisms that enable new invasive species to become established (Foster et al., 2016).

The Characteristics of the Recipient Community and Niche Availability

Invasive non-natives occupy significant structural and functional areas within the invaded ecosystems (Ojaveer et al., 2018). According to Zhan et al. (2015), once the ascidian species is established, it often spreads locally and regionally through 'stepping-stone' introductions associated with a variety of human-mediated vectors, including movement. Ascidians such as *S. clava* and *D. vexillum* are long-term dominant resident ascidians in many harbors along the New England coasts, but they do not spread more open coastal sites since communities with low-diversity have fewer competitors for any newly-settled recruits and juvenile life-stages. This indicates that their invasion success has been limited by competitors, e.g. predators (Osman & Whitlatch, 2007).

The increased bio-fouling complexity in habitats can allow for the introduction of additional species because this complexity can offer suitable habitats, food, and sheltered niche areas (Ulman et al., 2019b). However, if there is not enough environmental niche availability for colonization and there is greater biological resistance in the form of predators and competitors, the invasive non-native species establishment, secondary distribution and colonization may not be possible (Afonso et al., 2020).

The Role of Transport Vectors on Invasive Non-Native Species Distribution

Invasions are caused largely by marine traffic, by the fouling species transport on vessel hulls, and through ballast water released into the area (Ulman et al., 2019b).

Aquaculture facilities are also essential vectors for the movements of invasive non-natives. For example, *D. vexillum* was introduced in the Gulf of Maine when Pacific oysters (*Crassostrea gigas*) were transported for aquaculture purposes (Zhan et al., 2015). Recreational traffic is another important vector for these species in bigger locations where human activity is more prevalent (Afonso et al., 2020).

For example, *S.clava* is native to the Northwest Pacific shores of Asia and Russia (NEMESIS, 2020). This species have probably been introduced to Great Britain (GB) from Korea as well as the seaboards of North America, Australia, and New Zealand (GISD, 2020). *D. vexillum* is native to eastern Japan and first recorded in the marina in North Wales in autumn 2008 (GISD, 2020). The specific vectors for introduction are largely unknown, though international shipping, local boat traffic, and transport of aquaculture species are likely sources (CABI, 2020). *C. mutica* is native to the Northwest Pacific. These caprellids have been introduced to the East (Delaware-Newfoundland) and West Coasts (California-Alaska) of North America, Europe (from Spain to Norway and Germany), and New Zealand (NEMESIS, 2020).

C. fornicata is native from Point Escuminac, Canada, and can be along the East Coast of America, down to the Caribbean (GISD, 2020). In the English Channel, *C. fornicata* has spread from east to west. They were transported into Europe along with American oysters (*Crassostrea virginica*) dredged from oyster beds of Atlantic estuaries (CABI, 2020). At the end of the nineteenth century, these invasive non-natives were accidentally introduced in Europe where they found suitable conditions to settle and develop free surfaces of sandy, coarse sediment, an optimal water temperature range, abundant suspended organic matter as food and no predators. These factors allow for rapid growth and reproductive success (CABI, 2020). *W. subtorquata* is an encrusting bryozoan widely distributed around the world. These invasive non-natives have been introduced to the Northeast Pacific, much of the coast of Australia, New Zealand, and the Atlantic coast of France (NEMESIS, 2020). Their native range has not been determined, but they are becoming common in various regions worldwide on cool temperate coasts. *W. subtorquata* was first detected in 2008 in marinas in Plymouth (Devon) and Poole (Dorset), and their transport to GB is likely to have taken place by recreational craft (GISD, 2020). Their appearances in France are related to the culture of *C. gigas* (NEMESIS, 2020).

Hull Fouling and Ballast Water

The risk of invasion differs with the global shipping trend of vessels and the various coastal environments (Jägerbrand et al., 2019). For remote dispersal, the hulls and sea chests of ships represent major vectors, primarily for the transportation of juvenile and/or adult ascidians. In general, ballast water is not understood to be the key vector for remote dispersion, primarily owing to the limited survival period of free-swimming larvae, but the soil, ground and/or internal surfaces within ballast tanks can distribute harbour ascidians (Zhan et al., 2015). Therefore, three decades, the ballast water effect (via commercial shipping) has become widely understood to be a key vector of species introductions to coastal ecosystems. Despite enhanced global attempts to reduce the risk of ballast water-mediated invasions, ballast water remains a potent vector of invasive non-native aquatic species introductions (Darling et al., 2018).

The ballast water is used to stabilise vessels on the sea and contains suspended matter that can establish as sediment within the ballast tanks. The quantity of the sediment load becomes greater if the ballast water is loaded in shallow waters, rivers and estuaries. These physical factors mean that when a species is released into a new area, it does not automatically establish itself as a viable community (Jägerbrand et al., 2019). Also, the sediments must be removed from the ballast tanks, but this process interferes with the ship's activities (Maglić et al., 2019) because of a significant osmotic shock impact owing to the exposure of high salinity ocean water, so some species remain in the ballast water tanks. This process is called Ballast Water Exchange (BWE) and is greater when connected with transit between marine ports (Gray et al., 2007). In addition, recreational shipping has important effects via hull-fouling, whereas aquaculture and fishery practices have a role in culture of species and transfer of material (Ojaveer et al., 2018).

Recreational Boating

While recreational boats may not be a significant vector for the dispersal of invasive non-native species over great distances, they may play an important role in successful introductions on a local scale (Ros et al., 2013). This means of invasive non-native distribution can be successful due to short and relatively slow voyages undertaken by recreational craft (Foster et al., 2016), although recreational vessels are usually considered low-risk vectors for the same reason (Dafforn et al., 2009). They are connected with highly invaded systems as they occupy smaller marinas for invasive non-natives distribution (Foster et al., 2016). These areas allow for the occurrence of introductory vectors such as marine ports (fouling and ballast water), marinas and aquaculture facilities in recreational areas (Afonso et al., 2020). In commercial shipping the expulsion of ship ballast water/sediments and hull fouling occur because ship travel is increasingly faster, leading to an increase in the survival rate of the species in ballast tanks (Ulman et al., 2019b).

Marina Features As Hotspots for Invasive Non-Native Species Distribution

With their sheltered habitat and high propagule pressure, marinas have become 'hotspots' for the distribution of invasive non-natives (Ulman et al., 2019b). Marinas are called as 'secured islands' for underwater invasive non-native species and provide an entry point for non-natives via recreational yachts or through a network of appropriate ecosystems (Ashton, 2006). Marinas have diverse and complicated natural ecosystems, as well as offering a strong point of connectivity among marine systems. These systems have hydrographic boundaries at greater spatial scales than terrestrial ecosystems, and therefore the distribution of marine species is harder to evaluate than in coastal environments (Ros et al., 2013). In this case, the characteristics of marinas can be used to identify the influence of Non-native Invasion Species (NIS) prevalence (Foster et al., 2016).

Non-natural benthic surfaces (known as artificial substrates) such as floating docks, pilings, and boat hulls have been identified as places for the first arrival and establishment of many introduced marine species, as distributed by anthropogenic vectors (Lambert, 2019). For example, in all parts of its native and introduced range, *S. clava* is more frequently reported on anthropogenic structures than natural surfaces (NEMESIS, 2020). Hard-bottom communities, especially within artificial hard substrates such as docks and pilings, allow to the colonization of invasive non-natives within bays and estuaries (Ros et al., 2013). In particular, invasive non-natives in enclosed habitats are correlated with the artificial hard substrate, especially with fouling communities in harbours and marinas (Ulman et al., 2019a).

The number of berths contributes to the higher invasive non-native species quantity as they increase vessel traffic in a marina (Ulman et al., 2019a). Larger marina sizes also impact this distribution through transport vectors, as marina length becomes one of the most effective factors for invasive non-native species distribution in artificial environments over natural ecosystems (Orlando-Bonaca et al., 2019). Additionally, in marinas, the presence of floating pontoons has a significant role because these species has larger distribution in shallower areas than in their deeper equivalents owing to their distance from the seafloor (Ulman et al., 2019a). Pontoon length represents the availability of a hard infrastructure for invasive non-native species colonization, but is also an indirect measurement of the size of marinas (Dafforn et al., 2009).

The primary aim of the study is to research the ecology and distribution of important invasive non-natives in the UK and show how marina characteristics affect the diversity of invasive non-native species in Welsh coasts. Key factors in this study are therefore marina identity; position within marina; orientation of tile; and the period for colonization. This study evaluates each of these factors to analyze how they affect non-native species diversity and abundance. The study aims test the following hypotheses:

- Invasive non-native species diversity increases with marina size;
- Invasive non-native species diversity is greater within enclosed areas of the marina compared to marina entrances;
- Invasive non-native species diversity is greater on horizontally oriented surfaces than vertical.

In this study, as there was a lot of boat traffic in the largest marina, it was determined that the non-native species diversity was the highest in this marina. The effect of position and orientation varies among marinas, but there was no consistency in the difference between inner and outer in the abundance of some invasive non-native species. In addition, as colonisation period increases, the non-natives have more preferred to distribute vertically some enclosed marinas while some of them have preferred to horizontally distribute in some marina entrance.

Materials and Methods

Study Area

This study was conducted on eight marinas in Wales: Pwllheli (Pwll), Holyhead (HH), Burry Port(BP), Deganwy (DG) and Milford Haven (MH), Swansea (SW), Neyland (NY) and Victoria Dock (VD) in August and September 2009 (Figure 1).

Implementation of Design

The study design consists of an ecological field experiment to assess how marina characteristics in eight marinas affect invasive non-native colonization. The study site has deployed settlement tiles at two positions in each marina: the inner tile, which is well within the marina, and the outer tile at the marina entrance. An equal number of vertical and horizontal tiles was deployed at each site with half sampled at two weeks (very early colonization) and half sampled at eight weeks (later colonization) (Figure 2).

Figure 1

Locations of Marinas in Wales Surveyed for Invasive Non-Native Species (DiGSBS250K, 2011)

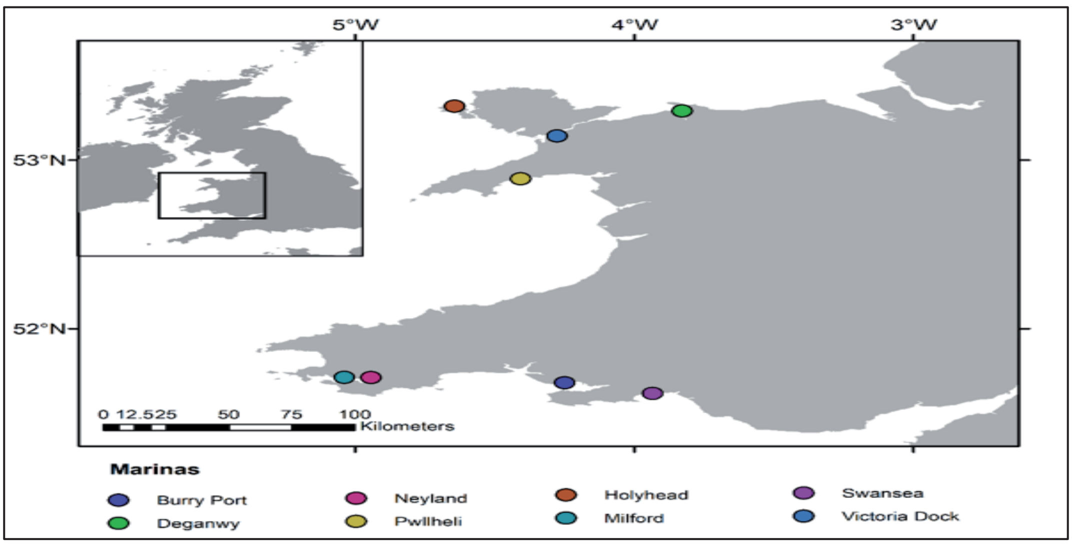


Figure 2

Samplings for Two Weeks and Eight Weeks in Eight Marinas on the Welsh Coasts

Note. N=Panel numbers

In this study, five panels were vertically and horizontally spaced inner and outer of each marina, with 160 samplings taken, totalling 320 samplings across all sites for two weeks and eight weeks colonization. The settlement tiles, which were made from black 'Correx'(approximately 4mm wide) (Figure 3) to provide a vertical and horizontal component, were deployed at a two-meter depth (Figure 4) using a thin nylon cord tied to marina pontoons and weighted with a small fishing weight.

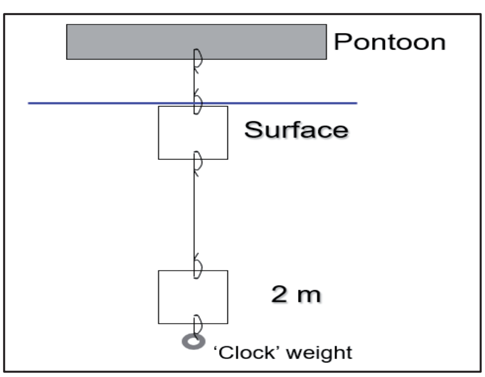
After the tiles were removed, at two weeks and eight weeks, they were scored in the laboratory under a dissecting microscope using a grid to aid the determination of % cover (in colonial organisms) or the number of organisms (for solitary organisms). All recognizable organisms were identified to the lowest possible resolution. After identification, the organisms were characterized as taxa.

Figure 3

Black 'Correx' and Eight-Week Panel Taken in the Survey Area

Figure 4

The Depth Level (Two-Meter) for Both Colonization Period



Data Analysis

The analysis was run separately for two-week data (very early colonization) and eight-week data (later colonization). Firstly, univariate analysis was conducted by using a combination of Excel and R studio to determine the effects of each marina position (inner, outer) and orientation (vertical, horizontal) among marinas on univariate response variables such as community diversity [Simpson's diversity index

($1-\lambda$) and Margalef species richness index (d)], native species and abundance of invasive non-native *Austrominius modestus* (Darwin, 1854), *Ciona intestinalis* (Linnaeus, 1767)*, Botrylloides violaceus* (Oka, 1927)*, Bugula neritina* (Linnaeus, 1758), *Tricellaria inopinata* (D'Hondt & Ambrogi, 1985).

Secondly, raw data (late colonization) was used and three-way mixed-model ANOVA, which is fully factorial, was run to examine an interaction effect between three independent variables [marina, position (inner/outer), and orientation (vertical/horizontal)] on invasive non-native species diversity, richness, and abundance by calculating variance homogeneity. This allows for the application of a crossed model with a marina, position in the marina, and orientation. Cochran's test was used to determine homogeneity (P-value<0.05=heterogeneity or P-value>0.05 = homogeneity).

Finally, a multivariate analysis was conducted. The biological similarity matrix (Bray-Curtis) was calculated using square root-transformed abundance data, and PERMANOVA Analysis was conducted using the same three-way model described above. Following PERMANOVA analysis, multi-dimension scaling (MDS) plots were created to explore significant interactions in each marina in PRİMER.

Results

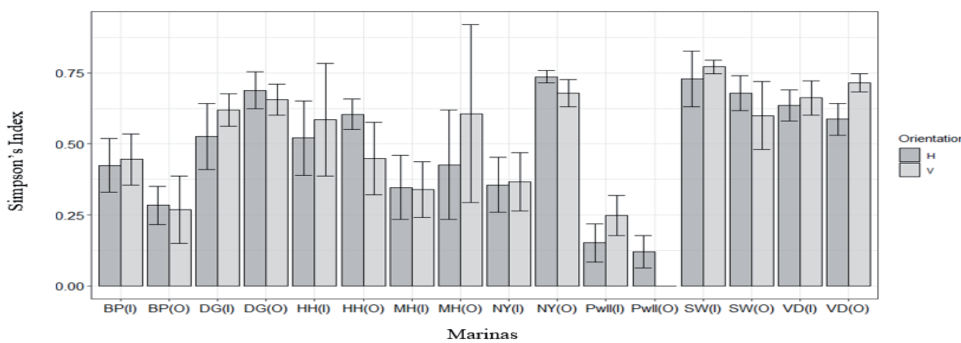
Invasive Non-Native Species Composition

In the survey, there were six species of solitary ascidian, eight species of colonial ascidians, two species of Mollusca, five species of worms, 13 species of Bryozoan, three species of Barnacle, four species of Hydroids, four species of Sponges, one species of Shrimp, one species of Macroalgae, and egg mass for both two weeks and eight weeks colonization.

Diversity indices of benthic communities; Simpson's index ($1-\lambda$) and Margalef species richness index (d) in each marina; the results of univariate analysis and three-way mixed factorial model ANOVA have been shown respectively (Figures 5**,** 6 and Table 1**).** According to Cochran's test results, the data had heterogeneous variance ($P<0.05$). After log transforming, Cochran's test showed no heterogeneity ($P>0.05$). There was a significant difference in Simpson diversity index among marinas [$F\ (7,128) = 17, 34$, P-value<0.001], and significant interaction between marina and position [$F\ (7,128) = 3.63$, P-value<0.05]. This means the effect of position varied among marinas. Investigating further using a Student–Newman–Keuls (SNK) post hoc test, there was no consistency in the difference between inner and outer in Simpson diversity (Table 1).

Figure 5

Simpson Diversity in Eight Marinas for Early Colonization



Note. BP: Burry Port, DG: Deganwy, HH: Holyhead, MH: Milford Haven, NY: Neyland, Pwll: Pwllheli, SW: Swansea, VD: Victoria Dock in two positions (I): Inner or (O): Outer through two orientation tiles H: Horizontal and V: Vertical in the survey area.

Table 1

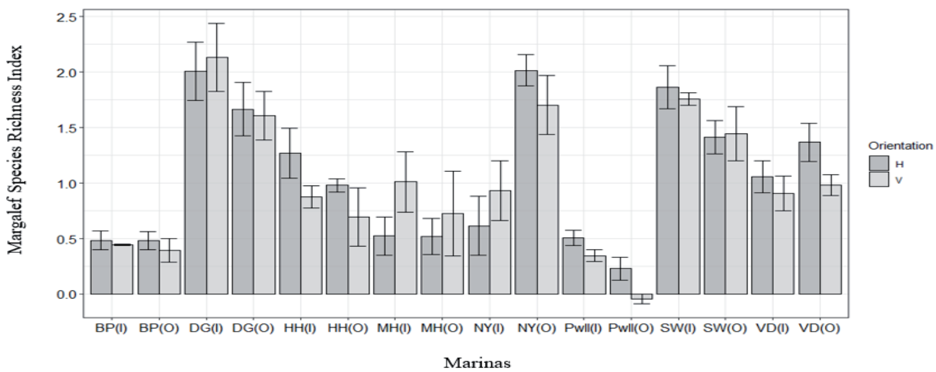
The Results of Three-Way Mixed Model ANOVA Showing Differences in Simpson Diversity among Responsible Variables (Level of Significance P-Value<0.05)

Source	df	Mean Squares (MS)	F-value	P-value
Marina	7	0.3592	17.34	0.0000
Position	1	0.0038	0.05	0.8285
Orientation	1	0.0021	0.35	0.5723
Marina*Position	7	0.0752	3.63	0.0013
Marina*Orientation	7	0.0059	0.28	0.9591
Position*Orientation	1	0.0273	1.93	0.2075
Marina*Position*Orientation	7	0.0142	0.68	0.6853
RES	128	0.0207		
TOTAL	159			

For species richness, according to Cochran's test results, the data had homogeneous variance (P>0.05). After log-transforming, the result of Cochran's test did not change. There was a significant difference in species richness among marinas (F (7, 128) = 32.49, P-value<0.001), and a significant interaction between marina and position (F (7, 128) = 7.35, P-value<0.001). This means the effect of position varies among marinas. Investigating further using an SNK post hoc test, there was no consistency in the difference between inner and outer in species richness (Table 2).

Figure 6

Species Richness in Eight Marinas for Early Colonization



Note. BP: Burry Port, DG: Deganwy, HH: Holyhead, MH: Milford Haven, NY: Neyland, Pwll: Pwllheli, SW: Swansea, VD: Victoria Dock in two positions (I): Inner or (O): Outer through two orientation tiles H: Horizontal and V: Vertical in the survey area.

Table 2

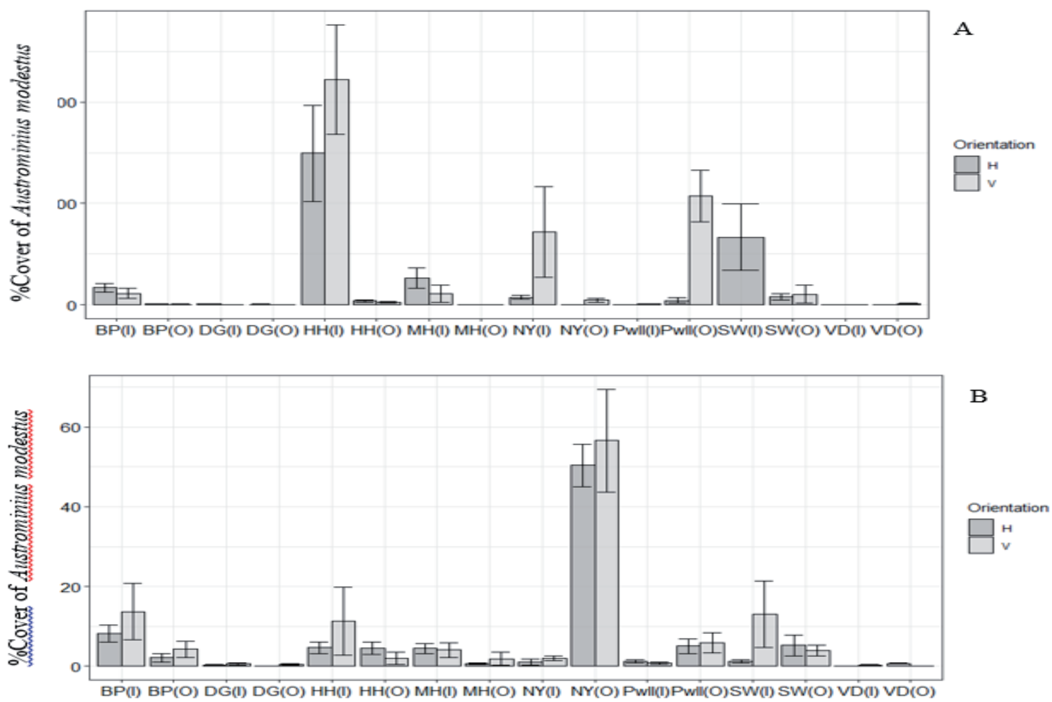
The Results of the Three-Way Mixed Model ANOVA Show Differences in Species Richness among Responsible Variables (Level of Significance P-Value < 0.05)

Source	df	Mean Squares (MS)	F-value	P-value
Marina	7	104.4679	32.49	0.0000
Position	1	0.9000	0.04	0.8508
Orientation	1	3.6000	0.85	0.3876
Marina*Position	7	23.6286	7.35	0.0000
Marina*Orientation	7	4.2429	1.32	0.2462
Position*Orientation	1	4.2250	2.62	0.1494
Marina*Position*Orientation	7	1.6107	0.50	0.8324
RES	128	3.2156		
TOTAL	159			

The univariate test for the selected five discriminating species showed there was a significant difference in the abundance of these invasive non-natives (P-value<0.05) according to marina position in orientation for both very early colonization and later colonization. The very early colonization of *A. modestus* was more vertical within HH marina, whereas there was more later colonization of *A. modestus* in vertical orientation in enclosed NY marina. This means that as colonization period increases, *A. modestus* has more preferred to vertically distribute in enclosed HH marinas (Figures 7A and 7B).

Figures 7A and 7B

The Percentage Cover of Austrominius modestus Abundance Collected from Eight Marinas in Two-Meter Depth



Note. BP: Burry Port, DG: Deganwy, HH: Holyhead, MH: Milford Haven, NY: Neyland, Pwll: Pwllheli, SW: Swansea, VD: Victoria Dock) in two positions (I): Inner or (O): Outer through two orientation tiles H: Horizontal and V: Vertical at the end of two weeks (A) and eight weeks (B).

According to Cochran's test results, the eight-week data had heterogeneous variance ($P<0.05$). After log transforming, Cochran's test showed no heterogeneity ($P>0.05$). This shows a significant difference in the abundance of *A. modestus* among marinas [$F (7,128) =23.50$, P-value<0.001], and a significant interaction between marina and position [$F (7,128) =21.10$, P-value<0.001]. Therefore, the effect of position varies among marinas, but there was no consistency in the difference between inner and outer in the abundance of *A. modestus* (Figure 7B, Table 3).

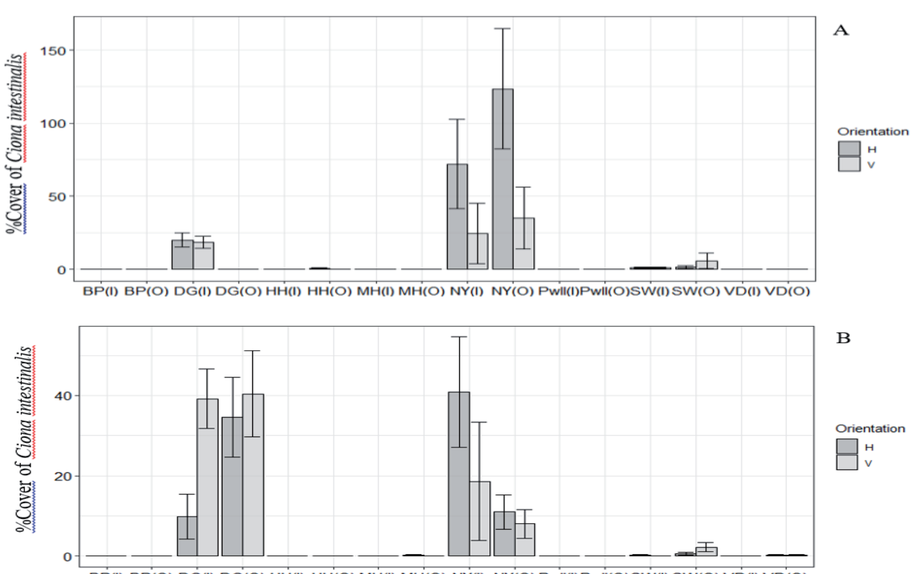
Table 3

The Results of Three-Way Mixed Model ANOVA Show Differences in Austrominius modestus Abundance among Responsible Variables (Level of Significance P-Value < 0.05)

Source	df	Mean Squares (MS)	F-value	P-value
Marina	7	10.7054	23.50	0.0000
Position	1	1.7871	0.19	0.6793
Orientation	1	1.1082	2.50	0.1577
Marina*Position	7	9.6149	21.10	0.0000
Marina*Orientation	7	0.4428	0.97	0.4547
Position*Orientation	1	1.1314	1.69	0.2348
Marina*Position*Orientation	7	0.6695	1.47	0.1838
RES	128	0.4556		
TOTAL	159			

Figures 8A and 8B

The Percentage Cover of Ciona intestinalis Abundance Collected from Eight Marinas in Two-Meter Depth



Note. BP: Burry Port, DG: Deganwy, HH: Holyhead, MH: Milford Haven, NY: Neyland, Pwll: Pwllheli, SW: Swansea, VD: Victoria Dock in two positions (I): Inner or (O): Outer through two orientation tiles H: Horizontal and V: Vertical at the end of two-weeks (A) and eight-weeks (B).

In the very early colonization, *C. intestinalis* has more abundance in horizontal orientation enclosed in the NY marina. The abundance of *C. intestinalis* decreased both within and enclosed NY marina in horizontal orientation in later colonization, while the distribution of *C. intestinalis* increased vertically enclosed in the DG marina in the later colonization. This means that as colonization period increases, these invasive non-natives have more preferred to distribute vertically enclosed in the DG marina (Figures 8A and 8B).

According to Cochran's test results, the eight-week data had heterogeneous variance (P>0.05). After log transforming, the result of Cochran's test did not change. This shows a significant difference in the abundance of *C. intestinalis* among marinas [F (7,128) = 32.30, P-value<0.001]. There was also a significant interaction between marina and position as well as marina and orientation [F (7,128) = 2.76, P-value<0.05], [F (7,128) = 0.97, P-value<0.05]. Therefore, the effect of position and orientation varies among marinas. SNK exploration of these interactions shows that there were some differences between positions, but the direction of difference was not consistent (Figure 8B, Table 4).

Table 4

The Results of Three-Way Mixed Model ANOVA Show Differences in Ciona intestinalis Abundance among Responsible Variables (Level of Significance P-Value<0.05)

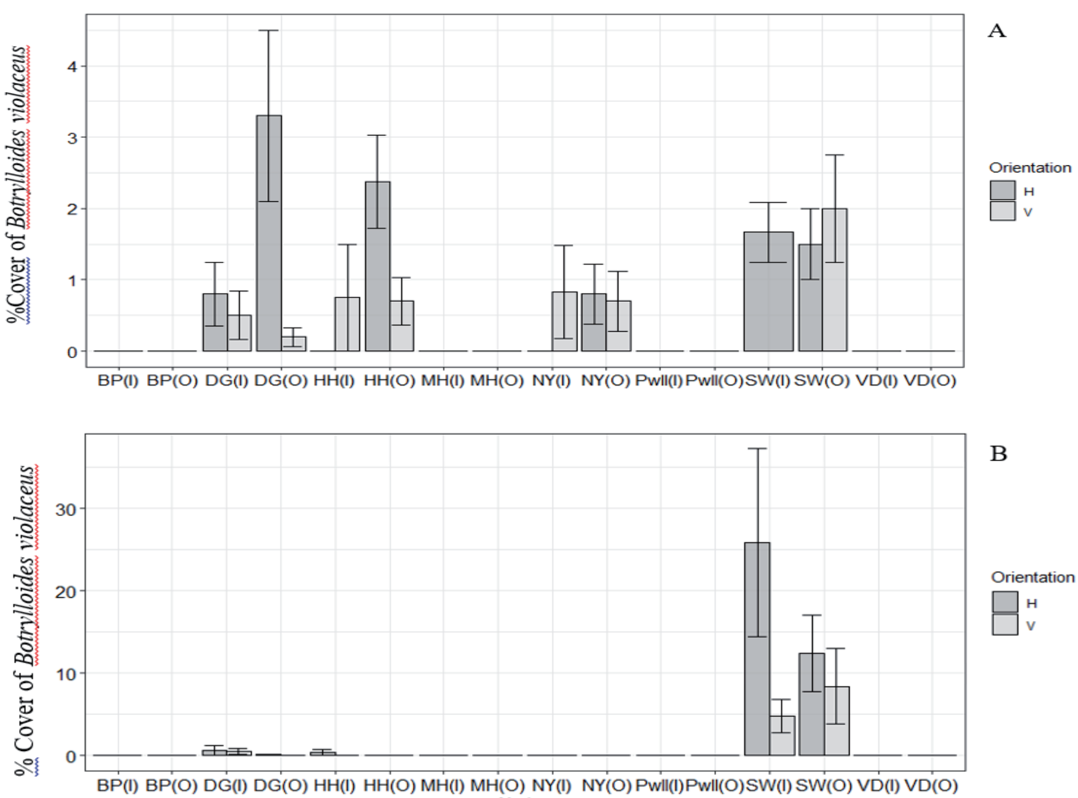
Source	df	Mean Squares (MS)	F-value	P-value
Marina	7	2978.0023	39.30	0.0000
Position	1	4.1924	0.02	0.8819
Orientation	1	1.7060	2.33	0.9306
Marina*Position	7	176.4683	2.76	0.0286
Marina*Orientation	7	209.3304	0.97	0.0105
Position*Orientation	1	6.0000	0.05	0.8312
Marina*Position*Orientation	7	122.5614	1.62	0.1361
RES	128	75.7792		
TOTAL	159			

In the very early colonization, *B. violaceus* has more abundant in enclosed DG marina in horizontal orientation, whereas the abundance of *B. violaceus* increased in horizontal orientation within SW marina in the later colonization period. Thus, as the colonization period increases, *B. violaceus* has preferred to horizontally distribute within SW marina (Figures 9A and 9B).

According to Cochran's test results, the eight-week data had heterogeneous variance (P>0.05).After log transforming, the result of Cochran's test did not change. This shows a significant difference in the abundance of *B. violaceus* among marinas [F (7,128) =34.79, P-value<0.001]. There was also a significant interaction between marina and orientation [F (7,128) = 3.97, P-value<0.001], meaning the effect of orientation varies among marinas. SNK exploration of this interaction shows that at the only marina (SW) where *B.violaceus* was abundant, there was significantly more *B. violaceus* on horizontal surfaces than vertical (Figure 9B, Table 5).

Figure 9

The Percentage Cover of Botrylloides violaceus Abundance Collected from Eight Marinas in Two-Meter Depth



Note. BP: Burry Port, DG: Deganwy, HH: Holyhead, MH: Milford Haven, NY: Neyland, Pwll: Pwllheli, SW: Swansea, VD: Victoria Dock in two positions (I): Inner or (O): Outer through two orientation tiles H: Horizontal and: Vertical at the end of two weeks (A) and eight weeks (B).

Table 5

The Results of Three-Way Mixed Model ANOVA Show Differences in Botrylloides violaceus Abundance among Responsible Variables (Level of Significance P-Value<0.05)

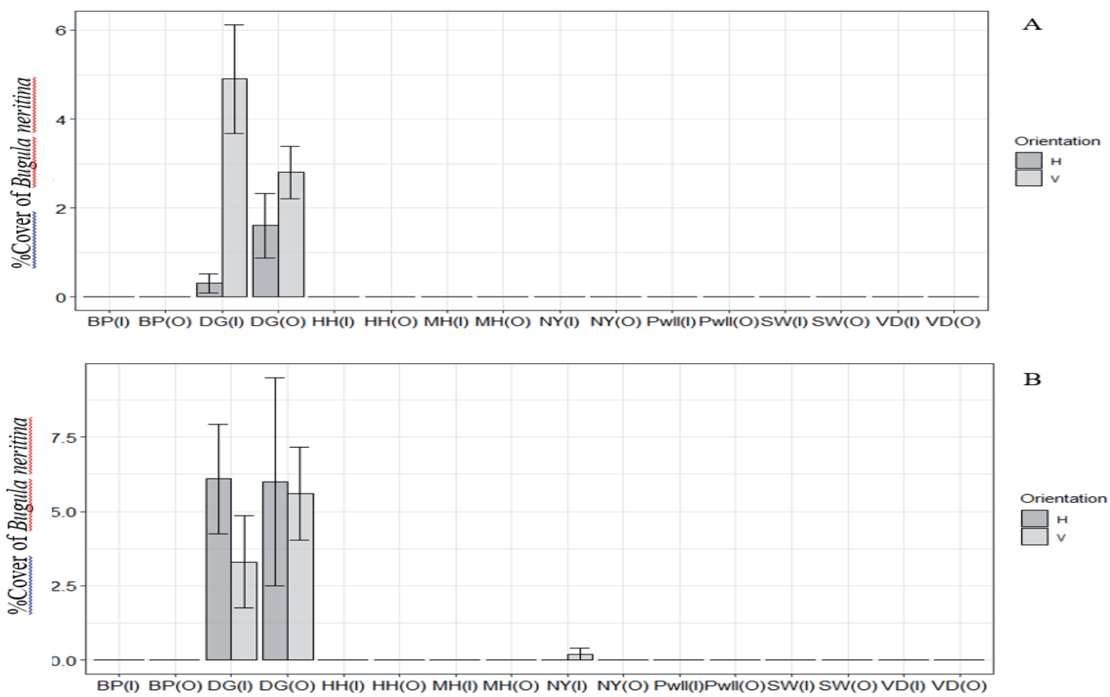
Source	df	Mean Squares(MS)	F-value	P-value
Marina	7	753.8307	34.79	0.0000
Position	1	33.2952	2.44	0.1626
Orientation	1	103.2190	1.20	0.3098
Marina*Position	7	13.6703	0.63	0.7297
Marina*Orientation	7	86.1147	3.97	0.0006
Position*Orientation	1	26.6753	1.04	0.3423
Marina*Position*Orientation	7	25.7125	1.19	0.3151
RES	128	21.6704		
TOTAL	159			

In the early colonization, *B. neritina* is the only species within DG marina in vertical orientation, whereas the abundance of *B. neritina* increased in horizontal orientation in enclosed DG marina in the later colonization period. This means that as the colonization period increased, *B. neritina* preferred to horizontally spread in enclosed DG marina (Figures 10A and 10B).

According to Cochran's test results, the eight-week data had heterogeneous variance (P>0.05).After log transforming, the result of Cochran's test did not change. This shows a significant difference in the abundance of *B.neritina* among marinas [F (7,128) = 73.51, P-value<0.001], but there was no significant interaction between marina and orientation or marina and position. This means the effects of orientation and position do not vary among marinas. However, SNK exploration of this interaction shows the only marina (DG) where *B. neritina* was abundant on vertical orientation rather than horizontal (Figure 10B, Table 6).

Figures 10A and 10B

The Percentage Cover Of Bugula neritina Abundance Collected From Eight Marinas In Two-Meter Depth



Note. BP: Burry Port, DG: Deganwy, HH: Holyhead, MH: Milford Haven, NY: Neyland, Pwll: Pwllheli, SW: Swansea, VD: Victoria Dock in two positions (I): Inner or (O): Outer through two orientation tiles H: Horizontal and V: Vertical at the end of two weeks (A) and eight weeks (B).

T. inopinata has more abundance in horizontal orientation in enclosed DG marina for both colonization periods. As colonization period increases, the distribution of *T. inopinata* has horizontally increased in the enclosed NY marina and vertically in the enclosed SW marina although their abundance has decreased both within and enclosed other marinas. Even so, these invasive non-native species have preferred to distribute vertically outside marinas (Figures 11A and 11B).

According to Cochran's test results, the eight-week data had heterogeneous variance (P>0.05). After log transforming, the result of Cochran's test did not change. This shows a significant difference in the abundance of T. inopinata among marinas [F (7,128) =16.82, P-value<0.001]. There was also a significant interaction between marina and position [F (7,128) =3.13, P-value<0.05], meaning the effect of position varies among marinas. SNK exploration of this interaction shows that there were some differences between positions, but the direction of difference was not consistent (Figure 11B, Table 7).

Table 6

The Results of Three-Way Mixed Model ANOVA Show Differences in Bugula neritina Abundance among Responsible Variables (Level of Significance P-Value<0.05)

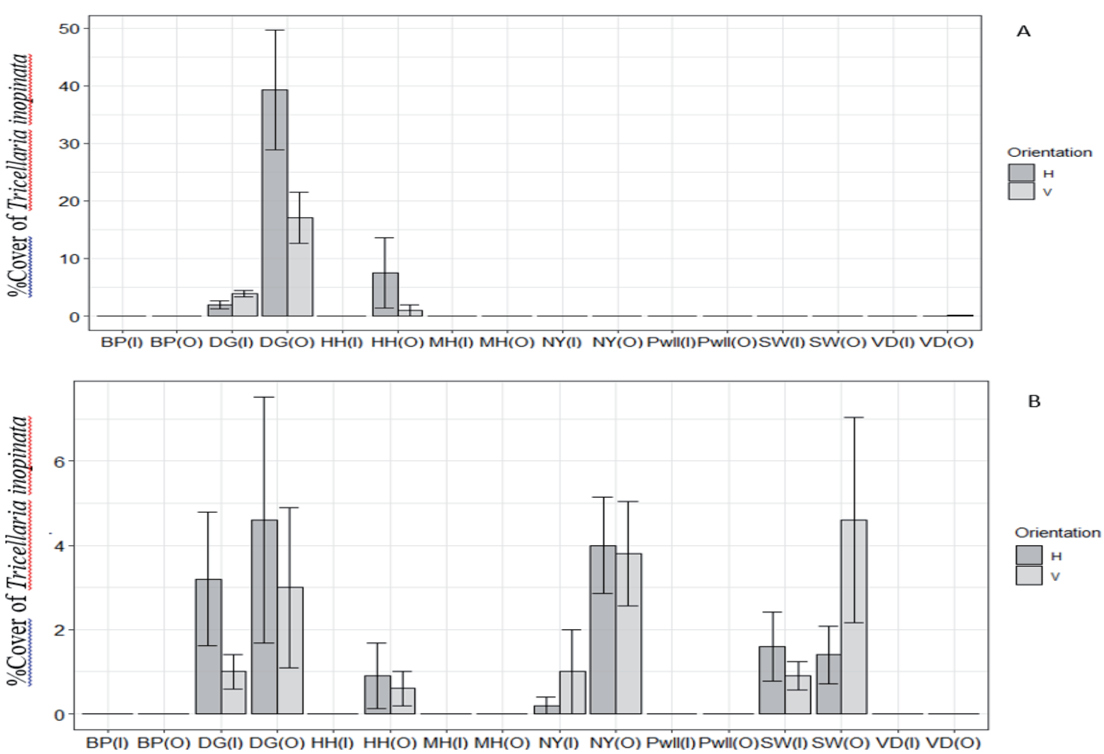
Source	df	Mean Squares (MS)	F-value	P-value
Marina	7	361.0389	73.51	0.0000
Position	1	0.6725	0.34	0.5796
Orientation	1	0.8140	0.37	0.8972
Marina*Position	7	1.9935	0.41	0.7297
Marina*Orientation	7	2.2203	0.45	0.8672
Position*Orientation	1	1.9203	0.50	0.5017
Marina*Position*Orientation	7	3.8280	0.78	0.6057
RES	128	4.9114		
TOTAL	159			

For multivariate analysis, the results of community structure analysis undertaken using PRIMER and the PERMANOVA based on Bray-Curtis similarity for the abundance of dominant species is shown through three responsible factors (Marina-random, Position-fixed, Orientation–fixed) (Table 8), and the produced MDS are presented in Figure 12.

In Table 8, there is a significant effect of marina and significant interaction between marina and position (P<0.05). Then, MDS plots were created individually for each marina to explore significant interactions. These MDS plots demonstrate that there is a clear effect of position for some marinas (VD, BP, and NY). This effect is less clear through an examination of MDS's for orientation (Figure 12).

Figures 11A and 11B

The Percentage Cover of Tricellaria inopinata Abundance Collected from Eight Marinas in Two-Meter Depth



Note. BP: Burry Port, DG: Deganwy, HH: Holyhead, MH: Milford Haven, NY: Neyland, Pwll: Pwlheli, SW: Swansea, VD: Victoria Dock in two positions (I): Inner or (O): Outer through two orientation tiles H: Horizontal and V: Vertical at the end of two weeks (A) and eight weeks (B).

Table 7

The Results of Three-Way Mixed Model ANOVA Show Differences in Tricellaria inopinata Abundance among Responsible Variables (Level of Significance P-Value<0.05)

Source	df	Mean Squares (MS)	F-value	P-value
Marina	7	232.7167	16.82	0.0000
Position	1	153.1174	3.54	0.1019
Orientation	1	0.8928	0.08	0.7912
Marina*Position	7	43.2406	3.13	0.0044
Marina*Orientation	7	11.8000	0.85	0.5457
Position*Orientation	1	3.1887	0.43	0.5317
Marina*Position*Orientation	7	7.3684	0.53	0.8084
RES	128	13.8324		
TOTAL	159			

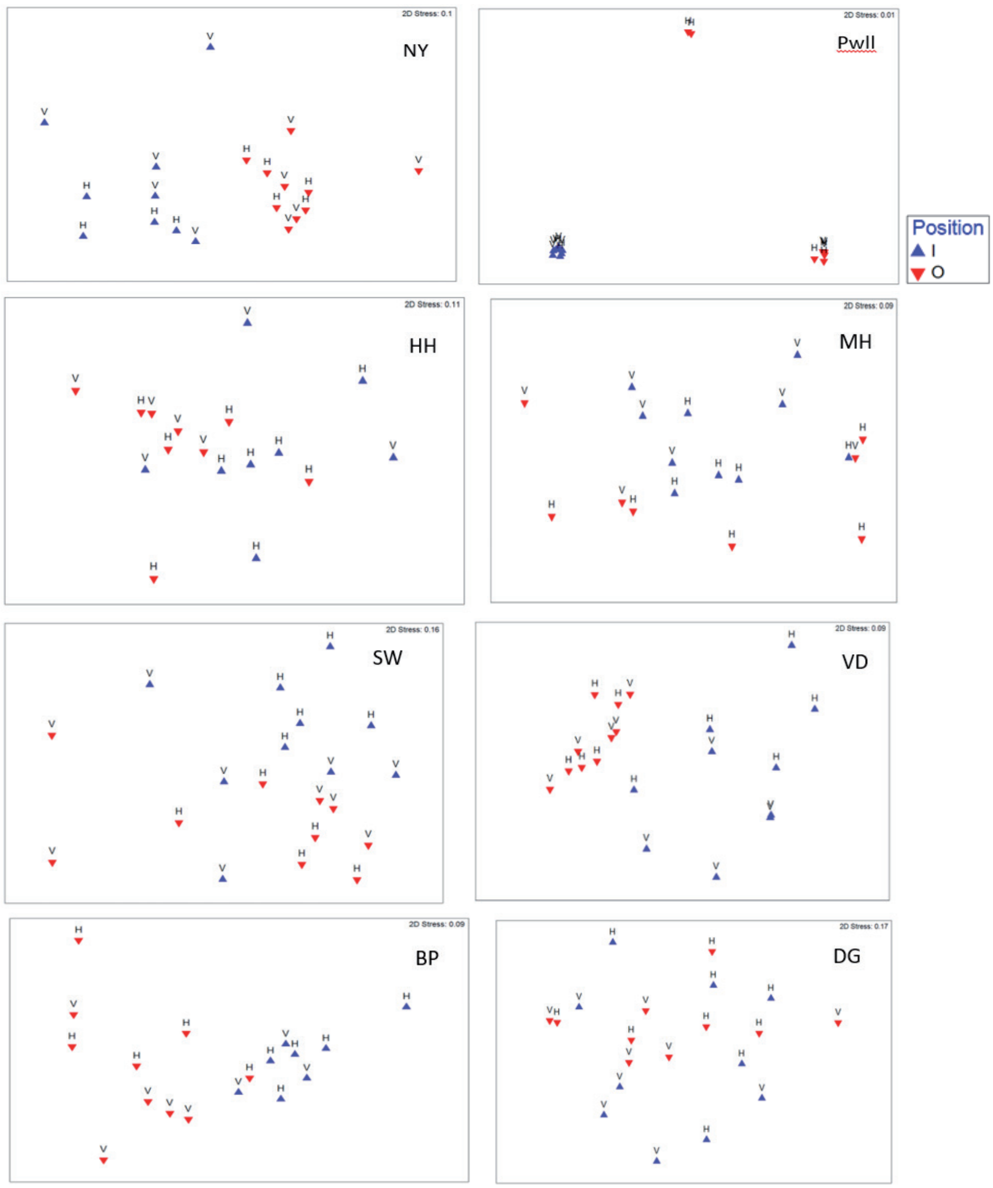
Table 8

PERMANOVA Table of Results

Source	df	Mean Squares (MS)	Pseudo-F	P(perm)
Marina	7	38557	42.262	0.001
Position	1	5989.6	0.85975	0.579
Orientation	1	872.91	0.72952	0.569
Marina*Position	7	6997.6	7.67	0.001
Marina*Orientation	7	1198	1.3131	0.099
Position*Orientation	1	686.42	0.68154	0.612
Marina*Position*Orientation	7	1007.6	1.1045	0.31
RES	120	912.33		
TOTAL	151			

Figure 12

The Significant Interaction Between Fixed Factors (Orientation and Position) and Random Factor (Marina) in Eight Marinas



Note. BP: Burry Port, DG: Deganwy, HH: Holyhead, MH: Milford Haven, NY: Neyland, Pwll: Pwlheli, SW: Swansea, VD: Victoria Dock, in two positions (I): Inner or (O): Outer through two orientation tiles H: Horizontal and V: Vertical at the end of eight weeks.

Discussion and Conclusion

How Do Invasive Non-Natives Distribute in the UK?

The Effects of Invasion

The clarification of invasive non-natives is a crucial pre-requisite step to addressing several fundamental questions in species invasion biology, such as: who are invaders? Where are they coming from? What are the effects they cause in the invaded habitats? (Zhan et al., 2015). This study has mentioned how the species number, their biological and physiological characteristics, and the quality of recipient environment have an important role in the introduction success, changing the propagule size and frequency. In addition, the distribution of invasive non-native or other species affects the other invasive non-native distribution, damaging the ecosystem because the species compete for space for food and habitat changes. However, novel substrates or attaching to other species protects invasive non-natives. Still, there can be stress factors like predators, depth levels, salinity and temperature concentration, tolerance capacity, and competitors.

The Effects of Environmental Factors

Researchers also observed that macro benthic populations exhibit spatial variations along a gradient of size. Arrighetti and Penchaszadeh (2010) proposed that sediment characteristics played a key role in the spatial dynamics of macro benthic assemblies. In this study, potential prospects for colonization of unstable ecosystems are different. The proportion of species have appeared in only a few stations such as VD, BP, and NY. Additionally, competition, predation, parasitism and symbiotic relations between macro benthos may also affect the spatial patterns of macro benthic assemblies. Recognizing major environmental variables that form the distribution of macro benthic assemblies is not an easy task, as they always vary between space and may represent various interactive factors (Lu, 2005). The relationship between the spatial patterns of the macro benthic assemblies and the environmental variables is directly linked to the type of data selected in local conditions (Arrighetti & Penchaszadeh, 2010).

How is The Invasive Non-Native Species Diversity Affected by Marina Characteristics?

The study found there was a significant difference in the abundance of five discriminating species among marinas. Invasive non-native species variations depend on some factors.

Firstly, a key factor is a closeness to the marina. In the marina, the closeness depends on the salinity range and in general marinas which are fully saline are subject to infrequent salinity excursions and harbour more invasive non-native species than brackish water sites or those subject to regular fluctuations e.g. in an estuary (Foster et al., 2016). Holyhead and Bury Port are marina sites, so are more susceptible to invasion more than Deganwy, Victoria Dock, Pwllheli Haven, and Swansea which are brackish water sites. Neyland is both a marina and brackish water site (Wood et al., 2015).

Secondly, the bigger marinas increase the risk of invasion by spreading locally, nationally and internationally, so they have high numbers of invasive non-native species, and are easily accessible (Foster et al., 2016). In this study, the number of invasive non-natives was the highest in Holyhead marina, likely a consequence of its large size and high boat traffic (Wood et al., 2015).

Thirdly, there is the factor of larval retention within more enclosed marinas which may lead to larger populations of NIS (Wood et al., 2015). Larval dispersal and recruitment are likely to occur when water temperatures increase and may result in the spread of invasive non-natives from the marina into the wider harbour area (Arenas et al., 2006). As the temperature decreases, metabolic activity decreases (Kaldy et al., 2015). Thus, as the water temperature increases, the development of species increases. This allows upper intertidal colonization and cold stratification, and increased metabolic activity that may have a significant impact on the species colonization ability (Kaldy et al., 2015). For example, the temperature range in Holyhead Marina is between 5°C and 22°C throughout the year, so it is expected that regressed colonies increase in size during the spring and summer when water temperatures reach above 8–12°C and become favourable for asexual growth. The presence of invasive non-native species in Holyhead Marina and their absence in the wider harbour area suggests that they were introduced into the region on the hulls of one or more infected recreational vessels (Arenas et al., 2006b). SM and VD are superabundant and there is a severe fouling nuisance on yacht hulls, pontoons and ropes (Wood et al., 2015).

In this study, there were significant interactions between marina and position for *A. modestus* and *T. inopinata* and significant interactions between marina and position as well as orientation effect for *C. intestinalis*. *A. modestus* is the most frequently recorded species from marinas around the UK, especially in habitats subjected to fluctuating salinity. *T. inopinata* is a frequently recorded species on primary hard substrates (Wood et al., 2015). *C. intestinalis* grows in the shallower depths (Bishop et al., 2015). According to Darling et al. (2018), through BWE, the diversity of open ocean species increase, resulting in an overall change in population composition. While in many cases this leads to dramatic declines in propagule pressure at recipient ports, several studies have suggested that the efficacy can vary widely depending on the vessel's route, travel duration, biotic composition, and environmental conditions (Darling et al., 2018). In this case, fouling rates change widely between environments, being strongly affected by factors such as local productivity, and the structure and nature of available habitats (Johnson & Shanks, 2003).

Another factor is depth. Shallow water sites may dry out during low tides. Deeper waters can provide refuges from low salinity events, as when the waters are often highly stratified with the freshwater forming a surface layer over a higher-salinity lower base layer (Wood et al., 2015). This means that narrow areas with low salinity have more niche availability because of the freshwater effect, so invasive non-natives are more vulnerable to colonization in shallow areas (Afonso et al., 2020). These species may survive at depth on ropes, chains and pilings and then recolonize rapidly on surface structures at a later date (Wood et al., 2015). In this study, Holyhead, Swansea, and Milford Haven marinas have more invasive non-native species abundance because of the increasing temperature fluctuations with depth. Especially in Swansea Marina, there was a significant interaction between marina and orientation for *B. violaceus*. The depth also affects artificial light presence. Dafforn et al. (2009) stated that marine vessels lead to biological effects of artificial light in marine ecosystems because of decreasing light with depth. Another factor is contaminant concentration. Marina vessels increase contaminants as well as the recruitment of species (Johnson & Shanks, 2003).

In terms of the depth levels, freshwater layers can persist on the surface after heavy rainfall, which is an advantage for *B. neritina* during settlement and transport on a boat and contributes to the spread of invaders on the hulls of ships (Dafforn et al., 2009). In this study, there was no significant interaction between marina and position as well as orientation effect for *B. neritina*. According to Jagerbrand et al. (2019), this outcome can also arise because of unsuitable habitats to invade a marina. In a previous study by Ulman et al. (2019a), it was stated that most invasive non-natives do not invade artificial habitats in the marinas when the surrounding habitats are not suitable for colonization due to limited circulation and/or larval scattering regimes. The high invasion success has been reported in disturbed ecosystems and communities with low species diversity because these disturbed habitats have high and frequent inputs of invasive non-natives in harbours and marinas. This integration increases the invasion success, and thus the colonization risk increases in the established communitie (Riera et al., 2018). In contrast, in polluted marine habitats, propagule pressure restricts invasive non-native settlement compared to other parameters such as abiotic factors (pollutants) or environmental disturbance, so it is interesting to note that under natural conditions, these disturbed habitats and propagule pressures are often related to each other in terms of invasive non-native diversity (Riera et al., 2018).

Overall, the number of NIS per marina varies among marinas in the UK, especially with marinas situated on the south coast of England where there is the greatest NIS number. The research field has a major spatial variability owing to geological, hydrodynamic, and anthropogenic practices. Biotic variables should be viewed in the sense of macro benthic distribution studies. Relationships between the spatial attempts of macro benthic assemblages and the environmental variables of biological parameters need to be considered in certain ways, such that the relationships have proved to shape the distribution of macro benthic abundance, complexity and multivariate composition of assemblages. In this survey, the settlement panels were used for the detection and monitoring of invasive non-natives. This method can be a major problem because identifying many of the species is difficult before they are fully developed and it is challenging to distinguish the invasive non-native species from other, often closely related, native species. Therefore, it is recommended that this method should not be used to collect samples in future surveys.

Acknowledgement

First of all, this article has been compiled from my master's thesis that I wrote at Bangor University in England. Since the field studies were cancelled due to the Covid 19 pandemic, I should state that, samples containing the ten invasive non-native species mentioned in the article were collected during the field studies of Prof. Stuart JENKINS's team in previous years, but the statistics were studied by me for the first time.

I am very thankful Prof. Stuart JENKINS, who has encouraged and supported me throughout both my data analysis and writing process during the Covid 19 pandemic. I extend this thanks to Turkish Republic, Ministry of National Education who granted me an official scholarship opportunity for my master's degree at Bangor University School of Ocean Science. Finally, I thank my mother Fatma, my father Hasan, my brother Hüseyin KOCAMAN and my friend Wint HTE, who brightened my days with their supports.

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Extended Turkish Abstract
(Genişletilmiş Türkçe Özet)

Marina Özelliklerinin İstilacı Yerli Olmayan Türlerin Kolonileşmesi Üzerindeki Etkisi

Deniz ortamında, yerli olmayan türlerin oldukça hızlı gerçekleşen dağılım oranları mevcut diğer türlere göre farklılık gösterir. Bu nedenle, genellikle bazı yerli olmayan türler, hakimiyet anlamına gelen 'istilacı yerli olmayan tür' olarak adlandırılır. Başka bir ifade ile; istilacı yerli olmayan türler önceki doğal dağılımlarının dışında bir alana tanıtılan ve yeni yerleşim ortamları üzerinde olumsuz çevresel, ekonomik veya sosyal etkisi olan türlerdir. Marinalar, çeşitli ve karmaşık doğal ekosistemlere sahip olmalarının yanı sıra, deniz sistemleri arasında güçlü bir bağlantı noktası sunar. Bu durumda, marinaların özellikleri, istilacı yerli olmayan türlerin dağılımları üzerindeki etkisini belirler. Ayrıca, marinalarda tuzluluk aralığı, gelgit dalgalanmaları, derinlik, ve ascidan varlığı gibi faktörler de istilacı yerli olmayan türlerin dağılımını etkiler. Bununla birlikte, taşıma vektörleri, su ürünleri yetiştiriciliği ve balıkçılık uygulamaları da tür istilası sürecinde istilacı yerli olmayan türlerin dağılımında önemli bir role sahiptir.

İstilacı yerli olmayan türler, rekabet, avlanma, çevresel faktörler gibi etmenlerle yerli türler üzerinde olumsuz bir etkiye sahip olabileceğinden, dünya okyanusları için önemli bir tehdit oluşturur. İstilacı yerli olmayan türlerin toplulukları, tanıtıldıkları alanlara göre kendi alanlarında strese daha az toleranslıdır. Bununla birlikte, habitatlarındaki artan biyolojik kirlilik karmaşıklığı, uygun habitatlar, yiyecek ve korunaklı niş alanları sunduğundan ek türlerin girmesine izin verebilir. Fakat, kolonizasyon için yeterli çevresel niş mevcudiyeti yoksa ve avcılar ve rakipler gibi daha büyük biyolojik direnç varsa, istilacı yerli olmayan türlerin istila ettiği ortamda kurulması, ikincil dağıtım ve kolonizasyonu mümkün olmayabilir.

İstilaların büyük çoğunluğu deniz trafiğinden, istilacı yerli olmayan türlerin gemi gövdelerinde taşınmasından ve bölgeye salınan balast sularından kaynaklanır. Balast suyunun, öncelikle serbest yüzen larvaların sınırlı hayatta kalma süresi nedeniyle, uzaktan dağılım için anahtar vektör olduğu anlaşılmasada balast tanklarındaki toprak, zemin ve/veya iç yüzeyler istilacı yerli olmayan türleri dağıtabilir. Bununla birlikte, balast suyu, aracılık ettiği istila riskini azaltmak için geliştirilmiş küresel girişimlere rağmen, istilacı yerli olmayan sucul türlerin girişlerinin güçlü bir vektörü olmaya devam ederek istilacı yerli olmayan türlerin istila sürecinde önemli role sahiptir. Sıcaklık gibi çevresel faktörlerde istilacı türlerin dağılımında önemli rol oynar. Su sıcaklığının artışı istilacı yabancı türlerin sayısını artırarak türün metabolik aktivitesininde artmasına sebep olarak , o türün tür kolonileşme yeteniği üzerinde önemli bir etkiye sahip olur.

Bu çalışmada, saha araştırmalarına ve mevcut literatüre dayanarak, Galler'deki toplam on istilacı yerli olmayan türden; beş istilacı yerli olmayan türün [*Styela clava* (Herdman, 1882), *Didemnum vexillum* (Kott, 2002), *Caprella mutica* (Schrin, 1935), *Crepidula fornicata* (Linnaeus, 1758), *Watersipora subtorquata* (d'Orbigny, 1852)] dağılımı ve ekolojisi, ayrıca diğer beş istilacı yerli olmayan türün [*Austrominius modestus* (Darwin, 1854), *Ciona intestinalis* (Linnaeus, 1767), *Botrylloides violaceus* (Oka, 1927), *Tricellaria inopinata* (D'Hondt & Ambrogi, 1985), *Bugula neritina* (Linnaeus, 1758)] kolonileşmesi üzerinde marina karakterlerinin etkileri araştırılmıştır. Marinalardaki karektarizasyon belirli alanları istilaya karşı savunmasız bırakarak istilacı yerli olmayan türlerin bu alanlarda kolonileşmesine yol açar. Buna bağlı olarak; çalışma alanı herbir marinaya iki farklı konumda olacak şekilde marina girişi ve marina dışı levha olmak üzere yerleştirilmiştir. Bu levhaların yarısı iki haftada (çok erken kolonizasyon) ve yarısı sekiz haftada (sonraki kolonizasyon) olmak üzere her alana eşit sayıda dikey ve yatay olarak konuşlandırılmıştır.

Çalışmanın birincil amacı, Birleşik Krallık'taki önemli istilacı yerli olmayan türlerin ekolojisini ve dağılımını araştırmak ve marina özelliklerinin Galler kıyılarındaki istilacı yerli olmayan türlerin çeşitliliğini nasıl etkilediğini göstermektir. Bu çalışmadaki kilit faktörler bu nedenle marina karakterleri; marina içi veya dışında levhanın konumu; ve kolonizasyon dönemidir. Bu çalışma, yerli olmayan tür çeşitliliğini ve bolluğunu nasıl etkilediklerini analiz etmek için bu faktörlerin her birini değerlendirip, istilacı yerli olmayan tür çeşitliliğinin marina büyüklüğü ile artığını, marina girişlerine kıyasla marinanın kapalı alanlarında istilacı yerli olmayan tür çeşitliliğinin daha fazla olduğunu, istilacı yerli olmayan tür çeşitliliğinin, yatay olarak yönlendirilmiş yüzeylerde dikeyden daha fazla olduğu yönündeki hipotezleri elde edilen veriler doğrultusunda çeşitli istatistik progamlar kullanılarak belirlemeyi hedeflemiştir.

Elde edilen verilere göre; en büyük marinada tekne trafiğinin fazla olması nedeniyle yerli olmayan tür çeşitliliğinin en fazla bu marinada olduğu, konum ve oryantasyonun etkisinin marinalar arasında değiştiği, ancak bazı istilacı yerli olmayan türlerin bolluğunda marina içi ve dışı arasındaki farkta tutarlılık olmadığı belirlenmiştir. Ayrıca, kolonizasyon süresi arttıkça, istilacı yerli olmayan türlerin kapalı marinaların bazılarında dikey, bazı marina girişlerinde ise yatay olarak dağılım yapmayı tercih ettiği belirlenmiştir. Nihayetinde, istilacı yerli olmayan türlerin diğer türlerden ya da yakın ilişkili olduğu yerel türlerden ayırt edilmesinin zor olması, veri eksikliği, deniz ekosistemindeki varyasyonların sürekli değişkenlik göstermesi ya da kullanılan metodların bazı türlerin araştırma zamanında tanımlanması için uygun olmayışı elde edilen çıktıların yorumlanmasını zorlaştırabilir. Fakat, ileride yapılacak çalışmalarda bu kriterlere daha dikkat edilmesi, farklı metodların kullanılması elde edilecek çıktıların daha güvenilir olmasını sağlayacaktır. Ayrıca, bu çalışmanın yorumlanması aşamasında Covid 19 pandemisinin saha çalışmalarını etkilemiş olması ve kullanılan verilerin mümkün olduğunca en güncellerinin kullanılmaya çalışılması, istatistik çalışmaları için kütüphane ve program bulmada sıkıntı yaşanması, yinede bu durumun mümkün olduğunca tolere edilmiş olmasıda göz önünde bulundurulmalıdır.