MARINE INVADERS . 04 July 2018
assessment and impacts on aquatic ecosystems

Escola Superior de Turismo e Tecnologia do Mar . Peniche . Portugal
special session included in the International Meeting on Marine Research 2018 . 4 - 6 July 2018

Book of Abstracts
Invasive species are recognized worldwide as great threats to natural communities and seriously compromising the ecosystem services, while sometimes representing useful resources if duly valued. By exploring the knowledge on these species, understanding their dynamics, and predicting their behaviour, eventual prevention and mitigation measures might be addressed to control the presence and abundance of some non-indigenous species (NIS).

The session "MARINE INVADERS - assessment and impact on aquatic ecosystems", included in the “International Meeting on Marine Research” (IMMR' 18), held at the Polytechnic of Leiria at the 4th of July 2018 at Peniche, Portugal, is therefore, an excellent opportunity to gather scientists investigating NIS, exchanging experiences on the state-of-the-art of one of the most hot and trendy issues on global changes.

This session aimed to bring into discussion the last findings concerning the latest technics used on the detection of this kind of biological pollution, but also on the quantification, the determination of the specific cellular compounds these NIS are rich in and its economic applicability, but also searching for innovative methods used to measure the negative and positive impact of invasive species on the recipient environment (e.g., competition for space, interference on ecosystems food web, new resource item). This problem, being global, having no borders, and presently in an escalating stage, represents a paramount issue threatening global ecosystems and economies with increasing information and researchers working on the topic.

We expect MARINE INVADERS to be a great forum and an opportunity to discuss these topics, reinforcing and widening the dissemination of researcher's findings over the meeting’s audience, while also providing the chance to further publish in a special issue of Ecological Indicators Journal, being prepared by the guest editors chairing this session.

Chairs
João M. Neto
Marco F.L. Lemos
Sara C. Novais
:: Wednesday 4th July 2018 ::

11.00 | Registration for Participants

13.30 | Welcome Coffee

13.45 | Welcome Address

14.00 | ORAL PRESENTATIONS (chairs: João Neto & Celia Olabarria)

- **14.00**: Are Marine Protected Areas a good tool against invasions? // Andreu Blanco, João M. Neto, Jesús Troncoso, Leonel Pereira, Marco F.L. Lemos & Celia Olabarria
- **14.15**: Grazing preferences on native and non-native macroalgae // André C. Cardoso, João N. Franco, Isabel Sousa-Pinto & Francisco Arenas
- **14.30**: Assessment of the colonization and dispersal success of non-indigenous species introduced in recreational marinas // Inês Afonso, Estibaliz Berecibar, Nuno Castro, José Lino Costa, Paulo Fria, Pedro Moreira, Pedro Oliveira, Filipe Henriques, Gilda Silva & Paula Chainho
- **14.45**: Saltmarsh evolution after restoration of an invasive plant-dominated estuary: what leads to failure or success? // Cristina Galván, María Recio, Araceli Puente & José A. Juanes
- **15.00**: Spatial distribution, abundance and diversity of non-indigenous species in two portuguese estuarine systems // Sara Cabral, Frederico Carvalho, Miguel Gaspar, João Ramajal, Érica Sá, Cátia Santos, Gilda Silva, António Sousa, José Lino Costa & Paula Chainho
- **15.15**: Interactive effects of the introduced seaweed Gracilaria vermiculophylla and other anthropogenic stressors on the seagrass, Zostera noltei // Vieira R, Engelen AH, Thomsen MS & Francisco Arenas

15.30 | COFFEE-BREAK + POSTER SESSION

**POSTER CORNER**

**Poster 1**: Distribution of invasive Magallana (Crassostrea) gigas and native Ostrea edulis oysters in natural habitats of the Northern Adriatic Sea // Nika Stagličić, Tanja Šegvić Bubić, Leon Grubišić, Dubravka Bojanić Varezić, Daria Ezgeta-Balić

**Poster 2**: Where do invaders fit in a coastal food web? - an isotopic approach // Catarina Vinagre, Vanessa Mendonça, Rodrigo Silva, Augusto A.V. Flores, Alexandra Baeta, João C. Marques
Poster 3 :: The effects of invasive Asparagopsis armata on macroalgae assemblages: evidences from rock pools manipulation // Carla O. Silva, João M. Neto, Rui Gaspar, Sara C. Novais & Marco F.L. Lemos

Poster 4 :: Feeding habits of the invasive Magallana gigas and native Ostrea edulis oysters in the Adriatic Sea – are they in competition? // Daria Ezgeta-Balić, Tanja Šegvić Bubić, Iva Žužul, Dubravka Bojanić Varezić, Nika Staglić, Melita Peharda & Ivana Mandić

16.15 | ORAL PRESENTATIONS (chair: João Neto & Celia Olabarria)

- 16.15 :: The influence of waves and currents on growth rates of native and invasive marine bivalves // Patrick Joyce, Louise Kregting & Jaimie Dick
- 16.30 :: Developmental performance of ascidian populations to an extreme warming event // Elizabeth Morgan, Gaston Alurralde & Tiago Repolho
- 17.00 :: Not all marshes are invaded equally: Population contamination history conditions its feedback towards climate change // Bernardo Duarte, João A. Carreiras, Jésus A. Pérez-Romero, Enrique Mateos-Naranjo, Susana Redondo-Goméz, João Carlos Marques & Isabel Caçador
- 17.15 :: Environmental DNA for detection of species causing harmful algal blooms // Marcos Suárez, Serge Planes, Eva García-Vázquez & Alba Ardura
- 17.30 :: Analysis of seedling development of invasive species Baccharis halimifolia using an experimental approach // Felipe Calleja, Bárbara Ondiviela & José Antonio Juanes
- 17.45 :: Use of explanatory and predictive models to assess and manage the establishment of the Manila clam in Portuguese estuarine systems // Frederico Carvalho, Miguel Gaspar, João Ramajal, João Paulo Medeiros, José Lino Costa, Paula Moura, Paulo Vasconcelos & Paula Chainho

18.00 | PENICHE OF HONOUR - FAREWELL DRINK

Note: The underlined authors indicate the presenting author
Abstracts
Are Marine Protected Areas a good tool against invasions?

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Marine macroalgae are a significant component of introduced non-indigenous species and pose a major threat to marine ecosystems with significant negative ecological impacts. As a result, several contingency plans and strong worldwide policies have been proposed in order to prevent the dispersal of non-indigenous marine species, including macroalgae. Marine Protected Areas (MPAs) are conservation tools aiming to ensure resilience and conservation of marine biodiversity. Therefore, in agreement with the ‘Biotic Resistance Hypothesis’, MPAs, by enhancing biological biodiversity, should restrain the spread and introduction of non-indigenous species. However, the role of MPAs in controlling biological invasion is still poorly understood. In this context, we studied the effects of protection and wave-exposure in controlling the invasion success of six macroalgae (Grateloupia turuturu, Asparagopsis armata, Colpomenia peregrina, Sargassum muticum, Undaria pinnatifida, and Codium fragile ssp. fragile) at two MPAs of the western Iberian Peninsula, Illas Atlánticas National Park (Spain) and Berlengas Marine Reserve (Portugal). Among the invasive species studied, A. armata was the most widespread in both Spain and Portugal. The results showed that protection, wave-exposure and Simpson’s diversity index showed opposite effects on the invasiveness of the target species in the two MPAs. In addition, biomass of invasive macroalgae showed opposite trends as it was greater outside the MPA in Spain and greater inside the MPA in Portugal, whereas the wave-exposure performed similarly in both MPAs. Such differences between MPAs suggest that management plans should be addressed at a local scale in order to ensure their conservation goals.
Grazing preferences on native and non-native macroalgae

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Herbivory plays a major role in shaping community dynamics across marine, freshwater, and terrestrial habitats. Grazing exerts a strong control on patterns of abundance, distribution and dynamics of primary producers, including macroalgae. In the context of biological invasions, the proliferation of non-native seaweeds have been often attributed to limited grazing by native herbivores on introduced species (“Enemy Release Hypothesis”, ERH). In our study, we used manipulative experiments to assess food preferences by a very abundant grazer on native and non-native seaweed species present in northwest coast of Iberia. Specifically, we determined the preferences of the sea urchin Paracentrotus lividus on brown seaweeds i.e. Laminaria ochroleuca, Saccorhiza polyschides and the non-native Undaria pinnatifida and red seaweeds i.e. Chondrus crispus, Mastocarpus stellatus and the non-native Grateloupia turuturu. For each group of the species, biomass consumption and preference was examined. In parallel, the nutritional (organic carbon and nitrogen) and chemical (polyphenolic content) features were also analysed and its effects on consumption and preference by P. lividus were examined. Herbivore food preferences, as demonstrated in laboratory feeding experiments, are helpful in predicting which species are most likely to be consumed in the field and consequently which species are likely to persist. Despite the high variability of seaweed consumption by the P. lividus, results suggest preference of native over invasive seaweeds. The results suggest that non-native seaweeds when compared with native species might not be under significant herbivory pressure leading to a lower biotic control, at least in the case of sea urchin herbivory at the region of study.
Assessment of the colonization and dispersal success of non-indigenous species introduced in recreational marinas

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The introduction of non indigenous species (NIS) is considered as one of the main causes associated with biodiversity loss. In the last decades the number of NIS has increased significantly, emphasizing the need to know and manage the processes of biological invasions. Since fouling is one of the main NIS introduction vectors, recreational marinas are points of entry of potential colonizers and are described as "sheltered-islands" and/or stepping-stones for the spread of these species. The main objectives of this work were i) to assess the distribution patterns of the fouling communities located at recreational marinas along the estuarine gradient of the Tagus estuary, ii) to identify the relationship between the number of NIS and local environmental conditions and iii) to evaluate NIS dispersion ability. The number and abundance of fouling communities was assessed at four different recreational marinas located along the Tagus estuary haline gradient and in neighbouring hard substrate areas. The native communities of the recreational marinas showed a spatial gradient consistent with the haline gradient, with a higher similarity between marinas with higher marine influence. 14 different NIS species were identified at the marinas but no NIS occurred at Vila Franca de Xira marina, located in the upstream area of the estuary (higher freshwater influence). Although NIS distribution pattern reflected, in some extent, the haline gradient, there was a lower heterogeneity between locations, evidencing a greater tolerance of NIS to a wider range of environmental conditions. A total of 9 of the NIS identified in the recreational marinas were also found in the neighboring areas, thus confirming the dispersal ability of these species. NIS that were able to disperse outside the recreational marinas have planktonic larval stages and higher environmental tolerance, which seems to have contributed to the successful spread. These results emphasize the importance of monitoring NIS occurrence in recreational marinas, in order to have an early warning on the arrival of species with higher invasion risks and to prevent its dispersal to sensitive ecosystems.
Saltmarsh evolution after restoration of an invasive plant-dominated estuary: what leads to failure or success?

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For decades, the accumulation of anthropogenic pressures on estuaries have altered their ecosystem structure and functioning around the world. In this context, Baccharis halimifolia, taking opportunistic advantage of habitat alteration, is aggressively invading saltmarshes along the European coast. This invasive alien species is one of the leading direct causes of biodiversity loss in estuaries. Mitigating native species decline, when interactive effects are operating, requires the implementation of appropriate management strategies. The Oyambre estuary (Northern Spain) is a good site to test apart the relative importance of restoration treatments for habitat disturbance and invasion on native species recovering. Two restoration strategies, that is, active management of invasive species (i.e., mechanical removal) combined or not with active restoration that involves removal of flow barriers (i.e., dike), were implemented in different sectors of the estuary in order to promote growth of native marsh vegetation and prevent colonization by invasive species. In this study, we explored the short and long-term changes in vegetation trajectories after restoration. The ecological monitoring of the saltmarsh evolution revealed that mechanical elimination of B. halimifolia in a disturbed habitat was not an effective treatment to restore the native plant communities at a medium term. In a period of five years, the invasive alien species recolonized the managed area. On the other hand, the combination of habitat recovering and mechanical removing of invasive species resulted in persistent and self-sustaining structural and compositional shifts, significantly lower invasive species abundance, a more complex saltmarsh structure and greater native vegetation recruitment. The salinity increased after restoring the tidal flow, hindering the re-growth of B. halimifolia in the estuary and allowing the spread of native saltmarsh species. Pioneer species colonized the sediment one year after the implementation of the restoration treatments, and they were gradually replaced by other successional native species. Five years after restoration, saltmarsh community reach a stable stage balanced with the surrounding native vegetation. These results highlight the need for a greater awareness of the interactions among multiple drivers of species loss in invasive plant-dominated estuaries.
Spatial distribution, abundance and diversity of non-indigenous species in two Portuguese estuarine systems

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The number of non-indigenous species (NIS) in estuaries and coastal areas increased in the last few decades due to globalization. Ballast water and fouling are considered major vectors of introduction of NIS, but aquaculture, and live bait importation are also relevant vectors. Most studies have assessed NIS on hard-substrates, including artificial structures but few quantitative data is available for soft sediments communities. This study was conducted in two major Portuguese estuarine systems, the Tagus and the Sado estuaries. Important shipping ports are located in both estuaries and an increase of activity in the aquaculture sector has been observed in the Sado estuary in the last ten years. The major objectives of this study were i) to compare the overall contribution of NIS to soft-sediment invertebrate species composition, abundance and distribution, ii) to understand if there are different invasion patterns along the estuarine gradient and iii) to identify temporal trends of biological invasions. Sampling was conducted in 2014 and 2015 in the Tagus estuary and in 2015 in the Sado estuary. Sampling locations were randomly chosen in order to assess different habitats types along the subtidal estuarine gradient. A bottom trawl net was used to collect the benthic communities and water and sediment parameters were measured at each sampling location. A total of 41 and 53 species were identified at the Tagus estuary, respectively in 2014 and 2015 and 48 species were identified at the Sado estuary in 2015. Two NIS species were identified at the Tagus estuary in 2014, accounting for more than 37% of the total abundance, while in 2015 there were 5 NIS species collected at this estuary, accounting for 26% of the total invertebrate abundance. Two NIS species were identified at the Sado estuary, accounting for nearly 4% of the total invertebrate abundance. A higher diversity and abundance of NIS was recorded in the intermediate area of both estuaries and *Ruditapes philippinarum* was the most abundant NIS in both systems, irrespectively of the year. The number and abundance of NIS found in the Tagus estuary increased significantly between years, indicating a higher risk associated with biological invasions. Moreover, although the level of invasion is still lower in the Sado estuary, the high pressure presented by different introduction vectors corroborates the implementation of continuous monitoring of NIS in these estuarine systems.
Interactive effects of the introduced seaweed *Gracilaria vermiculophylla* and other anthropogenic stressors on the seagrass, *Zostera noltei*

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Coastal ecosystems are subjected to multiple anthropogenic stressors which usually do not operate independently but rather interact to produce combined impacts on the structure and functioning of biological communities. In particular, seagrass meadows are among the most rapidly declining coastal habitats on Earth. Both increased turbidity and nutrient loading, i.e., eutrophication, are claimed to be associated with this decline. Additionally, blooming seaweeds have increasingly been implicated in the decline of seagrass beds, mainly where eutrophication is high or where invasive seaweeds have been introduced. To evaluate the simultaneous impact of stressors on the seagrass beds of *Zostera noltei* we carried out a factorial experiment at the Ria de Aveiro lagoon. The aim of this study was to examine the possible interactive effects among three anthropogenic related stressors: nutrient, sediment and the invasive seaweed *Gracilaria vermiculophylla* enrichment on *Zostera noltei* beds. Our results demonstrate that seagrass in estuarine system may be affected jointly by the presence of biological and physical stressors with unpredictable overall effects. When considering total *Zostera* biomass, the presence of the invasive *Gracilaria vermiculophylla* impacted the seagrass beds only at the highest invasion level. Sediment addition effects were more intense under ambient nutrient conditions. Most importantly, the highly abundant grazer *Peringia ulvae* seemed to mediate impacts on seagrass beds by the tested physical and biological stressors. In ecosystems, species interact and thus to forecast the effects of global or local stressors requires not only scrutinizing into vulnerability of single species to those stressors but also examining how interactions are modified. Particularly, consumer effects may lead disproportionate changes in assemblages. In conclusion, both direct and indirect effects should be always considered in order to fully understand the direction and intensity of the changes triggered by human activities.

Distribution of invasive *Magallana (Crassostrea) gigas* and native *Ostrea edulis* oysters in natural habitats of the Northern Adriatic Sea

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Oyster species are distributed worldwide in tropical and temperate waters and are predominantly coastal, occupying various types of hard substrate in the intertidal and/or shallow subtidal zones of enclosed, wave sheltered estuaries and bays. Lim Bay in the Croatian northern Adriatic provides such suitable habitat and is hence also one of the main shellfish aquaculture areas of the region. The native flat oyster, *Ostrea edulis*, is the only oyster species traditionally cultured in Croatia. Nevertheless, in natural habitats of Lim Bay and along the coastline of Istria peninsula, feral populations of the non-native *Magallana (Crassostrea) gigas* oysters have been recorded. At present it is unclear whether the introduction of *M. gigas* resulted from short-lived intentional aquaculture attempts in the Lim Bay in 1970s or via dispersion from neighbouring Italian coasts where *M. gigas* is cultivated commercially. Given the high invasion success of *M. gigas* the aim of this study is to investigate whether the native and non-native oysters are in competition for space in their natural habitats. The distribution and abundance of oysters was determined by in situ visual counts at 3 depth zones (surface, 3 m, 6 m) of 6 locations (2 within the Lim Bay, 2 on Istria coastline north and 2 on coastline south to the estuary). *O. edulis* mostly occurred as solitary specimens and density slightly increased with depth. *M. gigas* were found exclusively at the surface layer where it formed thick, dense clusters resulting in much higher densities compared to *O. edulis* in all locations (10.4±4.9 to 141.7±31.2 ind/m2 vs. 0.5±1.8 to 1.0±2.4 ind/m2) except to the north of estuary where the distribution and abundance of two species resembled (0.5±1.8 to 3.6±5.0 ind/m2 vs. 1.6±2.8 to 2.1±3.1 ind/m2). Interestingly, the coexistence of oyster species at surface was such that *M. gigas* were located always in the medio-littoral zone while all recorded *O. edulis* were below the low–tide line. There seems to be no overlap in depth distribution of the two oyster species, while their spatial distribution with higest densities of *M. gigas* within the bay and locations to the south might indicate the local introduction origin. However, to corroborate this, further studies on a larger spatial scale, as well as population genetic studies, are needed.

This study is the first quantitative assessment of *M. gigas* in the Adriatic and provides a base for monitoring changes in its distribution.
Where do invaders fit in a coastal food web? - an isotopic approach

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Increasing human connectivity has greatly facilitated the dispersal of marine invasive organisms, with multiple invasions occurring in some coastal areas. Knowledge on where invaders fit within a food web is essential for ecosystem management and to allow predictions on the future of such communities. It is also crucial to understand the local food web structure, trophic links and energy pathways. Isotopic analyses were applied to the tropical intertidal and subtidal rocky shores of Southeastern Brazil, with the aim of 1) describing the general food web structure, 2) estimating the trophic level of the invaders, and 3) their dependence on different energy pathways. In intertidal waters, two invasive crustaceans were found among the top consumers, the Japanese peppermint shrimp, *Lysmata lipkei* (TL=3.0), and the Indo-Pacific swimming crab, *Charybdis hellerii* (TL=2.3). Among the primary consumers, one invasive bivalve was found, *Isognomon bicolor*. In subtidal waters, invaded by the sun corals *Tubastrea* sp., another invading species was found, the mytilid *Leiosolenus aristatus*, both are primary consumers in a food web dominated by suspension feeders. Climate change models preview an important increase in precipitation for this area (+60%), which will probably favour an increase in the biomass of suspension-feeders, such as *I. bicolor*, *Tubastrea* sp and *L. aristatus*, which may in the future find the perfect conditions to proliferate further.
The effects of the invasive *Asparagopsis armata* on macroalgae assemblages: evidences from rock pools manipulation

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Biological invasions represent threats to ecosystems, through competition and habitat destruction. *Asparagopsis armata* is a red macroalgae (Rodophyta), globally recognized as an invasive species that induces significant changes into the invaded community. It is found from the intertidal to shallow subtidal areas, on rock or epiphytic, forming dense vegetation belts on exposed coasts. This study aims to evaluate the variation observed on intertidal seaweed assemblages inhabiting rock pools with and without the presence of the invasive macroalgae *A. armata*. To achieve this objective, manipulation experiments were done in rock pools in Peniche, Portugal (Praia da Areia Norte). Two biological samples were collected inside each selected pool by removing the inner material from a 0.1x0.1 m sampling square, randomly placed on the rocky surface, and immediately sorted for taxonomic identification and abundance quantification. Three rock pools were maintained without *A. armata* by manual removal of macroalgae. Three other rock pools were not manipulated during the study period and *A. armata* was freely present. In this work the variations between different rock pools were assessed. Results showed different patterns in the taxonomic composition of rock pools assemblages. From January to March, the general tendency was an increase on the number of species for pools without *A. armata*, and a decrease in pools with *A. armata*. Pools containing *A. armata* showed a more constant and conservative structure, with minor variation of its taxonomic composition than the pools from where *A. armata* was removed. The variability between samples was always higher for the last pools after the first macroalgae removals, with the presence of some species exclusively on pools without *A. armata*. Despite these first elucidative results, further data is needed to observe long-term patterns (full year of sampling) and to understand the effects of the invasive *A. armata* on native macroalgal assemblages.
Feeding habits of the invasive *Magallana gigas* and native *Ostrea edulis* oysters in the Adriatic Sea – are they in competition?

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In the eastern Adriatic Sea non-native invasive oyster *Magallana gigas* (Thunberg, 1793) started to spread and could present a threat to the native European flat oyster *Ostrea edulis* Linnaeus, 1758, especially in the aquaculture areas. Although, *M. gigas* is cultured in the Italian part of Adriatic, in the Croatian part it is not the case, and it is considered an invasive species. *Magallana gigas* is detected in the eastern Adriatic, but there is no information about its effect on the native oyster populations.

The main objective of this study was to explore food competition between the invasive and native oysters applying three different approaches: microscopically and molecular analysis of stomach content and analysis of stable isotopes. The study was conducted at the Lim Bay, bivalve aquaculture area where all production relies entirely on seed collected from nature. *Magallana gigas* individuals were put in the experimental aquaculture in the same area with *O. edulis*. Each month, 15 specimens of both species were collected, fixed with 70% ethanol and stomach content was isolated and examined under the microscope. Results confirmed that both species consume phytoplankton, zooplankton, and also considerable quantities of undetermined detritus. Ingested zooplankton taxa were mostly bivalve larvae, copepods, unidentified eggs and gastropod larvae. Stable isotope analysis will reveal detailed diet overlapping of native and invasive oysters.

As bivalve larvae were present in the *M. gigas* stomach, further analysis was performed to determinate if those are of *O. edulis*. Bivalve larvae were isolated from the water column and from the stomach of *M. gigas*, fixed in 96% ethanol and used for genetic analyses. Species-specific primers designed for *O. edulis* were used for cytochrome oxidase I (COI) partial region amplification. The obtained results genetically confirmed that adult *M. gigas* consumed larval stages of *O. edulis*. In order to analyse the effect of time after prey ingestion on species identification, *M. gigas* individuals were fed by *O. edulis* larva under controlled conditions. *M. gigas* stomach analysis was conducted at specified time-intervals (15, 30, 60 min, 1, 2, 6, 12, 48, 72 hours) after prey ingestion. Results showed that molecular signal of *O. edulis* larva was present in the stomach of *M. gigas* even after 72 h. Findings are discussed in the context of the possible effects that *M. gigas* introduction in the aquaculture could have on the *O. edulis* in this region.
The influence of waves and currents on growth rates of native and invasive marine bivalves

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The ecological impacts of invasive species can be severe and there is an ever-increasing number of invasions worldwide. Knowledge of how invasive marine species respond to changes in environmental contexts, such as hydrodynamic variability, are therefore key in predicting their spread and success. Animals that exist along coastlines are exposed to a range of hydrodynamic conditions, including waves and currents. Although water motion can be a key mediator of species distributions, there is little research investigating how these different forms of water motion can affect organisms. Here, a field study was conducted throughout an autumn and winter period to investigate growth and competitive interactions of the native mussel, Mytilus edulis, and invasive Pacific oyster, Magallana gigas, in four different hydrodynamic conditions (high wave, low wave, high current, low current). Throughout the study period, temperature was measured along with monthly samples assessing water chlorophyll, particulate matter and nutrients. In autumn, both species had higher growth rates in currents compared to waves and both species had highest growth rates at the low current site. Lowest growth for both species occurred at the low wave site. In winter, growth rates of both species were reduced compared to autumn and showed no differences among sites. Growth rates of both species were unaffected by the presence of each other at all sites. Environmental variables were similar among sites suggesting that differences in growth rates were due to hydrodynamic condition. Reduced growth rates in winter are likely linked to reduced temperature and chlorophyll. Here, although growth rates of native M. edulis were unaffected by the presence of M. gigas, the rapid growth of both species in current dominated areas may lead to space limited competition and are thus at a higher risk of ecological impacts caused by M. gigas. Quantifying responses of invasive species under environmental contexts, such as water motion, gives valuable information which may allow further predictions of their spread and success throughout ecosystems through the use of physical-biological coupled models.
Developmental performance of ascidian populations to an extreme warming event

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Coastal environments are increasingly experiencing an upsurge of anomalously high seawater temperature events, with unpredictable effects over marine biota. Marine heat wave episodes have been identified as a major climate change driver, which can prompt, to a more or less extent, detrimental outcomes to marine species. As a result of an increase in the frequency and timespan of short-term acute warming events, invasive species proliferation is expected to intensify, thus resulting in a loss of native biodiversity, within invaded ecosystems. Under this perspective, we investigated the effect of an acute temperature increase (simulating a marine heat wave), on the developmental performance of \textit{Ciona intestinalis} early life stages (ELS), derived from populations of anthropogenically-modified and undisturbed environments. Fertilisation rate, embryo and larvae development, settlement and metamorphosis success, and juvenile heart beat rate were assessed. With the exception for fertilization rate and heart beat rates, temperature had a significant overall effect over analysed endpoints. \textit{Ciona intestinalis} ELS, derived from undisturbed environments, were the most negatively affected by increased temperature conditions. Opposingl, anthropogenically impacted populations showed an overall consistency in their positive response to thermal stress. Interaction between temperature and population origin (i.e. anthropogenically impacted or undisturbed environments), was statistically significant for three of the ELS analysed endpoints, namely: embryo and larvae development, and metamorphosis. A higher proportion of larvae development and settlement success was observed under increased temperature conditions. Additionally, a higher metamorphosis success rate was observed in individuals exposed to increased temperature conditions, derived from populations from anthropogenically impacted locations. Considering heart beat rates, no differences were observed between sampled populations and experimental temperature conditions. Our findings suggest that future marine heat wave events, together with stress resilience attained by \textit{C. intestinalis} populations as a result of anthropogenic forcing exposure, could provide favourable breeding conditions towards their environmental proliferation, with unpredictable effects within invaded ecosystems.
Present and future invasion perspectives of an alien shrimp in South Atlantic coastal waters – a physiology assessment under ocean warming scenarios

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Climate change, particularly ocean warming, is thought to benefit the spread of invasive species due to their increased tolerance to temperature fluctuations when compared to native species. However, the physiological tolerance of invasive species as a potential mechanism driving invasion success has been overlooked. Here, we experimentally evaluated the physiological responses of a recent invader in the Southern Atlantic, the shrimp Lysmata lipkei, under a warming ocean scenario. Adult shrimps were collected from rocky shores in southeastern Brazil (the present study has the first records of this species for this area) and subjected to experimental trials under a control and a +3°C scenario temperature. Molecular biomarkers (in gills and muscle), upper thermal limits, acclimation response ratio, thermal safety margins, mortality, body condition and energy reserves were all measured throughout one month of experimental trials. Results suggest that higher temperatures elicit physiological adjustments at the molecular level, which underpin the high thermal tolerances here observed. Additionally, results show that this invasive shrimp has significant acclimation capacity, without negative performance consequences under an ocean warming scenario. Thermal safety margins were low for intertidal habitat but considerably high for subtidal habitat. We conclude that this shrimp possesses the ability to continue its invasion in subtropical waters of the Atlantic Ocean (mainly in subtidal habitats) both under present conditions and future climate warming scenarios.
Not all marshes are invaded equally: Population contamination history conditions its feedback towards climate change

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The invasion of exotic species to new environments are regulated by numerous abiotic restrictions, the same is applied to the distribution and survival of the native species when the forecasted climate change phenomenon alters the ecosystem abiotic settings. Halophyte species tolerance and resilience to new abiotic factors is meaningfully influenced by their pre-conditioning history. This reinforces the fact that plants, with a large abiotic tolerance spectrum, have an active physiological plasticity according to their environmental specificity. This represents an adaptation to the stresses present in their specific habitat, as a result of cross-tolerance, that will have significant effects in how plants’ mechanisms will act and respond to upcoming abiotic stresses, thus determining plant growth and development. Spartina patens is currently invading several marshes along the Portuguese Atlantic coast. This species competes for space and resources with the endemic flora, such as the mediterranean Halimione portulacoides. From our results show evident that halotolerance and thermotolerance of the previously studied plants that are clearly interconnected with their pre-conditioning, presenting an intraspecific physiological variation with significant ecological impact on the evolution of two neighboring salt marshes. Consequently, this key factor needs to be taken into account when modeling and predicting climate change scenarios on individual salt marshes. In order to understand the pre-conditioning influence on the invasion ecology was taken by researching metal induced cross-tolerance to thermal and saline stresses, relying on a multidisciplinary approach, considering both biochemical and biophysical responses and translating it to an ecological meaning. This can also be a tool useful to more efficiently manage appropriate conservation actions, highlighting the services of all salt marshes in order to be able to benefit from their unique and valuable resources in the future. Additionally, the heterogeneity between salt marsh habitats should also be protected to maintain intraspecific variability safeguarding a variety of physiological specializations that will, in some instances, result in an advantageous cross-tolerances.
In the past few decades the frequency and geographic distribution of harmful algal blooms (HABs) has increased worldwide. Dinoflagellates are responsible for many of such outbreaks. The accelerated eutrophication of coastal waters from human activities (e.g. agriculture, aquaculture and waste management) and unintentional introductions of dinoflagellates are some of the proposed reasons for the increased number of HABs. Cells and especially cysts of some dinoflagellates can be successfully transported in ballast tanks allowing the dispersion of different strains or new species to previously unaffected ecosystems. Algal blooms may produce toxins together with biomass development and decay, damaging marine ecosystems, human health, and economic activities around marine resources. The coastal lagoons within the Mediterranean Sea have a rich biodiversity, large human populations nearby, and support important economic activities such as aquaculture, fisheries and leisure activities. Several HABs have been reported there in the last years, mainly caused by species of the genera Alexandrium, Dinophysis and Karenia, among others. The objective of this study was the detection and identification of dinoflagellates that produce HABs in 10 Mediterranean coastal lagoons within the Gulf of Lion, analysing environmental samples as a source of DNA and employing molecular tools. Ballast water from different ships was also analyzed because it is a likely way of dinoflagellate dispersal. The results served to identify species potentially involved in HABs, and to recommend actions for management and control of their potential agents.
Alien species *Baccharis halimifolia* L. (Asteraceae) represents an environmental threat to European estuaries, as it displaces native species such as *Juncus maritimus* Lam. and transforms the estuarine substrate by raising its elevation and terrestrializing the otherwise muddy soil. The objective of this research is to analyze the germination and early development of *B. halimifolia* and *J. maritimus* under various conditions of water salinity, immersion time and presence of competing species, using a mesocosms experimental approach. Seeds were sown in soil cores of different heights, that were introduced inside plastic boxes with a varying inundation regime of saline water. The analyzed factors were salinity (0, 5, 18), immersion time (0, 20, 40% of the day immersed) and competition (competition, no competition). Half of the cores received seeds only of one species (50 seeds), whilst the other half received seeds from both the alien and the native species (25 seeds of each). All experimental units were located in a growth chamber with controlled lighting and temperature (photoperiod: 14 h, photon flux: 200 µmol/m2/s, 20ºC dark-25ºC light). The experiment was analyzed as a split plot design, with the salinity as the whole-plot factor, and immersion time and competition as the subplot factors. The cores inside the box were set in a completely randomized design. Differences between factors were tested using a mixed model ANOVA with the lmer package in R. The dependent variables were the survival percentage after 6 weeks since sowing, and the aboveground length of the seedlings at the end of the experiment. Survival percentage includes the germination, establishment and survival of the individuals by the end of the experimental period. Preliminary results show that for *B. Halimifolia* salinity and immersion have effect on both dependent variables. For *J. maritimus*, the immersion time seems to have the highest effect on the measured variables. Competition does not seem to significantly affect either species. The survival percentages of *B. halimifolia* are lower than the germination rates from previous experiments, where seeds were germinated in petri dishes with univariate designs, underlying the importance of multivariate mesocosms experiments for the adequate analysis of the early stages of vegetation development.
Use of explanatory and predictive models to assess and manage the establishment of the Manila clam in Portuguese estuarine systems

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The Manila clam (Ruditapes philippinarum) is native to Southeast Asia and it has been introduced in Europe in the early 1980’s. Its occurrence in Portugal has been registered in several estuarine systems and coastal lagoons since 1984. This bivalve is considered an invasive species due to its high capacity of dispersion and adaptation to new habitats. An exponential increase in abundance of this bivalve was observed after its introduction in the Tagus estuary, known since 2009. This increase led to a growth on the number of harvesters (legal and illegal) and a high fishing effort, due to its commercial value and high production. Therefore, the correct management of the harvesting demand requires a good knowledge on the establishment status and potential for spatial distribution expansion of this bivalve in the different colonized areas. This study aims to (i) determine which environmental variables better explain the distribution of this species in the Tagus estuary, using data collected in 2014 and 2015, (ii) elaborate a modeling function of the potential distribution and abundance of the Manila clam in the Sado estuary, and (iii) validate the predictive results with data collected in the Sado estuary in 2015. Sampling surveys conducted in the Tagus estuary showed that this species is the most abundant bivalve in this system, with a wide spatial distribution. A GLM (Generalized Linear Model) model was used to identify the explanatory variables, using the following variables as predictors: salinity, depth, temperature, dissolved oxygen, sediment grain size (phi mean value and sediment type), year, total organic matter and distance to river mouth. Modelling results indicate that depth and salinity are the environmental factors that better explain the occurrence of the Manila clam but temperature, salinity and year are the major explanatory variables for this bivalve abundance. This function was used to predict the potential spatial distribution of this species in the Sado estuary. The comparison between predicted areas and real distribution data collected in the Sado estuary indicated that there is potential for a spatial distribution expansion of this population, which showed a smaller distribution and abundance than the Tagus estuary population. These results provide a useful support to identify and predict the distribution and abundance of the Manila clam in other estuarine systems, contributing to the management of this invasive species.
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