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Referência do projecto
Project reference
PTDC/AAC-AMB/102866/2008

1. Identificação do projecto
1. Project description

Área científica principal
Main Area
Ambiente e Alterações Climáticas - Ambiente

Área científica Secundária
Secondary area
Ciências e Tecnologias do Mar

Título do projecto (em português)
Project title (in portuguese)
CIEF - Os impactos combinados da mudança da invasão e de clima na funções litorais do ecossistema

Título do projecto (em inglês)
Project title (in english)
CIeF - The combined impacts of invasion and climate change on coastal ecosystem functioning

Financiamento solicitado
Requested funding
155.724,00€

Palavra-chave 1
Alterações Climáticas

Keyword 1
Climate change

Palavra-chave 2
Invasões Biológicas

Keyword 2
Biological invasions

Palavra-chave 3
Função de Ecossistema

Keyword 3
ecosystem functioning

Palavra-chave 4
Áreas costeiras atlânticas

Keyword 4
Atlantic coastal areas

Data de início do projecto
Starting date
01-01-2010

Duração do projecto em meses
Duration in months
36

2. Instituições envolvidas
2. Institutions and their roles

Instituição Proponente
Principal Contractor
Instituto do Mar (IMAR)
Departamento de Zoologia - Faculdade de Ciências e Tecnologia da Universidade de Coimbra
3004-517Coimbra

Instituição Participante
Participating Institution
Centro de Investigação Marinha e Ambiental (CIIMAR)
Rua dos Bragas - 289
4050-123Porto
Universidad Rey Juan Carlos (URJC)
C/Tulipán s/n
28933Móstoles
Universidade de Vigo-Facultade de Biologia (UVIGO)
Campus Universitario Lagoas-Marcosende
3620036200-Vigo

Unidade de Investigação
Research Unit
Instituto do Mar, Centro Interdisciplinar de Coimbra (IMAR Coimbra/IMAR)
Departamento de Zoologia
3004-517Coimbra

Unidade de Investigação Adicional
Additional Research Unit
Centro de Investigação Marinha e Ambiental (CIIMAR)
Rua dos Bragas - 289
4050-123Porto

Instituição de Acolhimento
Host Institution
Instituto do Mar (IMAR)
Departamento de Zoologia - Faculdade de Ciências e Tecnologia da Universidade de Coimbra
3004-517Coimbra

3. Componente Científica
3. Scientific Component

3.1. Sumário
3.1 Summary

3.1.a Sumário Executivo (em português)
3.1.a Executive Summary (in Portuguese)

Nos sistemas marinhos costeiros, o risco de invasões biológicas está rapidamente a aumentar acompanhando a ocorrência de alterações climáticas (Stachowicz et al. 2002). No actual cenário, com o aumento das temperaturas médias atmosférica e à superfície do oceano e com o acréscimo da quantidade de $CO2$ dissolvido, também se observa um incremento do nível de acidificação dos oceanos (Caldeira & Wickett 2003). Apesar de ser comummente aceite que estas alterações climáticas simultaneamente com a ocorrência de espécies invasoras podem pôr em risco os ecossistemas marinhos, pouca atenção tem sido dada a evidências experimentais, impossibilitando uma representação holística de cenários futuros. Em particular, não se sabe de que forma a interacção entre perturbações climáticas e invasão pode modificar a estrutura e funcionamento das comunidades marinhas costeiras (Worm et al. 2006). Informação experimental quantitativa ajudará a aumentar o grau de precisão e correcção de modelos ecológicos e da previsão de como os ecossistemas marinhos se poderão alterar num futuro próximo. Adicionalmente, o conhecimento do efeito simultâneo de diferentes perturbações nos ecossistemas, permitirá desenvolver e implementar planos de gestão nacionais e europeus realmente efectivos. Neste projecto, iremos avaliar os efeitos de dois factores climatéricos (aumento da temperatura e $CO2$) e as suas interacções com espécies invasoras na composição (identidade e diversidade de taxa) e funcionamento (aspectos relacionados com a transferência de energia) de

comunidades marinhas bentónicas.
Os objectivos específicos serão 1) conhecer o papel da temperatura e da acidificação na determinação do grau de invasão de espécies de macroalgas exóticas, 2) compreender como é que a interacção entre factores perturbadores climáticos e espécies de macroalgas invasoras poderá afectar as comunidades intertidais de substrato rochoso e qual o papel da diversidade destas comunidades na contraposição desses efeitos; 3) perceber como a interacção entre temperatura e detritos de macroalgas invasoras poderá alterar a comunidade de consumidores das praias arenosas e a taxa de decomposição das macroalgas invasoras; 4) seguir, ao longo das redes tróficas, o percurso do carbono orgânico resultante das macroalgas invasoras e determinar se o aumento do risco de invasão e da temperatura podem limitar a capacidade de armazenamento de CO_2 pelos sistemas costeiros.
Praias rochosas e arenosas serão utilizadas como sistemas modelo para testar hipóteses sobre as interacções entre alterações climáticas e invasão no funcionamento dos sistemas costeiros. No campo e em mesocosmos, provocaremos o aumento deliberado da temperatura e da pressão de CO_2 de forma a medir as alterações na distribuição e biomassa de espécies invasoras, na composição e estrutura trófica das comunidades bentónicas, na produção da comunidade e no fluxo de carbono através da rede trófica.
O projecto recorrerá a técnicas inovadoras para aumentar o CO_2 e para estudar os fluxos de carbono (ex. 13C tracking no campo).
A equipa de investigação tem vasta e reconhecida experiência em ecologia experimental, quer em praias rochosas, quer arenosas. Para além disso, tem também larga experiência nas áreas de fisiologia macroalgal, invasões e estudo da função dos ecossistemas. Estamos convictos que esta equipa garante o sucesso da proposta. A colaboração, como consultor externo, do Prof JJ Middelburg (perito de renome internacional na utilização de isótopos estáveis e no estudo dos fluxos de carbono), irá contribuir amplamente para a compreensão e modelação dos processos envolvidos na transferência de carbono através da rede trófica.

3.1.b Sumário Executivo (em inglês)
3.1.b Executive Summary (in English)

The risk of biological invasions on marine coastal habitats is rapidly increasing in concomitance to the changes in the climate (Stackowicz et al. 2002). Under present climate change scenario, average atmospheric and sea surface temperatures are increasing and more CO_2 will dissolve in the ocean and lower ocean pH. Despite it is generally agreed that these effects of climate change and invasive species may simultaneously impact marine ecosystem, experimental evidence is limited and does not allow a holistic representation of future scenarios. In particular, we do not know how the interaction between climate stressors and invasion will modify the structure and functions of marine coastal communities (Worm et al. 2006). Such quantitative experimental information will help increasing the precision and accuracy of ecological models and predicting how marine ecosystems will change in the near future. In addition, this knowledge on the simultaneous effects of different stressors on ecosystems will allow the development and implementation of effective National and European management plans.
In this project, we will evaluate the effects of these two climate-driven stressors (temperature and water acidification), and their interactions with invasive macoalgae on the composition (identity and diversity of taxa) and functioning (aspects related to the energy transfer) of marine benthic communities. The specific tasks we propose are to establish: 1) the role of temperature and acidification in determining invasibility of exotic seaweeds, including Sargassum muticum; 2) the role of macroalgal diversity in counteracting the interacting effects of climate stressors and invasive seaweeds on rocky intertidal communities; 3) the role of macroalgal detritus diversity in counteracting the effect of temperature and invasive seaweeds on sandy beach consumers and on detritus decomposition; 4) the path of the organic carbon derived from invasive seaweeds in the food webs under temperature increase to determine how these stressors may modify carbon storage by coastal systems.
We will use rocky shore and sandy beaches as convenient model systems to test hypotheses on the interactive effects of invasion and climate change on coastal functioning. In the field and in mesocosm experiments we will deliberately increase temperature and CO_2 pressure and measure changes in the distribution of invasive species, in the composition and trophic structure of benthic assemblages, in the community production and in the carbon flow to the food web. The project will make use of innovative techniques to increase CO_2 and to study carbon flow (e.g. 13C-tracking experiments in the field).
The team members have long recognised experience in experimental ecology of both rocky shores and sandy beaches as well as in macroalgal physiology, invasions and ecosystem functioning. Such team guarantees the success of the proposal. The external collaboration with Prof JJ Middelburg, who has renowned expertise in carbon cycling and use of stable isotopes will greatly contribute to the understanding and modelling of the carbon recycling.

3.2. Descrição Técnica
3.2 Technical Description

3.2.1. Revisão da Literatura
3.2.1. Literature Review

There is strong scientific consensus that coastal marine ecosystems are threatened by several factors such as pollution, habitat destruction, eutrophication, overfishing, climate change (increasing sea temperatures, changing circulation patterns, increased storminess and ocean acidification) or invasion by non-indigenous species (Worm et al. 2006). In particular, biological invasions have become one of the most prominent elements of this global degradation, and are considered the second-most important cause of global diversity loss after habitat destruction. Non-indigenous species may have serious consequences not only on biodiversity per se, but also on the management and restoration of natural ecosystems. By disrupting ecosystem structure and function, invasive species alter the ability of natural systems to provide high-value goods and services (Stackowicz et al. 2002).
Adding to the threat posed by non-indigenous species, predicted climate change scenarios are accelerating changes in the

structure and function of coastal marine systems with unprecedented ecological, economic and social implications (Harley et al. 2006). Increasing green house gas concentrations will have important impacts on ocean biogeochemistry, by changing carbon dioxide concentration and temperature. Atmospheric carbon dioxide concentration is expected to rise from the current 380 parts per million by volume (ppmv) to 600-1550 ppmv by the year 2100, depending on future emission scenarios (IPCC, 2007). This rate of increase in atmospheric CO2 will substantially decrease oceanic pH over the next few centuries up to 0.4 units before 2100, four times more than the present decrease of 0.1 pH units due to industrial times (Caldeira & Wickett, 2003). Ocean acidification will lead to a shift in inorganic carbon equilibrium, which will have negative effects on calcifying organisms such as coralline algae, corals, echinoderms or molluscs and will modify sources of inorganic carbon for photosynthesis by primary producers (Guinotte & Fabry 2008 and references therein).
The current trend of increasing atmosphere CO2 is accompanied by changes in other climatic factors, primarily temperature and its variability (IPCC, 2007). Air and sea-surface average temperatures have risen in the past century (1906-2005) by 0.56-0.92°C and these trends are also expected to accelerate in the current century (IPCC, 2007). Increasing temperature may provoke shifts in the distribution and abundance of species according to their thermal tolerance and ability to adapt to the new conditions (Harley et al. 2006). There will be severe implications for the ecosystem functioning associated to this species shift. Ecosystems will change in productivity and carbon recycling and they may become less resistant to invasions by non-indigenous species (Stachowicz et al. 2002).
Stressors are expected to exert complex effects that cannot be easily inferred using single-stressor studies because synergistic or antagonistic interactions may occur (Folt et al. 1999). For instance, some evidence suggests that interactions between climate change and biological invasions are likely to have widespread and unexpected effects on coastal ecosystem dynamics (Harley et al. 2006). Nonetheless, despite the mounting research effort dedicated to study climate change and non-indigenous species in the marine realm, empirical studies linking these stressors are limited and mostly observational preventing any prediction of future scenarios.Quantitative experimental information on these effects will help increasing the precision and accuracy of ecological models and predicting how marine ecosystems will change in the near future (Widdicombe & Spicer, 2008). From a management point of view, addressing the impacts of both climate change stressors and invasive species will provide basic information to design efficient and innovative mitigation plans in coastal areas.
In this project, we will evaluate the effects of two climate-driven stressors (temperature and CO2 increase), and their interactions with non-indigenous species on the structure (identity and number of taxa) and functioning (energy and nutrients transfer fluxes) of benthic marine communities on intertidal rocky shores and sandy beaches. We will use these two habitats as traceable model systems because they provide essential ecological functions, including the recycling of organic matter of marine and terrestrial origin as well as the uptake of CO2 from the atmosphere or dissolved in the water column. Carbon and nutrient cycling is largely done by interactions between primary producers and grazers on rocky shores, where inorganic carbon is taken up by seaweeds and moved into the food web by the grazers. The residual seaweeds, not consumed by grazers, are exported as detritus and may deposit on the sandy beaches adjacent to the rocky shores. There, this macroalgal detritus, commonly called wrack, provides important spatial subsidies to the consumers inhabiting the beach (Orr et al. 2005). These consumers, in association to microbes may recycle even a large part of this detritus, through microbial respiration or moving carbon and nitrogen into the detritus food web (Moore et al. 2004). Such understanding is also particularly important for the Portuguese shores, where marine benthic communities hold several non-indigenous species, including some of the most invasive macroalgae (e.g., Sargassum muticum, Grateloupia turuturu and Undaria pinnatifida)and increased sea-surface temperature (0.01-0.05 °C/year since 1940) is modifying upwelling regime (Gómez-Gesteira et al. 2008)and changing marine benthic species (Lima et al. 2007).

3.2.2. Plano e Métodos

3.2.2. Plan and Methods

The key aim of the project is to investigate how two of the most prominent global stressors, namely climate change and biological invasions, will impact marine coastal ecosystems. Specifically we will examine how the forecasted future climate scenario for marine systems (e.g. CO2 water acidification and temperature) will alter the dynamics of invasive seaweeds and how temperature and acidification will interact with invasive species to affect the productivity and carbon recycling of rocky shores and beaches. Our working hypothesis is that climate-driven stressors and invasion will have a synergistic effect on marine coastal biodiversity and functioning. To accomplish our main objective, we will first investigate the effects of climate change on the invasibility of macroalgae in rocky shores (Task 1). Then, we will test how climate-driven stressors and invasive macroalgae modify communites and their properties emphasizing the role of macroalgal diversity in driving these patterns on rocky shores (Task 2) and beaches (Task 3).Finally we will follow the path of carbon derived from invasive seaweeds into the benthic food web(Task 4).

Climate change and invasions may substantially change species identity and diversity with direct implications on ecosystem-level aggregate functions such as energy fluxes, stability and resistance to invasions (Stachowitz et al. 2002). However, there is lack of empirical data on how biological invasions affect the structure of marine benthic communities and ecosystem function under temperature and CO2 increase (see for review Harley et al. 2006; Widdicombe & Spicer, 2008). Furthermore, while effects of individual climate stressors and non-indigenous species have been reported for several marine invertebrates and algae (Britton-Simmons, 2004; Rodil et al. 2008; Olabarria et al. 2009), no experimental study has tested interactions among these stressors. Nonetheless, multiple stressor effects cannot be predicted from knowledge on singlestressor effects (e.g. Folt et al. 1999; Harley et al. 2006). Given that these stressors act simultaneously, we need to understand their reciprocal influence on ecosystems.

Task 1 will examine how climate change modifies the susceptibility of macroalgal communities to invasion. Evidence for plant communities suggests that invasions occur when resources are available. Climate change may influence resource availability through changes in species distribution. For example, declines in abundance and local extinctions of native species could create new opportunities for the establishment of new non-indigenous species. In addition, disturbances may affect native and introduced species differently modifying species interactions and the probability of invasion success (Davis et al. 2000; Arenas et al. 2006). In task 1 we will experimentally invade communities under different levels of climate stressors and measure the growth and standing crop of invasive species.

In the following two tasks (2 and 3) we will deliberately modify macroalgal diversity and measure how climate-driven factors and the presence of invasive seaweeds modify benthic communities and aggregate or emerging functions. Species diversity (species richness and abundance) can counteract the destabilizing effect of environmental changes through compensatory species dynamics and complementary use of resources (Yachi & Loreau, 1999). Experimental evidence has however suggested that species identity rather than diversity per se may become more important (Rossi et al. 2008). Furthermore, diversity may change simultaneously to ecosystem functioning under environmental disturbance and there may be dynamic, reciprocal interactions during disturbance and during the recovery after disturbance ends (Rossi et al. in press). In task 2 we will use a novel experimental approach to test how macroalgal communities of variable diversity respond to temperature and pCO_2 increase in presence of invasive seaweeds. Synthetic communities have been already constructed at the CIIMAR (Arenas et al. 2006). These synthetic communities resemble very closely natural communities and will be our model-system. We will apply press-type stress treatments for several weeks and we will measure quick responses (photosynthetic efficiency, primary productivity, nutrient uptake and carbon fluxes) using benthic chambers and long term responses in the communities (structural changes in species diversity and abundance) during and after disturbance. In task 3, we will investigate experimentally how diversity of macroalgal wrack may change the effect of temperature increase and invasive wrack on consumer communities and wrack decomposition rate on sandy beaches. In the field, we will deliberately increase the temperature in patches of wrack of different macroalgal composition, with and without invasive seaweeds.

Eventually, task 4 will study the flow of carbon derived from invasive wrack to the benthic food webs, e.g. how the macroalgae that invaded a coastal area (task 1) and modified communities and their functioning (task 2 and 3), under climate change may be recycled by these benthic communities. Herbivores and detritivores, by feeding on seaweeds or wrack, may literally "pack" the carbon fixed by plants and move it up to the food web. Temperature, by reducing metabolism and feeding capacity of invertebrates, enhancing bacterial metabolism (Viergutz et al. 2007) and regulating decomposition rate of macroalgal detritus, may affect such carbon recycling into the food web. Non-native wrack, having different decomposition rate, nutritional value and edibility may vary their contribution to the carbon cycling. When invasive species cannot be eaten by invertebrates, there will be a cul-de-sac for this carbon flow in the food web. We will deliberately add seaweed detritus composed of invasive species and native species that have been previously 15N and 13C-labelled in the laboratory to follow the fate of carbon and nitrogen in the food web (Rossi, 2007).

The project is mainly experimental and includes field and mesocosm manipulations. In the field, we will increase temperature up to 2-4 °C for a period of approximately one month, during day time. On beaches the increase of temperature will be created by low-power (5000 BTU) propane heaters (Allison, 2004), whereas in rock pools the increase of temperature will be created by titanium heaters similar to those used in aquaria (see www.coral-reef.es). In the mesocosm, we will also modify CO_2 adapting the methodology of Findlay et a.l (2008), with mesocosms consisting of 2 parts, a lower section containing internal heating elements and an upper section (a tent) where the atmospheric CO_2 will be controlled by continuous addition of high CO_2 air mixtures. The upper section will contain vents which will prevent the built-up of gas. We will also deliberately create assemblages of macroalgae at different levels of diversity, including exotic species. Specific experimental designs are described in the specific tasks. As measures of ecosystem functions we will use community productivity, quantum photosynthetic efficiency, and 13C-tracking experiments, which are decribed in the specific tasks and above in this section. All the experimental work proposed in this project will be carry out in areas where the studied invaders are already well established. None of the experiments will transfer alien species to new areas.

The expertise of the research team will guarantee the success of the proposal. All the participants of the team have recognized expertise in ecological research on the coastal areas with wide experience and expertise in quantitative and experimental ecology (field and laboratory). Team skills cover expertise in soft sediments bio-geochemistry (Dr. F. Rossi), biodiversity and ecosystem functioning (Dr F. Rossi; Dr C. Olabarria; Dr F. Arenas), ecophysiology, population dynamics, and community and ecosystem level impacts of marine macroalgal invaders (Dr F. Arenas, Dr R. Viejo, Dr C. Olabarria, Dr M. Incera). The researchers have also well-known experience on beach ecology (Prof. J. C. Marques, Dr. C. Olabarria, Dr. M. Incera), food webs (Dr. F. Rossi, A. Baeta and Dr. J. Patricio) and rocky-shore ecology (Dr F. Arenas, Dr. C. Olabarria and Dr R. Viejo). All participants have been involved in several National and European projects and some of them have participated in European excellence networks such as MARBEF (funded by the EC 6th Framework Program from 2004-2009). In addition, all researchers have been involved in the supervision and training of students at different levels. With more than 100 publications in SCI journals (see curricula) the group is therefore able to integrate empirical research into different benthic systems, both hard and soft substrata, and to tackle complex experimental approaches like those described in this proposal. Furthermore, the external consultancy of Prof JJ Middelburg, a renowned scientist with large experience in carbon recycling will allow a thoughtful understanding on future changes in the carbon recycling of coastal waters to the light of increasing invasion risk and climate change.

3.2.3. Tarefas
3.2.3. Tasks

Lista de tarefas (4)
Task list (4)

Designação da tarefa Task denomination	**Data de início** Start date	**Data de fim** End date	**Duração** Duration	**Pessoas * mês** Person * months
Task 1 : Climate-driven effects on ma...	01-01-2010	31-12-2010	12	28

Descrição da tarefa e Resultados Esperados
Task description and Expected results

Description of the task
Climate change can alter the biotic resistance of communities to invasion by displacing native species and creating new opportunities for colonization. The combined effect of several stressors will depend on the sign and magnitude of the native species co-tolerance to them. For example, some functional groups of seaweeds like canopy-forming species are more sensitive to anthropogenic disturbances and these species seems also to be very relevant in preventing invasion by other algal species (Arenas et al 2006). Moreover, results of very recent work suggested that coralline algae would be negatively affected by increases in CO_2 concentrations and the recruitment of invaders may be modified by these reductions of coralline turfs (e.g. Findley et al. 2008). Thus, the interplay between the impacts of climate change stressors on native communities and their susceptibility to invasions will finally decide the probability of success.
The specific objective of task 1 is to investigate in natural communities how the forecasted new climate change scenarios (increase of seawater pCO_2 and temperature) will modify the functional structure of algal communities and subsequently their susceptibility to invasion.
Our initial hypothesis is:
- Climate change impacts will increase the susceptibility of native communities to invasion through changes in their abundance and species composition.

Expected results
- Knowledge of how multiple climate stressors affect the resistance of marine communities to invasion.
- Results for the first paper of the project.
- Results for the first Master thesis (MSc 1) relate to the project.

Experimental procedure
We will use rock-pool boulders with natural algal communities dominated by perennial species as model communities. These boulders are very abundant in Portuguese shores and Dr. Arenas has already used them in other experiments. Boulders of similar medium size will be selected, tagged and sampled to measure initial species diversity and abundance. The boulders will be assembled in buckets at the CIIMAR outdoor facilities placed a few kilometres away from the shore where all the communities will be deployed, Aguda beach. Aguda is a very convenient rocky shore with several macroalgal invaders well established. Environmental stressors (High temperature (T) and High CO_2 level (C) will be applied daily to the communities for 8 non-consecutive weeks using 3 different stress combinations plus a non stress control: 1) Control; 2) High Temp; 3) High CO_2; 4) High CO_2-High Temp. Twelve replicates per stress level will be included (48 boulders). We will use two levels of CO_2 concentration (ambient levels and average values of 750 ppmv – corresponding to a "continually increasing" IPCC scenario by 2100) - and two temperatures (ambient and an increase of 2-4 ºC above ambient levels, this increase being within the range of IPCC estimates for 2090-2099).
Once the stress treatments have been applied to the communities we will inoculate the buckets with spores of invasive macroalgae.
Invasibility of communities will be measured as number, growth and final standing biomass of the invasive species at several successive times after the invasion. We will use Sargassum muticum and Grateloupia turuturu as model invasive species, applying 3 treatment additions within each CO_2-temperature combinations: i) only Sargassum, ii) only Grateloupia, iii) both exotic species simultaneously (4 replicates per treatment addition within stress combinations).

Membros da equipa de investigação nesta tarefa
Members of the research team in this task
(BI) Bolseiro de Investigação (Lic. ou Bacharel) 1; (BIC) Bolseiro de Iniciação Científica 1; Celia Olabarria Uzquiano; Francesca Rossi; Francisco Arenas Parra; Isabel Maria Trigueiros Sousa Pinto ; Mónica Incera Filgueira; Rosa Viejo;

Designação da tarefa Task denomination	**Data de início** Start date	**Data de fim** End date	**Duração** Duration	**Pessoas * mês** Person * months
Task 2: The interaction between clima...	01-06-2011	31-05-2012	12	22

Descrição da tarefa e Resultados Esperados
Task description and Expected results

Description of the task
In intertidal macroalgal communities ocean acidification and temperature increase may provoke important effects especially in presence of invasive species. In this second task we will include the presence/absence of exotic invaders as additional stressor acting on native algal communities. As already described in task 1, results of very recent work suggested that the group of coralline algae will be negatively affected by ocean acidification, with potential community shifts towards non-calcifying algae. Increasing temperature, however, may counteract the effect of rising pCO_2 by increasing carbonate ion concentrations in seawater, though the magnitude of this effect will be feasibly small within the ranges predicted by IPCC scenarios (Orr et al. 2005). Ocean warming and acidification, on the other hand, may enhance the growth rates of other groups, especially invasive algal species which are often tolerant to several stressors (Stachowicz et al. 2002). The additive, counteractive or interactive effects of increases in temperature and pCO_2 on seaweed communities are largely untested, particularly in relation to changes in diversity and to the interactions with invasive species.

The following hypothesis will be bested:
- Increases in pCO2 will negatively affect the abundance of the coralline algal group. These negative effects could be ameliorated by increasing temperature, but the development of other species will be enhanced, particularly those species with rapid growth, such as the invasive species S. muticum.
- Expected results
- Increasing our understanding of direct interactions between climate-driven stressors and marine invaders
- Results for the second and third articles (one on innovative methods for CO2 enrichment and synthetic communities using boulders, combined to results of task 1)
- Results for the second Master thesis (MSc 2) relate to the project.
Experimental procedure
The experiment will be set up in mesocosm tanks with continuous supply of flowing seawater.
Seawater will be filtered in order to avoid the entrance of grazers to the system. Synthetic communities of varying levels of "functional" richness and identity will be assembled using tile-like structures (see Arenas et al. 2006). The potential functional groups used will be: calcareous crusts and turfs, non-calcareous turfs and canopy-forming algae. Within the group of canopy-forming species we will manipulate the number and identity of species, using at least two, maximum three, different species, including the invasive S. muticum. Different levels of functional diversity/identity will be used, with the restriction of always including one calcareous group. Within the canopy-forming algae we will manipulate the number and identity of species: e.g. Cystoseira, Sargassum, Sargassum + Cystoseira.
Tanks will be installed in ECIMAT, University of Vigo and CIIMAR, Porto. The treatments and levels of CO2 concentration and temperature will be the same as in task 1. Manipulation of stressors will be done for a period of about 1 month, and experiment will be set up in two periods, spring and autumn. Response variables will be species abundance, productivity and biomass. Measures will be taken at different times in order to estimate temporal stability of the system.
For the CO2 addition we will adapt the methodology of Findlay et al. (2008), with mesocosms consisting of 2 parts, a lower section containing internal heating elements and an upper section (a tent) where the atmospheric CO2 will be controlled by continuous addition of high CO2 air mixtures.

Membros da equipa de investigação nesta tarefa
Members of the research team in this task
(BI) Bolseiro de Investigação (Lic. ou Bacharel) 1; (BIC) Bolseiro de Iniciação Científica 2; Celia Olabarria Uzquiano; Francesca Rossi; Francisco Arenas Parra; Isabel Maria Trigueiros Sousa Pinto ; Mónica Incera Filgueira; Rosa Viejo;

Designação da tarefa Task denomination	**Data de início** Start date	**Data de fim** End date	**Duração** Duration	**Pessoas * mês** Person * months
Task 3: The interaction between tempe...	01-06-2011	31-05-2012	12	21

Descrição da tarefa e Resultados Esperados
Task description and Expected results
Description of the task
On sandy beaches, invertebrate consumers often rely on external inputs of organic matter (e.g. spatial subsidies) such as macroalgal detritus (commonly called "wrack"). Therefore, any change in the availability of this wrack may greatly affect consumer communities (Orr et al. (b) 2005).
Temperature increase and invasive wrack may affect both decomposition rate and consumer communities. First, atmospheric temperature increase may rapidly heat up sand and greatly reduce their metabolism (Viergutz et al. 2007). Furthermore, temperature increase may enhance decomposition rate, through chemistry and microbial metabolism. Second, non-native wrack may have different capacity to break chemical linkages and be less edible than native species, thereby providing food of different quality to consumers (Rodil et al. 2008). Furthermore, similarly to what can happen in leaf-litter decomposing in streams, more diverse wrack assemblages may decompose differently from wrack that is formed by one species because more diverse species may create microclimatic conditions (e.g. water retention, temperature, structural complexity, etc.) and produce toxins that may decelerate decomposition and prevent animal grazing (Joarmalain et al. 2001). There are virtually no studies on the diversity role in decomposition of invasive seaweed.
The specific objective of task 3 is to investigate how the increase of temperature will modify the consumer communities and their effect in decomposition rate of non-native species.
Our initial hypothesis is:
- Temperature increase will affect wrack decomposition rate and consumer communities. This change will be modulated by the diversity of the macroalgal species composing the wrack assemblages. We expect an interaction between temperature and diversity to affect invasive wrack decomposition and consumer communities.
Expected results
- Knowledge of how temperature affects the capacity of wrack-associated communities of invertebrates to use spatial subsidies composed of non-native seaweeds when macroalgal communities that subsidy the beaches are reduced in diversity due to increasing disturbance
- Results for the fourth paper of the project.
- Results for the third Master thesis (MSc 3) relate to the project.

Experimental procedure
Native wrack will be collected in the field, cleaned and assembled before deploying them on the sediment patches. There will be wrack of varying diversity with and without the invasive seaweed Sargassum muticum.

The wrack will be deployed in patches of 0.25 m2 on beaches adjacent to rocky-shores as they potentially receive spatial subsidy from that shore. Temperature will be increased of about 2-4 °C (following predictions IPCC, 2007) for a period of approximately one month, during day time. The increase of temperature will be created by low-power (5000 BTU) propane heaters (Allison, 2004). Temperature will be manipulated in the patches added with wrack at different areas, following a fully orthogonal design with three factors: wrack diversity (D, 3 levels), temperature (T, 2 levels: control vs. increase of temperature) and non-native species (N, 2 levels). We will sample at 3 different times after temperature increase to establish recovery (total samples: 72). We expect a significant interaction D x T x N in the response variables.
Response variables will be abundance and species numbers of invertebrate consumers, isotope signatures (13C and 15N) of each wrack species and consumers (to evaluate their trophic links) and macroalgal decomposition rate by weighting remaining wrack at different times from deposition. Statistical analyses will be based on univariate ANOVA analyses, and multivariate techniques (PERMANOVA).

Membros da equipa de investigação nesta tarefa
Members of the research team in this task
(BI) Bolseiro de Investigação (Lic. ou Bacharel) 2; (BIC) Bolseiro de Iniciação Científica 3; Celia Olabarria Uzquiano; Francesca Rossi; João Carlos Sousa Marques; Mónica Incera Filgueira; Rosa Viejo;

Designação da tarefa Task denomination	**Data de início** Start date	**Data de fim** End date	**Duração** Duration	**Pessoas * mês** Person * months
Task 4: The recycling of non-native w...	01-01-2012	31-12-2012	12	35

Descrição da tarefa e Resultados Esperados
Task description and Expected results
Description of the task
On rocky shores, the recycling of inorganic carbon is lead by interactions between seaweeds and herbivores. Nonetheless, a large part of the primary production become detritus and it is transferred to adjacent ecosystems where it may be used by detritivores and thus enter the food web in an alternative way (Cebrian, 1999). On sandy beaches, invertebrate consumers of detritus may greatly contribute to the transfer of this macroalgal carbon up to the food web since they are prey for many marine and terrestrial predators (Orr et al. (b) 2005; Rossi, 2007). The remaining detritus carbon not entering food webs is eliminated through respiration as CO2 (Wigley & Schimel 2000). A full consideration of how and how much the primary producers enter the food web will greatly help understanding whether coastal ecosystems will become a source or sink of CO2 in the near future under impending effects of climate change and increased risk of invasion.
Temperature increase, by changing the metabolism of consumers and microbes (Viergutz et al.2007), and invasive species, by having differential decomposition rate and edibility (see also task 3), may greatly change carbon recycling in the food web and thus their capacity of regulating the flux of carbon. When invasive species replacing native seaweeds in rocky shores and as wrack on beaches cannot be eaten by invertebrates or eaten in a small proportion, there will be a cul-de-sac for this carbon flow in the food web.
The following hypothesis will be bested:
- The flow of carbon derived from invasive seaweeds and from invasive wrack in benthic consumers (e.g. herbivores and detritivores) will be different from that of native seaweeds and native wrack and vary according to temperature.
Expected results
- Increasing our understanding of the fate of invasive species into the food web to the light of increasing temperature
- Results for the fifth and sixth articles in peer-reviewed journals
- Results for the fourth Master thesis (MSc 4) relate to the project.
Experimental procedure
We will perform experiments in mesocosms rock pools and beaches. In mesocosms, we will use the artificial communities of task 2, with and without invasive seaweeds. The sampling design will follow that showed in task 2. At selected artificial communities treated with different levels of temperature, with and without invasive seaweeds, we will add 13C-bicarbonate to label seaweeds. We will then included temporary these artificial comunities in natural rock pools and allow colonization by grazers. Then, at selected times, we will sample for seaweeds and herbivores. On the beach, we will deliberately add seaweed detritus composed of invasive species S. muticum and of native species (Sacchoriza polyschides, Fucus vesiculosus or Ulva sp.) that have been previously 13C-labelled in the laboratory (Rossi, 2007) at different levels of temperature manipulation (see task 3 for details on temperature increase). Sampling in this case will be done at 3 times, during macroalgal decomposition (total samples 72).
The experimental design for both experiments will include a fully orthogonal design with 2 treatments: Temperature (T, 2 levels: control vs. increase of temperature) and seaweed or wrack-type (W, 2 levels, invasive vs. native). Experiments will be done in different sites and there will be replicated rock-pools or wrack patches. There will be at least 3 replicates per treatment. We expect significant effects in the interaction W x T.
Statistical analyses will be based on univariate ANOVA analyses, special classes of generalized linear models like Generalized Estimating Equations (GEEs), and multivariate techniques (PERMANOVA, MDS). Data collected in this task will be used to build food web models, using Ecopath with Ecosim software that will help to assess the effectiveness of the ecosystem network approach in capturing the ongoing changes. This task will use 13C tracking experiment to understand the fate of carbon, which will be greatly supported by the collaboration with Prof JJ Middelburg.

Membros da equipa de investigação nesta tarefa
Members of the research team in this task

(BI) Bolseiro de Investigação (Lic. ou Bacharel) 2; (BIC) Bolseiro de Iniciação Científica 4; Alexandra Sofia Baptista Vicente Baeta; Celia Olabarria Uzquiano; Francesca Rossi; Francisco Arenas Parra; Joana Mateus Patrício; João Carlos Sousa Marques; Mónica Incera Filgueira; Rosa Viejo;

3.2.4. Calendarização e Gestão do Projecto
3.2.4. Project Timeline and Management

3.2.4.a Descrição da Estrutura de Gestão
3.2.4.a Description of the Management Structure

This project is composed of 4 experimental Tasks. Each task includes experimental set-up, data collection, statistical analyses and result dissemination. Each task will be manage by a Portuguese responsible investigator and will be actively supported by foreign collaborators. All tasks will be developed independently, but all participants will work in tight contact, given that all tasks are of manipulative nature and require intensive field work and maintenance of experimental setups. Data collection and laboratory analyses will be done as soon as possible to guarantee a continuous flux of data since the beginning of the project. There will be informal meetings every 3 months and at the end of each task, once results are obtained in order to decide strategies for publication and dissemination of results in conferences and to the public. A final workshop will be organized at the end of the project. Once a year the PI will write a report on the activity done an on the strategies to adopt in order to accomplish all objectives in the best way possible. Such report will be approved by all participants.
A final report will be done at the end of the project. The project will start 01-01-2010 and end 31-12-2012.

3.2.4.b Lista de Milestones
3.2.4.b Milestone List

Data Date	**Designação da milestone** Milestone denomination
31-12-2010	end of task 1

Descrição
Description

The first results on how invasion is enhanced by temperature and CO2 will be available. The experimental set-up for the other mesocosm experiments will be ready (task 2 and 4).

Data Date	**Designação da milestone** Milestone denomination
01-06-2011	end of task 2

Descrição
Description

The first results on how invasion and climate change will impact consumer communities on rocky shores will be available

Data Date	**Designação da milestone** Milestone denomination
01-07-2012	end of task 3

Descrição
Description

The first results on how invasion and climate change will impact consumer communities on beaches and differences in carbon recycling will be available

Data Date	**Designação da milestone** Milestone denomination
31-12-2012	Final Report and publications

Descrição
Description

End of the project and final results

3.2.4.c Cronograma
3.2.4.c Timeline

Ficheiro com a designação "timeline.pdf", no 9. Ficheiros Anexos, desta Visão Global (caso exista).
File with the name "timeline.pdf" at 9. Attachments (if exists).

3.3. Referências Bibliográficas
3.3. Bibliographic References

Referência Reference	**Ano** Year	**Publicação** Publication
Allison	2004	Allison, G. 2004. The influence of species diversity and stress intensity on community resistance and resilience. Ecological Monographs, 74: 117-134.

Arenas et al.	2006	Arenas, F., Sánchez, I.; Hawkins, S. J., Jenkins, S.R. 2006. The invasibility of marine algal assemblages: role of functional diversity and identity. Ecology, 87: 2851–2861.
Bishop & Kelaher	2008	Bishop, M.J., Kelaher, B.P. 2008. Detrital species richness is less important than identity or mixing in determining soft sediment community structure.Oikos, 117: 531-542.
Britton-Simmons	2004	Britton-Simmons, K.H., 2004. Direct and indirect effects of the introduced alga Sargassum muticum on benthic, subtidal communities of Washington State, USA. Marine Ecology Progress Series, 277: 61-78.
Caldeira & Wickett	2003	Caldeira, K., Wickett, M.E. 2003. Anthropogenic carbon and ocean pH. Nature, 425: 365.
Cebrian	1999	Cebrian, J. 1999. Patterns in the fate of production in plant communities. American Naturalist, 154: 449-468
Davis et al.	2000	Davis, M.A., Grime, P.S., Thompson, K. 2000. Fluctuating resources in plant communities: a general theory of invasibility. Journal of Ecology, 88: 528-534
Findley et al.	2008	Findlay, H.S., Kendall, M.A., Spicer, J.I., Turley, C., Widdicombe, S. 2008. Novel microcosm system for investigating the effects of elevated carbon dioxide and temperature on intertidal organisms. Aquatic Biology, 3: 51-61
Folt et al.	2009	Folt, C.L., Chen, C.Y., Moore, M.V., Burnaford, J. 1999. Synergism and antagonism among multiple stressors. Limmnology and Oceanography, 44: 864-877
Harley et al.	2006	Harley, C.D.G., Hughes, A.R., Hultgren, K.M., Miner, B.G., Sorte, J.B., Thornber, C.S.et al. 2006. The impacts of climate change in coastal marine systems. Ecology Letters, 9: 228-241
IPCC	2007	IPCC. 2007. Climate Change 2007, The Physical Science Basis. Summary for Policymakers. Intergovernmental Panel on Climate Change.Cambridge University Press, Cambridge, U.K. 1-21
Lemos et al.	2000	Lemos, R.T., Pires, H.O. 2004. The upwelling regime off the west portuguese coast, 1941-2000. International Journal of Climatology, 24: 511-524
Lima et al.	2007	Lima, F., Ribeiro, P.A., Queiroz, N., Hawkins, S.J., Santos, A.M. 2007. Do distributional shifts of northern and southern species of algae match the warming pattern? Global Change Biology, 13: 2592¬2604
Moore et al.	2004	Moore JC, Berlow EL, Coleman DC, Dong Q, Hastings A, Johnson NC, McCann KS, Melville K, Morin PJ, Nadelhoffer J, Rosemond AD, Post DM, Sabo JL, Scow KM, Vanni MJ, Wall DH (2004) Detritus, trophic dynamics and biodiversity Ecology Letters, 7: 584-600
Olabarria et al.	2009	**Olabarria, C., Rodil, I.F., Incera, M., Troncoso, J.S. 2009. Limited impact of Sargassum muticum native algal assemblages from rocky intertidal habitats. Marine Environmental Research**
Orr et al.	2005	Orr, J.C., Fabry, V.J., Aumont, O., Bopp, L., Doney, S.C., Feely, R.A., Gnanadesikan, A. et al. 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifiying organisms. Nature, 437: 681-686.
Orr et al.	2005	Orr, M., Zimmer, H., Jelinski, D.E., Mews, M. 2005. Wrack deposition on different beach types: spatial and temporal variation in the pattern of subsidy. Ecology, 86: 1496-1507
Rodil et al.	2008	Rodil, I.F., Olabarria, C., Lastra, M., López, J. 2008. Differential effects of native and invasive algal wrack on macrofaunalassemblages inhabiting exposed sandy beaches. Journal of Experimental Marine Biology and Ecology, 358: 1-13
Rossi et al.	2009	Rossi, F., Vos, M., Middelburg, J.J. 2009. Diversity and carbon flow in assembling communities. Oikos in press
Rossi et al.	2008	Rossi, F., Gribsholt, B., Middelburg, J.J, Heip, C. 2008. Context-dependent effects of Cerastoderma edule on ecosystem functioning-a field study. Marine Ecology Progress Series 354: 47-57
Rossi	2007	Rossi, F. 2007. Recycle of buried macroalgal detritus in sediments: use of dual-labelling experiments in the field. Marine Biology, 150: 1073-1081
Stachowicz et al.	2002	Stachowicz, J.J., Terwin, J.R., Whitlatch, R.B., Osman, R.W. 2002. Linking climate change and biological invasions: ocean warming facilitates nonindigenous species invasion. Proceeding National Academy of Sciences, 99: 15497-15500
Vinebrooke et al.	2004	Vinebrooke, R.D. Cottingham, K.L., Norberg, J., Scheffer, M., Dodson, S.I., Maberly, S.C., Sommer, U. 2004. Impacts of multiple stressors on biodiversity and ecosystem functioning: the role of species co-tolerance. Oikos, 104: 451-457
Viergutz et al.	2007	Viergutz, C., Kathol, M., Norf, H., Arndt, H., Weitere, M. 2007. Control of microbial communities by the macrofauna: a sensitive interaction in the context of extreme summer temperatures?. Oecologia, 151: 115-124
Wigley & Schimel	2000	Wigley, T.M., Schimel, D.S. 2000. The carbon cycle. Cambridge University Press

Worm et al.	2006	Worm, B., Barbier, E.B., Beaumont, N., Duffy, E.J., Folke, C., Halpern, B.S., Jackson, J.B. et al. 2006. Impacts of biodiversity loss on ocean ecosystem services. Science, 314: 787-790.
Yachi & Loreau	1999	Yachi, N.D., Loreau, M. 1999. Biodiversity and ecosystem productivity in a fluctuating environment: the insurance hypothesis. Proceedings of the National Academy of Sciencies, USA, 96: 1463-1468.
Jormalainen et al.	2001	Jormalainen, V., Honkanen, T., Heikkilä, N. 2001. Feeding preferences and performance of a marine isopod on seaweed hosts: cost of habitat specialization. Marine Ecology Progress Series, 220: 219–230
Widdicombe & Spicer	2008	Widdicombe, S., Spicer, J.I. 2008. Predicting the impact of ocean acidification on benthic biodiversity: what can animal physiology tell us?. Journal of Experimental Marine Biology and Ecology, 366: 187-197
Guinotte & Fabry	2008	Guinotte, J.M., Fabry, V.J. 2008. Ocean acidification and its potential effects on marine ecosystems. Annals of the New York Academy of Sciences, 1134: 320-342

3.4. Publicações Anteriores
3.4. Past Publications

Referência Reference	**Ano** Year	**Publicação** Publication
Rossi	2007	**Rossi F. (2007) Recycle of buried macroalgal detritus in sediments: use of dual-label experiments in the field. Marine biology 150: 1073-1081**
Rossi et al.	2009	**Rossi F., Vos M., Middelburg J.J. (2009) Species identity, diversity and microbial carbon flow in reassembling macrobenthic communities Oikos in press**
Arenas et al.	2006	**Arenas F., Sanchez I., Hawkins S.J., Jenkins S.R. (2006) The invasibility of marine algal assemblages: role of functional diversity and identity. Ecology 87: 2851-2861**
Olabarria et al.	2009	**Olabarria C., Incera M., Rodil I., Troncoso J. S. (2009) Limited impact of Sargassum muticum on native algal assemblages from rocky intertidal shores. Marine environmental Research in press**
Viejo et al.	2008	**Viejo R., Arenas F., Fernandez C, Gomez M (2008) Mechanisms of succession along the emersion gradient in intertidal rocky shore assemblages. Oikos 117: 376-389**

4. Equipa de investigação
4. Research team

-

4.1 Lista de membros
4.1. Members list

Nome Name	**Função** Role	**Grau académico** Academic degree	**%tempo** %time	**CV nuclear** Core CV
Francesca Rossi	Inv. Responsável	DOUTORAMENTO	30	✓
Celia Olabarria Uzquiano	Investigador	DOUTORAMENTO	20	✓
Francisco Arenas Parra	Investigador	DOUTORAMENTO	20	✓
Isabel Maria Trigueiros Sousa Pinto	Investigador	DOUTORAMENTO	10	✗
Joana Mateus Patrício	Investigador	DOUTORAMENTO	10	✗
João Carlos Sousa Marques	Investigador	AGREGAÇÃO	10	✗
Mónica Incera Filgueira	Investigador	DOUTORAMENTO	10	✗
Rosa Viejo	Investigador	DOUTORAMENTO	10	✓
Alexandra Sofia Baptista Vicente Baet...	Bolseiro	MESTRADO	10	✗

(O curriculum vitae de cada membro da equipa está disponível clicando no nome correspondente)
(Curriculum vitae for each research team member is available by clicking on the corresponding name)
Total: 9

4.2. Lista de membros a contratar durante a execução do projecto
4.2. Members list to hire during project"s execution

Membro da equipa Team member	**Função** Role	**Duração** Duration	**%tempo** %time
(BI) Bolseiro de Investigação (Lic. ou Bacharel) 1	Bolseiro	18	100
(BI) Bolseiro de Investigação (Lic. ou Bacharel) 2	Bolseiro	18	100
(BIC) Bolseiro de Iniciação Científica 1	Bolseiro	6	100
(BIC) Bolseiro de Iniciação Científica 2	Bolseiro	6	100

(BIC) Bolseiro de Iniciação Científica 3	Bolseiro	6	100
(BIC) Bolseiro de Iniciação Científica 4	Bolseiro	6	100

Total: 6

5. Projectos financiados
5. Funded projects

(Sem projectos financiados)
(No funded projects)

6. Indicadores previstos
6. Expected indicators

Indicadores de realização previstos para o projecto
Expected output indicators

Descrição Description	**2009**	**2010**	**2011**	**2012**	**2013**	**Total**
A - Publicações Publications						
Livros Books	0	0	0	0	0	**0**
Artigos em revistas internacionais Papers in international journals	0	0	1	5	0	**6**
Artigos em revistas nacionais Papers in national journals	0	0	0	0	0	**0**
B - Comunicações Communications						
Comunicações em encontros científicos internacionais Communications in international meetings	0	0	2	2	0	**4**
Comunicações em encontros científicos nacionais Communications in national meetings	0	0	0	0	0	**0**
C - Relatórios Reports	0	1	1	1	0	**3**
D - Organização de seminários e conferências Organization of seminars and conferences	0	0	0	1	0	**1**
E - Formação avançada Advanced training						
Teses de Doutoramento PhD theses	0	0	0	2	0	**2**
Teses de Mestrado Master theses	0	0	2	2	0	**4**
Outras Others	0	0	0	0	0	**0**
F - Modelos Models	0	0	0	0	0	**0**
G - Aplicações computacionais Software	0	0	0	0	0	**0**
H - Instalações piloto Pilot plants	0	1	0	0	0	**1**
I - Protótipos laboratoriais Prototypes	0	0	0	0	0	**0**
J - Patentes Patents	0	0	0	0	0	**0**
L - Outros Other						
	0	0	0	0	0	**0**
	0	0	0	0	0	**0**
	0	0	0	0	0	**0**

Acções de divulgação da actividade científica
Scientific activity spreading actions

The mesocosms that will be built at CIMAR, Porto will serve as prototype to show to the interested public small-scale composition of rock pools and their importance in the coastal system. Guided tours for people involved in education and for students at any level are proposed. Some of the participants are already involved in education activities within the MARBEF network of excellence and the project will offer the opportunities to develop such work.

7. Orçamento
7. Budget

-

Instituição Proponente
Principal Contractor

Instituto do Mar

Descrição / Description	2009	2010	2011	2012	2013	Total
Recursos Humanos / Human resources	0,00	0,00	13.050,00	7.980,00	0,00	**21.030,00**
Missões / Missions	0,00	420,00	7.460,00	2.250,00	0,00	**10.130,00**
Consultores / Consultants	0,00	0,00	2.000,00	3.000,00	0,00	**5.000,00**
Aquisição de bens e serviços / Service procurement and acquisitions	0,00	13.000,00	10.500,00	8.000,00	0,00	**31.500,00**
Registo de patentes / Patent registration	0,00	0,00	0,00	0,00	0,00	**0,00**
Adaptação de edifícios e instalações / Adaptation of buildings and facilities	0,00	0,00	0,00	0,00	0,00	**0,00**
Gastos gerais / Overheads	0,00	3.424,00	6.602,00	4.246,00	0,00	**14.272,00**
TOTAL DESPESAS CORRENTES / TOTAL CURRENT EXPENSES	**0,00**	**16.844,00**	**39.612,00**	**25.476,00**	**0,00**	**81.932,00**
Equipamento / Equipment	0,00	3.700,00	0,00	0,00	0,00	**3.700,00**
Total	**0,00**	**20.544,00**	**39.612,00**	**25.476,00**	**0,00**	**85.632,00**

Instituições Participantes
Participating Institutions

Centro de Investigação Marinha e Ambiental

Descrição / Description	2009	2010	2011	2012	2013	Total
Recursos Humanos / Human resources	0,00	13.050,00	7.980,00	0,00	0,00	**21.030,00**
Missões / Missions	0,00	5.490,00	4.620,00	960,00	0,00	**11.070,00**
Consultores / Consultants	0,00	0,00	0,00	0,00	0,00	**0,00**
Aquisição de bens e serviços / Service procurement and acquisitions	0,00	3.500,00	4.000,00	1.000,00	0,00	**8.500,00**
Registo de patentes / Patent registration	0,00	0,00	0,00	0,00	0,00	**0,00**
Adaptação de edifícios e instalações / Adaptation of buildings and facilities	0,00	0,00	0,00	0,00	0,00	**0,00**
Gastos gerais / Overheads	0,00	7.970,00	3.320,00	392,00	0,00	**11.682,00**
TOTAL DESPESAS CORRENTES / TOTAL CURRENT EXPENSES	**0,00**	**30.010,00**	**19.920,00**	**2.352,00**	**0,00**	**52.282,00**
Equipamento / Equipment	0,00	17.810,00	0,00	0,00	0,00	**17.810,00**
Total	**0,00**	**47.820,00**	**19.920,00**	**2.352,00**	**0,00**	**70.092,00**

Universidad Rey Juan Carlos

Descrição / Description	2009	2010	2011	2012	2013	Total

Recursos Humanos Human resources	0,00	0,00	0,00	0,00	0,00	**0,00**
Missões Missions	0,00	0,00	0,00	0,00	0,00	**0,00**
Consultores Consultants	0,00	0,00	0,00	0,00	0,00	**0,00**
Aquisição de bens e serviços Service procurement and acquisitions	0,00	0,00	0,00	0,00	0,00	**0,00**
Registo de patentes Patent registration	0,00	0,00	0,00	0,00	0,00	**0,00**
Adaptação de edifícios e instalações Adaptation of buildings and facilities	0,00	0,00	0,00	0,00	0,00	**0,00**
Gastos gerais Overheads	0,00	0,00	0,00	0,00	0,00	**0,00**
TOTAL DESPESAS CORRENTES TOTAL CURRENT EXPENSES	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
Equipamento Equipment	0,00	0,00	0,00	0,00	0,00	**0,00**
Total	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**

Universidade de Vigo-Facultade de Biologia

Descrição Description	**2009**	**2010**	**2011**	**2012**	**2013**	**Total**
Recursos Humanos Human resources	0,00	0,00	0,00	0,00	0,00	**0,00**
Missões Missions	0,00	0,00	0,00	0,00	0,00	**0,00**
Consultores Consultants	0,00	0,00	0,00	0,00	0,00	**0,00**
Aquisição de bens e serviços Service procurement and acquisitions	0,00	0,00	0,00	0,00	0,00	**0,00**
Registo de patentes Patent registration	0,00	0,00	0,00	0,00	0,00	**0,00**
Adaptação de edifícios e instalações Adaptation of buildings and facilities	0,00	0,00	0,00	0,00	0,00	**0,00**
Gastos gerais Overheads	0,00	0,00	0,00	0,00	0,00	**0,00**
TOTAL DESPESAS CORRENTES TOTAL CURRENT EXPENSES	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**
Equipamento Equipment	0,00	0,00	0,00	0,00	0,00	**0,00**
Total	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**	**0,00**

Orçamento Global
Global budget

Descrição Description	**2009**	**2010**	**2011**	**2012**	**2013**	**Total**
Recursos Humanos Human resources	0,00	13.050,00	21.030,00	7.980,00	0,00	**42.060,00**
Missões Missions	0,00	5.910,00	12.080,00	3.210,00	0,00	**21.200,00**
Consultores Consultants	0,00	0,00	2.000,00	3.000,00	0,00	**5.000,00**
Aquisição de bens e serviços Service procurement and acquisitions	0,00	16.500,00	14.500,00	9.000,00	0,00	**40.000,00**
Registo de patentes Patent registration	0,00	0,00	0,00	0,00	0,00	**0,00**

Adaptação de edifícios e instalações Adaptation of buildings and facilities	0,00	0,00	0,00	0,00	0,00	**0,00**
Gastos gerais Overheads	0,00	11.394,00	9.922,00	4.638,00	0,00	**25.954,00**
TOTAL DESPESAS CORRENTES TOTAL CURRENT EXPENSES	**0,00**	**46.854,00**	**59.532,00**	**27.828,00**	**0,00**	**134.214,00**
Equipamento Equipment	0,00	21.510,00	0,00	0,00	0,00	**21.510,00**
Total	**0,00**	**68.364,00**	**59.532,00**	**27.828,00**	**0,00**	**155.724,00**

Plano de financiamento
Finance plan

Descrição Description	**2009**	**2010**	**2011**	**2012**	**2013**	**Total**
Financiamento solicitado à FCT Requested funding	0,00	68.364,00	59.532,00	27.828,00	0,00	**155.724,00**
Financiamento próprio Own funding	0,00	0,00	0,00	0,00	0,00	**0,00**
Outro financiamento público Other public-sector funding	0,00	0,00	0,00	0,00	0,00	**0,00**
Outro financiamento privado Other private funding	0,00	0,00	0,00	0,00	0,00	**0,00**
Total do Projecto Total of the project	**0,00**	**68.364,00**	**59.532,00**	**27.828,00**	**0,00**	**155.724,00**

8. Justificação do orçamento
8. Budget rationale

-

8.1. Justificação dos recursos humanos
8.1. Human resources rationale

Tipo
Type
(BI) Bolsa de Investigação (Lic. ou Bacharel)

Nº de pessoas
No. of persons
2

Duração (em meses)
Duration (in months)
18

Custo envolvido (€) *(calculado)*
Total cost (€) *(estimated)*
26.820,00

Outros custos (€)
Other costs (€)
3.600,00

Justificação do financiamento solicitado
Rationale for requested funding

The intensive field work require two full time BI (Lic). One BI will be involved in tasks 1 and 2 and will be in charge to construct the synthetic assemblages. The other BI will help in the fild work and animal sorting of tasks 3 and 4 and in the preparation of samples for laboratory analyses (istopes). The additional costs concern the insurance for field work and the volunteer social security

Tipo
Type
(BIC) Bolsa de Iniciação Científica

Nº de pessoas
No. of persons
4

Duração (em meses)
Duration (in months)
6

Custo envolvido (€) *(calculado)*
Total cost (€) *(estimated)*
9.240,00

Outros custos (€)
Other costs (€)
2.400,00

Justificação do financiamento solicitado
Rationale for requested funding

This work also requires technical and scientific support. We request two BIC grants (6 months each, one in 2010, two in 2011 and one in 2012) to help experimental set-up and laboratory analyses. These grants will support final year first-degree students, which will be scientifically trained according to the BIC aims. The additional cost concerns the insurance fo field work and the volunteer social insurance

8.2. Justificação de missões
8.2. Missions rationale

Tipo
Type
Trabalho de campo

Nº de deslocações
No. of participations
8

Local
Venue
field sites

Custo envolvido (€)
Cost (€)
13.300,00

Justificação do financiamento solicitado
Rationale for requested funding
Given the large part of our proposal is to collect data in the field and mesocosms after difficult and innovative manipulations of diversity, temperature, CO2 and addition of invasive species bThe majority of our expenses for mission regard the numerous fieldtrips necessary for doing the field and mesocosm work.

Tipo
Type
Participação em congressos

Nº de deslocações
No. of participations
4

Local
Venue
abroad

Custo envolvido (€)
Cost (€)
7.900,00

Justificação do financiamento solicitado
Rationale for requested funding
To disseminate the results, we propose to attend at 3 international conferences (2 IMAR and 1 CIMAR), where the major results of our experiments will be brought to attention of the international scientific community

8.3. Justificação de consultores
8.3. Consultants rationale

Nome completo
Full name
Middelburg, Jacobus

Instituição
Institution
NIOO-KNAW

Fase do projecto
Project phase
2011-2012

Custo (€)
Cost (€)
5.000,00

Justificação do financiamento solicitado
Rationale for requested funding
Prof. Middelburg is a well known marine biogeochemist with a worldwide experience on marine coastal carbon recycling and isotope tracing experiments. His help will be fundamental to improve data interpretation and analyse n the task for of the project. Costs are for travelling to and from Netherlands, where Prof. Middelburg lives

Página na Internet onde pode ser consultado o CV do consultor
Web page where the consultant's CV can be accessed
http://194.171.24.200/ppages/jmiddelburg/

8.4. Justificação de aquisição de bens e serviços
8.4. Service procurement and acquisitions

Tipo
Type
Laboratory analyses and field work consumables

Custo (€)
Cost (€)
40.000,00

Justificação do financiamento solicitado
Rationale for requested funding
We include here the cost of the reagents for 13C-tracking experiments of task 4 (8000euro, Perkin Elmer H13CO3, 99% pure, 20 g), the IRMS analyses (done at the IMAR: 10 euros* 2000 samples), the cost of propane bottles for using heaters to increase temperature (270 recharges), sampling tubes, filters and reagents for water nutrient analysis with CIIMAR Autoanalyser (tasks 1 and 2), field and laboratory consumables required to run the experiments (Screws, PVC plates, sieves, cool boxes, plastic trays and buckets, silicon tubes, aquarium air pumps, bags).

8.6. Justificação do Equipamento
8.6. Equipment rationale

8.6.1. Equipamento já disponível para a execução do projecto
8.6.1 Available equipment

Tipo de equipamento Equipment type	Fabricante Manufacturer	Modelo Model	Ano Year
Freezers	several	several	2008

Tipo de equipamento	Fabricante	Modelo	Ano

Equipment type	Manufacturer	Model	Year
Stable isotope analyzer (IRSM)	Thermo	Flash EA 1112 Series	2007

Tipo de equipamento Equipment type	**Fabricante** Manufacturer	**Modelo** Model	**Ano** Year
Working car	Citroen	Berlingo	2002

Tipo de equipamento Equipment type	**Fabricante** Manufacturer	**Modelo** Model	**Ano** Year
Freeze dryer	SNIJDERS	LY3TTE	2007

Tipo de equipamento Equipment type	**Fabricante** Manufacturer	**Modelo** Model	**Ano** Year
Computing facilities and peripherals	several	several	2004

Tipo de equipamento Equipment type	**Fabricante** Manufacturer	**Modelo** Model	**Ano** Year
Stereoscopic Microscope	Leica	several	2001

8.6.2. Discriminação do equipamento a adquirir

8.6.2. New equipment requested

Tipo de equipamento Equipment type	**Fabricante** Manufacturer	**Modelo** Model	**Custo (€)** Cost (€)
Gas-powered catalytic heaters (9 units)	Coleman	QuadCat 3000	500,00

Justificação do financiamento solicitado

Rationale for requested funding

We need to use these camping heater to increase the temperature of any beaches, relative to the exeriments of the tasks 3 and 4. Such heaters will be distributed in each patch of sand added with wrack composed of different macroalgae included invasive species

Tipo de equipamento Equipment type	**Fabricante** Manufacturer	**Modelo** Model	**Custo (€)** Cost (€)
HQ40d multiparametric datalogger with LDO & pH probes	Hach-Lange	HQ40D	4.590,00

Justificação do financiamento solicitado

Rationale for requested funding

We need the probes to check for temperature increase, pH change, and oxygen fluxes. We will need these probes in every experiment relative to any task

Tipo de equipamento Equipment type	**Fabricante** Manufacturer	**Modelo** Model	**Custo (€)** Cost (€)
Addtional disolved oxygen probe (LDO)	Hach-Lange	LDO10105	890,00

Justificação do financiamento solicitado

Rationale for requested funding

This probe, to be used in the same equipment described above is need to check for dfferences in oxygen due to the saturation of CO_2 in the mesocosms and to check for changes in oxygen during decomposition of wrack

Tipo de equipamento Equipment type	**Fabricante** Manufacturer	**Modelo** Model	**Custo (€)** Cost (€)
Incubator chambers	Acripol	n.a.	1.000,00

Justificação do financiamento solicitado

Rationale for requested funding

Transparent perplex incubation chambers with water pumps to perform incubations in temperature and light controlled conditions. They will be used to measure primary productivty and nutrient uptake during experiments included in tasks 1 & 2.

Tipo de equipamento Equipment type	**Fabricante** Manufacturer	**Modelo** Model	**Custo (€)** Cost (€)
IRGA	Licor	Li 820	5.900,00

Justificação do financiamento solicitado
Rationale for requested funding

Infrared gas analyser to measure air CO2 concetrations. This machine will be used in the experiments including pCO2 chanbes (Task 1 & 2).

Tipo de equipamento Equipment type	Fabricante Manufacturer	Modelo Model	Custo (€) Cost (€)
Rock saw	Sigma	Dakar	950,00

Justificação do financiamento solicitado
Rationale for requested funding

This equipment will allow to cut and shape the pieces necessary to construct the synthetic macroalgal assemblages included in task 2. Dr F. Arenas has expertise in the use of these machines.

Tipo de equipamento Equipment type	Fabricante Manufacturer	Modelo Model	Custo (€) Cost (€)
CO2 increasing system	Onset	Hobo	1.050,00

Justificação do financiamento solicitado
Rationale for requested funding

Underwater temperature loogers

Tipo de equipamento Equipment type	Fabricante Manufacturer	Modelo Model	Custo (€) Cost (€)
2 Mini laptop Computer (3 unidades)	Asus	Eee PC 1000H Black Windows	1.350,00

Justificação do financiamento solicitado
Rationale for requested funding

This equiment will be the datalooger conected to the IRGA gas analizer

Tipo de equipamento Equipment type	Fabricante Manufacturer	Modelo Model	Custo (€) Cost (€)
CO2 cilinders and re-charge	n.a.	n.a.	2.390,00

Justificação do financiamento solicitado
Rationale for requested funding

to increase CO2 It includes liquid air L-50-mezcla cristal. Regulator-reductor HBS 240-3-2. 5 cpm

Tipo de equipamento Equipment type	Fabricante Manufacturer	Modelo Model	Custo (€) Cost (€)
CO2 gas flux regulators	n.a.	n.a.	2.890,00

Justificação do financiamento solicitado
Rationale for requested funding

kit with 2 flux valves (395 euros/unidad) x 2. Two Aalborg tubes (350 euros/unidad) x 6, which serve to connect the mesocosms to the CO2 bottles

8.7. Justificação de registo de patentes
8.7. Patent registration

(Vazio)
(Void)

8.8. Justificação de adaptação de edifícios e instalações
8.8. Adaptation of buildings and facilities

(Vazio)
(Void)

9. Ficheiros Anexos
9. Attachments

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Nome Name	Tamanho Size
timeline.pdf	21Kb

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