

SPATIAL AND ORGANIZATIONAL DYNAMICS

DISCUSSION PAPERS

Nº8

Resilience and Potential in Maritime Clusters

Contributions towards a Cluster Strategy for the Sea in the Algarve

Hard Working Ant: An Eco-tourism Spin-off Creation Tale

Regional Economic Resilience & the Deepwater Horizon Oil Spill: The Case of New Orleans' Tourism and Fishing Clusters

The Sea as a Connection between Residents and Tourists in Coastal Destinations: A Case in Algarve

SPECIAL SECTION: SCIENCE, TECHNOLOGY AND INNOVATION FOR COASTAL AND MARINE RESOURCES MANAGEMENT

Monitoring and Forecasting Ocean Dynamics at a Regional Scale

Exploring the Industrial Value of the Portuguese Deep Sea Microorganisms

Networking Systems for a Sustained Presence in the Ocean

Optical Methods for Water Pollution Monitoring

DISCUSSION PAPERS N° 8:

SPATIAL AND ORGANIZATIONAL DYNAMICS

Special Issue on “Maritime Clusters”

Organizer: Hugo Pinto

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Philip Cooke

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Luísa Bastos, Machiel Bos, Rui Caldeira, Xavier Couvelard, Sheila Allis, Ana Bio, Isabel Araújo, Joana Fernandes and Clara Lázaro

Cátia Rodrigues, Ana Rodrigues Martins, Gonçalo Andrade, Marta Cerejo, Ricardo Pinheiro, Patrícia Calado, Helena Vieira

João Tasso de Figueiredo Borges de Sousa

Andrei B. Utkin, Alexander V. Lavrov, Rui Vilar, Sergey Babichenko, Sergey Shchemelyov, Innokenty Sobolev, Luísa Bastos, Richard A. Deurloo, Jesús Torres Palenzuela, Nina V. Yarovenko, Isabel Cruz

**November 2011
University of Algarve**

TECHNICAL INFORMATION

Title - Discussion Papers N° 8: Spatial and Organizational Dynamics

Subtitle - Special Issue on “Maritime Clusters”

Organizer: Hugo Pinto

Authors - Several

Edition:

University of Algarve (www.ualg.pt)

CIEO – Research Centre for Spatial and Organizational Dynamics

(Centro de Investigação sobre o Espaço e as Organizações)

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Page Layout:

Marlene Fernandes

Design and Cover Concept:

Helder Rodrigues

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ISSN: 1647-3183

Special Issue on “Maritime Clusters” N° 8

Faro, November 2011

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PREFACE

REGIONAL DEVELOPMENT OF CLUSTERS AND THE SEA

DESENVOLVIMENTO REGIONAL DE CLUSTERS E O MAR

The performance of regions depends on the economic and social environment and on the strong relationships that their actors establish among themselves. A region can affirm its nature if the whole community works to exceed the stage of fragmentation, where each one gives a surplus attention to each activity, and if the community adopts a common project with a strong capacity to mobilize.

According to this perspective, stakeholders in the economy of the regions should try to structure their activities to achieve a high degree of integration, contributing to the regional added value and expect that this added value is always greater than the sum of the contribution of the different sectors.

This view could be consolidated by two levels of agreements: formal agreements and tacit agreements.

For formal agreements, the community members want and express the desire to work in partnership to achieve certain collective goals and formalize that option in the format of an association, board or policy.

For tacit agreements, the community members create continuously an environment of informal cooperation that, at any time, allows an atmosphere to contribute to the main regional options of development, promoting the adoption of collective solutions and innovation projects.

This is how we could create regional clusters, adding activities, promoting labour mobility, attracting talents and skills, and valuing each others mutual resources. The regional cluster needs to generate high density of relations between those members.

We could stress with that statement that the regional development depends more on the mobilizing capacity of the community than on physical or financial resources.

In the case of maritime regions, the Sea has proved to be a decisive factor in building regional clusters around the activities that depend on or exploit the marine and coastal resources.

Depending on the specificity of each region, the sectors that integrate the maritime cluster are connected to a variety of economic activities. From the exploitation of fisheries and other marine living resources to maritime transports, from coastal tourism and recreational boating to biotechnologies resources, from energy to shipbuilding and navy, from marine equipment to seaports management, a huge number of activities, professions and resources characterize the cluster of the sea.

We know that the sectors that generate higher revenues in Europe maritime clusters are the shipping and maritime tourism activities, particularly those related to cruises. In this latter area we have observed, in recent years, the construction of luxury boats, like real big cities, cathedrals of leisure, where the daily prices are supported only by high-level income families. The sun and beach tourism is another activity mobilizing thousands and thousands of people, often generating tensions with natural ecosystems and with other uses of coastal environment.

We can recall fisheries and related activities that have today an enormous degree of heterogeneity. This activity that in the past was the main occupation of the coastal communities, has reached today a dramatic level of complexity, associated with the decay of some segments and the rise of productivity of others, that creates difficulties in managing the sector as a whole. In addition to fisheries, the production of other marine living resources has benefited from a rational management of stocks, pointing to a limited exploitation of these resources to guarantee the ecological potential. It also includes productions created in artificial or semi-artificial environments.

We can evoke the potential to generate energy based on wind, ocean waves or solar radiation, from facilities in coastal areas or placed on platforms on the ocean surface. They are alternative forms of energy that may allow to replace the energy-intensive fossil fuel economy and to contribute to a more balanced environment.

Finally the exploitation of biological resources in-depth represents a wealth of biotechnology products, with many applications still unclear, which may allow producing valuable products to pharmaceutical, food, and energy sectors, and can reach the market in the form of several valuable innovations.

The cluster of the sea is still in its youth.

In terms of interest of research I have to underline at this point that the maritime focus in the cluster literature is not yet mature and so requires a huge effort in understanding how a sea cluster can operate. It is important to find the differences with other marine clusters in different ecological environments in others areas of the planet. It is also relevant to import methodologies and information from typical clusters more studied in regional science, in disciplines like Economics, Geography or Sociology. Only with this global approach Science can inform policy-making in the way to instigate a robust maritime cluster.

In more practical terms, the combination of production and research in these areas benefits the economy of the sea and, there is no doubt, accounts for a greater diversification of food sources, energy or materials. I have no doubt that the cluster of the sea can have a huge impact in the strengthening of Atlantic regional economies.

The University of Algarve is part of a group that intends to contribute for the cluster of the sea in the Algarve. Following similar initiatives developed in the North and Centre regions of Portugal, our region will proceed now with the constitution of an association bringing together companies, government agencies, research institutes and universities to formalize the contribution of the sea cluster in the Algarve.

I would like to mention that the University of Algarve devotes a large part of its research activity to marine science, from the management of biological resources to coastal environment. In this domain the University of Algarve has a relevant number of international partners. In the last years we have participated in the creation of a set of *Erasmus Mundus* masters and doctorates, an initiative that attracts a large number of foreign students who want to study marine sciences at the University of Algarve. The KIMERAA project is an opportunity to reinforce the need of a strong sea cluster, and to increase the networks with research institutions, universities and companies working in the sea activities in several regions and countries.

João Guerreiro

Rector of the University of Algarve

November 2011

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EMERGENCE OF MARITIME CLUSTERS IN EUROPEAN ATLANTIC REGIONS – INTRODUCTION TO THE SPECIAL ISSUE

EMERGÊNCIA DOS CLUSTERS MARÍTIMOS NAS REGIÕES ATLÂNTICAS NA EUROPA – INTRODUÇÃO AO NÚMERO ESPECIAL

In this short introduction for the Spatial and Organizational Dynamics Special Issue on “Maritime clusters” I will begin by going back to 2006. At that time I was working, as external consultant, in several strategic documents that were trying to instigate regional development in Algarve, the southern region in mainland Portugal. One of these documents was the Algarve’s Regional Innovation Plan. To my knowledge it was the first time that a regional strategic document in the Algarve thought the Sea as a resource that could be explored in the perspective of cluster. This vision, which the plan’s work team constructed around the need of clusterization of the Sea, was in fact nothing original and only a natural outcome from ideas that were being developed in higher spheres of decision making. One example was the contemporaneous European Commission Green Paper “Towards a future Maritime Policy for the Union: a European vision for the oceans and seas” where this approach was present. At regional scale it is important to underline that the regional authority, CCDR Algarve, was beginning to promote the relevance of the Sea and in the same year they organized an event in the city of Portimao, “*Mar algarvio – um oceano de oportunidades*”, that was an occasion to declare intentions to develop a regional Sea Forum as a facilitator of the cooperation and integration of maritime economic activities. This regional attention was related with two main strengths. The first was the need to diversify the Algarve’s economic base from tourism and the weight that some maritime activities still had in the regional economy. Fisheries or aquaculture remained activities with strong economic significance. The other issue was associated with the specific evolution of the University of Algarve, focused, since its early days, in the Sea as a critical area of education and research. Its success in marine sciences and technologies gave to the region a critical mass of researchers and research organizations that doesn’t have parallel with any other scientific domain in the Algarve. The natural conditions of the Algarve were also friendly to research. The rare lagoon ecosystems, such as Ria Formosa, were attracting researchers from the country and abroad to study particular phenomena with more ease in the Algarve.

Nevertheless, in a somewhat sceptical perspective, I have to assume in this introduction, that few decisive steps were given in the Algarve since 2006. We can try to justify this fact in different ways, like underlining that tourism is still profitable and so economic agents thought least risky to invest in this sector or that economic turbulence avoids strategic planning implementation, even if any of these excuses seems really convincing. The situation has to be changed. To confirm this opinion, the external shocks of the international crisis heavily hit the Algarve, an international tourism destination based in sun and beach product. The rapid loss of employment is a record that no one is proud of. From the region that had the lowest unemployment rate in the country, around 5-6%, in the end of 2011 it is reaching the 15%. The success story that was commonly accepted about tourism and the economic development of the Algarve is closing a chapter. Even if it was assumed that the economic base of the region required diversification at the risk of putting all the eggs in the same basket, as sadly was confirmed, with the economic turbulence, several entities, continued to have a stylized vision of what was the Algarve.

Algarve was low value added sun and beach tourism. But this economic emergency created the need for emergence of new areas that can give additional resilience to the regional economy. It is in this circumstance that today the activities based in marine and coastal resources appear to regional stakeholders as evident to overcome the constraints in development. CCDDR Algarve pressured for the creation of a regional agenda of the Sea, and pushed all other regional stakeholders for the formalization of the maritime cluster¹.

In June 2009, the University of Algarve, with a group of entities representing the regions of Norte (Portugal), Basque Country and Huelva (Spain), Wales (United Kingdom) and Border, Midland and Western (Ireland), submitted a proposal to Atlantic Area Cooperation Programme willing to instigate knowledge transfer to reinforce regional economies and develop economic niches of excellence in maritime clusters. In the approved project, KIMERAA - Knowledge transfer to Improve Marine Economy in Regions from the Atlantic Area, the notion of maritime cluster was a broad idea that encompassed all economic activities based in maritime, marine and coastal resources, from fisheries, aquaculture, to blue biotech, going to shipbuilding or coastal tourism. In the vision of the project, on-going until the end of 2012, it is essential for the progress of Atlantic Area regional economies to build strong linkages between firms and scientific communities. Thus, cooperation of all types of stakeholders is central for cluster consolidation. KIMERAA developed three main groups of activities. Firstly, the project promoted the evaluation of maritime clusters in the participating regions (Cooke et al, 2011) and a series of additional analysis of maritime clustering processes. Secondly, an online tool, named Sea Directory (available at www.kimeraa.eu), with basic information of different types of maritime cluster actors was launched to facilitate cooperation among different organizations. Finally, ENKTAA - European Network of Knowledge Transfer in Atlantic Area is being structured to support a deeper coordination on networking activities for maritime stakeholders.

In the context of KIMERAA, the seminar “Competencies and Services in Marine Sciences and Clusters in Atlantic Area” took place on the 4th July 2011 in Faro, Portugal. In this seminar several communications debated the construction and consolidation of maritime clusters, the bridging of science and business gap in marine sciences and technologies or knowledge transfer practices within this cluster. The issue that you have in your hands is a selection of articles presented in that seminar. This number is organized in two sections. The first includes five original articles in different domains of social sciences that cover several topics from resilience and potential of maritime clusters, consolidation of cluster strategies, entrepreneurship and network creation, clusters facing extreme disasters, to the evaluation of Sea as a resource to connect residents and tourism. These articles provide insights for a deeper understanding of maritime clusters’ emergence and consolidation. The second section includes four short articles about science, technology and innovation for coastal and marine management. These are empirical developments that may be relevant for an effective exploration of resources.

To conclude, the value of clusters is that they are the context where externalities and spill-overs can multiply. Connecting technologies, skills, knowledge and purchased inputs is easier with geographical proximity of interconnected companies, suppliers, service providers and associated institutions, but also with the talent and knowledge exchange that concentrates within the cluster. Sea is a resource that remains unexplored in Atlantic regions despite its immense potential. From the research in KIMERAA, several questions still require additional attention. Why marine resources in Atlantic regions continue to have this limited exploration? Why the constant mismatch between scientists and firms?

¹ This formalization was only achieved in July 2011 with the creation of the Algarve’s Sea Platform (Plataforma do Mar Algarve), a non-profit association to be the pivot of the regional maritime cluster. The founding members were five companies, the University of Algarve and the municipalities of Faro, Olhão and Portimão. The role that the Platform can assume is a challenge for the future.

What is the importance of mediating entities in these contacts? What are the central actors within innovation systems and the minimum density of connections for the emergence of maritime clusters? Is coastal tourism a critical activity in the maritime cluster even in regions where this might not be as evident as in the case of Algarve? What is the role of knowledge-based companies with greater value added to territorial resilience in the current economic turmoil? How to guarantee the coexistence of top-bottom coordination mechanisms in the maritime cluster governance and the active bottom-up involvement of stakeholders, in particular, the enrolment of firms? The majority of these questions will remain with no straightforward answer in the times to come but I hope this special issue can stimulate more researchers to contribute for the understanding of maritime clusters.

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RESILIENCE AND POTENTIAL IN MARITIME CLUSTERS

RESILIÊNCIA E POTENCIAL NOS CLUSTERS MARÍTIMOS

Philip Cooke

ABSTRACT

Theoretical analysis of the relevance of the concept of path dependence for regional analysis has made progress. This has occurred on the spatial *process* (or regional paradigm) dimension of spatial evolution. Progress has also occurred after further reflections on the roles of ‘conventions’ in understanding the ‘soft institutional’ dimension of regional regime formation and change. This adds considerably to the more common ‘institutions and organisations’ aspects of governance structures for innovation regarding the typical analytical content of regional *regime* and innovation system analysis. In this paper the concepts of ‘relatedness’ and ‘transversality’ capture the processes of knowledge recombination for innovation classically introduced by Schumpeter. Two live cases are presented whereby regional relatedness of industry regarding ‘green’ competences, on the one hand, and engineering and materials processing, on the other, have resulted in new clusters or cluster trajectories. The exemplar cases come from either end of Europe, Sweden, in the first instance, Italy in the second. Both clearly support the new ‘transversal’ theory of cluster emergence.

Keywords: Region; Maritime Clusters; Relatedness; Transversality.

RESUMO

As análises teóricas da relevância do conceito de dependência de trajetória para a análise regional progrediram. Tal tem ocorrido numa dimensão do processo espacial (ou paradigma regional) baseado na evolução espacial. Este progresso ocorre com as reflexões sobre a função das ‘convenções’ na compreensão da dimensão institucional ‘soft’ na formação e mudança de regimes regionais. Assim as instituições e organizações mais comuns são adicionadas de outros aspectos das estruturas de governação para a inovação em relação ao conteúdo analítico típico de um regime regional e da análise de um sistema de inovação. Este artigo apresenta os conceitos de ‘vinculação’ (relatedness) e ‘transversalidade’ que tentam capturar os processos de recombinação de conhecimento para a inovação, introduzidos desde os textos clássicos de Schumpeter. Dois casos são apresentados onde, por um lado, a vinculação regional da indústria em relação a competências ‘verdes’ e, por outro, a engenharia e o processamento de materiais, resultaram em novos clusters ou trajetórias de clusterização. Os exemplos vêm de pontos extremos da Europa, Suécia, em primeira instância, e Itália, em segunda. Ambos os casos suportam claramente esta nova teoria ‘transversal’ sobre emergência de clusters.

Palavras-chave: Região; Clusters Marítimos; Vinculação; Transversalidade.

JEL Classification: A14, O33, R11, R58

1. INTRODUCTION

In this paper, we shall explore new ideas about regional development in which clusters are utilised not in order to drill down deeper in a vertical manner following the seam of gold that may have become exhausted but, much more intelligently, by seeking the goldmines in the heads of workers and entrepreneurs in neighbouring clusters. This approach is newly theorised but has been practised for some years by certain accomplished regional development agencies. These include the Bavarian innovation agency *Bayern Innovativ*, the Lower Austrian development agency responsible for *Clusterland*, and the Scanian and Gothenburg regional development agencies in Sweden (Cooke & Eriksson, 2011). The first of two cluster exemplars reported in this paper that refer to maritime industries is in the Gothenburg region of Sweden (Västragötaland) managed by the Swedish Maritime Technology Forum. The Forum (SMTF) is a not-for-profit organization, established in 2007, beginning its work in June 2008. It has resources of €1.2 million in public and private sector funding through Tilväxtverket (the Swedish Economic Development Agency), bank investment, services to the market and membership fees. SMTF has 200 companies involved in all projects with which it is involved and has a regular membership of 40. Membership is growing moderately well. The cluster focuses on heavy shipbuilding equipment and components, on the one hand, and leisure yacht design and construction, on the other. The second exemplar is in the Marche region of Italy, where the regional development agency (SVIM), three industrial district Technology Centres and a number of entrepreneurs utilised their strong business networks in the region to connect the furniture, leather and white goods industries to evolve a new cluster at Ancona based on luxury yacht building and marine services. The paper proceeds with a discussion of the theoretical and practical rationales behind these initiatives. It then provides an account of the SMTF cluster, followed by one for the SVIM cluster. Finally, conclusions are provided.

2. THEORETICAL PERSPECTIVES

Recent theoretical analysis of the relevance of the concept of path dependence for regional analysis has made progress on the spatial *process* (or regional paradigm) dimension of spatial evolution (Martin, 2010; 2011; Martin & Sunley, 2006; 2011). Moreover, Sunley's (2011) and Tödtling & Trippel's (2011) further reflections on the roles of 'conventions' in understanding the 'soft institutional' dimension of regional regime formation and change add considerably to the analytical content of regional *regime* and innovation system analysis. In a complementary manner Cooke & Rehfeld (2011) have analysed the relations between such conventions - meaning relational 'soft institutions' - and firmer *structural* institutions and organizations that compose regional regimes. Here a set of comparative and contrastive 'frames' were drawn up to capture different densities of regime narrative. These could be seen ranging from ethnic to urban, political, labour and business 'framings' in accounting for variety in the intersections of regional and corporate cultures. The integrated regional paradigm and regime is referred to as the *regional socio-technical system*.

Two recurring themes in this co-evolutionary spatial analysis are *relatedness* of industry, by means of which regional growth is assisted, and *path dependence*, by means of which it can be constrained. Exploration of the first is a relatively recent phenomenon, pioneered by Frenken et al., (2007) but already it is a core body of theory and empirical research in evolutionary economic geography (Boschma, 2005; Boschma & Frenken, 2003; Boschma & Wenting, 2007). The main mechanism by which relatedness influences regional growth

is through knowledge transfer between firms, one result of which can be innovation. The key agents of such transfer are employees developing their careers by changing jobs in neighbouring areas and new companies being formed by the spin-off process that may also be a vehicle for innovations. Path dependence is a more established concept arising in economic history, particularly the branch interested in the history of innovation (David, 1985). It has been analysed fruitfully in the context of evolutionary economic geography and particularly regional development, adaptation and change.

The champions of 'relatedness' indicate the pivotal position occupied by the idea of 'related variety' in evolutionary economic geography. Comparable to 'proximity', it has numerous dimensions, notably the cognitive, social, organizational, institutional and the geographical. Much research effort is exercised in relation to both concepts seeking to assess the relative importance of each in understanding the evolution of agglomerations or clusters, the core problematic of economic geography. In doing this, light is cast on the role of numerous other of the key process elements of interest to evolutionary economic geography, such as: innovation, technology, knowledge spillovers, learning and the creation of new regional developmental pathways. Foremost, authors take the two most frequently identified types of relatedness; geographical and cognitive as their main focus. Not a new idea, this distinguishes the base meaning of 'proximity' as 'shared space' from a distortion of that meaning, which allows a spaceless 'community of interest' kind of cultural closeness or 'proximity' to evolve (Webber, 1963). They then apply these perspectives to issues of externalities and regional growth, on the one hand, and technological change in new path creation, on the other.

With respect to externalities and regional growth Boschma (2005) and Frenken et al., (2007) note that a key research question has been the extent to which firms in agglomerations benefit most, if at all, from 'Romer externalities' of *localisation* or 'Jacobs externalities' of *urbanisation*. Specialisation and diversification are the key differentiating dynamics respectively of these two perspectives on growth and agglomeration. Specialisation has been a mantra of the supply-side, clustering and cluster policy era, with which, as 'Smart Specialisation' European Union regional policy makers remain obstinately obsessed. Even as key neo-liberal proponents abandoned ship after the financial crisis of 2007-2009 there was little policy recognition of the perils of unreflective advocacy of 'regional specialisation' (Porter & Kramer, 2010). This was doubly ironic since every policy body from the International Monetary Fund and European Union on down was calling for post-crisis economic re-balancing away from specialisation in financial 'securitisation' towards meeting 'Grand Challenges' like climate change. This was to be achieved by supporting greater economic *variety* in diverse forms of 'Sustainable Economic Development' of the kind facilitated by 'urbanisation' processes of knowledge cross-fertilisation. According to textbook perfect market conditions, specialisation would logically require low inter-industry knowledge transfer effort. This is because similar specialist technologies being utilised mean lateral absorptive capacity among incumbents would be accordingly high, requiring little policy intervention. However, because of market failure, especially in inter-sectoral knowledge transfer, such is seldom the case. Therefore, the gains from efforts by intermediary agencies to assist knowledge transfer among similar *and* different industries might yield a greater regional reward than awaiting intermittent market signals for firms to react to. Beyond sectoral relatedness, evolutionists also place strong emphasis on *technological* relatedness, even among diverse industries, as being a necessary but not sufficient condition for cognitive proximity, meaning clarity of understanding of the other's business model, processes and potential, possibly leading to innovation-led profitability (Kaplan, 2008). The empirical research of Frenken et al., (2007) shows advantage accrues from the absorption of knowledge spillovers from

regional (and extra-regional) industry that is cognitively relatively proximate in some way (technological, inputs, skills) whereas gains from Romer externalities (specialisation) are less so.

These early analyses were static so attention turned to the dynamics of technological relatedness and regional branching (new path creation). This invited discussion of relatedness in the short and long term, one hypothesis being that constructing advantage from related variety only brings short-term advantage. Long-term, some wholly new branches are needed to sustain regional growth. This is clearly an open question, warranting deep thought because at the heart of spatial evolution is a notion of an industrial ecosystem, which means complementarities foster growth while unrelatedness destroys it. As noted in 'transversality' analysis of regional innovation and growth, keeping industry conscious of regional relatedness is one of the key tasks of the advanced regional development agency (Cooke, 2011). This raises a key question about the strength and longevity of radical innovation. Many authors use the term 'radical innovation' to denote relatively short-term but regime shifting change, for example in fashion markets (Verganti, 2006). More typically it has been utilised to signify a major, long-lasting waveform transition in the dominant technological paradigm (eras of mechanisation, motorisation, informatisation etc.). Path dependence applies to the period of 'normal science' (Kuhn, 1962) or unpunctuated regional equilibrium, which is the short-term in 'episodic' or short term radical innovation. But multi-level interaction between regime elements and paradigm elements is far more diffuse and complex during long-term, more 'epochal' periods. Because the 'relatedness' perspective can appear 'dis-embedded' from neo-Schumpeterian concerns about innovation and policy, it can also appear to be vulnerable to randomness in its predictive qualities. However, this aspect improves with the introduction of a dynamic element into the analysis represented in such branching processes as entrepreneurship, merger & acquisition, and exploitation of industrial density. These are also mechanisms that contribute to regional path dependence, which impose a heavy effect on regional evolution such that new path creation is generally influenced by the industrial legacy. This makes the Silicon Valley phenomenon really an extreme exception rather than the rule of regional development, which is one reason why it has never been replicated.

The idea of the regional economy as a path dependent system is the subject research by Martin (2010; 2011) and Sunley (2011). Among the conceptual issues raised are questions such as the extent the regional paradigm and its 'regime' are uniform, or composed of elements on different paths; to what extent are paths articulated even if they are on different paths; indeed, can regional evolution be characterised as systemic at all? Clearly these are salient questions because articulation would suggest relatedness and disarticulation the opposite, namely chaos. Hypothetically, therefore, the disarticulated region would be expected to be weaker in economic terms than the systemically articulated one. Much depends on refinements of conceptual degree and intensity. Thus it may be unnecessarily misleading to inquire whether regions display path dependence in certain industries or not. Many are 'externally-controlled', some are endogenously so. As Cooke & Rehfeld (2011) show this makes a real difference in regional paradigm embeddedness. Thus Westphalia-Lippe in Germany remains endogenously path dependent on strong, internationally competitive, quality products produced in family firms. Wales, by contrast is path inter-dependent on both legacies and opportunities in engineering, energy and agro-food. This helps illuminate important aspects of what qualifies an economic region to be differentiated between displaying path dependent and path inter-dependent socio-technical system characteristics at the regional level. One element is clearly 'agglomeration', another may be 'origins', ownership or 'embeddedness' meaning when and why key events

first occurred, evolved and diversified or ‘branched’ in a particular region. Martin (2011) suggests the predominant way in which regional path dependence has been conceived is either in terms of industry ‘selection’ of one from a number of candidate regions, or why regional ‘specialisation’ occurs in a specific industry.

However, a second approach involves the conscious quest for regional path-interdependence between industries; in other words its entire ‘paradigm’ and ‘regime’ evolution such as would allow profiling systemic regional articulation. This question is also asked in investigations of ‘regional varieties of capitalism’ and ‘regional corporate cultures’. Regional path inter-dependence introduces the historical dimension quite profoundly. Cooke (2011) advances evidence for this in small, Nordic regions. Here early path dependence (e.g. ship’s propellers; milk coolers; plough design) remains embedded in later path dependent industry (wind turbine blades) in north Jutland, while forestry (pulp and paper) reveals early path dependence and flexography (packaging; printing; film scripts) are later emanations of an initial resource endowment in Värmland, Sweden. Connecting to the earlier discussion of ‘epochal’ and ‘episodic’ radical innovation both transitions described above have ‘origins’ in ‘epochal’ (long wave) exploitation of natural resources such as Schumpeterian ‘mechanisation’. But paradigms have been ‘episodically’ innovated according to opportunities arising from intersections of epochs (e.g. ‘mechanisation’ and ‘electrification’ for windmills; ‘mechanisation’ and ‘informatisation’ for flexographics). Of course, path dependence with renewal also applies to epochal long waves and their after-shocks. This seems more satisfying than the ‘randomness’ that some path dependence analyses share with some ‘relatedness’ perspectives (David, 1985; Arthur, 1994)

3. GREENSHIPPING IN SWEDEN

In this section an account is given of the emergence, focus, mode of operation and relatedness interactions of a shipping cluster in Sweden (SMTF) that is leading efforts on a global scale to produce ‘greenshipping’ practices among global maritime players. Other advanced ideas being deployed include gender dimensions of yacht design as Volvo initiated in the past in relation to its ‘Concept’ car.

SMTF Projects: The typical way to build the cluster is to engage firms in projects. Projects are ongoing among the shipbuilding community in general. Hence it may be that some potential members do not join SMTF because they have their own private projects with local or even more distant partners (e.g. Green Shipping project of *Wilhelmsen*). Or in the case of the Finns who want to sell a whole package rather than shipping components, which is what the region specializes in. Nevertheless the cluster is key to allow learning opportunities to evolve such as in the ‘Lean Marine’ project. This brings lean production methodologies developed in the automotive sector to ship building.

Clean technology (*Cleantech*) informs numerous SMTF projects. Thus Denmark’s *BluDenmark* initiative stimulated a clean shipping strategy by SMTF that aims to produce a Clean Shipping Index. It was found that many Swedish firms had developed Cleantech solutions but had not marketed them strongly. An advantage of the cluster is that it could encourage higher prioritization of these products and market them better at trade fairs. It was further realized early on that the future of shipping energy lay in gas (liquefied natural gas – LNG) rather than heavy diesel which is more polluting, in order to achieve the ‘Clean Ship’. Each such element feeds into the Clean Shipping Index. This Index will

be validated by Lloyds Register, Ericsson and IKEA, for example – all practiced in Green Production and Services. However, such bunkering of gas to replace diesel has as yet no regulations or legislation that would speed along Greenshipping development.

Greenshipping is one of the major projects promoted by SMTF. This has resulted in innovative designs being produced for two merchant ships, a Ro Ro Ferry and a Tanker. Key parts of these ships are capable of massive reductions in CO₂. The skill of the Uddevalla and Gothenburg ship builders lies in making components that are assembled by final producers, many of which are in Asia, notably China and South Korea. *Maersk* alone generates 9 billion tons of CO₂, for example. The Board of SMTF is generally supportive, but as in other Swedish cluster initiatives, attendance is variable. Companies are the best attenders at SMTF Board meetings. Politicians, however, are not regular attenders. It is noted by the SMTF managers that there is a communication problem between politicians and shipbuilders. Thus larger firms inquire why foreign firms can't be SMTF members while W. Gotland sub-areas like Fyrbodalen are unclear why SMTF has to be a national initiative since they prioritise actions that benefit their localities.

SMTF Markets: the current recession affects both shipping and leisure boats. SMTF continues to conduct meetings and organize or attend exhibitions (361 attended a recent one). They also engage in match-making events for Swedish firms, which work well and are known as the 'meeting machine'. However, Swedish shipping businesses are less prominent at some international events than, for example Norwegians. Thus two Swedish representatives displayed at an exhibition at Archangelsk about the White Sea and North East Passage to China, whereas over 30 Norwegian firms attended, including two delegates from the Norwegian Foreign Office. SMTF considers Norway's National Maritime Strategy to be an advantage for which there is no equivalent in Sweden.

The recession also means that SMTF could be assisting ship workers who become redundant into the leisure yacht business. High school training would be arranged but at present demand for leisure yachts is also low and firms are not hiring. So SMTF is negotiating with the Employment Agency with the incentive that if a person undertakes the conversion training programme they will get a job in 4 months. This may be speeded up by redundancies announced in January 2010 at SAAB where automotive engineers may be re-trained with Employment Agency assistance to enter the ship engineering business.

Growth barriers for the cluster include the following. There is an initial reluctance by firms to engage in networking. This is because they come from a highly independent tradition. So getting started on match-making can be hard. However the chances are high that a firm may at the second meeting get an order, in which case they become more willing. There are many such success stories. Connecting to Nordic exhibitions can also be valuable as in the case of the recent Norwegian exhibition on Greenshipping, which was of great relevance to the W. Gotland ship engineers. Russian business is thought promising by SMTF.

85% of Sweden's shipbuilding is in W. Gotland and many firms and engineers already act as mentors to Russian firms. But below Sweden's 'Big Five' SMTF lamented the absence of industry-wide representation which would make Swedish ship building a more proactive industry than at present. For instance, the Swedish Export Board was said to have to be paid to represent Swedish shipbuilders and this acts as a disincentive for a small organization like SMTF. SMTF manages a service cluster in shipbuilding. They seek to show designs of new ships to shipowners and shipyards e.g. through the Swedish-Chinese Maritime Association. China has for a long time (since 1980s) had what now

has evolved to over 70 Swedish firms present in that country. Russia, as noted is another target market.

Foresight & Future: SMTF is future oriented in both shipbuilding and leisure yachts. A project in the latter is the CONCEPT leisure yacht for women initiative. Neighbouring Volvo once designed a prototype CONCEPT car, many of whose innovations are now found embodied in modern cars. Yachts are a male preserve in design, image and practicalities. But women are a new market segment. SMTF did a survey to find out what women want from yachts. They identified over 20 current design weaknesses ranging from comfort and convenience to safety. These were exhibited successfully in cartoon form and agreed by the industry to be in need of attention. SMTF arranged for Stockholm Design College and Uddevalla's nearby Industrial Design department to design modules for such as women's yacht market. Servicing yachts for tourists is also seen as a new growth market. Making ships from composite materials is also being studied both for yachts and superstructures of large ships.

Shipbuilding is unlike automotives in being very horizontally integrated while automotives is vertically structured. Thus it is open to innovation by cross-fertilization or cross-pollination, which is a strength in this era of distributed knowledge flows from different hotspots around the world. Greenshipping designs recognize this, as does the Concept initiative for yachts, which connects to creative industries and probably Cleantech. Knowledge is also combined with energy providers on the LNG project. SMTF have built the first Swedish shipbuilder database. SMTF notes that as W. Gotland shipyards went down, so with them went any Swedish National Shipbuilding Strategy.

Policies – of most assistance here has been the Tillväxtverket support package for SMTF. W. Gotland region supplies even more financial support and has been very positive and committed to SMTF support. The European (ERDF & ESF) Structural Funds are in the picture supporting SMTF too. The ERDF fund is already successfully accessed while bids are being composed for ESF funding and also InterReg project support. The SMTF aim is to make the Forum an AB (private company) eventually. There would be immediate VAT savings of 25% if that happened. For the moment the future funding sources are expected to be as above with reliance on regional, EU and possibly private services sales as sources of support. Arranging exhibitions as at Stavanger, Sandefjord, Poseidonia and Hamburg could be services for which a fee is charged in future. Selling green services, the Green Index and so on would also contribute to SMTF coffers. Arranging yacht services for tourists, mainly from Germany, Denmark and Norway would be another. But no strategy for exiting Tillväxtverket support is yet in place or substantively under discussion.

SMTF Summary – SMTF is a competent, hard working and well-informed cluster organization. It has good profile that could be enhanced by a public relations drive such as that conducted by some other Swedish clusters but efforts to promote shipping and yachting at local, national and international exhibitions are exemplary. Employees of SMTF are innovative, as the Greenshipping and Gender focus on products and services show. Future funding is an issue, though currently the budget - while a little on the low side – compares favourably with some, better-funded Vinnova (Sweden's innovation agency) cluster projects. Local and regional support as well as EU will be crucial in future. Some of this brings unwelcome bureaucracy, so project management software to reduce this burden, as developed by the FPX 'positioning' cluster is recommended if it can be afforded. This would free-up valuable management time for more productive activities.

The Board needs reviewing – if representatives do not turn up, they should be replaced. More business representation may be necessary. But in general SMTF is an impressive and interesting organization. It should continue to be supported by Tillväxtverket.

4. TRANSVERSALITY & ORCHESTRATION IN CLUSTER RENEWAL: MARCHE REGION, ITALY

Marche region in Italy has branded itself with the grand narrative of being a classic, creative Italian industrial district economy. As farming declined from the 1950s and 1960s entrepreneurship and innovation grew in small-firm networks concentrating on agro-food processing; footwear and leather; textiles; white goods; and furniture. Like Värmland it is seen as peripheral, yet it has above-average regional GDP for Italy and sees itself as a quality economy, promoted with the 'Made in Marche' brand. However, in the depths of the global financial crisis of late 2009 the common perception of policy and representative economic actors with respect to the Marche regional economy was that it had been deeply, possibly fatally, undermined by the crisis. Many small firms had gone to the wall; even larger firms in the agro-food industry had been bankrupted. Globalisation had, in any case, made trading conditions for Marche firms considerably more difficult, not least because most were in traditional industries like footwear and leather, textiles, furniture and food. Only the substantial electro-mechanical industry, boasting such globally-recognised names as *Indesit-Hotpoint* and *Ariston* white goods production were at least somewhat future-oriented in their business planning. First, as is shown in regions that have long-established clusters, it is possible for cluster managers, for example those who manage the specific cluster Technology Centres, to scale up cluster activity by creating a 'conversation' about developing a new cluster. A regional development agency may be a crucial facilitator of such an initiative, but equally it may come from below, including from a single firm that perceives advantage in clustering its activities across normal company boundaries. The case to be discussed below is from Italy's Marche region, but it has obvious relevance for VGR where a major part of Sweden's yacht production is concentrated. Recently, SMTF VGR's marine technology cluster has commissioned new modular designs for improved facilities such as bathrooms, kitchens, seating areas and so on in response to criticisms of traditional boat designs from women consumers.

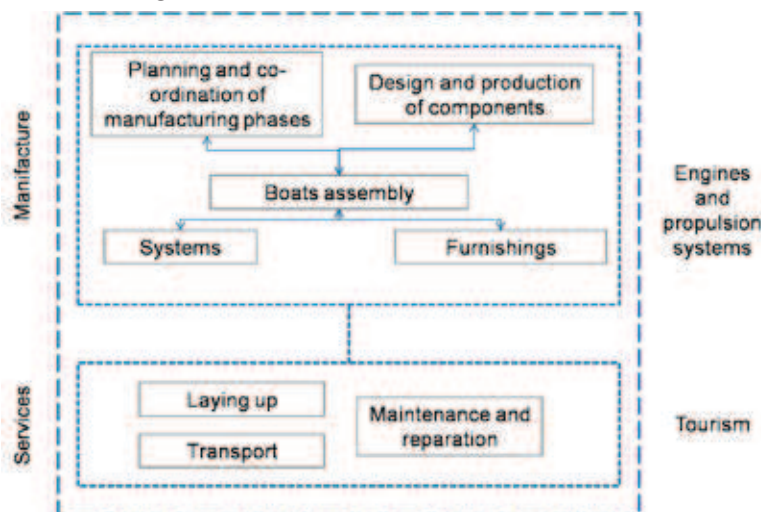
The key economic development orchestrator is *Sviluppo in Marche* (SVIM). This is a small agency that interprets innovation strategy guided by the Laws passed by the regional government. These give 'rules of the game' for different policy areas and SVIM forms its sense of priorities and activities according to its interpretation of these. Hence, for example, most of the time of the thirty staff of SVIM is spent on the arduous task of tendering mostly successful bids for EU Structural and Framework Funds. The efficiency of Marche Region in disbursing such funds means that in 2009 it was the first Italian region in actually ensuring allocation of funds to recipient organisations and partners. Such funds as these form the largest part of the SVIM budget. In 2008 this was reflected in a global budget for projects of all kinds, numbering 150 approved, of €35 million. The annual budget of the organisation, by contrast, was of the order of €3-5 million. Seeking such funding is guided by five fields of activity: Innovation; Research; Energy; Credit Access; and Internationalisation. However, this focus had occasioned closure of the 'Localisation (FDI) of Companies' and 'Sustainable Environment' functions leaving Environment embedded – usefully – but secondarily in the Innovation function.

There is a widespread perception in Marche that the clusters that have served the region well for decades are in need of renewal. But the global financial crisis of 2008-9

had a more profound effect on Marche firms than previous downturns. This is almost certainly because of the fact that it was principally a crisis of the banks and specifically a crisis which froze credit, especially to small family businesses. Here is revealed, perhaps for the first time, a negative aspect of the Marche model. It was clearly built on the assumption that small, regular amounts of credit would be available through high trust, reputational links among small firms and regional or local banks. While that assumption prevailed the system could function in a flexible but specialised way within the distinctive clusters. But when even local banks, knowing their creditors for decades, experienced something akin to a collective nervous breakdown in late 2008, credit dried up, firms started to go to the wall and pressure on the regional government to respond with an extensive system of credit guarantees became irresistible.

The marine cluster project was launched by the Marche region in October 2004 with the goal of establishing a new, technically specialist yacht and shipbuilding system in Ancona. In 2008 agreement to implement this decision was reached among the relevant clusters and networks of enterprises in the region. The initiative will develop a system of goods and services related to navigation, namely shipbuilding, pleasure craft, accessories and infrastructure for tourism and commerce and horizontally connected to the other main regional sectors like wood-furniture, textile-clothing, manufacture, mechanics and electronics with the aim of further integrating the different clusters. The innovative dynamic of this cluster is that it utilises the existing skill sets and entrepreneurial strength from the diverse sectors in the Marche region and coalesces them into forming an effective manufacturing productive system in both shipbuilding and in the building of pleasure crafts. Competences, entrepreneurship and experience of cluster management in related industries means process management gains natural support but assistance from the RDA (SVIM) is crucial in accessing State and EU regional development funding. The innovation in the marine cluster is internally driven by the interaction between previously demarcated industries, a powerful example of the concept of related variety.

Figure 1: Schematic Marche Marine Cluster



Source: Marche Region

Support for process management is evidenced where several leading companies from other regional clusters have synergies with the shipbuilding and pleasure craft sector. The Group Poltrona Frau, for example, diversified towards the nautical sector such as the agreement with Ferretti Group for a set of innovative and research based products tailor-

made for the interior decoration of the Pershing yacht series. Mobilificio Meneghini (a furniture company) created a special brand “Meneghini Yacht Line” for the realisation of luxury yacht kitchens. The key conclusion to be drawn from this example is that clusters can revitalise themselves by cross-pollination to those displaying ‘related variety’ which in turn brings efficiencies due to knowledge spillovers and good absorptive capacity among neighbouring technology producers.

5. CONCLUSIONS

It is evident that this new perspective on knowledge flows introduces numerous new concepts. Most of these are not difficult. The key ones are ‘relatedness’ and ‘transversality’: ‘relatedness’ refers to industries or clusters in a region that cross-pollinate their respective knowledges. This happens in circumstances where they seek to create innovation. Thus an automotive firm might use an aerospace innovation in the simple version of ‘relatedness’. More interestingly, in exploring the unknown, firms might, together, create a new knowledge combination that leads to an innovation that founds a new industry. This occurred when steam engines were applied to wheeled vehicles, setting in motion an important new phase in the industrial revolution. It happened again when Daimler put an Otto internal combustion engine on a bicycle, creating the motorcycle in 1885, then with Maybach did it again in the same year with a four-wheeled vehicle. Because relatedness is so important to the knowledge recombination that creates innovation, some innovation agencies induce such ‘transversality’ from regionally neighbouring firms by organising ‘storytelling’ or ‘innovation theatre’ events where firms learn of innovations in related as well as unrelated industries. They then support early-stage exploration of the ‘preadaptation’ qualities to the new use (Kauffman, 2008; Schreyögg & Höpfl, 2004). ‘Framing’ is proposed by cognitive organisational theorists like Weick (1995). A frame packages the rhetorical devices in favour of certain interpretations of meaning and against others. Finally, a ‘paradigm’ is the predominant industrial or service ‘culture’ in a ‘domain space’ like a region and a ‘regime’ is its governance system.

What was shown in the material described and discussed for the two maritime clusters that were focused upon is that both were examples of resilience, influenced by the strong policy perception that making knowledge recombination connections from maritime to related clusters was an advanced ‘business model’ not being conducted by their competitors to any great extent. Accordingly looking out from traditional, obsolescent shipping that had been out-competed by Asian countries enabled SMTF to find ‘green engineering’, women’s yacht and general leisure boat design capabilities in neighbouring clusters and institutions. Lateral thinking helped the cluster identify production niches that were open for exploration. In Marche region the crisis and its expectation caused entrepreneurs and SVIM to put together a transversal plan based on the relatedness of neighbouring clusters of leather, wooden furniture and white goods to think up a new maritime cluster that would both design and construct luxury yachts but also supply services to the pre-existing and evolving maritime industries.

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CONTRIBUTIONS TOWARDS A CLUSTER STRATEGY FOR THE SEA IN THE ALGARVE

CONTRIBUIÇÕES PARA UMA ESTRATÉGIA DE CLUSTERS PARA O MAR NO ALGARVE

Pedro Valadas Monteiro, Teresa de Noronha, Paulo Neto

ABSTRACT

This article advocates the relevance and crucial need for a strategic vision of the Algarve based on a cluster approach for its economy of the sea. The article reviews the literature on clusters and relevant topics related and relevant to that issue. It starts by summarizing the scope and structure of the article, followed by a theoretical framework, which highlight the key features and benefits associated with the cluster approach taken, the role of knowledge - intensive service activities as key drivers for innovation and entrepreneurship, taken as critical factors for successful cluster strategy advocated, along with the networking and cooperation, innovation systems and the importance of knowledge spillovers for knowledge management within the cluster.

Keywords: Cluster; Innovation; Network; Spillover.

RESUMO

Neste artigo defende-se a emergência de uma visão estratégica para o desenvolvimento regional do Algarve, assente numa abordagem de *cluster* que integre as actividades ligadas à economia do mar no Algarve. O artigo faz uma revisão da bibliografia relacionada com esta temática, nomeadamente dos tópicos que se assumem de particular relevo para tal efeito. Assim, após uma introdução onde se identificam o âmbito e estrutura em que o mesmo se elabora, parte-se para a apresentação do quadro conceptual e teórico que deverá estar subjacente, o qual ressalta as características chave e principais vantagens que advém da abordagem *cluster* preconizada, o papel das actividades baseadas em serviços de conhecimento intensivo, enquanto vectores para a inovação e o empreendedorismo, passando pelo enfoque nos processos de *networking* e de cooperação, e terminando na relevância crítica crescente desempenhada pelos sistemas de inovação e dos *knowledge spillovers* para a gestão do conhecimento no seio dos *clusters*.

Palavras-chave: Cluster; Inovação; Rede; Spillover.

JEL Classification: O13, Q00, R11

1. INTRODUCTION

The importance of the ocean and seas to mankind has been widely recognized within the United Nations and other international fora. Around the world in recent decades, awareness has emerged that the management and governance of the ocean, coastal zones and human activities associated with it should be addressed at an ecosystem approach, of sustainable development, based on a comprehensive view, not sectoral and integrated, towards (EMAM, 2007, p.13): “The use of windows of opportunity for the development of new activities and uses of ocean and coastal areas, minimizing, in advance, potential conflicts of use between the various users and activities that make use of the sea to fulfil its objectives or as a resource, such as tourism, recreation and leisure, water sports, sea and inland cruises, shipping, dredging and coastal protection works, nature conservation and biodiversity, underwater archeology, recreational and commercial fishing, aquaculture, renewable energy, exploration and extraction of geological resources, the passage of cables, pipelines and broadcasters, commercial and fishing ports, marinas, scientific research and technology, engineering and shipbuilding, military exercises, the use of genetic resources, inter alia, by biotechnology. “

The maritime regions, which house 40% of the EU population, account for more than 40% of its gross domestic product (GDP), as expressed in CCE (2007). The maritime economy represents five million jobs and about 3-5% of EU GDP comes directly from the industries and services in the maritime sector (CE, 2007). This figure is much higher when taken into account the indirect contributions of other sectors such as tourism.

According to SaeR (2009), in the context of the first quarter of the century, there are five areas of vocation that Portugal can explore and learn to develop according to the resources at its disposal. On the whole, and if they are exploited in an integrated manner, have enough potential to constitute a platform of modernization that drag other more traditional sectors, through their interconnections and by the dissemination of good business practices and appropriate social behaviors. Also, they have a strong potential for job creation, viewed as a relevant condition to support the transition phase between the development model of the national economy (with its social safety nets) and the development model of competitiveness (where the devices of social protection will depend on value creation within that economy and society). These five areas of national vocation are tourism, the environment, the enhancement of cities' role as centers of development, the value-added services and the economy of the sea. These five domains are not strictly economic sectors, but from them emerge areas of economic activities that structure the economic sectors.

Portugal has the largest Exclusive Economic Zone (EEZ) of the European Union and the 11th worldwide, with more than 1,700,000 km², which corresponds to about 18 times its land area. Besides that, it's even possible that Portugal come to rely on maritime zones under their jurisdiction (only concerning the rights to the seabed and subsoil and not to any rights to exploit fishing) that could more than double the current area of the EEZ, if the claim already presented by the Mission Structure for Extension of the Continental Shelf at the International Commission on the Limits of the Continental Shelf of the United Nations is approved. If so, Portugal will achieve a territorial acquisition of over 2.1 million km².

The Algarve, with a coastline of 220km, approximately, has with the sea a particular affinity, as a result of its excellent natural conditions: the famous Nautical School of Sagres created by Prince Henry, where the navigation pilots, who initiated Portugal's Age of Discoveries, received instruction, became the core of the portuguese maritime expansion during the first half of the XV century, the most advanced center for studies

and research worldwide; historically, the fisheries sector in the Algarve has always been an important economic activity with a strong tradition; and more recently nautical activities, such as tourism and recreational boating, have been gaining increasing importance. In the domain of the R & D / TT, this region can be considered well-equipped in terms of number and quality of the reference institutions in science and marine technologies regionally located, which are important cornerstones of the regional and national innovation system in this field.

The strongly specialized development assumed in the Algarve in recent decades, has led major regional traditional sectors, such as coastal fishing, canning industry, shipbuilding and naval repair, among others, to a situation of general decline, that is worsening over time (partly as a result of these sectors own inability in adapting to new operating logics of the market), along with a deeply asymmetrical territorial occupation. It not seems to be merely circumstantial the fact that Algarve is currently the portuguese region more strongly penalized by the economic crisis that has developed in a more acute way since 2008: in this strongly depressed context, unemployment is undoubtedly the main social scourge affecting Algarve. It's urgent to fight against this situation, because it's undermining the cohesion and the fundamentals of the regional socio-economic model itself.

It is urgent to rethink the model for future development of the Algarve, which must pass necessarily by the election of new areas of activity that add value and / or introduce virtuous complementarities to the core business of the region. Only the strengthening of the regional competitiveness will ensure its economic success in a society increasingly globalized and competitive, while ensuring the creation of wealth and of more remunerated jobs, along with the preservation of social cohesion. Making the Algarve an innovative community, territorially ordered, respectful of the environmental and socially cohesive, should form the main components of a strategy for sustainable regional progress.

In this context, based on a redefinition of priorities aiming the promotion of a more diversified and sustained regional economy, with a strong technological base, it is imperative exploring a new strategic plan, which is the strengthening of the association between the Region and the Sea. A maritime cluster will help to achieve a better articulation, will maximize the use of synergies and economies of scale, while it will contribute to build a sustainable and integrated view of the Algarve sea, of its resources and of the various activities associated with this, emphasizing its importance as one of our main economic resources and projecting it as an important engine for the economic development of the Algarve.

With this article, we make a strong defence for the appearance of a real and substantive alternative towards the diversification of the economic base through a regional cluster of the sea in the Algarve, to create and take advantage of potential complementarities with the core business activities that exist at regional level (e.g. tourism, construction and real estate). The guidelines for a regional strategy for tapping the potential associated with the Sea, should, necessarily, involve the identification of areas of expertise to respond to the increased competitiveness that we face as a region within the overall framework in general. In this context, the cluster approach, while complex of activities and interrelationships, is likely to add value to them, not only for its unifying and mobilizing nature, involving the various actors, but also as a matrix methodology for the implementation of a regional strategy in this area.

2. THE CLUSTER CONCEPT

The notion of “agglomeration economies” refers to the efficiency gains that might benefit production activities in a situation of proximity and that would not exist if the activities had isolated locations. Traditionally, spatial economics distinguishes between three types of agglomeration economies (Pontes, 2005):

- Economies arising from industrial concentration, in other words, the increasing returns to scale that determine the geographic concentration of production in the same establishment;
- “Location economies” resulting from the geographical proximity of independent establishments, but belonging to the same industry or sector of activity in particular;
- “Urbanization economies” that arise from the geographical proximity between production establishments belonging to different industries or sectors of activity.

In this context, Porter (1998, p.197) gives us an instrumental definition of the cluster concept which will serve as the guiding thread of the problem assumed in this article:

“Clusters are geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (for example, universities, standard agencies, and trade associations) in particular fields that compete but also cooperate.”

Porter states that a cluster is the full manifestation of the functioning of the “diamond” economy, in which proximity (understood as the placement of companies, customers, and suppliers) amplifies all the existing pressures to innovate and improve economic performance.

Porter (1990) also discusses the role of opportunity and of the state within the diamond’s vertices (competitiveness factors). Inside the cluster and its supporting forces, the resulting benefits (e.g. information and innovation) flow in several directions (Porter, 1990), allowing, thus, boosting growth, encouraging competition and innovation in related support companies.

According to Andersson *et al.* (2004) clusters are inherently idiosyncratic in nature, with different applications of the concept suiting various situations. However, collecting all the contribution of several authors regarding the cluster, seven elements can be adopted as key for the notions:

- Geographical concentration*: firms locate in geographic proximity due to hard factors, such as external economies of scale, as well as soft factors such as social capital and learning processes;
- Specialisation*: clusters are centred around a core activity to which all actors are related;
- Multiple actors*: clusters and cluster initiatives do not only consist of firms, but also involve public authorities, academia, members of the financial sector, and institutions for collaboration;
- Competition and co-operation*: this combination characterises the relations between these interlinked actors;
- Critical mass*: is required to achieve inner dynamics;
- The cluster life cycle*: clusters and cluster initiatives are not temporary short-term phenomena, but are ongoing with long-term perspectives, and finally;
- Innovation*: firms in clusters are involved in processes of technological, commercial and/or organisational change.

Many structural properties of clusters are mentioned in the definitions and descriptions in the cluster literature. These are presented as either constitutive or complementary and can also be used to characterise clusters. The identification of clusters across geographies

however remains difficult. Structural properties of a cluster may include, according to Sydow *et al.* (2007):

- Sophisticated local customers and downstream-industries
- Competitive related industries
- Suppliers of complementary goods and services
- Capable locally-based specialized suppliers of goods and services
- Accessible financial services
- Innovative core companies and original equipment manufacturer (OEM)
- Locally-based competitors
- Sophisticated local labour market
- Involvement of the local education system
- Research and development and knowledge transfer infrastructure
- (Trade and labour) associations
- State actors and regional economic development
- Critical mass of organizations

Regarding its typology and classification, this paper will distinguish four types of clusters, namely (Chorincas *et al.* (2001):

- “Micro Cluster” or “Local Cluster” - is a set of geographically close companies and institutions, inter-related by common and complementary elements, acting in a particular field of activity (in the same sector or possibly in the same segment of an industry); these firms compete simultaneously in the market for products (or services) and are able to cooperate, and in doing so increase the competitiveness of the whole; the case of “industrial districts” fit into this notion, in which the focus of companies on a small range of activities or business segments is a key feature;
- “Industrial Cluster” (using the broader notion of industry, common in Anglo-Saxon literature), or simply “Cluster” - is a set of interconnected companies, specialized suppliers, service providers, of companies belonging to related industries, and associated institutions (from universities to quality certification centers and trade associations) that are active in different fields, using different but complementary technologies, and through the innovation that is generated by some, benefits are realized for the others, all benefiting from improved global competitiveness;
- “Regional Cluster” - is essentially an “industrial cluster”, with the main joints functioning within a given regional area (sub-national); these joints can be repeated elsewhere in whole or in part of the same country; at this level are more relevant the effects of geographical proximity on the dynamics of interaction between actors and at the level of competitiveness and innovation of the set;
- “Mega Cluster” - according to the OECD definition is a distinct set of activities, whose goods or services meet the demand of a single large “functional area of final demand”, using basic skills and exploring the complementary advantages of networking between themselves and with other entities, including those that allow the accumulation of intangible capital for all the companies involved, such as the state research institutions, NGOs, among others.

Marshall (1920) was one of the first economists dealing with the concept of cluster, observing the creation of industrial districts. Marshall noted the apparent importance of industrial localisation while looking at English industrial regions of the 19th century, noticing the intangible dimensions of localisation, as evidenced in his famous comment about the secrets of industry being in the air. According with this author an “industrial district” is a concentration of large numbers of small businesses of a similar kind in the same locality. Agglomeration economies are associated with the cost savings to a business resulting from the proximity to markets and to inputs (supplies, labour force etc.). More specifically, as additional firms locate in the same geographic area, the lower the cost of production that can be achieved from suppliers competing for business, a

greater specialization of supporting firms, and a specialized labour force. Furthermore, the greater the number of firms located in an area, the greater the overall market to which a business can sell its goods or services.

Becattini (1992) has made several important contributions to our knowledge about industrial districts based on Marshall's reasoning. Becattini defines the "industrial district" as a "(...) socio-territorial entity which is characterised by the active presence of both a community of people and a population of firms in one naturally and historically bounded area. In the district, unlike in other environments, such as the manufacturing towns, community and firms tend to merge". Thus, Becattini extended Marshall's analysis of the purely economic effects of agglomeration to a broader perspective, to include the social, cultural and institutional foundations of local industrial growth. The economic miracle of Italy in the 1970's, during which small and medium sized enterprises (SMEs) started contributing substantially to the economic development and welfare in Italy, has initiated a large stream of theoretical work focusing on the competitive advantages of being located in industrial districts: Becattini based his considerations on Tuscany, particularly on a textile district located in Prato, near Florence. With its thousands of firms, mostly very small and specialised in a single production phase, Prato became the prototypical Italianate industrial district.

The analytical precision regarding varieties of clusters has evolved markedly since the pioneering intervention of Markusen (1996), who identified five types of industrial district:

- Marshallian – small firms, localized investment links, preferred suppliers, labour market loyalty, flexible work regime.
- Marshallian (Italianate variant) – with added cooperation, design intensive work and collective institutions plus local government support.
- Hub and spoke – structured around one or few dominant firms supporting the regional cluster, while suppliers and other activities spread around the hubs like the wheel spokes. In a hub-and-spoke cluster, inter-firm collaborations usually occur only between hub and non-hub firms, and the terms of cooperation are in many cases set by the hub firms. Collaborations between smaller firms are rarely seen as the smaller ones are usually very focused on benefiting from the large anchor.
- Satellite platform – largely consists of a congregation of branch facilities of externally based multiplant firms. In many cases, a satellite platform cluster emerged when certain local or national policies were developed to create a favourable investment environment for externally headquartered firms.
- State-anchored – the local business structure in this type of clusters is dominated by the presence of one or few large public or non-profit entities, such as universities, public research institutions, or military bases. The key public entities are typically surrounded by smaller firms/organizations, thus forming a structure similar to a hub-and-spoke cluster.

The overall market potential of a functional region, i.e. its size and density, is an infrastructure phenomenon in itself. It changes in a process of very slow adjustments and provides collective market opportunities that benefit both households and firms. In growing functional regions, the location of households and firms form a self reinforcing dynamic process, i.e. a process with positive feedbacks. Over time, the (slow) formation of regional infrastructure affects the process by gradually building up the basic conditions for the household milieu and the economic milieu of firms (Karlsson, 2008). Once again Karlsson (2008), states that this approach is a resource-based theory of location and clustering (and trade). The critical resources have the character of durable capacities which consists, on the one hand, of natural resources and, on the other hand, of the supply of infrastructure in the form of facilities and networks, R&D organizations,

existing production capacities with specific techniques, and the supply of different immobile labour categories.

The impact of economies of scale in the form of external economies of location had already been highlighted by Marshall (1920). A given company, operating under constant returns to scale, can benefit from external economies derived from the positive externalities produced by other businesses in the region, ie external economies of scale (Chipman, 1970). The economies of location often play a central role in many urban and regional economic models, as well as in models of spatial product cycles. According to the theoretical framework of Marshall, there are three sources of specific positive effects derived from the clusters, i.e., obtained through the agglomeration of businesses, that include: (1) local inputs non-tradables, (2) supply of local and specialized labour, and (3) information spillovers.

The processes of formation of clusters, although not linear, can be described as adaptive and of self-organizing nature. These processes involve entrepreneurs, as well as policy makers, and they contribute to the establishment of support functions and governance, as well as tangible and intangible infrastructures, often with the aid of public funds. This implies that either the cluster or a specialized region, created as a result of the activities of entrepreneurs, tend to be unique due to its particular history (Krugman, 1991) and as such difficult to imitate (Feldman and Martin apud Karlsson, 2008). Depending on the success achieved by entrepreneurs, their activities will be able to strengthen the regional economic environment, including its institutions and its capital, in parallel with the increase of possibilities to take advantage of economies of scale, both internal and external, as well as the establishment of new businesses (Karlsson, 2008). Successful clusters not only create their own resources, institutions and potential, but are also able to attract resources, such as financial capital, labour and entrepreneurs from other functional regions. However, there is no guarantee that the clusters that have developed well in the early stages, will continue to do so subsequently. From the moment entrepreneurs start their business and acquire resources and market potential, they become a crucial factor in the dynamic process of formation and development of the cluster. Very often, new companies are created in places where entrepreneurs live and where they established commercial and social networks, along with the access to a market of potential customers, as well as to a potential supply of inputs.

3. THE ROLE OF KNOWLEDGE AND INNOVATION SYSTEMS

The cluster concept has been successfully applied in various regions, countries and sectors linked to the sea. Although many clusters are concentrated in coastal areas, the maritime economy, very often, has impacts beyond those coastal regions and because of so it is also necessary to establish relationships with stakeholders from such remote areas. The challenges faced, go widely beyond the simple sharing and collaboration *inter pares*. There are other key elements to be considered, such as the production and management of knowledge, the carry out of joint research and innovation (product development), the joint efforts in education and training, the sharing of innovative methods of organization within a group of companies (acquisition and distribution) or strategies for common promotion.

Cooke *et al.* (2007), quoting Choo and Bontis, define a regional knowledge and innovation system as a dynamic and evolving constellation of actors shaped by the knowledge embedded in organizational systems and embodied in associated technological systems. It has been argued that firms and research centres of expertise/excellence play

a dual role within a region, both creating (or co-creating) knowledge and absorbing knowledge from outside the region. Optimizing the potential contribution to regional development of a region's knowledge stock, however, will require complementarity between the regional knowledge base and the requirements of regional firms (Gunasekara apud Cooke et al., 2007).

For instance, the evidence suggests that, in general terms, spillovers and productivity benefits are probably greatest from publicly funded basic research which contributes to the related public knowledge stock. The heart of this issue lies in the fact that from the standpoint of its impact on regional development, the nature of knowledge, clearly, can not be considered isolated. Instead, a systemic view, more contextualised, is needed, since it reflects the provision of knowledge and their specific characteristics, as well as the different absorption capacities on the part of potential users of knowledge and effectiveness of knowledge transfer processes.

According to OECD (2007), the research concerning the sources of advantage in terms of improved productivity of the factors associated with clusters, has focused mainly on the movement of people and knowledge, in generating innovative ideas and into the development of new products and technologies. In the past, the academic work undertaken in this area, considered knowledge as a public good and technological progress as an exogenous factor to the economic system, equally affecting all businesses, regions and countries. However, the latest evolutionary theories have challenged this basic concept, recognizing that the generation, adoption and diffusion of new technologies is a complex process, and, therefore, endogenous to growth models (Romer, 1990).

Since long ago, companies face and have to solve the need for remote resources, optimizing the spatial configuration of their supply and/or production network. These solutions are particularly suitable when the resource is a variable factor of production, manpower or explicit knowledge (e.g. a foreign technology 'closed' in a machine). But, in many cases, these factors have left or are leaving of being strategic, as all companies in a variety of sources, have or will have equal access to them (also as a result of globalization). On the other hand, the location and even the nature of the critical technology for an industry, usually stable, cease to be so. This can occur in a technological discontinuity, in a migration of skills from one region to another, in the evolution of a product, or even in the convergence of industries (e.g. computers, communications and contents). As pointed out by Furtado (2004), the concept of innovation to market represents a kind of innovation closer to the original idea of Schumpeterian innovation. Considering the impact on the pattern of competitiveness and on the accumulation of technological capability in the company responsible for its promotion, it can be classified as an innovation qualitatively superior to those that are only new to companies but not for the market. In contrast, pioneering innovations that are only so for companies, are closer to the Schumpeterian concept of technological diffusion (or absorption).

The interactive process perspective of organizational innovation has gained popularity in recent years for investigating the nature of the innovation process, examining how and why innovations emerge, develop, grow and end. This perspective describes innovation as a complex process (not static), produced by interactions between structural influences and the actions of individuals, which occur simultaneously. The term "interactive process" has been used to describe the activities within and between companies (Edwards, 2000). According to Giget (1997), the innovative process is not deterministic and does not follow a set formula, it is socially constructed by the actors involved or interested in the generation of innovation and, therefore, must be understood as a series of interactions and exchanges between researchers, users, technicians, scientists, governments, companies, which are the innovation network. Thus, the interactive view of innovation is the basis

for many conceptual constructions, related to the innovative process, which considers the increase in complexity, the importance of knowledge sources external to the organization and the intra and inter-relationships, fundamental for successful innovation.

Increased innovation is about improving one's competitive position through product, service, and process innovations (von Krogh *et al.* apud Back *et al.*, 2005). Innovations are mostly based on procedural knowledge and cultural conditions which are not easily imitable by competitors. Procedural knowledge is knowledge that has something to do with the generic innovation processes. Such a process consists of different phases, such as concept development, evaluation and selection of alternatives, and development of prototypes (Nonaka and Takeuchi apud Back *et al.*, 2005). Cultural conditions encompass shared values and modes of behaviour within the company (von Krogh *et al.* apud Back *et al.*, 2005). For larger companies with many business units, the challenge is to leverage their procedural knowledge to develop different innovations throughout the company and thus achieve a sustainable competitive advantage.

Henderson and Clark (1990) identify four types of innovations, which are linked to specific changes in knowledge:

- *Incremental Innovation*: Improves component knowledge and leaves architectural knowledge unchanged.
- *Modular Innovation*: Architectural knowledge unchanged, component knowledge of one or more components reduced in value.
- *Architectural Innovation*: Component knowledge unchanged, architectural knowledge reduced in value.
- *Radical Innovation*: Both component knowledge and architectural knowledge reduced in value.

For the purpose of this article, we highlight two of those types: incremental and radical innovation. Freeman (1988) argues that one can understand the radical innovation as the development and introduction of a new product, process or way of organizing production entirely new. Such innovations may represent a structural break with the previous standard of technology, creating new industries, sectors, markets, generating cost savings and quality improvements in existing products. The innovations of incremental nature refer to the introduction of any improvement in product, process or production organization, within a company, with no change in industrial structure.

4. IMPORTANCE OF NETWORKING AND KNOWLEDGE INTENSIVE BUSINESS SERVICES

One of the most important changes that emerged in the last decade, concerns the growing role of service sectors intensive in information, technology and science, in the so-called knowledge-based economies¹. The idea of an innovation economy applied to the service sector opens a new approach with a wide analytical capability and recognizes the strategic role of this sector in generating wealth.

The concept of Knowledge Intensive Service Activities (KISA) is well summarised by Martinez-Fernandez (2006) as the activities originated by the production and integration of knowledge-intensive services crucial for the innovation process of the firm. Typical examples of KISA include R&D services, management consulting, IT services, human resource management services, legal services, accounting, financing, and marketing services. Activities oriented toward the use and integration of knowledge are instrumental for building and maintaining a firm's innovation capability. In practice, KISA in a firm are

¹ Economies that are directly based on the production, distribution and use of knowledge and information (OECD, 1996).

achieved by the use of in-house, or the combination of in-house and external, expertise. The capacity of the firm to perform these KISA more effectively may indeed be what differentiates a firm from its competitors.

Networks and clusters are not necessarily linked to the extent that networks can take place between firms located at different points, while clusters are geographically located in a country or region. Although they represent different concepts, clusters and networks are inter-related and both refer to beneficial relationships between companies, being networks the essence for the functioning of clusters. Clusters can be defined as a network of networks because within a cluster can exist several networks (Chapman, McRae-Williams, Whalley and den Hertog apud Santos, 2007).

Asheim and Cooke (1999) contend that there exist two main types of innovation networks:

- Endogenous networks that appear on the basis of local industrial clusters of small- and medium-sized enterprises with traditions and expertise of mutually beneficial exchange of information as well as interactive learning in the process of joint innovation activity (e.g., Baden-Württemberg in Southern Germany, and Tuscany and Emilia-Romagna in Italy);
- Exogenous innovation networks existing mainly as technoparks in technopolises. They appear under the following circumstances: when large companies single out R&D into a separate functional unit and place it in a territory that is best for the emergence of non commercial interdependencies (e.g., Sofia-Antipolis in Greece and Ile-de-France in France); or when an innovation network is set up administratively as a planned action to establish and deepen cooperation between research institutes and enterprises (e.g. the technoparks in the United States and the United Kingdom).

The following characteristics are recognized as essential for the Regional Innovation Systems (Poruchnyk and Brykova., 2006):

- An organizational structure comprising companies and leading participants in the innovation process;
- Inter-corporate interrelationships, namely an intense interaction among the business sector and other organizations;
- A role for the state and state innovation policy;
- An institutionalised financial structure;
- Activity and funding of R&D (according to a ratio involving private and state sectors);
- An industrial structure (comprising average sized companies, an efficient competitive environment, primary industrial sectors, etc.);
- A territorial organizational structure (urbanization, availability of regional production net-works) and a scale of inter-regional agglomerations (innovation clusters, spinoff enterprises² and spillover effects);
- A level of openness and integration into the global production system, an ability to attract external resources of development;
- Historical specificities, cultural rules and traditions affecting economic activity.

On the perspective presented at DG Enterprise and Industry (2007), innovation is increasingly characterised as an open process, in which many different actors - companies, customers, investors, universities, and other organisations - cooperate in a complex ways. Ideas move across institutional boundaries more frequently. The traditional linear model of innovation with clearly assigned roles for basic research at the university, and applied research in a company R&D centre, is no longer relevant. Innovation can benefit from geographic proximity which facilitates the flows of tacit knowledge and the unplanned interactions that are critical parts of the innovation process. This is one of the reasons why innovation occurs locally whereas its benefits spread more widely through

² Spinoff enterprises are defined as associated firms promoting the process of exchange of information and transfer of technologies through different channels of interactive learning.

productivity gains. Clusters may embody the characteristics of the modern innovation process: they can be considered as “reduced scale innovation systems”. Successful clusters encapsulate all the activities needed to deliver a particular value to customers; they cross the traditional definitions of industries and of manufacturing versus services. They can emerge even where companies’ locations are not determined by the location of markets or natural resources. Their specific nature, including their spatial coverage, differs according to technology, market conditions, and other factors that influence the geographic extent and relative strength of linkages.

The Triple Helix thesis states that in addition to the knowledge infrastructure of university-industry-government relations, an overlay of communications and negotiations among these institutional partners has become increasingly important for the dynamics of the overall system. The emergent networks of internationalization, ICT, and globalization feed back on the carrying institutions so that the overlay provides competitive advantages in the reconstruction of the underlying systems. Knowledge organization and knowledge-based reconstructions can be transformed into a third coordination mechanism of social change in addition to the economics of the market and government interventions. The political economy is thus reshaped into a knowledge-based economy containing this more complex dynamics because of the evolutionary advantages of the combinations (Leydesdorff and Etzkowitz, 2003).

According to Goktepe (2003), the synergy of the three helices that compound the model of network innovation is the most efficient way to disseminate and use knowledge and enhance learning. The Triple Helix of university, industry and government, does not constitute an end in itself, but it configures new designs of innovation, scientific and economic. A balanced positioning of these three actors is an essential component for the innovation network strategy of any knowledge-based economy.

5. RELEVANCE OF KNOWLEDGE SPILLOVERS

There are different views in the understanding of a knowledge economy, as has been pointed out by Smith apud Cooke *et al.* (2007). The first is that *knowledge as an input* is becoming quantitatively and qualitatively more important than before. This is reflected in an increase of knowledge related investment, such as R&D, education, software and information technologies, as observed for example, by the OECD apud Cooke *et al.* (2007). Another perspective reflects the idea that *knowledge as a product* is getting more important than in the past. Theories on firm performance emphasise the innovative process, notably the quality of factor inputs such as education, the positive rivalry between firms that drives innovation, and the structures/institutions that support innovation (Porter, 1990).

The role of geographical proximity has been discussed in the literature concerning regional innovation systems, as well as the related with knowledge spillovers. The proponents of the view that proximity offers innovation advantages in itself, begins in relatively recent times with Jaffe *et al.* (1993). The argument here was that R&D in particular constitutes a public good in locations where it concentrates and that this is sufficient to cause firms to concentrate in proximity to such knowledge spillover opportunities to access them as free goods in advance of competitors.

Innovation and entrepreneurial behavior is, as a consequence, heavily impacted or influenced by proximity conditions. While proximity is important for knowledge transmission and entrepreneurial effort, scale or agglomeration forces further amplify its effects. Therefore, large, well-integrated and relatively wealthy urban agglomerations are seen as locations where knowledge transmission is likely to be highest, *ceteris paribus*,

and consequently, locations of greatest entrepreneurial action (Karlsson *et al.*, 2006). Knowledge spillovers occur when a firm creates knowledge and that knowledge produces external benefits (“spills over”) onto other firms. Knowledge spillovers represent a positive externality in that the socially optimal level of knowledge is not created because innovative firms do not take into account the effect of their knowledge production on other firms. The result of knowledge spillovers is that spending on R&D will be below what is socially optimal, providing possible justification for government policies to increase innovative activity. By looking at the evolution of art capitals one needs to gain insight into the origin of creativity clusters and why some clusters overtake other clusters. This question is of utmost importance for policymakers seeking to overtake other regional clusters as firms have a strong incentive to locate in pre-existing clusters to take advantage of the high level of knowledge spillovers (Karlsson *et al.*, 2004). Also Audrescht *et al.* (2006) argue that entrepreneurship resulting from knowledge spillovers tend to be located geographically close to the sources that currently produce the relevant knowledge.

The work of Alfred Marshall pointed out reasons for increased business productivity, when several companies in the same industry are located close to each other, sharing the labour market, knowledge spillovers and specialized suppliers. Subsequent theories have argued that specialization in a particular industry, carries a cumulative process of assets and advantages, which is a direct consequence of strengthening the nature of this process (OECD, 2007).

Subsequent theories have argued that specialisation in a particular industry brings with it a process of accumulation of assets and advantages (cumulative causation), implying a self-reinforcing nature in this process. Additionally, market forces tend to concentrate investments in prosperous areas which offer better access to infrastructure and human capital, lower risks and better access to markets (Krugman and Venables, 1990).

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HARD WORKING ANT: AN ECO-TOURISM SPIN-OFF CREATION TALE

HARD WORKING ANT: UMA FÁBULA SOBRE A CRIAÇÃO DE UMA SPIN-OFF DE ECO-TURISMO

Hugo Pinto, Ana Rita Cruz, Ana Isabel Gonçalves

ABSTRACT

The creation of knowledge-based firms is of central importance due to its great impact in economic development. This article explores the case of E1, an academic spin-off operating in eco-tourism in the Algarve, Portugal. The theoretical framework of the Actor-Network Theory (ANT) is used as a methodological approach to understand translation and how different actors continuously share, disseminate and adapt their languages, problems, identities and interests. The use of ANT allows focusing on the knowledge transfer process, analyzing and understanding complex objects, where and how heterogeneous associations are created. The analysis highlights the limitations and challenges that a young and qualified entrepreneur finds to transform his ideas in a viable business.

Keywords: Eco-Tourism; Academic Entrepreneurship; Spin-off; Actor-Network Theory; Algarve.

RESUMO

A criação de empresas baseadas no conhecimento é de importância central devido ao seu grande impacto no desenvolvimento económico. Este artigo explora o caso de E1, uma spin-off académica em eco-turismo no Algarve, Portugal. O referencial teórico da Teoria do Ator-Rede (Actor-Network Theory - ANT) é usado como uma abordagem metodológica para compreender a tradução e como os diferentes atores continuamente se relacionam, disseminam e adaptam as suas linguagens, problemas, identidades e interesses. O uso da ANT permite focar o processo de transferência de conhecimento, examinar e compreender objetos complexos, onde e como associações heterogêneas são criadas. A análise destaca as limitações e desafios que um jovem empresário e qualificado encontra para transformar as suas ideias num negócio viável.

Palavras-chave: Eco-Turismo; Empreendedorismo Académico; Spin-off; Teoria Ator-Rede; Algarve.

JEL Classification: M13, 031, Q57

1. INTRODUCTION

Academic entrepreneurship has assumed a growing importance as a mechanism to promote employment and social cohesion and plays a central role in economic regeneration and competitiveness of the territories. In knowledge and technology intensive regions the relation between academic entrepreneurship and regional development is clear. In territories where the main economic activities have less evident technological content, like in tourism destinations, the role of universities may seem less relevant and academic entrepreneurship itself may be considered less critical.

The central objective of the paper is to understand the challenges that an academic entrepreneur has to face to implement its innovative idea in a mature tourism region. For that this article explores the case of E1, an academic spin-off in the Algarve operating in eco-tourism.

This southern Portuguese region faced in recent decades a significant economic dynamism due to the exploitation of excellence natural conditions for Sun and Beach tourism. The focus on tourism has attracted investments and promoted growth, but often an asymmetric one, dichotomized between the interior and the coast and causing a weak economic base exposed to external shocks (Guerreiro, 2008). Recently, emerging from the university, several entrepreneurs initiated their own businesses in eco-tourism providing innovative products that can give more resilience to the sector that heavily felt the recent economic turbulence (Cooke, Porter, Cruz and Pinto, 2011). Sustainable tourism products emerge as interesting areas for diversification of more mature destinations but remain unclear the potential and preferences of tourists (Miller, Rathouse, Scarles, Holmes and Tribe, 2010). Despite the tensions that exist in tourism where small entrepreneurs have great difficulty in adapting to the pressures of an activity dominated by large operators (Dahles and Bras, 1999), their role is central in the innovative dynamic and rejuvenation in the life cycle of tourist destinations (Russel and Faulkner, 2004).

In parallel, innovations in tourism are difficult to achieve but simple to imitate, especially when the processes are very visible and the technology content is less sophisticated (Weidenfeld, Williams and Butler, 2010). The case of E1 was in fact one of the first examples of this wave of regional small-scaled entrepreneurship on eco-tourism. The replication of innovations in tourism is mainly limited by the high tacit component of knowledge that many tourism activities contain.

To explore the case of E1 the article is organized as follows. In section 2, academic entrepreneurship is briefly introduced, underlining the main emergence of this notion as a crucial topic and stressing the relevance of this phenomenon as inducer of economic dynamics. A third section is the case study itself. Actor-Network Theory (ANT) is debated as a qualitative approach to study translation processes. E1 is presented in terms of its innovative character, a chronology with the moments of translation until the stabilization of the actor-network and its transformation in an obligatory passage point in Algarve's eco-tourism scene. The article closes with some conclusions.

2. ACADEMIC ENTREPRENEURSHIP AS A GROWTH ENGINE

2.1. The Emergence of Entrepreneurship

In the XVIII century, entrepreneurship was commonly defined as self-employment of any kind or a characteristic of someone who undertook a specific project (Hobday and Perini, 2005). Usually the birth of the expression is linked to Richard Cantillon who emphasized the role of intermediaries between the landowners and their tenants on

efficient agricultural production. This was a vision of entrepreneurship on the supply side showing the importance in production and distribution of goods and services. The entrepreneur was a mediator who assumed the market approach risks, being the actor that led the products from where they had smaller value to places where they worth more, for example, agricultural products from rural to urban areas.

However, the vision that made well-known the expression of entrepreneurship was Schumpeter's demand side notion (Link and Siegel, 2007). In this view, the entrepreneur takes a central role in changing the demand with the creation of new goods, services, raw materials and markets. The idea of creative destruction is linked to the renewal of demand and stresses the linkage between entrepreneurship, innovation and economic growth. The contribution of studies in the last quarter of the XX century and the beginning of the XXI allowed a conceptual evolution, from entrepreneurship to be defined to include much more than creating a business, generalizing to a notion that includes the generation and implementation of ideas with potential to succeed (Kaplan and Warren, 2007).

The entrepreneurship understanding needs to take into consideration the individual and their cognitive and non-cognitive dimensions, the planned project, the environment and external context as well as the connections between them over time. Entrepreneurship is a complex process where the result is only partially dependent on entrepreneurs' characteristics, although it remains to be seen as the main element (Gaglio and Katz, 2001; Shane, 2000). As underlined by Shane and Venkataraman (2000), entrepreneurship is composed by the sources of opportunities, the process of discovery, evaluation and exportation of opportunities and the set of actors who discovers, evaluates and exports these opportunities.

Focusing the entrepreneurship side connected with business creation is relevant to stress that it is not a linear process at all and is characterized by advances and retreats, essential to the success of the transformation of the idea in a viable company. One of the key aspects of entrepreneurship is the emergence of the idea that there is no more than the recognition of economic opportunity. The emergence of the idea and the recognition of new opportunities are often strongly linked to social networks which reveals the importance of these factors in the entrepreneurship phenomenon. The next stage to the emergence of the idea is that in which the entrepreneur decides to move forward. To this end, the entrepreneur negotiates with their networks the change of status, being crucial to this negotiation process the exogenous factors such as displeasure with the job, motivation, degree of involvement and the tolerance to risk, and the intrinsic factors, such as education, age or gender, and the environment factors, the competition, the available resources, government policy, legislation and incubation. Assuming that the phase that marks the decision to proceed is successful, the entrepreneur walks into the implementation phase, where the variables related to personal characteristics are largely decisive for the consolidation of the business and its development. Finally, the last stage to overcome is the phase of growth where emerge the importance of the organizational dimension, which together with the individual and the environmental, will determine the sustainability of the project.

2.2. The Relevance of Academic Entrepreneurship

It is increasingly difficult to separate entrepreneurship from knowledge, serving the entrepreneurial activities as means to induce knowledge spillovers, which will contribute to economic growth and assist regions being more able to seize entrepreneurial opportunities (Audretsch and Keilbach, 2007, 2008). Several authors suggest that knowledge spillovers are geographically limited and localized near the source of knowledge (Jaffe, 1989;

Audretsch and Feldman, 1996; Audretsch and Stephan, 1996), which transforms the university in the ideal context for the emergence of entrepreneurial activities. According to the studies of entrepreneurship and knowledge spillovers, a context with more accumulated knowledge will generate more entrepreneurial opportunities. By contrast, a context with an inadequate level of knowledge will not provide the emergence of entrepreneurial opportunities. The academic entrepreneurship by having a greater economic impact is increasingly present in the concerns of policy makers and scientific research in this field.

Djorkovic and Souitaris (2008) tried to provide a comprehensive review of the literature about the phenomenon of spinning-off from academic institutions focusing the different levels of comprehension. Firstly the authors identified the macro level studies, which corresponded to the analysis of incentives and policies for spinning-off at the governmental level. Secondly, the meso level, related to organizational structure, institutional dynamics and structure of incentives for the knowledge transfer corresponds to university level. Finally, a micro level approach which corresponds to the analysis of individual behavior, specially the characteristics of these companies and the common characteristics of those individuals that pursue entrepreneurial initiatives. A strict notion of spin-off is the proposed by Birley (2002), a company that emerges from the universities through the commercialization of intellectual property or knowledge transfer developed within academic institutions. This notion can be extended with the inclusion of start-ups that emerge from the regional context where the academia is located and benefits from existing knowledge or support from the university, for its consolidation. This support from the universities can be, for example, as specialized consultancy in knowledge transfer offices or incubation services in initial stages.

It is worth to distinguish between intrapreneurship and entrepreneurship (Pinchot, 1985). While entrepreneurship is the act of developing a new venture outside of an organization and is linked to the traditional vision of creating a company, intrapreneurship refers to the practice of developing a new venture within an existing organization in order to exploit a new opportunity capable of generating economic value. This last type of entrepreneurship, helps to the renewal and revitalization of the organization own activity, through innovation and continuous improvement. Parker (2009) exemplifies the factors that promote the nascent intrapreneurship in relation to the nascent entrepreneurship, focusing in the attention that literature has released around the importance of human capital (Becker, 1964; Zucker, Darby and Brewer, 1998; Helfat and Lieberman, 2002). Thus, the author focuses his approach in the distinction between general human capital and specific human capital. General human capital comprises the skills, knowledge, experience and capabilities useful in a variety of productive uses, including new or existing organizations. The specific human capital, in turn, refers to skills, experience, knowledge and capabilities, such as those implemented by companies in specific training programs, which are primarily useful for the organization that supplies them. Parker (2009) emphasizes that it is expected that human capital is more usually associated with nascent entrepreneurship than with nascent intrapreneurship.

Beyond the strong influence that human capital has about entrepreneurship, it is possible to enhance the not less importance that social capital contains on the development of an entrepreneurial activity and its success. Social capital refers to the number and intensity of actors' social relations. The intensity is higher when both parts have interactions with a longer duration and often, creating a cooperation and mutual trust history (Marsden and Campbell, 1984). The importance of social capital lies on the fact that facilitates the process of identifying opportunities and mobilizing resources. Moreover, social relations also help the entrepreneurs to have access to information about a particular industry or region that otherwise they didn't have. As discussed by

Rutten, Westlund and Boekema, (2010) social capital has a strong spatial dimension. The contributions of Dahl and Sorenson (2008) show that it is possible to see social capital importance through the choice of a location for entrepreneurs start their activity and the effect of this choice in their rate of success. The authors demonstrate that the lack of social capital leads to strong constraints on the ability of entrepreneurs to create a company in a region where they have not strong social connections. Focusing on the Danish case, these authors concluded that entrepreneurs tend to start businesses in areas where they have deep roots. Companies' performance has a tendency to improve with the location in regions where the entrepreneurs are embedded in relevant social networks. Thus, one of the corollaries of Dahl and Sorenson (2008) is the geographical dimension of social capital, something that fits with the idea that entrepreneurs cannot just carry their social capital, as they can with the financial and human capital. Consequently, social capital constrains the entrepreneurs' choice of location to develop a business, in the sense that it tends to fix them in areas where their social connections reside and in which they may have some advantage.

Thus, entrepreneurship is increasingly a phenomenon whose mechanisms has a central importance in economic growth, reflected in nowadays society characterized by more consolidated entrepreneurial dynamics. DeCleyne, Tietz, Braet and Schefczyk (2010) inquired 8507 spin-offs to analyze the current situation of academic entrepreneurship in Europe between 1985 and 2008. The results highlight the relevant socio-economic impact of this mechanism in generating income and employment, furthermore to the creation of markets especially in emerging sectors with high technological content. The most important factors for the creation of spin-offs were the universities ability to produce knowledge, measured by the university rank in the European context and the amount of budget available for research, but also the attention given to knowledge transfer activities, especially with the establishment of knowledge transfer offices with greater critical mass. To Audretsch (2009a, 2009b), emerges an entrepreneurial society, where knowledge-based entrepreneurship arise as the driving force of economic growth, job creation and competitiveness. The phenomenon of entrepreneurship in the academia can be considered as the ideal mean for the transmission of knowledge, crucial to the creation of advanced companies able to induce a greater economic potential of regions.

3. TRANSLATING INTERESTS IN AN ECO-TOURISM SPIN-OFF CREATION

3.1 Study Methods

In this article, the case study of the creation of the company EI is analyzed using notions imported from the Actor-Network Theory. ANT is an approach that results of work in the field of Social Studies of Science and that focuses the attention in the translation process, and as a determined central actor, usually known as the translation enabler, attempts to share its objectives and goals by engaging other actors around him to constitute obligatory points of passage in a specific domain. Classical applications of ANT are the analysis about the translation processes for the pasteurization of France (Latour, 1983) or the domestication of scallops and the fisherman of St. Briec Bay (Callon, 1986). For a recent summary of ANT, the volume of Latour (2005) synthesizes the main ideas of the theory and debates its impact in sociological thinking.

The novelty of ANT refers to its interest in analyzing these processes of collective engagement, construction and de-construction of human interaction trough linkages and networks. The fact that the all human interactions are social and happen in a context gives a broader meaning to the word "social". Social is not an adjective that disputes the

explanation of particular aspects of society with others, such as economic, environmental, scientific or organizational. The social realm is present in all human interaction, and thus the 'sociology of the social' should be replaced by the 'sociology of the associations'.

ANT gives particular attention to the agency that non-human actors may have in the translation process, supporting that artifacts may have agency in the course for the stabilization of a network. In this research attention is given to a diversity of human and non-human actors but the authors do not support the idea of a radical symmetry between these two types of entities. Humans remain central in the analysis even if particular artifacts may be crucial for the collective engagement.

The translation process is complex and involves a variety of actors, that gain relevance, abandon the process, helping for the constant instability of the network. It is common to identify four moments of translation. The first is the problematization. It regards the emergence of a specific problem that affect a group of actors and the idea of the translation enabler to become an obligatory passage point to overcome it. The second moment, the intersement, actors are attracted to the problem and begin to join forces. The third is the enrolment, where the roles of the actors are defined and coordinated. The translation enabler tries to be assumed as a spokesmen speaking for the intentions of all engaged actors. Finally, the mobilization, where actors are fully enrolled, aware of their parts and stabilize the actor-network concretizing the obligatory passage point. It is crucial to refer that even if these moments happen in time and space they should be understood as overlapping phases. The idea of stabilization in the ANT does not refer to a complete closure of the network but only a relative stabilization. The process of negotiation is never finished and a problem with a solution accepted as an obligatory passage point at a moment can be easily disappear or fade away if the actor-network is not capable of adapting for external modifications and for internal dynamics.

Our ANT implementation contrasts with the empirical analyses that focus normally quantitative dimensions to illustrate the factors that limit and increment academic entrepreneurship. This is indeed a trend of research on knowledge transfer and entrepreneurship that has given attention to quantitative dimensions. To complement the information from these quantitative studies it may be useful to use qualitative approaches in which are possible to try to understand the particularities of concrete cases.

Several authors have tested the adherence of ANT to the innovation process (Oliveira, 2008), to spinning-off dynamics (Pinto, 2010), to tourism economic activities (Johannesson, 2005; Van Der Duim, 2007; Paget et al, 2010) and even in tourism epistemic communities (Tribe, 2010) as it is possible to open the black boxes that sometimes these processes constitute and are not easily detected in quantitative studies.

The process of business creation is always a process of translation, where the entrepreneur tries to convince other actors to assist him in the various stages of the company construction. After the conception of the idea, there is a need to make an effective analysis to the market to evaluate the existence of a real business opportunity. At this stage the entrepreneur seeks the support of intermediary organizations, such as academic interface entities like the knowledge transfer offices, to better understand the market, think about the geographical location, and evaluate the degree of product innovation that aims to develop and its growth potential.

Upon completion of market analysis, the entrepreneur has to plan the introduction of the product in the market, identifying the needs that must be met to implement the business idea. The needs of personnel, equipment and facilities, among others, must be detected. In parallel, the entrepreneur must identify the legislation and seek to respond to requirements for tax payment and activity licensing which may affect the development of the project. Bearing in mind the resources required to implement the idea, a fundamental

step is to find appropriate financing solutions. The three types of funding that are available to the entrepreneurs, own money or family and friends, bank credit or the entry of investors in the company, always requires a complex process of convincing the others. Only with the achievement of the translation process, the entrepreneur will be in a position to implement the idea and, as above mentioned, move to the stage of the business implementation. Even after the stabilization of the actor-network in the spin-off creation will continue a range of negotiations between the entrepreneur and concerned parts in the activity of the company until the actor-network dissipates or transforms in a new entity with different goals.

The method used was a case study through the documental analysis and in-depth interviews. The analysis of the interview used the ANT referential in order to understand, from the entrepreneur perspective, the main factors and constraints for the company creation and mapping the network of heterogeneous associations that allowed the stabilization of the actor-network.

3.2. The Translation Process of a Spin-off in the Intersection between Tourism and Scientific Knowledge

3.2.1. The Innovative Character of E1

The company presented is designated as E1. The interest of studying this particular spin-off derives from the context in which this eco-tourism company operates, between the more established activities in the region linked to tourism sector and the scientific knowledge generated in the natural sciences domain, particularly in the fields of Marine Biology.

RB is a young entrepreneur, thirty years old in 2010, student of Biological Resources Engineering which ends to graduate and specialize with the conclusion of a Master in Barcelona on the Sports field. He is a semi-professional basketball player who mentioned the importance of higher education exchange programs like ERASMUS in his personal learning. As professional experience he was an elementary school teacher of Physical Education where he learned to enjoy working with children and young people.

The E1 is a company that from 2007 to 2010 achieved the transition to the economic and financial sustainability, broadening at the same time its range of activities. It is a company that focuses on innovation through a tourism offer associated to ecotourism and educational activities, engaging strategically in dissemination and communication activities through technological tools and by associating with science communication events.

In this study case it was assumed that the entrepreneur and promoter, RB, is the translation enabler, the actor that tries to stimulate the network to achieve its objectives through the translation of interests.

According RB, E1 is:

“[...] a company of tourism animation services, we offer three types of activities [...] an area related to nautical activities, therefore boat trips in a perfectly identified place, Ria Formosa. We have inland activities [...] hiking for introduction in nature, cultural and patrimonial integration, that are activities that we performed all over the Algarve [...] we have activities with schools, we use both, in physical terms, water and land; but we consider a

different area because the activities are organized and projected, launched and executed in a completely different way. They are anchored in national [educational] programs of different disciplines, we try to tailor programs to different stages of education from the first cycle to secondary education, but we already received university classes.”

For the entrepreneur, EI has a differentiating factor:

“[...] is really the knowledge. We try that our activities be almost like a classroom, passing from guide-client to teacher-student interaction. There isn't a thing so directional but we stimulate participation and pro-activity from clients and they are invited to join activities and find out, for example, what Ria Formosa has to offer. It is extremely interesting, from the economic standpoint, the production of bivalves and then we take the customer to a bivalve farm and explain how is the production, which species exist, how the creation is made, how the growth is done, mortality rates.

[T]his is the great heritage of the company, we differentiate from what exists in the market exactly for [...] different sources, in this case of bivalve was with [a research centre] with several activities in partnership [...] The other issue is that we really have a perspective of sustainable development, in which we really do not want this into a perspective completely managerial and economist, which may be questionable from the management point of view. But we face our presence on the market in a perspective of differentiation by quality, not only in content but in relation to other aspects such as security, such as the quality of materials that really influence the boat quality, the quality of the van, the quality of the tools in which we invest, which differ from the existing market offer.”

The EI working process depends on the type of product being offered and the season:

“[...]in summer we don't work with schools, of course kids are on vacations and we dedicate ourselves completely to nautical activities. What happens is that the phone rings thirty times a day and we have the boat completely full for two months. Without being in July and August, we must work harder. The way we have to sell the boat is through partners, through tourism offices of the tourism regional entity, e-mails, and our website, specialized blogs. We go into different communities and different social networks to disseminate our activities. The inland activities, are activities that have a more specific audience, which are people that really enjoys walking, likes to watch birds, enjoys cycling and here we have to use more specific communication channels, that are identified and we have to work them, obviously in different markets. For example, the birdwatching, currently we only make a bet on the

English market, we don't do it in the internal market. Soon we will extend to German and Dutch markets, because there is identified that tourists of this type of product are from English, Dutch and German markets, so that's where we work. In the summer, the boat is worth the investment, the internal dissemination, because we have clients for this kind of activity."

For the entrepreneur the market for Eco-tourism is small: "Nature tourist, so far, in my point of view, [Portugal] still lacks of internal market for consuming pure nature. Consuming nature is always a complement to something else."

Regarding the capture of knowledge RB refers that:

"We work in very specialized areas. For example, only birdwatching is a world, and only there we find companies only working in birdwatching. To operate at the highest level I must have a specialized person in birdwatching. And here we have a problem, which is the lack of means, resources, skilled and specialized labor. Because obviously this is an investment and we have to keep people, to attract and secure them, manage to get some attractiveness for them to stay and dedicate themselves to improving this region. Unfortunately we are not yet at this stage, we are walking there, but currently we do it with limitations in resources and have to do it ourselves, two people in winter and rises to four in the summer but without the expertise degree, people that have more generic competencies.

[T]here is always opportunities to promote these synergies that, for example, pass through the organization of joint activities with highly qualified companies. Specific case: the Algarve association of tourism invited a group of journalists [...] and regional companies to lead a three-day activity. We felt that we still lack in the capacity and expertise level that gives response to this type of challenge and so we hired another company that took us more than half the budget so we had no profit, but we knew that we were, besides providing a service of quality and we were up to these people, who are the people that better understand birdwatching in Europe, journalists with a high degree of specialization, people very critical and, because we are launching a product we could not put at risk the opportunity and let the golden eggs chicken die before birth [laughs]. So, at the same time that we insure quality of service and contribute to the correct product first steps and launch the product effectively, we were also helping our guides who were directly involved with, in this case a highly specialized guide, and during three days we learn the terrain, we released activities, we did activities itself, so we were absorbing all that information for our guides. There is no better way than, there are no classes, no universities to pass the information better than these practical lessons on the field.

[A]nother case study, a good opportunity to do an activity with a school that in the discipline of project creation were studying the mortality rate of the clams, we said that was not our expertise area and recommended a teacher who was doing a PhD thesis on exactly this subject. There was the opportunity to come together because we have the boat and, other means and because they have the knowledge, this professor even joined up for two or three trips, and we watched in loco, how the catches and other samples were made, which was the material taken aboard. It was an important analysis to be made and what was important to retain and so, from then, we also gained a better connection with what we see daily in the field, which is to go to the bivalve farm, to get in touch with the farmer, understand the information arising from the practice of this kind of experience that is very important!

The common sense and scientific knowledge... and we try to match it and obviously show a side and the other side of it. An example... there is a hill, a small island between the Armona and Culatra islands that due to its conditions concentrates many of the eggs that come in water currents and therefore there is a large growth, large birth rate... is a natural production area of wedge shell. The bivalve farmers think that area is an area extremely rich, because the lands are fertile lands and they got there and extract sand to take to their own bivalve farms and therefore they end up taking too much from these sands that are extremely important to fix wedge shell and also clams... there is in this case, a totally wrong idea of the bivalve farmers about reality. It is important to listen and know both sides [traditional and scientific knowledge] and obviously we try to show the both versions and is interesting the confrontation of these two visions. Obviously there are visions which are nothing contradictory, even they are very [...] complementary. It is interesting to listen, for example, the names that the fishermen give to birds, which are completely different [from researchers] and it is important to have these two visions and it's quite rewarding for us to have access to these two forms of knowledge."

The entrepreneur comments the importance of E1 participating actively in science communication activities.

"This kind of activities is part of our strategy of being closer to this type of entities [...] as a potential source for our skills improvement, in the organization of activities mainly related to schools, because I believe that the schools area, sooner or later will develop into something much larger than today, eventually even in partnership."

3.2.2. The Moments of Translation

The problematization moment began with RB studying abroad. His inspiration for the idea of EI services came up in his period in Barcelona:

“[I was confronted] with a project that involved the University of Barcelona, the Polytechnic, the regional government, the Barcelona port, the commercial port, I think that it were five, [...] these five entities, maybe the museum too, the maritime museum; and so [...] it was a project, [...] that involved these large entities, with the common goal of work as well in several areas in training, sailing licensing, educational activities in schools but also in other tourism activities with visits by boat to Barcelona commercial port. It had the great merit of promoting and disseminating the sea activities in its historical, cultural and environmental perspective. There are here a lot of similarities with what I tried to do. Obviously this project is contextualized in a place and time, and therefore I had to adapt it to my reality. Algarve’s weather is different from Catalonia’s, we have a little better [laughs]. Unfortunately, we are some years behind in other aspects and we also not do not have a commercial port..., we have Ria Formosa. So there are not only disadvantages, we also have advantages. And this project was born from this inspiration and so [break moment] adapting to our reality, and our reality in terms of educational offers.”

The consolidation phase of the idea for the company creation was with a training program developed by the young entrepreneurs association and the university knowledge transfer office.

“I think it definitely starts with the training to generate new entrepreneurs which was essential for the initial click of these processes and thus began the journey. Although the idea had come to be [matured] until then, the truth is that the crucial point was exactly then. I remember that the starting point came a bit little sooner, sometimes I even forget that it was very important, that was exactly a conversation with the [knowledge transfer office coordinator] that talked about my need of getting complementary training in [management and business creation]. It was a very interesting training that at the time I thought was the best could have happened to me. Now I realize that it was really interesting, it was nice to have been confronted with these new visions, to “drink” knowledge from some people, but at the current point of view, at the stage and level where I am now and I want, I feel that it was very rudimentary. But it was the level in where I was. In fact, I was one of the persons with a more concrete idea, more defined. From those people in the entrepreneurship training only two moved forward from projects to real companies.”

The interessement moment was parallel with the maturation of the idea was due mainly to the technical monitoring of these two structures, the technology transfer office and the business support to young entrepreneurs association, where the participation in a ideas contest permitted the development of the business plan and the first contacts with suppliers:

“Finishing that stage [...] that was very important and from the point of view of grabbing me and following to interviews, for instance, now I conclude that if had been me, making 100% decisions about with who and when to meet, probably I would not have done anything that happened. The way we went into the field, grabbed the car, went to Alcoutim, to Sagres, meet with council members, meet with catering’s and we started talking about [E1]. Then there was the question of the business plan, pass to the paper all the questions I had thought but there were issues that were not completely listed.”

The translation enabler highlights the constraints to entrepreneurship that he felt in this moment of the process: “[...] lack a bit of everything, isn’t it?! Lack training, lack the structures, lack the incubators, lack incentives to these people, but this is not an area I want to talk about [laughs].”

The beginning of the recognition of the idea as an idea with economic potential marks the begging of the enrolment moment of translation but matches with the emergence of bureaucratic obstacles that almost prevented the company creation.

“The Day of the Sea, [...] the University’s entrepreneurial sea related initiatives presentation, organized the knowledge transfer office, [...] was very important in the public recognition of the idea, in strengthening and maturing it. The development of the business plan, talking with investment banks, personal investment, right?! It also had to be done.

But the activities licensing, which was another chapter that gave a lot here to do... it as basically related with a matter of culture and education, so the question of licensing is not only the fact that there are five entities involved. It is going to the captaincy [...] and the lady there almost hit me because I said I wanted to sign up as a sailor and because that never happened in the past, she starts screaming at me.

So, there are a lot of questions that ignorance, the lack of knowledge and training that although the Simplex [administrative simplification program] was implemented, people remain the same and therefore it is difficult to interpret, is difficult to facilitate, is difficult to engage with ideas different from usual. If it is not a fishing boat, if it is not a taxi, it’s a mess. If it is not a forty horse gasoline engine, what they are used to, if is an eco-friendly electric motor you cannot have it. And so, were all these issues that I was struggling with. I learned to deal with them. In the very recent past I would punch the table and upset me and scream [...] and now I avoid these situations or

put other people talking and negotiating it, because I have small tolerance to this kind of incompetence [...] I realized that connections are important. Unfortunately it is important to know the right persons in the right places. Unfortunately, I stress.”

The administrative authorizations licensing process was very complex and long.

“To license was initially the [Institute for Ports and Maritime Transports], request for using boarding infrastructures; then the captaincy, then the maritime touristic licensing; after there are two entities that provide advice, [the Portuguese Entity of Tourism and the Natural Park], afterwards the navigation inspection, and because were two captaincies involved, came people from other captaincy that represent the Navy to know if the boat respected all the requirements regarding security conditions. And I still required an authorization from the police to use very-lights and so there were five or six entities.

There are very relevant things that now changed, fortunately, legislation changed and this all pass through the [entity of tourism], obviously not the inspection, the request for the use of very-lights neither; but there is no longer the question of going to institute of ports, back from the institute and move back and forward.

Besides these questions, it is also important to underline the way like this process was treated. For example, [...] they could answer me 30 days, if they didn't make the advice it was considered positive. And [...] at the last day, they call me to a meeting in the ports institute asking for a clarification request. In other words, I gathered all the deadlines that they had [...] and figured that it could take three months, or four months, or five months, in the maximum. With all the limit deadlines it still was more than expected. It means that even thinking that I am using all entities, I am using everyday until the end, it took me longer than that. This, for me, is not more than lack of respect and lack of awareness of what is entrepreneurship, what is necessary to achieve the project success, that in certain way are different and that bring added value to the region's offer. These are the people who need increasingly to have someone pointing the finger and saying that they're not performing well their role.”

The complex process of licensing the activity also contrasts with a lack of inspection that makes life easier for companies that do not follow the rules. The rules of the game are not the same for everyone.

“[...] then tell you that there is a need to supervise and there are no means to do that, but currently the inspection longs half an hour. Go to Google and

search for 'birdwatching Algarve' and call to the [institute of tourism] and ask if it is legal or not. In half an hour [it is verified] that person's activity, but there is no interest."

Other obstacle to the consolidation of new companies is the favoritism and lack of understanding of several entities.

"[...] I desire to have more respect and more understanding from the part of some entities, and that is what sometimes discourages me a little, to feel that there are people in certain positions, so little but with so much power... power that messes a lot with the company's internal organization. And so, that is what disappoints me a little, to know that we have an electric motor that in the summer cannot be loaded because the gentleman who manages the marina does not want, just because he does not want."

In fact, he already said to me: 'I do not want, because I do not want!' [laughs]. And so we reach a level in terms of organization and in terms of ethical behavior that it seems that we are not a country that belongs to Europe and that should be on the front line. And sometimes I wonder if it is really necessary, perhaps this guy want some kind of a [...] and I do not understand what it is [...] if I have to pay or if I do not, because sometimes it gives me the feeling that I am here in the middle of such people, in the middle of sharks. [laughs]"

In parallel, the funding difficulties were great. Tools such as micro-credit or credit lines from traditional banks dedicated to innovative projects had less favorable conditions than a personal loan from family due to their antiquity as clients. The last option ended up being the manner to finance E1. R.B. mentioned some of the obstacles he felt by trying to collaborate with other actors in structuring their project. These barriers can be understood as translation problems.

"[...] at this moment it is almost impossible to think in collaboration with the ports institute, municipalities, regional authority, maritime museum that belongs to the Navy. It is almost joke thinking in a consortium with these dinosaurs, with these 'gigantic' entities [laughs]. And this is the big challenge, we find people who have two neurons and makes you want to squeeze their neck, but if we believe and think that it is possible to reach a certain stage [...] It is what we have to think [...] and so there are a series of activities, as I said before, very specialized and with an enormous economic potential and it had to have at least a municipality supporting, the ministry of education supporting... many more support that we don't have, in a perspective to grab this potential and move forward [...] it would have to be a totally different tourism offer [for students], which is restricted to thematic parks and in Easter all going to Ibiza drink a few shots [laughs] and so we're missing a lot. But we have to wait and we know that change takes time to change."

The mobilization of allies turned out to include other entities beyond those originally planned.

“Initially, I thought the solution or part of the solution passed through all these synergies that were being created and are being created and many of them were lost. I thought would be [...] easy, starting the dialogue. Unfortunately, it was not always this way. But we had a series of partners identified, the natural park, the municipalities, the regional board of education, and other associations. We have abandoned some of these partnerships and dialogues and strengthening others. But without a doubt that in the support of the board of education was important. I think that it could have done more and I believe that it will do more, but it is the second year we are taking the first steps and so I think that we still are going on time. But [...] it is extremely relevant because it validated the competencies of our offer.

The Portuguese society for the study of birds, with which we have been carrying out inland activities, we have been developing activities for the members. We already participated by invitation of this society in a workshop about eco-tourism that was extremely important and in last year we were invited to talk about the company [...] this was the main reason that currently we have some advantage in terms of birdwatching services in the field, which was the first project matching nautical activities with birdwatching in continental Portugal.

This also [...] in science, [E1] was also a Researcher’s Night promoter, but apart from the institutional support and validation of some scientific programs, [...] we want to have a closer relationship in training and exchange of experiences in various educational activities. [T]he employers’ association of heritage, historic and cultural method, was very important in the creation and development of two school programs. And I do not want to forget anyone. The natural park has shown more openness, but is very little compared to what could be the relationship with companies that operate within a protected area... but ok. We try to work to promote and enhance these relations. Then in the area of tourism activities [E1] has several synergies with other local companies. We think that it could be much more, is not yet, but we are walking there.”

The entrepreneur assumes that he really feels like a hard working ant.

“I want to say that this was a personal choice but [...] and professional, but it gives me a great joy and I hope continue to be able to have this incentive at work, but sometimes I feel it is a great personal sacrifice and that I am the last one leaving the university, I leave here at 10 p.m., and in the next day

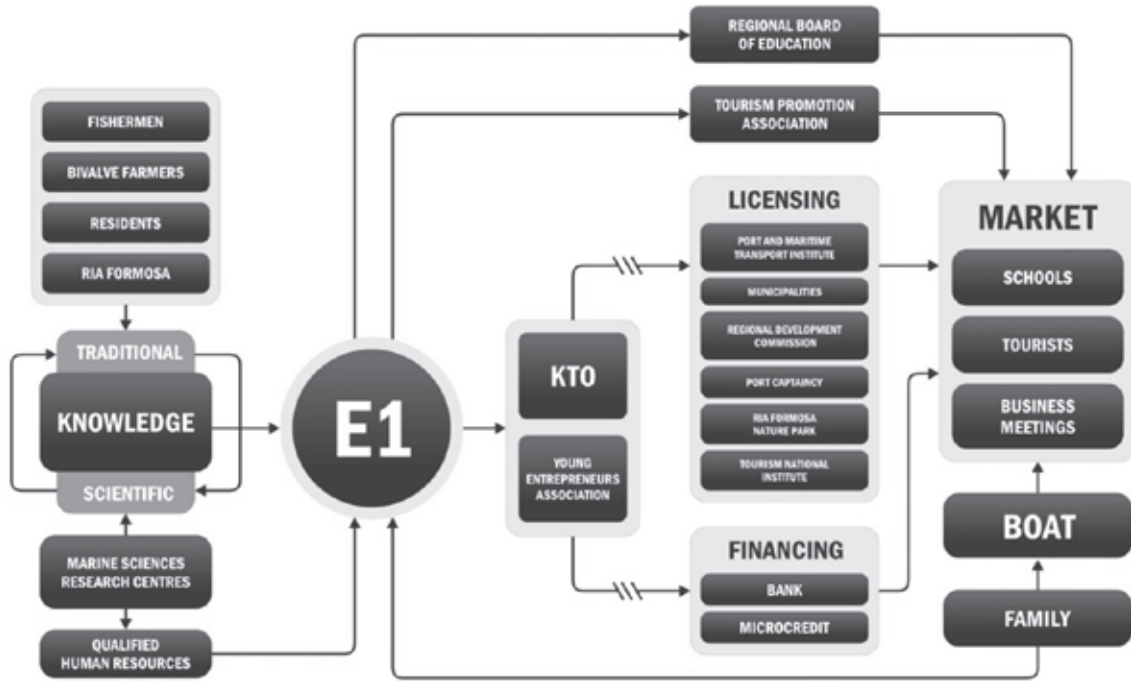
I'm already there in the morning, and sometimes I come there on Saturdays, I come there on Sundays and I do not say that this is paid with money or easy solutions or positive discrimination, just because I work harder."

3.2.3. Stabilization of the Actor-Network: E1 as an Obligatory Passage Point

The stabilization of the actor-network was not easy. But E1 achieved some success as RB was able to transform his idea in a company that is operating in the market and providing innovative services. The actor-network allows enhancing the set of connections that E1 had to reach the market and create a range of relations surrounding the goals for the company's services.

E1 is at the centre of a complex network of actors (Figure 1). To build the company based on the idea of ecotourism in Ria Formosa it was necessary to translate the interests to a broad range of other human and non-human actors. The knowledge on the thematic, key feature of E1 offer had two central sources that have been deployed continuously to the affirmation of the company. The first source of knowledge was the scientific knowledge of a marine science centre from the university, which served as basis for recruitment of qualified human resources but also to structure some of the company's service based in science through cooperation. In parallel, it was necessary to capture the traditional knowledge about Ria Formosa and to ensure the acceptance of a range of actors that intervened in this context. E1 was from the beginning proactive in seeking to adapt the activities to the fishermen, residents, bivalve farmers and also to the Ria itself. The systematic cooperation with all these actors not directly related to the market allowed the stabilization accessing to knowledge.

Figure 1: Actor-Network Stabilization



Source: Own Elaboration

To reach the market E1 needed to grant authorization for the activity, fund the activity, which in a very significant part consisted in a boat acquisition, and to convince the potential customers that the service offered by E1 might be of interest. As the extracts of R.B interview shown, the company benefited from two intermediaries, the knowledge transfer office and the young entrepreneurs association, who have accompanied in these processes with the creation of boundary objects. Even with this guidance, E1 had a lot of translation problems which enable a smooth licensing process. Licensing was, in the entrepreneur perspective, a long, painful and very unclear process. Simultaneously the demand for funding was being unsuccessful. The venture capital and micro-credit financial instruments shown to be inadequate to this new company situation that had to opt to a traditional personal loan for the investment needed. It was the family support that turned out to be central in the boat acquisition, central actor in the product offered by E1. The regional board of education and the association of tourism promotion were key actors to reach the market, in particular, specific publics such as schools and eco-tourists. Today E1 is considered an obligatory passage point in eco-tourism services providing in the Algarve region.

4. CONCLUSIONS

Academic entrepreneurship assumes, currently, a centrality as an instrument of regional development. The university and scientific knowledge role is reinforced through this channel linked with society allowing the generation of innovations, new products, processes and even markets. Through the analysis performed to different perspectives that focus the entrepreneurship phenomenon is possible to state that this concept emerged, in last decades, as a central mechanism to employment creation and competitiveness in territories. In the current context, seems clear that entrepreneurship can play a crucial role in economic growth. The case study of E1, using ANT that proved to be a useful

methodological approach, allows to underline the huge personal and financial investment that is made by an entrepreneur when compared with an employee with the same profile in the Portuguese context. An academic entrepreneur is a translation enabler that needs to engage a diversity of other actors for his own interest but is in parallel a hard working ant, that works more hours and gains less revenue in the early stage of the company's creation in the expectancy that the investment worth's in the long run.

The research demonstrates the role that the creating of networks play in the consolidation of a spin-off and it is also suggestive that social capital is critical for success. The search for funding is demonstrative of the inadequacy of available tools for the spin-offs companies in the Algarve. More financial tools and more diversified should be made available to the innovative ideas with economic feasibility. Personal loans from family became the most relevant funding source. The relevance of intermediation entities, creating specific boundary objects, like in this case the ideas contest and the business plan, are crucial for the start of the company, to guide the transformation of the idea into a business. Despite all the difficulties and the efforts of a real hard working ant, the entrepreneur summarizes his interest in creating the company: "*To own my own destiny and be able to do professionally what I like most!*"

Acknowledgements

Hugo Pinto acknowledges the financial support from the Portuguese Foundation for Science and Technology (FCT grant number SFRH/BD/35887/2007). This author is also thankful to the *Instituto de Estudios Sociales Avanzados del Consejo Superior de Investigaciones Científicas* (Spain) for receiving him as a visiting scholar during the course of this study. Ana Gonçalves and Ana Rita Cruz acknowledge the financial support of the European Atlantic Area project KIMERAA – *Knowledge Transfer to Improve Marine Economy in Regions from the Atlantic Area* (co-financed by ERDF) which supported part of this research. The authors are thankful to Ricardo Barradas for his availability for several interviews and information providing.

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REGIONAL ECONOMIC RESILIENCE & THE DEEPWATER HORIZON OIL SPILL: THE CASE OF NEW ORLEANS' TOURISM AND FISHING CLUSTERS

RESILIÊNCIA ECONÓMICA REGIONAL E O DERRAME DE PETRÓLEO DA DEEPWATER HORIZON: O CASO DOS CLUSTERS DO TURISMO E DAS PESCAS EM NOVA ORLEÃES

Julie Porter

ABSTRACT

The Deepwater Horizon oil spill dumped almost 5 million barrels of oil into the Gulf of Mexico over a three month period in 2010. This event had a significant economic impact (which compounded the recession effect) on the surrounding regions particularly those with a large marine industry presence. This paper seeks to address the issues that have arisen over the past year as a result of the oil spill, focusing on the capacity of the regional economy to respond to the exogenous shocks of mass pollution and global recession while highlighting any economic recovery efforts as well as any tensions created. To represent both the region and the industry, the coastal tourism and fishing clusters in Southern Louisiana will be used as case studies. Through the analysis of socioeconomic data and secondary source material, including historic economic recovery accounts in the region post-Hurricane Katrina, these issues will be assessed. Recommendations will be made regarding the recovery process which will take into account US government policy.

Keywords: Resilience; Maritime Cluster; Deepwater Horizon; Path Dependence.

RESUMO

O acidente da Deepwater Horizon originou que quase 5 milhões de barris de petróleo fossem derramados no Golfo do México ao longo de um período de três meses em 2010. Este evento teve um impacto económico significativo (e que agravou os efeitos da recessão) nas regiões em torno desta área, em particular aquelas com uma grande presença de indústria marítima. Este artigo procura abordar as questões que surgiram durante o ano passado como resultado deste derrame, focando a capacidade da economia regional para responder aos choques exógenos de poluição em massa e de recessão mundial ao destacar os esforços de recuperação económica, bem como as tensões criadas. Para representar tanto a região como a indústria, os clusters de pesca e do turismo costeiro no sul da Louisiana são utilizados como estudos de caso. Através da análise de dados socioeconómicos e material de fontes secundárias, como o historial de contas económicas na recuperação da região no pós-furacão Katrina, estas questões são avaliadas. Serão ainda efetuadas recomendações sobre o processo de recuperação tendo em conta a política do governo dos EUA.

Palavras-chave: Resiliência; Cluster Marítimo; Deepwater Horizon; Dependência de Trajetória.

JEL Classification: O18

1. INTRODUCTION

From 2005 until July 2011, the New Orleans region experienced several natural disasters and a mass pollution event that have had economic, social and emotional affects on the region and its communities. This paper will focus on the 'mass pollution event' when the Deepwater Horizon (DH) Oil spill, that started on April 20, 2010 when an oil rig in the Gulf of Mexico exploded killing eleven, dumped almost 5 million barrels of oil (200 gallons) into the surrounding ocean over a three month period (IEM, 2010, NC 2011, Upton, 2011). The rig and oil well were owned by British Petroleum (BP). Despite the short term nature of this spill, this event is expected to have economic repercussions in the region for the next decade (NC, 2011). In focusing on this event, the capacity of the region to recover economically will be assessed using examples from the region's previous recovery, specifically post-Hurricane Katrina. This section will highlight the economic attributes of the region both before and after the event, particularly in relation to the regions' fishing and coastal tourism clusters, due to their socioeconomic status within the region, and the impact this event had on their business performance.

The clusters in the New Orleans region have previously endured catastrophic events, largely related to extreme weather. In 2005, Hurricane Katrina hit this region and in the aftermath, resilience experts focused on the ability of the city to recover largely through the utilizing social capital to create community networks (Campanella, 2006). There were concerns at that time with the large displacement of New Orleans natives that the city would not recover. This concern was further exacerbated by the lack of regionalism as there was a disconnect between the city and its suburbs due to competition for regional funding (Lang & Danielsen, 2006). While this type of community resilience will not be addressed in this article, it is important to note that Hurricane Katrina may have lowered the regional resistance to external shocks¹ in its economic impact but it also prepared the local governments and the communities for future events such as the DH oil spill and the global recession. Furthermore, although dealing with a post-disaster region, this case study makes a significant contribution to the literature in the region's ability to recover economically and how that recovery will occur. Will the clusters innovate into a new field, return to their historic role or completely change paths?

Clusters²

The state of Louisiana relies on a diverse range of clusters that provide employment opportunities, regional economic support and the potential for innovation (Porter, 2011). While many of these clusters are located in science parks throughout the state, the fishing and tourism clusters are located in close proximity to one another, sometimes overlapping in terms of space, engaging in knowledge spillover activity and were directly affected by the oil spill due to their joint use of the Gulf of Mexico and the surrounding coastal areas. The fishing cluster greatly relies on shellfish such as shrimp (most lucrative), crab, oysters, and menhaden as well as commercial fishing and other parts of the supply chain

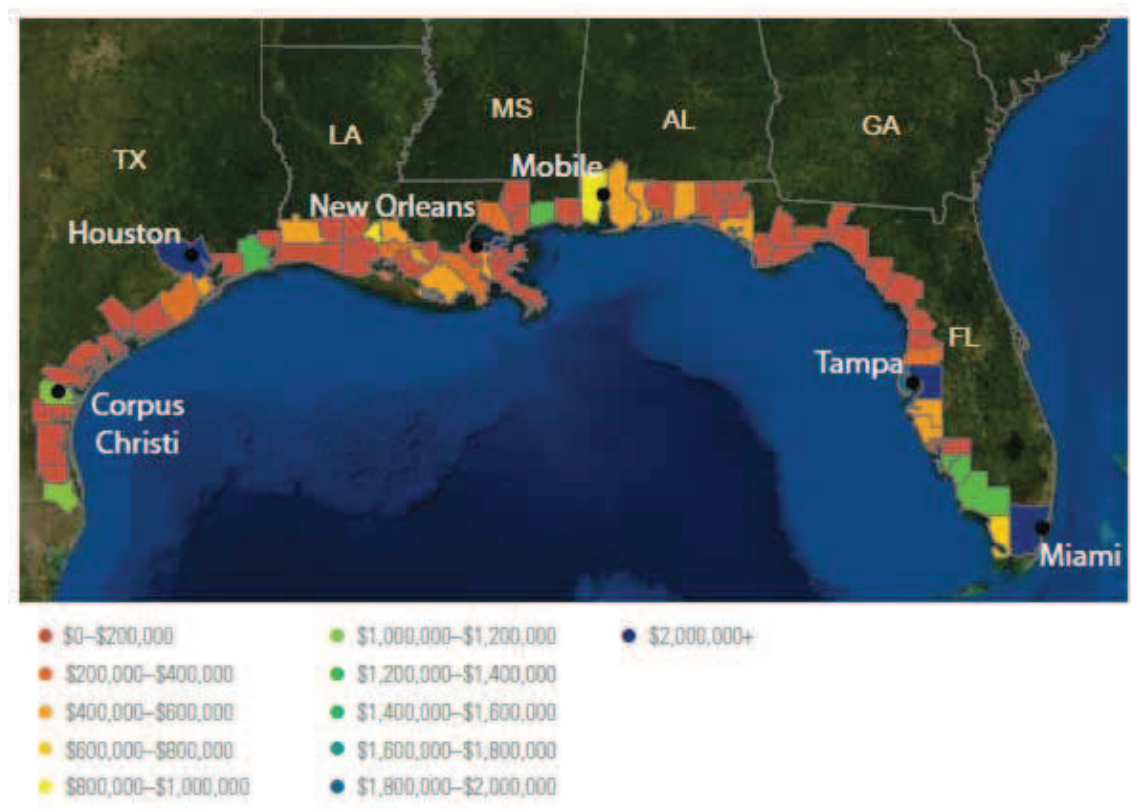
¹ 'Shocks' will refer to sudden shocks that can affect a system, of which there are three kinds: those caused by macroeconomic events such as an economic recession, those caused by industry-specific shocks such as movement of major firms out of the region or increased competitiveness, and those caused by natural disasters in the region (Hill et al, 2008). The first type of shock (macroeconomic) will be considered here.

² Porter argues that a cluster is a 'geographically proximate group of interconnected companies and associated institutions in a particular field linked by commonalities and complementarities' (1990). Alternatively Cooke & Morgan's argument reduces the relevance of geographic proximity and adds tacit knowledge transfer and competition, as well as collaboration, amongst those involved in the cluster to the definition (1998). While the clusters used in this case study are geographically proximate, in order to innovate within the respective fields, the actors within each cluster are collaborating both at the intra-cluster and inter-cluster level. Based on these assertions, the definition set forth by Cooke & Morgan will be used for the case of the fishing and tourism clusters in the New Orleans region.

(canning, etc.) (Upton, 2011). The tourism cluster is largely concentrated around coastal tourism as described in the note of map 1:

Tourism includes: sporting goods stores, scenic/sightseeing transport (water), fishing clubs/guides, hunting/fishing reserves, camps, boat rentals, casinos and nature parks. Fishing includes: finfish, shellfish, other seafood, canning, frozen seafood, seafood markets and wholesalers' US Economic Census, 2007

Map 1: Annual Tourism & Fishing Revenue by County



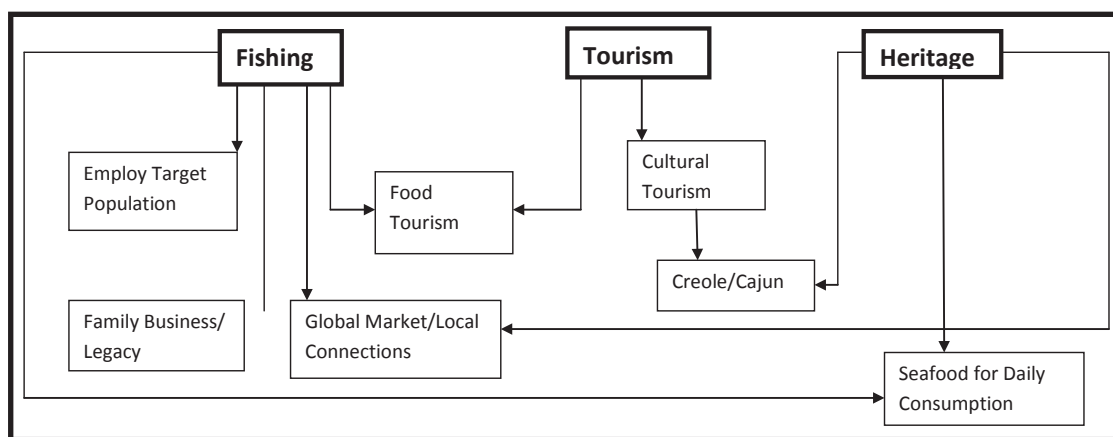
Source: 2007 U.S. Economics Census

Note: Tourism includes: sporting goods stores, scenic/sightseeing transport (water), fishing clubs/guides, hunting/fishing reserves, camps, boat rentals, hotels, casinos, and nature parks. Fishing includes: finfish, shellfish, other seafood, canning, frozen seafood, seafood markets and wholesalers.

In addition to their geographic linkages, these clusters are linked in terms of their supply chain dynamics. The same boat mechanics that fix the fishing boats also fix the speedboats popular with tourists. The clusters are further linked through the economic advantage of combining their industries as well as tourism. For the former, a considerable number of visitors to New Orleans come for the cuisine or for 'food tourism'. The culinary specialties revolve around the local seafood so the close relationship between the fishing and tourism clusters is needed. For the latter, there are historic linkages embedded in the cultural roots within the region. There are two main cultures present in New Orleans: Cajun and Creole. Neither of these cultures are exclusive to the region; however, the populations, along with the specific cuisine and music, are concentrated in the area. This cultural aspect is significant in both clusters but in different ways. In terms

of tourism, tourists are interested in sampling the cuisine and music that can be identified as Creole and these tourists can be categorized as ‘cultural tourists’ or, more specifically, ‘food tourists’. For the latter, due to the local diet that is rich in seafood, predominantly shellfish, the fish cluster could be integrated. Even without this specialized tourism, the local diet is greatly reliant on the fish cluster, sometimes eating seafood at each meal, and the cluster keeps many locals employed. Furthermore, prior to the oil spill, the locals embraced the economic benefits of both clusters, as well as the energy cluster, through festivals such as the Shrimp & Petroleum Festival (NC, 2011). See map 1 for a better understanding of the region and the geographic interplay between these two clusters. The black circle indicates what this article would consider ‘the region’. See figure 1 for an illustration of the linkages between the clusters and regional heritage.

Figure 1: Linkages between Fishing Cluster, Tourism Cluster & Regional Heritage



Source: Centre for Advanced Studies, Cardiff University, 2011

Impact of Oil Spill

Prior to the DH oil spill, it is estimated that the region brought in approximately \$4m a year in the fishing and tourism clusters as depicted in map 1 (NC, 2011). The regional fishing cluster employs approximately 35,000 people (Upton, 2011). The regional tourism cluster employs approximately 25,000 people. In terms of loss from DH, at the state level³, the fishing industry is expected to lose between \$115m to \$172m until 2013 (IEM, 2010). Again at the state level, the tourism industry is expected to lose \$691m over the next three years as a direct result of the oil spill (Economist, 2011). To put these figures into perspective, the tourism industry in the state of Louisiana has an estimated worth of \$6b and the Louisiana fishing industry has an estimated worth of the \$3b (Eubanks, 2010, Economist, 2011). It is projected that both industries, at the state level, will be in economic decline for at least the next three years for tourism and the next five years for fish which will be enough time to recover from the brand stigma (IEM b, 2010). Looking at the state figures, the economic toll is sizable but recoverable; however, regionally, the economic impact of the oil spill can be catastrophic, particularly due to the only recent resurgence in the post-Katrina period and the low industrial absorption capacity of the unemployed (NC, 2011). Furthermore, while New Orleans may not be as economically decimated from the oil spill as the Houston region, as displayed in Map 1, the natural landscape of New Orleans which positions the city-region below sea level is

³ When possible, regional level statistics were used; however, due to the recent nature of these events, in some cases it was unavailable and state level statistics were referenced.

expected to provide a disproportionate impact on the region from the oil spill in the long term (IEM, 2010).

A year after the oil spill, it is clear that the economic impact will be long term in the region. In the immediate period after the spill, the *US Oil Pollution Act* came into effect which allowed those individuals and businesses harmed by the event to claim from the responsible party, British Petroleum (BP) (NC, 2011). Through this Act, those harmed could claim costs/damages against BP. If BP did not accept liability after 90 days then the claimant could take BP to court or claim directly from the government under the Oil Spill Liability Trust Fund. As of August 23, 2010, BP paid, through the Gulf Coast Claims Facility (GCCF) that now handles the claims, \$395m of which over 33% went to the fisheries industry (Upton, 2011). In February 2011, the emergency payments to individuals and families affected by the oil spill in the fisheries industry was estimated at \$751m (Upton, 2011). The claimants have three years to submit their claims to the GCCF so the total economic impact from the side of BP will not be known until 2013.

In addition to direct funding, BP also established the Vessel of Opportunity program which provided short-term employment to the unemployed fishermen in the Gulf of Mexico as well as showing a renewed effort to clean-up the spill (IEM, 2010). The program trained fishermen to use their vessels to help contain and clean up the spill. Across the Gulf, approximately 3500 fishing boats were employed through this program; however, as of January 2011, the program was only still in place in Louisiana. The total cost for this project was \$594m⁴ (Upton, 2011). In the long term these fishermen, as well as the other people who are unemployed as a direct result of the oil spill, will have difficulties accessing jobs due to a lack of transferrable skills, lack of absorption capacity in the region, and brand stigma that is driving away consumers (IEM, 2010, Upton, 2011).

Outside of BP's efforts to support those who became unemployed as a result of the oil spill, BP has also assisted the Louisiana fishing industry as a whole with \$48m for seafood safety testing (Upton, 2011). The 'brand stigma' that has been discussed thus far is directly related to the health and safety of those consuming seafood (IEM (b), 2010). On the surface this fund looks to only help the fishing cluster; however, when taking into account the significance of commercial fishing as a form of tourism as well as food tourism, the fund really helps both clusters. It is unclear how much of this fund was set aside specifically for the New Orleans region; however, even with the scientific approval, the general public is concerned about the long-term health implications of eating the fish and swimming in the coastal waters. This is directly related to the aforementioned three and five year projections for the clusters as that is the estimated time to turn the brand around. Given the number of events that have caused the economic decline of the region particularly over the last 8 years, would it be realistic to consider alternative paths for these clusters to provide a sustainable future for the region?

The article will continue as follows. The next section will focus on analyzing the regional resilience literature highlighting any instances where New Orleans has been used as a case study for previous events such as Hurricane Katrina. This will be followed by a brief description of the methods used in conducting this research. After this, there will be a discussion on the findings from this research predominantly applying the theory in the literature review to this actual case. This section will also seek to identify ways in which New Orleans can recover from this shock. The final section will discuss the role of policy in this recovery, the BP response and provide a summary of the main points.

⁴ Through damage claims and cleanup, the cost to BP as of April 2011 was \$16b (Barker, 2011).

2. LITERATURE REVIEW

By assessing the economic impact of the oil spill on the clusters in the region, major themes have arisen predominantly focusing on the regional cultural and economic linkages to the clusters, the inter-cluster collaboration and the ability of the region and the clusters to recover to previous external shocks like Hurricane Katrina. All of these themes have implications for the region's resilience which will be discussed in this section.

Due to the history of these clusters in the region, the regional economic resilience literature will be discussed in relation to its evolutionary capacity focusing on evolutionary economic geography concepts. Using this perspective, the evolutionary aspect may be at odds with the equilibrium-based analysis of the New Orleans regional economic system. Christopherson et al, note that post-Hurricane Katrina, the resilience of the New Orleans region was measured through the tourist expenditure and employment as the system was returning to a state of equilibrium (2010). This is referred to as engineering resilience and considers resilience as the capacity of the system to return to or resume a state of equilibrium after an external shock (Simmie & Martin, 2010). The faster the system returns to a state of equilibrium, the more resilient it is to external shocks. Alternatively, ecological equilibrium is considered by some scholars to be an extension of engineering resilience; but, it differs due to the system's ability to have multiple equilibria which is more conducive to the ecological sciences (Holling, 1973, Simmie & Martin, 2010). In having multiple equilibria, ecological resilience is the ability of a system to absorb the shock before it is destabilised and transitions to another regime of behaviour (Holling, 1973). In Swanstrom's critical examination of the ecological framework, he argues that the ecological concept, with multiple equilibria, is more suitable when discussing regional resilience as it takes into account the ability of the industries in the region to adapt (2008). However, Simmie & Martin aptly note that the resilience of this system is measured by its ability to remain the same or 'absorb' an extreme shock (2010). This elasticity aspect of ecological resilience ties it closer to engineering resilience than any evolutionary-based theories.

The conflict between system equilibrium and system evolution in addressing resilience is widely disputed as 'returning to a state of equilibrium' implies that there is no change or evolution. Boschma & Martin, describe evolutionary economics in the ability of the economy to *self-transform from within* (2010). This transformation has three specific characteristics: dynamical, irreversible process and novelty. The first characteristic, dynamical, refers to the constant state of change the economy is in, ie. it is not static. The second characteristic, irreversible process, refers to the forward moving nature of the economy. The final characteristic, novelty, refers to the innovative emphasis in evolutionary economics to drive markets. In combining the first and second characteristic, where the economy needs to be changing and moving forward, it can be assumed that equilibrium-based economic notions can be abandoned. Using this evolutionary economics (EE) platform, evolutionary economic geography (EEG) is possible as the EE aspect deals with the transformation of the economy and the geography aspect deals with the space in which these transformations occur (Boschma & Martin, 2010). In understanding EEG, path dependence, as an evolution-based theories which addresses the aforementioned equilibrium question, will be discussed in its relevance to the adaptation of resilient regions.

In its truest form, path dependence focuses on the regional economy to be 'locked in' to a particular path. To further explain, the region is locked-into a certain method of economic development which is reinforced by significant returns to the local economy. If the regional economy, that is locked-in to a specific path, is impacted by a shock

then the resilience of the region can be gauged in the region's capacity to return to that path. Although some words have changed (regional economy instead of system, lock-in instead of equilibrium), this account of path dependence theory appears to be in line with engineering resilience (Simmie & Martin, 2010). If path dependence, through lock-in, is related to equilibrium-based resilience theories then how does it apply to adaptation and evolution? This question is particularly pertinent as the aforementioned definition of evolutionary economic geography specifically discounts the use of equilibrium based theories (Witt as cited in Boschma & Martin, 2010). Simmie and Martin consider the relationship between path dependence and evolution through theorising new path creation (2010). In creating the new path, which could be based on the old paths as they provide the skills and competences for development, the system (regional economy) demonstrates the evolutionary side to path dependence theory and also shows how the system can adapt or 'break free' from lock-in in response to the shock (Martin & Sunley, 2006, Simmie & Martin, 2010).

Substantial research has been completed focusing on path creation with contradictory findings that paths are created at random or they are shaped by old paths (Martin & Sunley, 2006). Using the evolutionary perspective, the latter finding will be explored further as a form of regional adaptation which could promote post-shock recovery. According to Martin & Sunley, possible EEG-based scenarios for escaping path lock-in include: branching and related variety (2006). 'Branching' or 'regional branching' is when industries, both mature/going into decline and new/ developing, work together to innovate another, technologically-based industry (Boschma & Frenken, 2011). This takes into account the related variety of industries already present in the region as well as the capacity for technological relatedness. Through the utilisation of knowledge transfer methods, the new industries can connect with existing industries to support innovation and growth. Regions that evolve in this way are traditionally characterised by being highly path dependent, usually referred to in an equilibrium capacity and experience incremental change (Cooke, 2010). An example of this would be the Pembrokeshire region of Wales where the co-evolving paths of non-renewable energy and maritime industries branched to create a non-renewable energy industry.

'Related variety' or 'relatedness' was mentioned in relation to branching and can be defined as the diverse agents present in a region that allow for knowledge spillover to occur amongst clusters, industries, or firms (Boschma et al, 2010). This related variety could be based on technology that can be applied in several different industries in the region initiating knowledge spillover. Basically, it is a common point (technology, innovation) that more than one agent can utilise which drives innovation. In relation to branching, related variety is a predecessor as it provides the foundation within the region for branching to occur. As related variety has already been found between the two clusters in the New Orleans region and entrepreneurs have already innovated to fill some of the demand created from this spillover, eg. Food tourism firms, branching will be discussed further below in regards to the region.

3. DISCUSSION & FINDINGS

Unlike previous events where the system only had to recover from one shock at a time, the situation in the New Orleans region at the current time, where there are four external shocks affecting the system simultaneously and the region has only recently recovered from the last major shock, is exceptional. While it may be the case that the system has traditionally gauged resilience as returning to a state of equilibrium, due to the growth

in both number of shocks and the intensity of the shocks, the system needs to change its recovery strategy focusing less on path lock-in and more on path evolution. The multiple shocks the region is currently encountering are illustrated in Figure 2.

Figure 2: External Shocks Affecting the Fishing & Tourism Clusters in the New Orleans Region



Source: Centre for Advanced Studies, Cardiff University, 2011

In terms of external shocks, the top left shock is the Deepwater Horizon Oil Spill which, although it has been a year since it occurred, will provide long-term economic decline in these regional clusters as discussed in the Introduction. Moving to the right, the global recession starting in 2007 originally only affected the demand in the region as fewer tourists went on holiday and more people chose less expensive options to seafood. However, four years on, the recession has led to high rates of unemployment across all traditional sectors, more part-time jobs for those searching for full-time employment, as well as higher rates of housing foreclosure which have disproportionately affected the low-income native population of the New Orleans region. In addition, there is recent speculation of a double-dip recession due to the stagnant economy. The next theme on the bottom right is peak oil. This is not to be confused with DH even though the oil spill and the global recession could have an impact on the price of oil. 'Peak Oil' could be considered the high price for filling the tank which can also be related to government foreign relations, war, and taxes. Regionally, this equates to less tourists due to increased petrol prices and potentially a higher price on fish due to the increased price of diesel for fishing boats. The last theme on the bottom left deals with extreme weather which some experts attribute to climate change. Through attributing it to climate change, experts can easily explain the increased frequency of the major weather events, the increased intensity of these events and the extension of the 'hurricane season' that is particularly relevant in the region. Given the current nature of the other three themes, the extreme weather external shock would not take into account Hurricane Katrina; however, it would take

into account the more recent flooding of the Mississippi River and the extreme tornadoes experienced in April 2011 in the region.

Due to the continuous introduction of new external shocks over the last 8 years, this is the time to assess the potential of the region to change or for the clusters to change paths through innovation as the regional economy may not be able to recover over time with the increased pressure. Adaptation is essential at this phase and, if considering food tourism, the spillover associated with related variety has already started; however, this fledgling industry could be considered a combination of existing firms as opposed to an innovation to move the region forward. While recombination can be successful, due to the multiple shocks the region is experiencing which directly influence these industries; a recombination of the industries will not enhance the economy. As mentioned in the last section, due to the low resistance because of the previous shocks, including the on-going global recession, the regional economy has not been able to support itself since the oil spill. This was noted in the Introduction in terms of the economic impact of the spill on the clusters. Beyond the resistance aspect is the recovery aspect. While this paper only seeks to examine the DH oil spill effects on the economy, it is difficult to separate it from the other external shocks. Ecologically, the DH oil spill has been cleaned up in the Gulf of Mexico, the fish have been tested and can be eaten and there is no oil washing up on the shore. Unfortunately, it takes more than a year and some tests to allow such demand-driven industries to recover economically. Due to the historic significance of the clusters to the region and the inter-dependence of the clusters themselves, branching to a significantly different path may be the best long-term option for regional growth.

According to Hudson as cited in Christopherson et al, 'the intersection of economic crisis and environmental crisis has enhanced the perceived sense of vulnerability and, hence, stimulated the search for new paths of resilience' (2010). The branching of existing paths provides limited opportunities for growth, particularly relating to the above issue where combining industries is an insufficient outlet. Nonetheless, there is sufficient overlap within the existing clusters to warrant knowledge spillover and innovation that can provide the regional economic growth needed to resist exogenous shocks. For example, a large portion of the fishing cluster revenue comes from commercial fishing which could easily also fit into coastal tourism. See map 1. Similarly, coastal tourism encompasses 'fishing clubs/guides' and 'sightseeing transport (water)' which could also be related to the fishing cluster. From this comparison, the fishing and tourism clusters could have firms focusing on eco-tourism. In the short-term, eco-tourism can relate to taking tourists into the Gulf of Mexico on boats to show them the effects of the DH oil spill and the way in which the ecosystem is resilient. This could bring tourists, if only inter-regional, back to the region. In the long term, this can equate to an eco-tourism micro-cluster within the tourism cluster, characterized by sustainably sourced, locally emphasized restaurants and low-carbon emitting hotels. It is a way of retaining the historic relevance of the region and the clusters while introducing something new to the usual visitors. While combining the interests of the two clusters, the ecotourism concept would be consistent branching through re- focusing the region on the green economy. Nonetheless, this is a possible future scenario based on the historical relevance of the clusters to the region as well as the need to adapt to increase resistance to future shocks. Currently, the resilience of the regional clusters to the oil spill has been gauged unemployment figures and a 'resumption of the norm' ie. Equilibrium-based arguments, as was the case post-Katrina.

4. REGIONAL INFRASTRUCTURE FACILITATING CHANGE

Thus far, the exogenous shocks affecting the system have been identified, the discussion on the regional economic landscape in the New Orleans region was addressed and the potential path change was proposed; however, little mention was given to the infrastructure that could make this change possible. While this last issue could be an article on its own, it will be briefly discussed to highlight the recovery work that has been completed in the region in the last year since the DH spill.

According to Wolfe, the regional factors influencing regional resilience outcomes are: 'the ability of regional and local governments to build on specialised regional assets, including public and private research infrastructure as well as unique concentrations of occupational and labour market skills, the presence or absence of 'civic capital' at the regional and local level and the ability of regional networks to work within and across associational boundaries to support the formulation and reinforcement of strategic management policies in response to external shocks' (2010, pg. 140). While this infrastructure may not have been present to help in the recovery effort after Hurricane Katrina given the specific attributes of that disaster, the current resilience infrastructure is a result of that turmoil. This infrastructure is characterised by the connectedness of several levels of government- national, state, regional & local- as well as regional Universities devoting more attention, by way of research centres, on resilience research. Examples of this institutional connectedness for resilience purposes are substantial.

The US Commerce Department, has provided New Orleans businesses the extra help they need to recover through a \$2.34m grant to aid the oil spill economic recovery effort which is comprised of public-private funds for the State of Louisiana to:

- Enhance the creative and bioscience industries through the 'Downtown Development District' of New Orleans,
- Fund marketing, rebranding and workforce training for the fishing-based industries in the State,
- Fund regional Universities to prepare a feasibility analysis for seafood processing in the New Orleans region,
- Establish a business incubator on wheels with state universities bringing it to the coastal communities affected by the DH spill. (Atwood, 2011)

This is in addition to the BP payouts through the GCCF campaign and any additional investment in the region. Beyond the government support, the Universities and individual communities are also encouraging recovery through devoting more time and attention to community resilience and its effect on regional resilience. See the Community and Regional Resilience Institute website for further details.

5. CONCLUSION

Sudden shocks affect maritime-based regions throughout the world and, as demonstrated by this case, there can be several shocks making an impact simultaneously. To a varying degree, these shocks have made an impact on industries throughout history. In some cases, the region flourished as a result of adaptation through diversifying the industry in an effort to provide more options in the event of an industry-specific shock. Other cases were less successful and the region, instead of adapting, went through a phase of decline characterised by high unemployment, low absorptive capacity and high crime. The case of the New Orleans region, along with many others, has demonstrated that the recovery

from a shock is not as black & white as the aforementioned 'adapt or decline' regional assessment has depicted.

In researching the resilience of the New Orleans regional clusters *ex post*, the co-evolution of the fishing and tourism clusters is obvious with several small firms starting on the basis of getting into this combined market; however, because of the number of shocks that have impacted the region, there is no way to link the result of the oil spill to the entrepreneurial activity. In addition, the ideal scenario for eco-based firms to grow would be with a drastic change of consciousness at all levels – government, general public & consumers- toward sustainable, fossil-free, living. To some extent, this change may be occurring, particularly with the oil spill obviously causing so many economic problems, but, if it is happening, it is to a much smaller degree than what is needed to trickle down to create a new path at the cluster level. This is evident in the way in which the regional and national governments have responded to the oil spill, focusing on 'equilibrium-based responses': to have the recently unemployed back in their old jobs (largely fishermen) and through providing funding into research on recovering the problematic industries. While this is a viable short term solution, if the shocks keep occurring at the current rate, there will again be long-term problems associated with these clusters.

Due to the demand-driven nature of these clusters, they will recover from the current shocks they are experiencing, albeit slower than in past situations due to the global nature of the economic crisis, and through non-evolutionary means. As a result of the latter, the region as a whole must begin to consider how to increase its resistance to shocks, possibly focusing on less demand-driven industries and more science-based industries, and how to construct recovery plans that focus more on adaptation in the future.

Acknowledgements

This article was stimulated by research funded under the KIMERAA: Knowledge Transfer to Improve the Marine Economy in Regions from the Atlantic Area project, co-financed by the European Cooperation Programme 2007-2013 Atlantic Area. The sponsors are thanked for their support and responsibility for this article lies entirely with its author.

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THE SEA AS A CONNECTION BETWEEN RESIDENTS AND TOURISTS IN COASTAL DESTINATIONS: A CASE IN ALGARVE

O MAR COMO ELO DE LIGAÇÃO ENTRE RESIDENTES E TURISTAS EM DESTINOS COSTEIROS: UM CASO NO ALGARVE

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ABSTRACT

Coastal regions involve a set of interactions between tourists and residents, which implies that management and marketing strategies should take into account both stakeholders. Indeed, one of the greatest challenges of destination management organizations is to understand that they serve not only tourists and stakeholders directly related to tourism, but also the local community. Thus, the central purpose of this study is to measure the destination image of both tourists' and residents' perspectives, identifying the major aspects of agreement and disagreement.

The data was collected in Lagos, one of the 16 municipalities of the Algarve (South Portugal), which, due to its coastal location, offers sun-beach tourism. Furthermore, due to historical, cultural and economic reasons, the sea has been a factor of identity for the coastal communities in the region. The empirical investigation includes a mixed methodology, with the use of open-ended questions followed by the application of a structured questionnaire to both tourists and residents.

The results meet the growing need to diversify the destination supply depending on "sun and beach", aiming at local sustainable development by focusing on the cultural component and the sea as an important attribute of the destination.

Keywords: Destination Image; Coastal Tourism; Sea; Residents; Algarve.

RESUMO

As regiões costeiras envolvem um conjunto de interações entre turistas e residentes, implicando que as estratégias de gestão e marketing contemplem ambos os stakeholders. Desta forma, um dos grandes desafios das organizações responsáveis pela gestão do destino é compreender que servem não apenas os turistas e os públicos relacionados com o turismo, mas também a comunidade local. Assim, o objectivo central do presente estudo é medir a imagem do destino na perspectiva de turistas e de residentes, identificando os principais aspectos de concordância e de divergência.

A recolha dos dados foi realizada em Lagos, um dos 16 municípios do Algarve (Sul de Portugal), que aliado à sua localização costeira oferece turismo de sol e praia. Ainda, devido a razões históricas, culturais e económicas, o mar tem sido um factor de identidade das comunidades costeiras da região algarvia. A investigação empírica inclui uma metodologia mista, com a aplicação de questões abertas, seguidas de um questionário estruturado, ambos dirigidos a turistas e a residentes.

Os resultados apontam para a crescente necessidade de diversificar a oferta dos destinos dependentes do produto “sol e praia”, visando o desenvolvimento local sustentável, com foco na componente cultural e no mar como um importante atributo do destino.

Palavras-chave: Imagem de Destino; Turismo Costeiro; Mar; Residentes; Algarve.

JEL Classification: M31

1. INTRODUCTION

Taking into account the continuing expansion of the tourism sector and the opportunities arising from the current international crisis, it becomes important to create strategies to develop competitive destinations. Indeed, destinations compete among them, in an environment where the supply is becoming progressively more similar and communication strategies are increasing towards the same market segments (Pike and Ryan, 2004). Therefore, if tourism marketing aims to attract people to particular places, the challenge lies in the differentiation based on attributes, tangible or intangible, allowing the development of a solid branding strategy around destinations (Kotler, Asplund, Rein and Haider, 1999; Phelps, 1986; Pike and Ryan, 2004).

Specifically, coastal regions offer the sea as a special attraction to people, not only as residents but also as tourists, looking for escape and pleasure during holidays. This phenomenon continues to increase around the world in countries such as Portugal. In fact, the sea has over the centuries shaped the lives and the history of Portuguese people. The Algarve region, specifically municipalities such as Lagos, was the stage of the “Age of Discovery” of the new world by sea, in the fifteenth and sixteenth centuries. In this context, the sea has been of crucial importance at cultural, economic, and communication levels. More recently, it has also become an important source of scientific endeavour (Guerreiro, 2007, Paula, 1992). Therefore, the sea can be a strategic resource to the destination, connecting the needs of both tourists and residents.

The study of destination image has been asserting itself as an instrument of differentiation, helping to increase the destinations competitiveness. Several authors state that destination image plays an important role in tourists’ behaviour, such as the recommendation of the destination to family and friends. Nevertheless, despite the growing importance of the theme, there is still a lack of scientific research regarding to cities image, compared with countries image, as well as a lack of comparative studies related to destination images formed by tourists and residents (Gallarza, Saura and García, 2002; Pike, 2002). Such studies are able to provide important management guidelines, since the focus on the consumer’s perspective will help destination managers to develop a more effective destination branding and a more original value creation process, contributing to the coastal destination differentiation.

In this context, the overall objective of this study is to analyse the image of Lagos in Algarve (Portugal), as a coastal destination, strongly culturally connected with the sea, from the tourists and residents’ point of view. In accordance with the stated objective, three research questions are proposed:

1. What are the main similarities and differences of the image of Lagos, as a tourist destination, through tourists’ and residents’ point of view?

2. Is the sea an important attribute of the destination for both tourists and residents?
3. Which attributes explain significantly the willingness of tourists to recommend Lagos as a tourist destination to family and friends?

2. LITERATURE REVIEW

2.1 The Importance of the Sea in Coastal Destinations Image

Coastal and marine tourism is one of the fastest growing areas within the world's largest industry (Hall, 2001; Honey and Krantz, 2007). Indeed, while tourism development has been spatially focused on the beach for much of the past 60 years, being an important attraction of many European destinations, the marine environment as a whole has become one of the new challenges in coastal destination strategies (European Commission, 2000). In this context, the concept of coastal tourism comprises the full range of tourism, leisure, and recreational activities that take place in the coastal zone and the offshore coastal waters. This concept can be also related to marine tourism that is directly related to ocean-based tourism such as deep-sea fishing and yacht cruising (Hall, 2001).

If tourists seek for new experiences related to the sea, at the same time, local people are increasingly concern to preserve their identity, environment, and natural, historical and cultural heritage from the impact of uncontrolled tourism. In this context, research has pinpointed the importance of the sea for coastal destinations image, in both perspectives of tourists and local community (European Commission, 2000). Indeed, tourism planning has been adapted and expanded to include broader environmental and socio-cultural concerns, focusing the potentialities of the sea to develop and promote sustainable economic development strategies at local, regional and national scales (Hall, 2001).

2.2 Tourists vs. Residents

Tourism involves a set of interactions between tourists and residents, which implies that strategies for developing the sector should take into account both stakeholders. In addition to tourists' perceptions, the study of the image that local communities have regarding to their place of residence as a tourism destination becomes necessary, as this public acts passively and actively in shaping the destination image from the perspective of tourists (Gallarza *et al.*, 2002). On one hand, locals may have images of their own place of residence, resulting in positive or negative word of mouth, which can be investigated in comparison with those of tourists (Simpson and Siguaw, 2008; Witter, 1985). On the other hand, residents are often seen as an attribute of the destination image and their support for tourism may affect the tourists' perceptions of the destination (Echtner and Ritchie, 1991; Gallarza *et al.*, 2002). Therefore, one of the greatest challenges of destination managers and marketers is to understand that they serve not only tourists and stakeholders directly related to the sector, but also to the local community (Howie, 2003; Ritchie, 1993).

2.3 Destination Image and Tourists' Behaviour

Destination image plays an important role in tourists' behaviour during the different moments which involve the tourist experience: a) in the decision process of choosing the destination (a priori image), b) in the process of comparison of expectations with experience, preceding the state of satisfaction and perceived quality (image in loco), and, finally, c) in the process of revisiting and recommending the destination to friends and family (a posteriori image) (Bosque, Martín, Collado and Salmones, 2009; Galí

and Donaire, 2005; Hunt, 1975; Selby and Morgan, 1996). Furthermore, since other factors influence the decision to revisit destinations, regardless of whether or not tourists choose to revisit, they can recommend the destination to their friends and relatives, as recommendation are the most credible informative agent in the process of choosing a holiday destination (Bigné, Sánchez and Sanz, 2009; Chen and Gursoy, 2001; Konecnik and Gartner, 2007; Stepchenkova and Mills, 2010). In this context, research should focus on the features of the destinations which significantly explain recommendation behaviour (Bigné *et al.*, 2009; Chen, 2003; Chen and Gursoy, 2001; Pike and Ryan, 2004; Vassiliadis, 2008).

Destination Image Dimensions

Several authors claim that destination image comprises three dimensions. The cognitive component relates to beliefs and knowledge that the individual has in terms of the attributes of the destination; the affective component refers to feelings that an individual associates to the destination (Baloglu and McCleary, 1999; Beerli and Martín, 2004; Bosque and Martín, 2008a); and the behavioral component is related to the actual conduct or intention to revisit and to recommend the destination to friends and family (Bosque and Martín, 2008b; Bosque *et al.*, 2009; Dann, 1996; Gartner, 1993; Pike and Ryan, 2004). These components contribute to the formation of the global destination image that several researchers consider to be bigger than the sum of its parts and it should be approached in a holistic perspective (Baloglu and McCleary, 1999; Beerli and Martín, 2004; Echtner and Ritchie, 1991; Fakeye and Crompton, 1991; Hunt, 1975; Phelps, 1986).

According to Echtner and Ritchie (1993), destination image can be measured through a functional-psychological *continuum*, encompassing individual and holistic impressions. The model proposed by these authors also allows the identification and differentiation of common functional and psychological attributes from distinctive or unique features. In this regard, despite the fact that several authors have suggested that Echtner and Ritchie's approach (1993) includes only the cognitive dimension and not the affective dimension of destination image (Bigné *et al.*, 2009), other researchers assume that the model encompasses both components (Stepchenkova and Morrison, 2008; Stepchenkova and Mills, 2010).

3. METHODOLOGY

In order to capture the complexity of the concept of destination image, the literature suggests a mixed methodology (unstructured and structured) able to retain as much information as possible, facilitating the analysis and comparison of results (Echtner and Ritchie, 1993; Jenkins, 1999).

3.1. Setting

Lagos is integrated in the region of the Algarve, which has an area of 4,996 km² and a coastline of around 220 Km (CCDR Algarve, 2008). The Algarve is characterized by a semi-mediterranean climate, marked by a soft winter and a long summer, low precipitation and an annual average temperature close to 18 °C. The region has about 430,000 inhabitants and receives around 2.9 million tourists, concentrated mostly in the summer (INE, 2009b). Being the Portuguese tourism destination with the highest number of overnights stays, the economy of the region is mainly dependent on tourism.

Lagos is one of the 16 municipalities in the Algarve region (Southern Portugal), and because of its coastal location, it offers mainly sun and beach tourism. In fact, the Bay of Lagos, which is over four kilometers long, is one of the largest bays in Europe. In order to cope with its dependence on sun and beach tourism and its related destination image, the strategic plan of the municipality of Lagos proposes the historical and cultural connection to the 'Age of Discovery' and the sea as a strategic opportunity to differentiate the destination. The municipality has 28 890 inhabitants (INE, 2009a) and receives around 143151 tourists a year (INE, 2009b).

3.2 Instruments and data

In the first phase of this study, in order to capture the main attributes adequate to measure the image of Lagos, in mid-July 2009, 50 tourists and 50 residents were surveyed in its downtown area. The three questions used in this survey were adapted from Echtner and Ritchie's study (1993), as follows: (1) What images or characteristics come to mind when you think of Lagos as a holiday destination?; (2) How would you describe the atmosphere or mood that you would expect to experience while visiting Lagos?; and (3) Please list any distinctive or unique tourist attractions that you can think of in Lagos. In the second phase, the results of the first phase were used to develop a questionnaire which was subjected to a pre-test. After this procedure, this questionnaire was distributed among 379 tourists and 378 residents, in August 2009, in the municipality of Lagos. The cluster sampling method was used. This is a random procedure in which all individuals within a particular area or location are considered as a cluster (Hill and Hill, 2008).

The questionnaire applied to tourists consisted of three groups of questions. Group 1 involved the 20 attributes yielded in the first stage of this study. In order to measure their level of agreement with these attributes, individuals were asked to respond to each item using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) (Baloglu and McCleary, 1999; Bigné et al., 2009). Group 2 embodied one question which was related to the behavioural component: "Would you recommend Lagos as a tourist destination to your family and friends?" The respondents were asked to respond using a five-point Likert scale, ranging from 1 (definitively not) to 5 (definitively yes) (Baker and Crompton, 2000; Bigné et al., 2009; Bosque and Martín, 2008b; Opperman, 2000; Pike and Ryan, 2004). Group 4 referred to sociodemographic information. The questionnaire for residents comprised two groups of questions using the same structure as the groups 1 and 4 of the tourists' questionnaires.

The tourists sample included 182 males (8.8% between 18 and 24 years old, 79.1% 25 and 64, and 12.1% 65 or older), and 197 females (10.7% between 18 and 24, 75.1% 25 and 64, and 14.2% 65 or older), making a total of 379 respondents. In terms of country of origin, 67.0% were foreign tourists and 33.0% were Portuguese tourists. In this sample, 51% of the participants had a university degree, 40% had completed secondary education, 7% had completed their primary education, and the other respondents had no level of education. The residents sample included 185 males (13.5% between 18 and 24, 66.0% 25 and 64, and 20.5% 65 or more) and 193 females (13.0% between 18 and 24, 62.2% 25 and 64, and 24.9% 65 years or more), together 378. Of these, 87.8% had Portuguese nationality and 12.2% foreign. More frequent levels of education were primary (38%), secondary (37%), and university (20%).

3.3. Data analysis methods

For data analysis, this research used univariate descriptive statistics, the Cronbach's alpha coefficient to verify the internal consistency of the items included in the questionnaire,

and the chi-square automatic interaction detector (CHAID) method. This multivariate technique was applied to understand the contribution of the cognitive component of the image of Lagos to tourists' recommendation of the destination to friends and family. This algorithm developed by Kass (1980) tends to find a classification of population groups which could describe the dependent variable as best as possible. CHAID is especially suitable for use with categorical variables, and produces segments that are mutually exclusive and exhaustive by performing chi-square tests with Bonferroni adjustment. This criterion-based technique possesses several advantages in comparison with non-criteria methods, such as cluster analysis, which consider all of the variables interdependently (Chen, 2003).

4. STUDY FINDINGS

4.1. Tourists vs. residents

Figure 1 corresponds to the results of the first and second questions of the survey used in the first phase of the study. Holistically, in the tourists' perspective, Lagos has great and beautiful beaches, white sand, bright sun, and good promenade in the historical and maritime scenarios. As for the residents, Lagos has good, long, and beautiful beaches, with calm sea, sun throughout the year, and a historical and cultural scenario. Additionally, tourists describe the destination as welcoming and hospitable while residents consider Lagos as a calm, relaxing and safe destination.

Figure 1: Holistic Image of Lagos - Tourists vs. Residents



Source: Own

Figure 2 shows the results of the third open-ended question. When asked to list any distinctive or unique tourist attractions in Lagos, tourists refer "historical center" (66%) followed by "beaches" (44%), and residents respond "beaches" (58%) followed by "bay" (30%).

Figure 2: Unique characteristics of Lagos - Tourists vs. Residents

Tourists		Residents	
Unique characteristics	%	Unique characteristics	%
Historical center	66%	Beaches	58%
Beaches	44%	Bay	30%
Forte Ponta da Bandeira	28%	Slave Market	28%
Churches	26%	Ponta da Piedade	26%
Caves	24%	Discovery Avenue	22%
Gastronomy	20%	Walls	22%
Fish Market	20%	Historical Center	20%
		St. António Church	20%

Source: Own

In the second phase of the study (Figure 3), the internal consistency of the 20 attributes detected in the exploratory study and in the literature (Gallarza *et al.*, 2002) was estimated using the Cronbach's coefficient alpha, which is in both questionnaires superior to 0.7, indicating that the measure is reliable (tourists, 0.837; residents, 0.793). Both publics confer a higher level of agreement to the attributes "good beaches" (tourists, 92.8%; residents, 95.8%) and "pleasant weather" (tourists, 93.9%; residents, 95.2%). The attribute "interesting cultural events" is what gets the lowest percentage of agreement, consensually by tourists (53.6%) and residents (60.6%). The highest difference refers to the attribute "good sports facilities" where the level of agreement is 36.9% for tourists and 68.8% for residents. The two groups also differ in the level of agreement related to the attributes "good value for money" (tourists, 70%; residents, 43.1%), "good bus system" (tourists, 58%; residents, 83.6%), "good nightlife" (tourists, 55.5%; residents, 36%) and "good shopping opportunities" (tourists, 52%; residents, 34%). These differences are statistically significant (t tests for equality between two population proportions: p -value = 0.000).

Figure 3 :Tourists' and Residents' level of agreement with the attributes of Lagos (agree + strongly agree)



Source: Own

Regarding to the second research question, the “sea” is spontaneously referred by both tourists and residents in the unstructured phase of the study as one of the features that they could think about Lagos as a tourist destination. Indeed, the beaches are referred as a unique characteristic of Lagos by both publics, while the residents also highlight the bay of the city. In the quantitative phase of the study, in addition to the “good beaches” already above analysed, both publics show that they highly associate Lagos to “pleasant marina” (tourists, 87.3%; residents, 89.7%) and “calm sea” (tourists, 73.3%; residents, 77.0%)

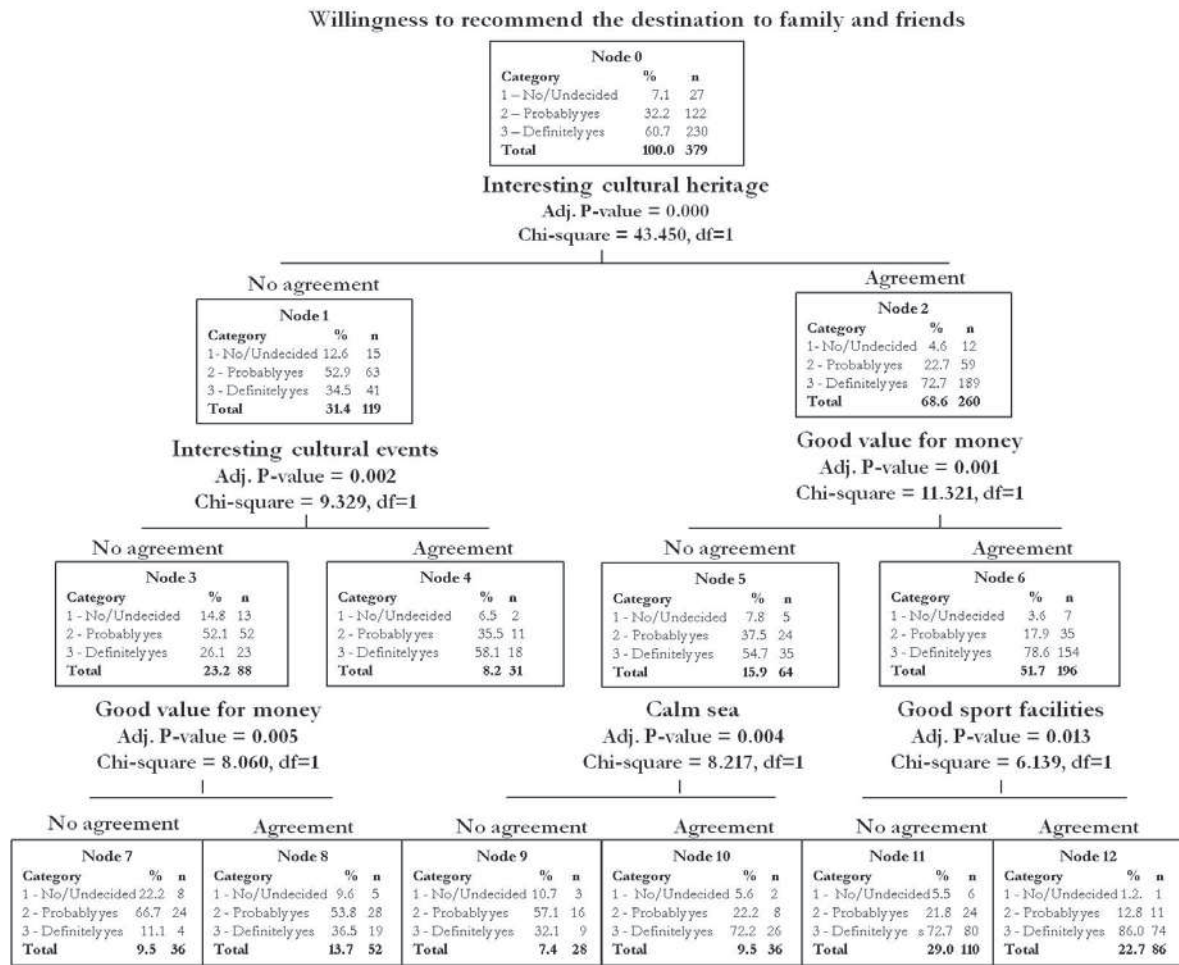
4.2. Destination image vs. tourist’s recommendation

In order to answer research question 3, it was used the CHAID methodology. The five original response categories were amalgamate into two categories (“no agreement” and “agreement”) for the dependent variable, and into three categories (“no/undecided”, “probably yes” and “definitely yes”) for the independent variables. This procedure was followed because some categories gather few answers. Criteria were also defined for tree growth: a minimum of 50 cases for parent nodes and 25 cases for child nodes.

It should be noted that of the 379 cases which were considered to be valid for CHAID analysis, 7.1% had no intention to recommend Lagos to their friends and family, or were undecided, while 32.2% said that they would “probably” recommend it and 60.7% were sure that they would do so (Figure 4). The tree presents seven terminal nodes (node 4 and nodes 7-12), suggesting seven segments of tourists. Five predictors out of the original set of 20 provided a significant explanation of the dependent variable, which led to the tree being divided into three levels: “interesting cultural heritage” (chi-square = 43.450; p -value = 0.000); “good value for money” (chi-square = 11.321; p -value = 0.001; chi-square = 8.060; p -value = 0.005), “interesting cultural events” (chi-square = 9.329; p -value = 0.002); “calm sea” (chi-square = 8.217; p -value = 0.004) and “good sports facilities” (chi-square = 6.139; p -value = 0.013), meaning that the variable “good value for money” was responsible for two partitions.

The final tree has an estimated risk of .298, with a standard error of 0.023, which means that the overall percentage of correct classification is 70.2%, being considered to be a good result (Escobar, 1998). As the number of cases was less than 1000, a cross-validation method was applied, which involved dividing the initial data into 10 different sub-samples, validating it, and estimating the errors of incorrect classifications (Pestana and Gageiro, 2009). In this study, the model presents a risk ratio for the overall sample (.298), which is close to the average of the estimated errors for each of the sub-samples (.325), not precluding the application of the model to other samples from the same population.

Figure 4: Tourists' willingness to recommend the destination to family and friends – CHAID Analysis



Source: Own

The authors conclude that the respondents who associate the significant attributes detected by the CHAID analysis to Lagos are more willing to recommend the destination to family and friends than those who don't agree. The main inference is based upon a comparison of node 7 and node 12. Node 7 includes tourists who have a less favourable image of the destination, with regard to the attributes "interesting cultural heritage", "interesting cultural events" and "good value for money". This segment includes a smaller percentage of tourists who were certain that they would recommend the destination in the future (11.1%). In turn, the opposite trend occurs in node 12. This group has a more favourable image of the destination, with regard to the attributes "interesting cultural heritage", "good value for money" and "good sports facilities", and it is also the group with the highest percentage of individuals who were sure that they would recommend the destination to others (86%).

Still regarding to research question 2, if the "sea" is whether or not an important attribute of the destination, it should be noted that "calm sea" is one of the five attributes which significantly explains tourist's recommendation. Moreover, of the tourists that think of Lagos as having a "calm sea", 72.2% are certain about their future recommendation, while of the tourists that have the opposite opinion, only 32.1 % are sure about their future recommendation. These results follow the two opposite trends found in the CHAID analysis.

5. CONCLUSION

The central purpose of this study, covering tourists and residents of Lagos, was to measure the destination image, identifying the major aspects of agreement and disagreement in the perspectives of these two stakeholders. For this aim, the attributes to use in the analysis were identified, taking into account that they were appropriate to this coastal destination and the two stakeholders simultaneously, through an exploratory study with the application of open-ended questions. After a holistic approach, questionnaires were applied in order to measure the level of agreement of both publics regarding to the features of the destination.

Regarding to the image of Lagos perceived by tourists and residents, it is important to note that there are more similarities than differences. In fact, along with the beaches and the weather, the maritime and historical scenario was referred by both publics in the first phase of the study and confirmed in the second stage of the research.

In this context, it should be stressed the importance of using an unstructured phase before performing the questionnaires. Indeed, the attributes “calm sea” and “pleasant marina” were included in the questionnaires because they were spontaneously referred by residents and tourists, respectively, in the unstructured phase of the study, as one of the features that they could think about Lagos as a tourist destination. Therefore, including open-ended questions in destination image studies is important in order to find attributes that usually are not included in the pre-existing lists of destination attributes (Echtner and Ritchie, 1993; Jenkins, 1999).

Accordingly, the results showed the importance of including both tourists and residents in destination image studies. In fact, although the attribute “calm sea” was only referred by residents in the first phase of the study, the analysis of the questionnaires showed that tourists also strongly associate this feature to the destination. Likewise, “pleasant marina” is spontaneously referred only by tourists as an evident characteristic of the destination but also confirmed by residents in the second phase of the study.

Furthermore, the CHAID analysis revealed that the sea is an important attribute which significantly explains the tourists’ willingness to recommend the destination to family and friends. Based on this method, the features which explain the future recommendation of Lagos as a destination are, in descending order of the significance level: “interesting cultural heritage”, “good value for money”, “interesting cultural events”, “calm sea” and “good sports facilities”. This analysis allows concluding that although with a higher level of concordance by both tourists and residents, “good beaches” and “pleasant weather” do not significantly discriminate the tourist’s intention to recommend the destination.

These results point to the importance of exploring the diversification of coastal destinations supply, depending on the product “sun and sand”, aiming the destination sustainability (Aguiló, Alegre and Sard, 2007; Crouch and Ritchie, 1999). One alternative is focusing on culture (Chen and Gursoy, 2001; Valle, Guerreiro, Mendes and Silva, 2011; Vassiliadis, 2008). Indeed, the Algarve region, specifically Lagos, is historically connected with the sea. In this context, the advantages of the existing relation between the beaches, the sea and culture, and the evident connection between tourists and residents’ perceived destination images, can become a challenge to the destination management and marketing. This can be materialised in providing conditions to different publics in order to live diversified experiences focusing the maritime scenario. In this context, Ryan (1996) claims, for example, that beaches are plural in their imagery, suggesting different uses of this natural resource. Thus, it is important to take a careful look at the wide range of activities comprised in coastal and maritime tourism, which can be, for example,

associated to culture or to sports. In fact, culture and sports are destination features that significantly explain the tourists' willingness to recommend Lagos as a tourist destination.

However, if on one hand, tourists expect to find a range of activities and a variety of experiences (Hall, 2001; Poon, 1993), on the other hand, local people are increasingly anxious to preserve their own identity. In this context, destination management organizations should develop strategies in order to preserve the environment, natural, historical and cultural heritage of the destination from the impact of uncontrolled tourism and its attendant problems (European Commission, 2000). Thus, these concerns should be taken into account aiming to provide a sustainable development for coastal destinations and the feeling of a win-win situation for all stakeholders.

The present study confirms that the strategic guideline suggested by the "Strategic Plan of Lagos", based on the cultural importance of the "Age of Discovery" and the connection of Lagos to the sea, is in line with the image of Lagos perceived by both tourists and residents. This conclusion reinforces the importance of the sea in coastal tourism, in the perspectives of the two stakeholders under study. Furthermore, the research pinpoints the richness of the sea as a natural resource which can be used in innovative forms, regarding leisure and sports, benefiting both the tourists and the community.

Hence, the results stress the wide spectrum of possibilities for diversification and innovation of coastal tourism focused on the sea, pointing this economic activity as crucial for the Algarve. Indeed, coastal tourism is essential for the development and consolidation of a maritime cluster in the region, along with the other maritime sectors, and is therefore a critical issue regarding to the sustainable development of the region (University of Algarve, 2011).

5.1 Limitations and further research

The model of analysis followed in this study relied on the involvement of two stakeholders - tourists and residents – needed to develop a marketing and management strategy for coastal destinations. In relation to this concern, there are some limitations associated with this study that need to be addressed. Firstly, the analysis was limited only to the referred stakeholders and does not cover, therefore, other publics also involved in the study of destination image, such as investors, traders, hotels and restaurants businessmen and employees, local power and visitors in general. The application of the questionnaires during the month of August, considered high season of tourism in the Algarve, it is also a limitation of the study, showing mainly a seasonal perspective (Baloglu and McCleary, 1999). Thus, there is a strong representation of British tourists, reinforcing the need of replicating the study at different times of the year. Recognizing the need of a more comprehensive and participatory implementation with the cooperation of host community, public and private sector, it becomes important to extend the study to the destination image conveyed by the media. Therefore, the methodological value of the presented study is based mainly on its potential as a reference tool to improve the process of decision making regarding to the destinations' strategy.

Acknowledgments

This paper is partially funded by the FCT – Foundation for Science and Technology, as the authors are members of the CIEO – Research Centre for Spatial and Organizational Dynamics. The authors gratefully acknowledge the support of the Town Hall of Lagos during the collection of data.

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SPECIAL SECTION

SCIENCE, TECHNOLOGY AND INNOVATION FOR COASTAL AND MARINE RESOURCES MANAGEMENT

MONITORING AND FORECASTING OCEAN DYNAMICS AT A REGIONAL SCALE

MONITORIZAÇÃO E PREVISÃO DA DINÂMICA OCEÂNICA NUMA ESCALA REGIONAL

Luísa Bastos, Machiel Bos, Rui Caldeira, Xavier Couvelard, Sheila Allis, Ana Bio, Isabel Araújo, Joana Fernandes and Clara Lázaro

ABSTRACT

A new Oceanic Observatory for the North-West Iberian Margin is being developed in the scope of the RAIA project. The objective of RAIA is not only to improve our scientific knowledge of the ocean in this North-East Atlantic region, but also to use the in situ observations and ocean models to derive commercial products and services for a range of marine activities related to: sediment transport, coastal erosion, pollution (spill) monitoring, understanding of marine life, search & rescue and renewable energies. The Coastal & Ocean Dynamics Group at CIIMAR is participating in this project and their contributions are presented here.

Keywords: Ocean Modelling; Sensors; Data-base; Tides.

RESUMO

Um novo Observatório Oceânico da Margem Ibérica Noroeste está a ser desenvolvido no âmbito do projecto RAIA. O objectivo do RAIA é não só melhorar o nosso conhecimento científico sobre o oceano nesta região do Atlântico Nordeste, mas também usar as observações in situ e os modelos oceânicos para a obtenção de produtos e serviços que possam ser de interesse para uma vasta gama de actividades marinhas relacionados com: o transporte de sedimentos, a erosão costeira, monitorização de poluição (derrames), a compreensão da vida marinha, acções de busca e salvamento, e energias renováveis. O Grupo de Dinâmica Costeira & Oceânica do CIIMAR participa neste projecto; as suas contribuições são aqui apresentadas.

Palavras-chave: Modelação Oceânica; Sensores; Base de Dados; Marés.

JEL Classification: Q55

1. INTRODUCTION

In 2009, the RAIA project was initiated with the objective to develop an oceanic observatory for the NW Iberian shelf. This Interreg IV-A project, between the North of Portugal and Galicia in Spain, will run until the end of 2011. It is led by MeteoGalicia and has in all 13 project partners as listed in Table 1. RAIA's main goal is the consolidation of

the operational oceanography of the NW Iberian Margin, given the economic importance of the activities developed in this zone such as maritime transport and safety, nautical sports and fishing. Currently, there are too little in situ measurements available to make operational oceanography feasible, especially in the Portuguese ZEE. In an effort to remedy this situation, five new buoys are being installed of which the location is given in Figure 1. Simultaneously to the set-up of this new infra-structure, new hydrodynamic models for the area are under development. These will incorporate the new measurements, allowing more reliable local ocean forecasting. To be useful for forecasting, these new observations have to be accessible in real-time. For that reason an e-infra-structure and links are being implemented by some of the partners, allowing the measurements to be transmitted directly to stations on land. The format of the observations and the output of the numerical models follow internationally established standards and are collected at a single internet portal (www.observatorioraia.org).

A marine cluster is defined as a network of firms, research, development and innovation units, and training organisations that co-operate with the aim of technology innovation and of increasing maritime industry's performance. In this sense, the RAIA project, which is executed by universities and development and innovation units, is providing the technology and information that can be used by the maritime industries to increase their performance.

In this paper we will present details of the contributions of CIIMAR's Coastal & Ocean Dynamics Group to the RAIA project. These include: acquisition of sensors for the Portuguese buoys in front of Leixões and Matosinhos, development and validation of a regional hydrodynamic model, including the river Douro estuary area, construction of a database with remote sensing data and the development of a regional tide model. Finally, we list the services that are now available.

Table 1: The participants in the RAIA project

• Consellería de Medio Ambiente, Territorio e Infraestructuras (MeteoGalicia)	• Centro Interdisciplinar de Investigação Marinha e Ambiental (CIIMAR)
• Instituto Tecnológico para o control do Medio Mariño de Galicia (INTECMAR)	• Instituto de Engenharia de Sistemas e Computadores do Porto (INESCP)
• Instituto Español de Oceanografía (IEO)	• Instituto de Engenharia Mecânica e Gestão Industrial (INEGI)
• Instituto de Investigaciones Mariñas (CSIC-IIM)	• Faculdade de Engenharia, Universidade do Porto
• Centro Tecnológico del Mar (CETMAR)	• Instituto Hidrográfico (IH)
• Grupo de Oceanografía Física de la Universidad de Vigo (GOFUVI)	• Universidade de Aveiro (UA)
	• Faculdade de Ciências, Universidade do Porto

2. SENSORS

Ocean models are not perfect physical representation of the ocean. In situ observations are therefore indispensable to ensure that the model does not deviate too much from reality. The process of integrating observations and models is called assimilation, but the observations also serve to tune the models in order to produce the best results. As mentioned in the introduction, five new buoys are being installed within RAIA. CIIMAR has provided an Acoustic Doppler Current Profiling (ADCP), type Teledyne RDI 300Khz,

a Global Navigation Satellite System (GNSS) receiver and antenna, plus a motion sensor for the first buoy that has been installed. This buoy, called Alfredo Magalhães Ramalho, was launched and installed on 23 May 2010 at the continental shelf edge off Leixões by the Instituto Hidrográfico, and will be maintained by this organization.

The GNSS system allows observations of the height of the antenna above the reference ellipsoid. Because the GNSS antenna is installed on top of the mast of the buoy and because the orientation of the buoy is changing over time due to wave motion, one has to correct for its orientation to obtain the correct sea level value above the ellipsoid. This orientation is measured with an Inertial Measuring Unit. The initial location of this buoy has been chosen carefully to ensure that it lied exactly under the ascending and descending tracks of the ERS Envisat satellite. This satellite carries a radar altimeter on-board that measures the sea level above the reference ellipsoid, which can thus be compared to the sea level observation of the buoy. After the initial six-month test period this buoy was moved to its actual position on the border of the continental shelf.

Figure 1: Location of existing buoys (green) and buoys that are being installed in the scope of the RIAA project (red)



A GNSS receiver/antenna and IMU system, as well as meteorological sensors and associated data-logger, including a GSM communication link, were also provided for the buoy that is installed in front of Leixões and which has been kindly made available by the company INDAQUA. Other types of sensors provided by the other project partners for both buoys deliver measurements for: wind, temperature, humidity, solar radiation, sea temperature and salinity at different levels, as well as oxygen and chlorophyll concentrations.

A third buoy will be equipped with meteorological and positioning sensors and anchored. This one, designed and built by INEGI, is specially suited for meteorological data acquisition and will be placed north of Leixões, where the bathymetry is around 30m.

3. REGIONAL HYDRODYNAMIC MODEL

To model the ocean of the NW Iberian region, the Regional Ocean Model System (Haidvogel et al. 2000, Shchepetkin and McWilliams 2005) software is used. Its computations are rather intensive and for that reason run on an IBM cluster with 160 CPU's at CIIMAR. The model domain lies between -15° and -5° East and between 38° and 46° North, with a spatial resolution of $1/36$ degree. At the open boundaries the model is forced by the daily output of the global Mercator model (<http://www.mercator.eu.org>). In addition to the oceanic forcing, the ocean is also affected by wind, atmospheric pressure, precipitation, air temperature and solar radiation. These forcing elements are taken from the NOAA/NCEP Global Forecast System (GFS) Atmospheric model (Kanamitsu, 1989, 1990; Kalney, 1990).

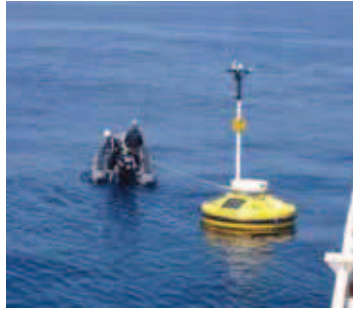
Initially, the water in the model is at rest and when the forcing is applied it takes time for the model to adjust to the new situation which is called "spin-up". To correct for this effect, the model is first forced for 3 years with climatological forcing. Afterwards the model is forced by Mercator and GFS data.

The model can be used to provide forecasts of up to 5 days ahead (in the future). Observational data is also assimilated into the Mercator and GFS models and one can therefore use their model outputs to run the model back in time to improve previous estimates. This hind-cast is done for up to 10 days (in the past). Model results are presented on the RAIA internet portal and on the CIIMAR website (<http://cod.ciimar.up.pt>).

To validate this regional ocean model, the computed fields of salinity and temperature were compared to ARGO float data for the period 2003-2006, see Allis et al. (2011). Panel a) of Figure 2 shows the launch of an ARGO float. For a single float, the trajectory is given in panel b). Simple statistical metrics, such as the root mean squared error, mean absolute error, correlation coefficient and bias, were used to quantify the differences between model predictions and observations. The result of the comparison, using a single ARGO float survey of temperature and salinity during three months in 2003, is presented in panels c) and d) of Figure 2. One can see that for most of the time and for most depths, the differences are small. However, there is a clear deviation at depths between 1100 and 1500 metres. This is probably caused by water outflow from the Mediterranean Sea which is not well represented in the model. Work is currently done to remedy the discrepancies, though one should remember that the development of an ocean model is never finished and that the constant comparison of observations with model outputs will allow the model to improve over time. The RAIA project delivers the best available results that can be used by third parties, while scientists continue to work to improve the model.

Next, this regional model will again be downscaled to another ocean model for a smaller domain but with a higher spatial resolution of $1/108$ degrees. The boundaries of this model will be between the latitudes 40° and 42° North and between the longitudes -11.5° and -8° East. This smaller domain will provide more detailed information of the water temperature, surface currents and sea surface height near the Portuguese coast. This can be of use for local fishermen and provides better information along the Portuguese beaches about the sea temperature and current.

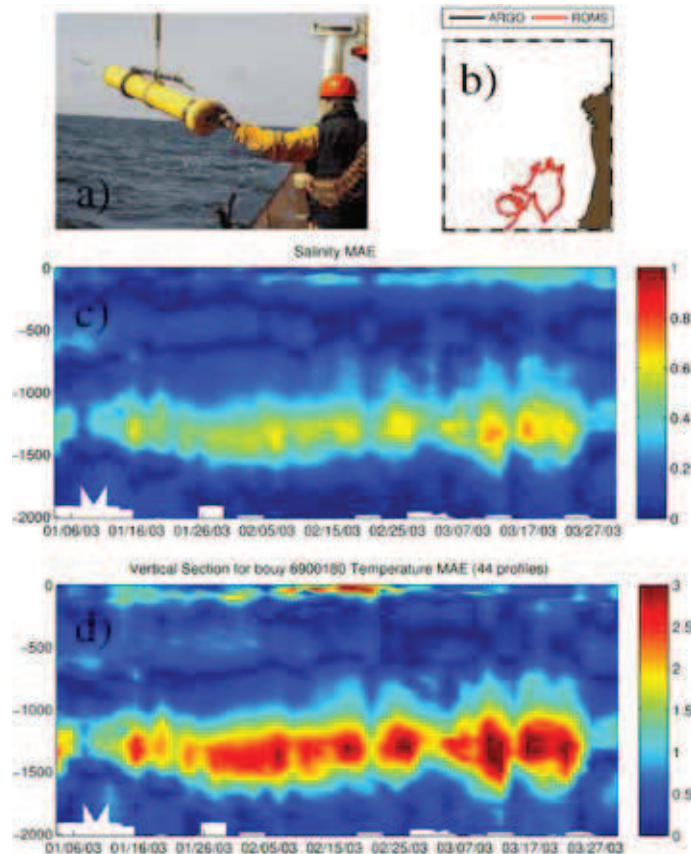
Figure 2: Alfredo Magalhães Ramalho buoy being deployed off the NW Iberian Margin



4. DATABASE

Data from Earth observing satellites also provide valuable information about the ocean along the Iberian margin. To optimize their use, CIIMAR has created a freely accessible database (<http://cod.ciimar.up.pt>) where one can find: global climatological data, outputs from regional ocean models and satellite data (MODIS ocean colour 8-day and monthly averages). The available climatological data is obtained from the Comprehensive Ocean-Atmosphere Data Set, COADS (Worley, 2005 and Levitus, 1982) which can be used as the forcing at the open boundaries of the regional ocean models. Some further data for areas outside the scope of RAI A are also included in the database, for instance outputs from Atmospheric models for Madeira.

Figure 3: a) The deployment of an ARGO float; b) The trajectory of an ARGO buoy used for this comparison; c) The Mean Absolute Error between the ROMS salinity output and the ARGO observations; d) The same as panel; c) but for temperature



To ensure easy accessibility, the data was stored on a Live Access Server (LAS) which is a web server that allows the user to select the type of data and the domain of interest before downloading. The selected data is also directly shown as a map on the screen (<http://cod.ciimar.up.pt/las/getUI.do>). In addition, the user can select the period for which he or she wants the data and the type of output files (netCDF, ASCII or arcGrid formats).

5. REGIONAL TIDE MODEL

The regional ocean model discussed in section 3 does not include ocean tides. However, these must be added to obtain the total sea surface height. For this purpose, we have developed a high resolution depth-integrated barotropic model, based on the Laplace Tidal Equations to compute these tides (Egbert et al., 1994). At the open boundaries the tidal elevations were taken from recent global tide models FES2004 (Lyard et al., 2006) and GOT4.7 (Ray, 1999) and the bathymetry was based on ETOPO1 (Amante et al., 2009). We adjusted our model results to fit the altimetry observations at cross-over points from the TOPEX/Poseidon and Jason satellites using smooth interpolation. We also investigated if errors in the open boundary conditions could explain the misfit between model results and observations at tide gauges. Our results show that by optimally adjusting the open boundaries by a few millimetres, the misfit can be reduced by 22% from 4.4 cm to 3.4 cm. Currently, the observations of the newly installed buoys are being processed to allow validation of the tide model and, if necessary, to perform further adjustments.

6. SUMMARY AND DISCUSSION

The RAIA project is building an Oceanic Observatory for northern Portugal and Galicia which will make ocean forecasting feasible and more reliable. This observatory consists of a network of in situ buoys, a collection of numerical ocean and atmospheric models which are accessible through an internet portal available to third parties. Great efforts have been made to ensure that these results are transmitted from the buoys to land in near real-time to increase their usefulness. The Coastal & Ocean Dynamics Group of CIIMAR is contributing to RAIA providing instrumentation for the buoys, processing data, maintaining databases with remote sensing data and developing and validating ocean models. The output of the RAIA project will also contribute to the development of further research related to: sediment transport, coastal erosion, pollution spills monitoring, understanding of marine life, search & rescue, tourism and renewable energies.

The RAIA project has already achieved important scientific results in terms of better knowledge of the state of the ocean. The RAIA project will change after 2011 into the RAIA.co project, ensuring its continuation for the coming years. However, ultimately this Oceanic Observatory must also generate financial income from commercial services to make it sustainable. Therefore, it is our hope that companies and local authorities become interested in using the RAIA results to form a marine cluster that will serve the local economy, serve the people with better information about the sea and provide the means to operate and maintain this Oceanic Observatory.

For more information see <http://www.observatoriaraia.org> and <http://cod.ciimar.up.pt>.

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EXPLORING THE INDUSTRIAL VALUE OF THE PORTUGUESE DEEP SEA MICROORGANISMS

EXPLORANDO O VALOR INDUSTRIAL DE MICRORGANISMOS PRESENTES NO FUNDO DO MAR PORTUGUÊS

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ABSTRACT

The interest in the usage of marine natural sources for bioactive discovery has increased tremendously in the last decade. BIOALVO owns a unique collection of more than 100 prokaryotic extremophiles isolated from deep sea hydrothermal vents in the Mid Atlantic Rift, near the Azores Islands. The extreme conditions of temperature and chemical composition of those vents make these microorganisms potential sources for bioactive compounds. Based on this assumption, a collection of both aqueous and organic extracts produced from those microorganisms, entitled PharmaBUG, has been tested for both pharmaceutical and cosmetic usages in BIOALVO's internal research projects and also in collaboration with partners. In order to expand the PharmaBUG library, new strains are being selected based on the diversity of environments from which they derive. The expanded collection is expected to reach 100.000 extracts, at the end of 2013. BIOALVO presents itself as a one-stop-shop for natural product development, based not only on its extensive, yet continuously expanding, comprehensive natural extract library and corresponding bioactivities, but also on expert and customizable assay development, which can be coupled to an in-house robotized screening facility, effectively speeding up the testing process and bringing a natural product solution closer and quicker to market.

Keywords: BIOALVO; GPS D²® Technology; Marine Natural Extracts; PharmaBUG collection.

RESUMO

O interesse na utilização de fontes marinhas naturais para a descoberta de bioactivos aumentou muito na última década. A BIOALVO possui uma colecção única de mais de 100 procariotas extremófilos que foram isolados de fontes hidrotermais da crista média do Atlântico, perto do arquipélago dos Açores. As condições extremas de temperatura e composição química destes locais permitem que estes sejam considerados uma potencial fonte para compostos bioativos. Assim, uma colecção de extractos aquosos e orgânicos produzidos a partir desses microrganismos, denominada PharmaBUG, está a ser testada tanto para usos farmacêuticos como cosméticos em projectos internos da BIOALVO e em colaboração com parceiros. De modo a aumentar a colecção PharmaBUG, novas estirpes estão a ser seleccionadas com base na diversidade ambiental de onde provêm. No final de 2013 é expectável que a expansão desta colecção origine 100.000 extractos. A BIOALVO actua de uma forma integrada num conceito de *one-stop-shop* para o desenvolvimento de produtos naturais. Este conceito é baseado não apenas na sua vasta biblioteca de extractos naturais e bioativos, ainda em expansão, como também no desenvolvimento de ensaios

celulares adaptáveis a vários alvos, que podem ser incorporados na unidade robótica de *screening*, acelerando eficientemente o processo de teste e proporcionando uma solução natural rápida e mais perto do mercado.

Palavras-chave: BIOALVO; Tecnologia GPS D2©; Extractos Marinhos Naturais; Colecção PharmaBUG.

JEL Classification: Q57

1. BIOALVO'S HISTORY

BIOALVO was founded in 2006 as a drug discovery company that developed its own pipeline of drugs against neurological disorders. It was the first Portuguese biotech company working in the early stages of drug discovery for neurological related disorders. Its platform technology was patented and demonstrated true potential to identify active compounds against different targets. In a constant search for innovative molecules and compounds, BIOALVO turned into the sea and other natural sources of new actives. This powerful combination provided very positive results in identifying new compounds and activities. Recently, in 2010, the company started to slowly enter into other pharmaceutical and cosmetics areas, establishing collaborations with its partners/clients. In 2011, BIOALVO made a deep repositioning strategy, focusing on the exploitation of its assets and uniqueness: the combination of unique and proprietary libraries of extracts with its patented GPS D2© (Global Platform Screening for Drug Discovery) technology that maximizes the applications of natural products/compounds in all possible industries. Today, BIOALVO is the Biotech for Natural Products.

2. NATURAL PRODUCTS – A NEW MARKET OPPORTUNITY

A natural product (NP) is a compound chemically produced by a living organism in nature that has a biological activity useful for different applications (Newman e Cragg, 2007). NPs represent an unlimited source of unique and complex molecular structures that have already led to drugs in all major medical areas. In fact, since the year 2000, the interest in the NPs as a source of new therapeutic molecules has increased. As the number of new drugs launched in the market did not increase proportionately to the efforts and resources spent on chemical synthetic libraries, the advantages of NPs have become more evident as time goes by (Newman e Cragg, 2007). It is now unquestionable that NPs display a big structural diversity, with most structures having a relatively small size, appropriate to the ideal profile of a drug. These molecules are also easily absorbed and metabolized, specifically in the human body. Nowadays, it is estimated that approximately 61% of 877 small molecules introduced as drugs in the world between 1981 and 2002 can be found in NPs or were inspired by NPs (Newman *et al.*, 2003). The NPs and related substances represented 40%, 24% and 26% of world sales of drugs in the Top 35 in 2000, 2001 and 2002, respectively (Zhu, 2011). Paclitaxel, an anticancer drug derived from a plant, made 1600 million dollar sales in 2000 (number 25 in sales this year). Between 2001 and 2005, 23 new drugs derived from NPs were marketed for indications as diverse as fungal and bacterial infections, cancer, diabetes, dyslipidemia, atopic dermatitis and Alzheimer's

disease (Chin *et al.*, 2006). These numbers confirm the importance of natural compounds as sources of new drugs or lead compounds suitable for further modification for the development of new drugs. In March 2008 there were 225 drugs derived from NPs in different stages of clinical development, with four molecules already in pre-registration (Chin *et al.*, 2006).

In addition to the pharmaceutical industry, also the cosmetic sector has shown increasing interest in natural and/or organic products. In fact, whereas the growth rate of conventional cosmetics has shown stagnation in recent years, natural and organic products, are reaching 10% of total sales of the cosmetics industry. The forecast of sales in the European organic and natural cosmetics market in 2010 was 2 thousand million Euros (<http://www.organicmonitor.com>).

3. PORTUGUESE DEEP SEA AS THE SOURCE FOR NEW NATURAL PRODUCTS

Being Earth more than 70% water, the search for natural compounds in aquatic environments is extremely appealing. Marine natural products have long attracted the attention of scientists around the world and have already led to the discovery of thousands of products, many of them with biological activity (<http://www.naturalcosmeticsnews.com>). These products are mostly natural compounds produced by plants, algae, invertebrates and marine microorganisms. The latter ones have the great advantage over the formers as they grow very fast, are reproducible and economically competitive, which encourages investment in the development of sustainable methodologies for this group of organisms.

According to EUROPABIO, the marine biotechnology, or blue biotechnology, can be defined as the discovery, exploitation and application of biological products and processes derived from marine and aquatic organisms, including whole organisms, cells, genes or other components to the manufacture of valuable products for the end user. Thus, marine biotechnology has a transversal application to several different sectors and the marine and aquatic environments provide resources to all of them. Some years ago, only few countries had initiated programs of national research and development in order to exploit the benefits of biotechnology from the marine sector for industrial, cosmetic, food, pharmaceutical, among others. This situation has been inverted in recent years and now it is estimated that the global marine biotechnology market reaches a value of 4.1 thousand million dollars in 2015 (<http://convention.biomarine.org/index>).

The sea is one of Portugal's greater richness's. Historically, it has been a factor of national identity, conditioning the perception that the Portuguese people have of them as a nation. In addition, the sea is a supplier of multiple resources and supports a comprehensive set of economic activities, generally referred to as the "sea economy". In recent years, important steps have been taken to ensure the strategic role of the sea in the Portuguese economy. It is important to highlight the creation of the Strategic Committee of the Oceans (*Comissão Estratégica dos Oceanos* - CEO) in 2003, the creation of the Mission Structure for Extended Continental Shelf (*Estrutura de Missão para a Extensão Plataforma Continental* - EMEPC) in 2005 and the creation of the Mission Structure for Sea Affairs (*Estrutura de Missão para os Assuntos do Mar* - EMAM), also in 2005, the later two recently merged into one, the EMAM. In December 2006, a National Strategy for the Sea was defined, with the aim of providing the necessary information for making strategic decisions and for the intensification and attraction of new investments related to the sea (<http://www.emam.com.pt>).

The Portuguese Exclusive Economic Zone (*Zona Económica Exclusiva* - ZEE) is one of the largest in Europe, accounting for a total of 1.7 million km², which represents approximately 18 times the country's land area. The ZEE is demarcated by the Portuguese continental shelf, which currently extends up to 200 miles off the coast (around 300 kilometers). The extensive maritime area, under the Portugal authority, comprises aquatic ecosystems of the highest importance, constituting a unique natural heritage. The main goal of EMAM is to achieve the extension of the Portuguese continental shelf from 200 to 350 nautic miles. For this purpose, the former EMEPC presented on May 11, 2009 a proposal to the Commission on the Limits for the Extension of Continental Shelf of the United Nations. The development of this proposal was based on several scientific papers that provide knowledge about the seafloor, in order to prove that the continental platform effectively extends beyond 200 nautic miles. If this claim is accepted, Portugal will have the second largest continental shelf of the world, with 2.15 million km², only supplanted by the continental shelf of the United States of America (<http://www.emam.com.pt>). In Portugal ZEE we can explore what is in the water column and in the soil and subsoil of the sea. In the Extended Continental Shelf, Portugal will have jurisdiction over the resources of soil and subsoil, including oil, gas, metals and biological resources with pharmaceutical, biotech and industrial applications.

4. A UNIQUE COMBINATION OF ASSETS

It is in this context that BIOALVO decided to explore the unique Portuguese resources of our ecosystems, mainly within the extended continental shelf, supported by the immense power of its flexible technological platform, GPS D²®. Using its unique high throughput screening (HTS) GPS D²® screening systems, and taking advantage of its in-house library of more than 50 000 chemically synthesized small molecules and its ever expanding proprietary natural extracts library, BIOALVO has identified, through its robotics unit, several bioactive molecules (Fig 1). These bioactives are currently under development for several applications in pharmaceuticals, well being and cosmetics industries.

Natural extracts collections

BIOALVO owns a large natural extract library, holding unique extracts derived mostly from a diverse array of microorganisms that can be industrially produced by laboratorial sustainable culturing methods. This collection is expected to reach 100.000 extracts, at the end of 2013, including a variety of exquisite sources, ranging from deep sea vents in the Azores, or secret diving spots of Portugal's Ministry of Defense, to some main land ecosystems. These natural extracts collections are used for internal R&D projects, resorting to the in-house cell-based robotized facility and are also made available to partners through licensing deals that explore the potential of these collections to their chosen field of application. The awarding of BES BIODIVERSIDADE 2011's top prize (Fig 2) to BIOALVO's new strategy to explore sustainably the marine Portuguese microbiological resources, in particular its marine natural extracts library, is a strong recognition of the quality of this asset and will undoubtedly improve BIOALVO's notoriety, both nationally and internationally.

As there are clear evidences that the marine environment is becoming a top stop for bioactive compounds, BIOALVO has developed or is developing the following subsets:

PharmaBUG

BIOALVO established a protocol with ICAT, Faculty of Sciences, University of Lisbon, for acquiring exclusive commercial rights over a 140 marine bacteria collection, named PharmaBUG. The samples from which this library was derived were isolated and collected during the Portuguese mission SEAHMA-1 (Seafloor and Sub-Seafloor Hydrothermal Modeling in the Azores Sea) that occurred in August 2002 within the SEAHMA project (PDCTM1999MAR15281). The PharmaBUG collection was obtained from water samples, small animals, sediments and chimneys isolated from hydrothermal vents in the Mid-Atlantic Rift: *Menez Gwen*, *Lucky Strike*, *Rainbow* and *Monte Saldanha*. Menez Gwen, Lucky Strike and Rainbow have intense hydrothermal activity and are characterized by expelling fluids at very high temperatures (around 300 °C). Monte Saldanha is a hydrothermal field yet in formation with small orifices scattered through the seafloor where the water temperature is only 3-4 °C higher than the one of the surrounding water. This marine bacteria collection contains 140 different and new strains, comprising to date about 430 extracts.

LUSOEXTRACT 2010

The LUSOEXTRACT collection is composed of 1330 samples of marine macroorganisms, bacteria, yeast and fungi and their 40.000 extracts isolated from unique Portuguese marine and terrestrial unique ecosystems. The marine macroorganism group is composed of sponges, anemones, corals and others. Among the bacteria group there are lactic bacteria, *Pseudomonas* and *Listeria*. The yeast group contains Ascomycetes and Basidiomycetes. Fungi can be Mitosporic or Basidiomycetes. This collection is being obtained from ongoing collaborations with the major Portuguese Universities and research centers, such as FCUL (Faculdade de Ciências da Universidade de Lisboa), FCT-UNL (Faculdade de Ciências e Tecnologias da Universidade Nova de Lisboa), CCMAR (Centro de Ciências do Mar da Universidade do Algarve), Universidade de Aveiro (UA) and FCUP (Faculdade de Ciências da Universidade do Porto). Crude aqueous and organic extracts from each isolated sample are being produced. Due to the extreme complexity that extracts may represent, each of them is being fractionated in order to obtain at least 10 fractions from each extract. The initial separation of crude extracts will result in a library consisting of almost 40000 fractions.

LUSOMAREXTRACT 2011

LUSOMAREXTRACT is an expansion of the PharmaBUG collection with over new 1000 deep sub seafloor microorganisms and their extracts. Sediments samples for new microorganism's isolation are being provided by EMAM. The LUSOMAREXTRACT library will be based on a bank of new 1100 bacteria and fungi, which are being grown for biomass production and subsequent extraction of compounds. Crude aqueous and organic extracts are being produced from each isolated sample and fractionated as described above. The initial separation of crude extracts will result in a library consisting of almost 50000 fractions.

GPS D²® Technology

BIOALVO, the Biotech for Natural Products, developed its own proprietary bioactive discovery platform technology based on *in vivo* assays.

BIOALVO's robust bioactive discovery assays are mainly based on genetically modified yeast strains, designed to express the desired target (human or not), in addition to a DNA

sensor, responsive to the presence of this target. This DNA sensor is operably linked to a reporter gene, allowing additional modulation readouts. This innovative and patented in-house technology was named GPS D²® and up to date has generated several patent applications [1] and attracted several interested partners.

Assays are especially designed to take advantage of the very simple, fast and cheap growth conditions of yeast in addition to its high amenability to HTS adaptation and its physiological response similar to many human aspects, making this elegant integrated platform technology truly unique. Designed in this specific manner this platform allows target-oriented modulator identification, but also broader phenotypic modulations. Additionally to these features, BIOALVO's yeast based bioactive discovery platform can promptly detect major toxicity features associated to the bioactives screened, together with the assessment of efficacy, in only one screen.

Hence, GPS D²® allows an adequate strategic response for reducing time and costs associated with the products' future development, which stands out as a competitive advantage. Moreover, through the miniaturization and robotic adaptation to the fully-automated robotics unit, comprising a Janus liquid handling unit (Perkin-Elmer), coupled to a temperature controlled, shaking STX40 44-plate incubator (LiCONic) associated to a VICTOR D plate reader (Perkin-Elmer), high-throughput needs up to 10.000 compounds/week can be met at interesting cost-benefit ratios.

The major advantage of the GPS D²® technology lies in its flexibility to be adapted to other human and non-human targets, making it a very powerful and versatile tool for bioactive discovery in a wide variety of biotechnology sectors. In fact, several targets have also been established, in non-pharmaceutical areas, or are currently under development for partners, to feed into their own pipeline development in several different industries. Hence, in this unit, BIOALVO develops, validates and performs its own, as well as its partners' high-throughput assays, making BIOALVO an integrated and one of a kind new bioactive identification provider.

5. WHAT'S IN IT FOR COSMETICS – A SUCCESSFUL EXAMPLE

The bioactivity potential of this library has already been tested for CNS targets, some immune disorders targets, cosmetic activity and also for some enzymatic activities. From these, anti-UV and anti-oxidant activities, amongst others, have been identified in the PharmaBUG extracts that can be useful for cosmetic industry.

Problems with skin irritations and allergies caused by some cosmetics in some consumers have been at the basis of the registered increase in the usage of natural cosmetics. However, in recent years, consumer demand has expanded greatly and natural cosmetics are sought now by consumers concerned about not only the presence of synthetic chemicals in conventional cosmetics, but also with the sustainability and ecological impact of these products. The presence of these chemicals has been demonstrated to be extremely harmful to human health and the environment. On the other hand, cosmetic application of marine products, such as algae, dates back several centuries ago. Only in the last 30 years, it is estimated that about 200 different types of algae have been used in cosmetic products. There are evidences supporting that the use of algae extracts more than doubled since 2004 and that this is currently one of the main products found in natural and organic facial treatment (<http://www.naturalcosmeticsnews.com>). Besides macro-algae, marine species such as bacteria, crustaceans, mollusks, worms and sponges have shown a promising potential for the production of compounds with cosmetic properties.

Beyond the search for new natural ingredients, another aspect has assumed particular importance in the cosmetic sector: the need for tests and scientific trials to prove the efficacy of products in development. The requirements from the regulatory frameworks can only be achieved through the use of efficacy and toxicity tests based on scientific evidence, as it is the procedure in the pharmaceutical sector. Thus, the cosmetic industry has been forced to adopt new technologies for biological assays to validate, not only the safety of products, but also its mechanism of action and efficacy claimed on market entry and subsequent application in humans.

BIOALVO has quickly recognized this niche market and is currently working in two fronts. One is on the production of several aqueous extracts to be incorporated in a new cosmetic product that will be launched in the market next year. This product has shown an interesting mode of action and powerful activities, such as anti-wrinkles and anti-oxidant, and is being developed in collaboration with an international partner. Other activities are expected to be present in many of other non-tested extracts and BIOALVO intends to further explore this avenue. Additionally, new and specific cellular assays using our GPS D²® platform as a basis are being developed to allow the identification of new bioactives with interesting properties for BIOALVO's new cosmetic unit.

6. PARTNERING OPPORTUNITIES

BIOALVO presents itself as a one-stop-shop for natural product development, based not only on its extensive, yet continuously expanding, comprehensive natural extract library and bioactivities, but also on expert and customizable assay development, which can be coupled to an in-house robotized screening facility, effectively speeding up the testing process and bringing a natural product solution closer and quicker to market. With a risk-sharing and milestone-coupled payment BIOALVO offers its partners a competitive approach to speed up their product development time as well as lowering their costs and risks. BIOALVO's assets are available for licensing and/or establishing development partnerships or research contracts, where partners and collaborators can take advantage of BIOALVO's proprietary platform and recognized assay development expertise to build new applications for their desired targets in any desired industry. The combination of miniaturization and high-throughput capabilities available for effective and quick bioactive identification, with the unique natural extract libraries available makes BIOALVO an integrated and one of a kind new bioactive identification partner.

BIOALVO has production capacity to provide all extracts at 25 mg/ml in DMSO, in a smaller scale in a 96-well plate format or in any other desired format and amount up to media-scale industrial production. Also, other sets of extracts can be supplied in different pre-defined growth conditions as requested by partners.

BIOALVO can, thus, build complete, or modular, new bioactive discovery programmes for interested partners, with an increased probability of success by using a seasoned, tested and patented system together with its unique sources of biodiversity and production expertise, which can make a decisive difference in its partner's strategy to market. Jointly with its interested partners, it is possible to design, implement and validate the desired bioactive discovery programme up to the production of the final identified ingredient, making BIOALVO a one-stop-shop for speeding up new product development.

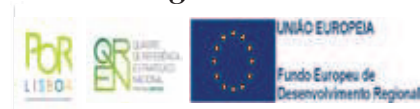
Partnering with BIOALVO will guarantee your products' efficiency and their natural source: The Portuguese Atlantic Ocean!

7. HOW BIOALVO IS HELPING TO FOSTER THE SEA ECONOMY?

Despite the long historical connection to the sea, only recently did Portugal set out to design and implement an economical strategy to the sea and the serious exploitation of its resources. This strategy is mainly focused in the contribution to the sea economy and maritime industries development. Several measures are described to strengthen our position in many sea related industries, as well as the definition of some of these as priorities. A clear sustainable perspective was developed to create economic wealth and employment through activities such as shipping, port activity, shipbuilding, fishing, tourism, renewable energy, science, technology and innovation, biotechnology and the exploitation of living or non-living resources. To enhance the Portuguese sea economic power, BIOALVO is investing in marine biotechnology, using the living-resources of our waters and submarine soils. BIOALVO is focusing particularly in the sustainable production of marine bacteria whose natural extracts have a true bioactive potential, enriching its portfolio of products derived from the sea and leveraging the exportation of these unique Marine Portuguese assets on a global scale. The exploitation of marine resources, still very incipient in Portugal and even in Europe, will allow several different commercial applications of these unexplored marine samples spreading again beyond known limits the Portuguese marine influence.

BIOALVO is developing a new paradigm in the discovery of bioactive molecules: the association of yeast genetic power with the most innovative source of compounds - the ocean.

Acknowledgments



Fundação para a Ciência e a Tecnologia (SFRH/B1/51091/2010)

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Figure 1: Description of the process from collection to production of BIOALVO's natural extracts collections



Figure 2: BIOALVO's team celebrating BES BIODIVERSIDADE 2011 prize

NETWORKING SYSTEMS FOR A SUSTAINED PRESENCE IN THE OCEAN

SISTEMAS DE REDES PARA UMA PRESENÇA SUSTENTADA NO OCEANO

João Tasso de Figueiredo Borges de Sousa

ABSTRACT

The problem of developing a sustained presence in the ocean is discussed, with special emphasis on networked vehicle systems. This is done in light of the recent technological developments and trends. First, we discuss illustrative examples of developments from the Laboratório de Sistemas e Tecnologias Subaquáticas (LSTS) from Faculdade de Engenharia da Universidade do Porto. Second, we show how networked vehicle systems have the potential to revolutionize oceanographic studies. Third, we discuss how, in spite of the technological and scientific advances, we are still far from being able to design and deploy networked vehicle systems in a systematic manner, and within an appropriate scientific and societal framework. Fourth, we call for interdisciplinary research and for experimentation and testing. However, this cannot be done without a long term sustainable development program; sustainable development cannot be achieved without a market orientation. The question is how to reconcile apparently irreconcilable goals, such as fundamental understanding and market orientation, especially in an environment where traditional knowledge institutions, such as universities, are now struggling to cope with the challenges of translating knowledge into action? Finally, we advocate the development of a national strategy which should be tightly aligned with international trends and strategies. Shared national challenges should help to bridge the islands of science and technology scattered around Portuguese universities and institutions.

Keywords: Autonomous Underwater Vehicles; Unmanned Air Vehicles; Data Collection; Networking; Cooperation.

RESUMO

O problema do desenvolvimento de uma presença sustentada no oceano é discutido neste artigo, com especial ênfase em redes de sistemas de veículos tripulados e não tripulados e tendo, como pano de fundo, os mais recentes desenvolvimentos e tendências tecnológicas. Em primeiro lugar apresentamos, como motivação, exemplos de desenvolvimentos do Laboratório de Sistemas e Tecnologias Subaquáticas (LSTS) from Faculdade de Engenharia da Universidade do Porto. Em segundo lugar mostramos como é as redes de sistemas de veículos tripulados e não tripulados têm o potencial para revolucionar a forma de nossa presença nos oceanos. Seguidamente, discutimos o facto de, apesar dos mais significativos desenvolvimentos científicos e tecnológicos, não existir ainda um enquadramento técnico-científico adequado à operação destes sistemas. Em quarto lugar, enunciamos a necessidade de uma abordagem inter-disciplinar com uma forte ênfase em teste e experimentação. Neste âmbito discutimos a importância de uma estratégia de desenvolvimento sustentado de longo prazo. Tal estratégia terá que ser necessariamente articulada com uma orientação de mercado. Torna-se, então, necessário

conciliar objetivos aparentemente antagônicos, como são o desenvolvimento de conhecimento fundamental e a orientação para o mercado, especialmente num ambiente em que as instituições de conhecimento tradicionais, como são as universidades, estão a encontrar desafios significativos para a tradução de conhecimento em acção. Finalmente, defendemos o desenvolvimento de uma estratégia nacional que deve estar intimamente e pragmaticamente alinhada com tendências e estratégias internacionais. Desafios de âmbito nacional permitirão estabelecer pontes de cooperação entre ilhas de excelência em ciência e tecnologia que se encontram dispersas pelas universidades e institutos nacionais.

Palavras-chave: Veículos Submarinos Autónomos; Veículos Aéreos sem Piloto; Recolha de Dados; Redes; Cooperação.

JEL Classification - O33, O38, R11

1. INTRODUCTION

The 21st century has been marked by the challenges that humankind is bound to face in the near future. Climate change, overexploitation of natural resources - notably, fresh water and hydrocarbons -, pollution, territory mismanagement, and degradation of biodiversity are well known, large scale, anthropogenic phenomena which question the human role and praxis on planet Earth. In order to properly address these challenges, a much better understanding of the various phenomena of interest and an effective assessment of the human footprint are required. The urgent need for a clear understanding of the ocean and climate processes and how these are affected by, or affect, mankind constitutes a strong motivation for the scientific and engineering communities to investigate novel approaches, systems and technologies to cope with the increasing demanding for field studies of varied types (environmental, climatological, oceanographic, hydrological, etc.).

Air and ocean going unmanned vehicles have already proved invaluable in some field studies by providing levels of spatial temporal sampling resolution which could have not been attained before. This has been mainly focused on single vehicle operations. The next step in operational deployments concerns the coordination of multiple vehicles. This cannot be done without networking capabilities.

Networked vehicle systems have the potential to revolutionize oceanographic studies. However, and in spite of the technological and scientific advances, we are still far from being able to design and deploy networked vehicle systems in a systematic manner, and within an appropriate scientific and societal framework. This is our challenge.

Our challenge calls for interdisciplinary research and for experimentation and testing. However, this cannot be done without a long term sustainable development program. On the other hand, sustainable development cannot be achieved without a market orientation. In fact, market is good test for user-oriented research.

The question is how to reconcile apparently irreconcilable goals, such as fundamental understanding and market orientation, especially in an environment where traditional knowledge institutions, such as universities, are now struggling to cope with the challenges of translating knowledge into action?

This paper discusses the roles of unmanned vehicle systems for a sustained presence in oceans. This is done in light of the recent technological developments and trends, with special emphasis on networked vehicle systems. The discussion is illustrated with

examples of developments from the Laboratório de Sistemas e Tecnologias Subaquáticas (LSTS) da Faculdade de Engenharia da Universidade do Porto. The paper is organized as follows. In section 2 we elaborate on the state of the art to present the background against which we discuss our developments at LST in section 3. In section 4 we discuss the challenges ahead and show how our developments are targeted at most of them. In section 5 we present the conclusions.

2. TRENDS IN UNMANNED VEHICLE SYSTEMS

In the recent past, we have seen increasing success of unmanned vehicle systems: Autonomous Underwater Vehicles (AUVs) operating under ice in the Arctic¹²; Unmanned Air Vehicles (UAVs) performing atmospheric research³; cars driving autonomously in the desert or in the city⁴; rovers performing data collection on Mars⁵; robots playing soccer⁶; etc. The operation of unmanned vehicles does not necessarily remove humans from the operation of the vehicle. In remotely operated (or piloted) vehicles, there is a human operator in charge of piloting the vehicle which may be located at some remote location. This is done with the help of a communication channel: sensor information is sent from the vehicle to the operator which, in turn, sends commands to the vehicle. The reliance on the operator and on the communication channel is the main limitation of this mode of operation. This is not compatible with the operation of vehicles in some remote environments, such as the ocean or the space, where communications are typically difficult.

Autonomous vehicles are the (partial) answer to the limitations of remotely operated vehicles. Autonomous vehicles are capable of executing mission plans without the intervention of human operators (i.e., autonomously). There are several degrees of autonomy, some of which are not feasible with the current technology. For example, full autonomy is still not feasible today: vehicles lack the sensing and reasoning capabilities required for that purpose. This is partly why the concept of mixed initiative operation was introduced in the last decade⁷. In this concept, human operators are part of the planning and control loops of the vehicle. For example, the operator is capable of generating plans and uploading these plans to the vehicle for autonomous execution; the operator is also able to override plan execution and re-task the vehicle to execute new plans.

Depending on the operational environment, key technical specifications for unmanned vehicles include endurance, size, payload, range, communication and navigation capabilities, and deployment mechanisms⁸. Endurance is highly correlated with the limitations of energy storage technologies. Usually, power is at premium in unmanned vehicles, especially when these are designed for operation in remote environments. The size of the vehicle typically constrains the payload and energy storage. The payload is what makes the vehicle useful. Payloads normally concern sensors and actuators.

Sensor development is one enabling technology for unmanned vehicles. Power and size are the major limitations of the payload. Range depends not only on endurance, but also on the operational environment.

Communication and navigation capabilities determine the level of human intervention, the practical endurance and the usefulness of the vehicle. The vehicle cannot go beyond the range imposed by limitations of the navigational equipment without becoming lost (e.g., the Global Positioning System (GPS) is not available everywhere). Communications are necessary for operating and retrieving information from the vehicle (the vehicle becomes useless if we cannot communicate with it). Deployment mechanisms determine how easy, and expensive, it is to deploy the vehicle.

There is not a Moore's law⁹ for unmanned vehicles. However, from the technological advancements in computation, power storage, sensor technologies and communications, it is possible to infer a few trends for unmanned vehicles: miniaturization (more capabilities in less space), longer endurance and better networking capabilities.

Networking is one of the major trends for unmanned vehicle systems; it is also one of the enabling technologies for distributed cooperation (and computation). Networked vehicle systems offer new possibilities to the operation of unmanned vehicles¹⁰. For example, in networked vehicle systems, information and commands are exchanged among multiple vehicles, sensors and operators, and the roles, relative positions, and dependencies of those vehicles and systems change during operations. These capabilities are essential for operations where the temporal and spatial coordination of vehicles is required, such as in oceanographic field studies. However, we are still far from realizing the potential of networked vehicle systems.

Figure 1: Networked vehicle systems



The research community is devoting significant efforts to the development of concepts of operation for networked vehicle systems. Surprisingly, or not, the role of human operators is receiving significant attention in these advances. In fact, this is the reason why researchers and technology developers have introduced the concept of mixed initiative interactions, where planning procedures and execution control must allow intervention by experienced human operators. In part, this is justified by the fact that essential experience and operational insight of these operators cannot be reflected in mathematical models, so the operators must approve or modify the plan and the execution. Also, it is impossible to design (say) vehicle and team controllers that can respond satisfactorily to every possible contingency. In unforeseen situations, these controllers ask the human operators for direction.

The problems of real-time oceanographic field studies are examined in several papers where adaptive sampling and aliasing are discussed, and conditions under which energy efficient sampling can take place are presented¹¹. The problem of mapping an ocean front with AUVs have also been treated in the literature¹². The problem of gradient descent based on point-wise measurements taken by multiple vehicles have also been studied¹³ as terrain mapping strategies for AUVs¹⁴.

The experience gained with field trials like the Monterey Bay 2006 field experiments (MB06) may help the community to understand the operation of sustained ocean observation¹⁵. MB06 took place over a two-month period from mid-July through mid-September 2006, and involved over a dozen different institutions, thirteen research vessels,

over three dozen robot submarines, and many other fixed and drifting oceanographic instruments. The scale of the experiments is explained by the uneven seafloor and constantly changing currents in the Monterey Bay. These experiments examined coastal ocean processes from different perspectives, and at unprecedented different physical scales. These took place on a 24/7 base. The Collaborative Ocean Observatory Portal was developed to support the day-to-day participation of the large group of researchers with ties to geographically diverse institutions throughout North America¹⁶. These investigators had to interact on a continual basis to optimize data collection and analysis.

UAVs are now being used for ocean field studies. This has to do with improved sensing capabilities and communications. Moreover, these proved essential for relaying data to and for remote assets located beyond line of sight communications (satellite communications are still very expensive).

3. OUR APPROACH

The Laboratório de Sistemas e Tecnologias Subaquáticas (LSTS) from Porto University has been designing, building and operating unmanned underwater, surface and air vehicle systems for innovative applications with strong societal impact since it was established in 1997. Currently the LSTS team has over 30 researchers, including faculty and students, with Electrical and Computer Engineering, Mechanical Engineering and Computer Science backgrounds. In 2006 the LSTS received the national BES Innovation National Award for the design of the Light AUV.

In the last 15 years we have successfully fielded unmanned air, ground, surface and underwater vehicles in innovative operations in Europe and in the United States of America. These include some world firsts, such as the underwater rendezvous between the Aries and Isurus AUVs, respectively from the Naval Postgraduate School and Porto University, which took place in 2006 in Monterey, California, under a cooperation project between the two institutions.

Currently, LSTS is leading several national and EU projects concerning the development of unmanned vehicle systems. The LSTS is tasked, under the SeaCon project funded by the Portuguese Ministry of Defence, to deliver three units of an advanced version of the award-winning Light AUV to the Portuguese Navy. The LSTS is leading, in cooperation with the Portuguese Air Force Academy, the Pitvant unmanned air vehicles program funded by the Portuguese Ministry of Defence. The LSTS is cooperating with the Portuguese Task Group for the Extension of the Continental Shelf in the operation of the Deep Sea Remotely Operated Vehicle Luso. The LSTS is developing tools and technologies for ocean observation under the Raia project funded by the EU Programa de Cooperação Transfronteiriça Espanha-Portugal. Under the Control for Coordination project, funded by the EU FP7, the LSTS developed coordination & control strategies which were demonstrated with ocean-going vehicles in 2011. More advanced multi-vehicle control strategies are being developed in the NOPTILUS EU FP7, which started in May 2011. The problem of coordinating ocean and air vehicles for littoral warfare will be addressed in the European Defense Agency NECSAVE, which involves partners from Italy, Spain and Holland.

The LSTS fleet includes two remotely operated submarines (rated for 200m and equipped with video cameras and side-scan sonar), two autonomous underwater vehicles (1.8m long, equipped with side-scan sonar, acoustic modem and ADCP), six Light autonomous under-water vehicles (1.5m long, which can be configured with CTD sensor, side-scan sonar and acoustic modem), one autonomous surface vehicle (can be used as a

communications gateway for wireless and underwater communications), six autonomous air vehicles (wingspans ranging from 1.8m to 3.6m), gateway buoys (supporting wire-less and underwater communications) and sixty Telos Motes with several sensor configurations.

Figure 2: LSTS ocean going vehicles



The LSTS is currently developing a scientific framework for the systematic design and deployment of cooperating networked vehicle and sensor systems in new applications with strong societal and scientific impact such as oceanographic or environmental surveys with high temporal and spatial resolution. These include persistent 24/7 operations. 24/7 system's level properties arise from the coordination and control of resources, which are not continuously available due to operational constraints (e.g. fuel limitations).

The idea of a system of systems captures the essential aspects of operation of these vehicle systems. In a system of systems, a significant part of the "system" is embodied not as physical devices, such as vehicles, sensors or communication networks, but as software applications which may be mobile. Moreover, mixed initiative interactions, where operators intervene in the planning and control loops, play a central role in operations thus making human factors an important consideration in the design of the system. These challenges entail a shift in the focus of existing methodologies: from prescribing and commanding the behavior of isolated systems to prescribing and commanding the behavior of networked systems.

The LSTS has a three-fold approach to these challenges: 1) low cost modular vehicles; 2) a planning, command and control framework within which the interactions among heterogeneous vehicles, sensors and operators are standardized and mediated; and 3) a software tool set which implements the framework over inter-operated (possibly intermittent) communication networks.

This is an inter-disciplinary effort that builds on advances in (1) dynamic networks of hybrid automata; (2) hierarchical architecture design for semi-automated, distributed teams of agents; (3) incorporating human intervention in mission planning and execution; and (4) models of systems with evolving structure.

We developed a software *tool chain* composed of the following tools for the implementation of our planning, command and control framework. *Neptus* is a distributed command, control, communications and intelligence framework for operations with networked vehicles, systems, and human operators¹⁷. *Neptus* supports all the phases of a mission life cycle: world representation; planning; simulation; execution and post-mission analysis. *Neptus* supports concurrent operations: vehicles, operators, and operator consoles come and go; operators are able to plan and supervise missions concurrently. *IMC* is a communications protocol that defines a common control message set understood by all types of LSTS nodes (vehicles, consoles or sensors) in networked environments¹⁸. This provides for standard coupling of heterogeneous components in terms of data interchange.

DUNE is the system for vehicle on-board software. It is used to write generic embedded software at the heart of the vehicle, e.g. code for control, navigation, or to access sensors and actuators. It provides an operating-system and architecture independent C++ programming environment for writing efficient real-time reactive tasks in modular fashion.

The fleet of the LSTS has seen action at least twice a month since 2007. We have been operating ocean going vehicles in the Atlantic and Pacific oceans and also in Portuguese and American rivers. Missions range from single vehicle to multi-vehicle operations over inter-operated communication networks with disruptive tolerant capabilities.

Figure 3 presents photographs of operations with unmanned air vehicles which took place at the Ota Air Base from the Portuguese Air Force. These were part of experiments carried out under the *PITVANT* project¹⁹, a major collaborative effort between the Portuguese Air Force Academy and Porto University. We have accumulated over 400 autonomous day and night flights with 6 different UAV platforms.

Figure 3: Air vehicles (PITVANT project)



The REP10 AUV experiment was organized and planned by the Portuguese Navy in cooperation with the Porto University, the Naval Undersea Warfare Center - Newport (NUWC), the Naval Research Laboratory and NURC²⁰. Also participating in the event were the companies SeeByte (Edinburgh, United Kingdom), OceanScan MST (Porto, Portugal), OceanServer Technology (Fall River, Massachusetts) and YSI (Yellow Springs, Ohio). The main objectives of the event were to assess the endurance, durability and navigational performance of low-cost man-portable AUVs, experiment with novel safety and emergency strategies, extend the communication range of autonomous vehicles by using fixed and mobile gateways, explore the intricacies of deploying a hybrid fleet of AUVs, validation and interpretation of remotely sensed data and assessment of the relative fidelity of this data compared with data acquired on-scene and ship and shore launching and recovery of AUVs. To support the event the Portuguese Navy deployed the ship N.R.P. Bacamarte - LDG203, a Bombarda class Landing Craft Utility ship built by the Portuguese Navy and in service since August 1985. The 2011 edition of the REP exercise was focused on the demonstration of the SeaCon AUV and of disruptive tolerant networking, including the transfer of sonar files from a SeaCon AUV to a small Unmanned Air Vehicle deployed from the N.R.P. Bacamarte.

Figure 4: REP10 AUV exercise



4. CHALLENGES

There are several obstacles in the road to the practical - as opposed to experimental - deployment of networked vehicle systems. These are briefly discussed next.

Currently, there are no legal frameworks to encompass the operation of unmanned vehicles. In most countries the operation of air vehicles in controlled air space is severely restricted. Efforts are underway to address this problem in some European countries and in the USA. The operation of unmanned ocean-going vehicles also presents legal challenges. The Society for Underwater Technology published a recommended code of practice²¹ and has published reports on this topic since the last decade²². But this is not the Law of the Sea²³, where issues such as the responsibility for collisions and the property of vehicles found at sea are treated in the context of piloted vehicles. This legal void precludes practical deployments with ocean-going vehicles. Each deployment is the exception, and not the rule.

The lack of standards for inter-operability is preventing researchers to operate, in a transparent manner, vehicles from different vendors in a network environment. The lack of standards is not unique to inter-operability. Currently there is no standardization in the area of underwater communications, to name just one example. There are several initiatives addressing these issues. NATO has been working on standards for inter-operability, namely the STANAG 4586²⁴, which has seen some acceptance in the UAV community; this is confirmed by the existence of commercial software products compliant with this standard. The Joint Architecture for Unmanned Systems (JAUS) is receiving wide acceptance in the military, especially in the USA²⁵. The NATO Undersea Research Center in La Spezia is developing the JANUS standard that will allow acoustic modems to coexist, advertise their presence and potentially inter-operate. A word of caution is needed here: the existence of standards does not imply standardization.

In general, commercial vehicles have not been developed as open systems. Moreover, the lack of standards for inter-operability is not conducive to open systems. Closed systems tend to raise vehicle and maintenance costs, and may be conducive to forms of market practice that are not necessarily in the benefit of the customer. This is especially critical in a field where technological obsolescence arises rapidly: vehicles and their components have to be upgraded periodically. The technological trends, namely those related to miniaturization and embedded systems, may contribute to change this state of affairs by

contributing to the reduction of cost. Low cost open systems may prove fundamental to the dissemination of networked vehicle systems.

Networking existing sensors has the potential to add value to the existing infrastructure. This value can be further increased with networked vehicle systems. Cities are one example where this idea can be easily applied. Different institutions (high schools, universities, companies, municipalities, etc.) have been using environmental sensors on their daily activities. The Internet is now pervasive, and connecting these sensors to the Internet is not a major technical problem. In fact, permanent connectivity is not needed. City transportation vehicles can be instrumented with sensors for area coverage. DTN technology allows the data collected along each route to be automatically stored on each vehicle and later forwarded to some Internet server at specific locations where short range (i.e. low cost) communications are available. Citizens can also contribute sensor measurements from either their mobile phones or from sensors connected to their home computers. This may lead to a sensing system of unprecedented dimension and capability, which has applications not only in environmental field studies, but also on civil protection and on improving the quality of city life. The new sensing system will have certainly new properties, which cannot be fully anticipated now. This model can be easily replicated; it may be a first step towards the instrumentation of the Earth.

Manned and unmanned operations at sea are very expensive. This becomes even more expensive for operations in the deep sea. The problem of funding developments is not a trivial one. Synergies must be sought for developments of dual use. Dual is used here in the sense of significant scientific and economic impact. Deep sea oil operations present such an example. For example, the impact of climate change on deep sea ecosystems is largely unknown²⁶. The tools and technologies for deep sea oil exploration have been used for scientific studies at the same locations.

This state of affairs should not prevent us from deploying unmanned vehicle systems. On the contrary, we are learning important lessons from our deployments. These may prove invaluable for the development of legal frameworks, standards and concepts of operation.

5. CONCLUSIONS

At the Laboratório de Sistemas e Tecnologias Subaquáticas at FEUP we have been building and developing social, technological, academic and institutional networks to address this question. Vehicle development is targeted not only at the experimentation of our developments, but also at innovative markets. A credible presence in the market, especially when coming from a country without a strong technological image, requires credible partners and demonstrations. Our cooperation with the Portuguese Navy and Air Force is already providing tangible results in terms of products and technologies. Tangible results are of interest to the international market, especially when these have distinctive features that are not only based on cost considerations. Our cooperation with the Portuguese Task Group for Maritime Affairs is motivated by the national interest, and is targeted at a sustained presence at sea. Our quest for fundamental understanding is the reason for our cooperation with leading institutions in areas relevant to network vehicle systems research. This leads to common developments, which can only strengthen our cooperation because these would not be possible without collaboration. In fact, no single institution in the world can now address all of the areas relevant to the research in marine systems. This trend makes our cooperation more meaningful when it is aligned with the development of systems and technologies that will deeply impact society, such as

networked vehicle systems. Demonstrations of unprecedented capabilities are crucial to both evaluate developments and test their practicality. We advocate the development of a national strategy which should be tightly aligned with international trends and strategies. Shared national challenges should help to bridge the islands of science and technology scattered around Portuguese universities and institutions.

The purpose of the paper is to stimulate the development and deployment of networked vehicle systems in these field studies over the next decades. The approach used to accomplish this goal was to present current developments in unmanned vehicle systems and in networked vehicle systems before examining future trends and challenges for these deployments. Examples of developments from the LSTS illustrated the key points.

The contribution of the paper is descriptive, not prescriptive, in nature. It neither advocates specific concepts for networked vehicle systems, nor prioritizes the requirements. It attempts, however, to present part of the technical and technological background required for development of new research and development programs for a sustained presence in the ocean. In addition, it sheds some light on some of the obstacles to practical deployments, thus attempting to contribute to the discussions conducive to their removal.

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OPTICAL METHODS FOR WATER POLLUTION MONITORING

MÉTODOS ÓPTICOS PARA MONITORIZAÇÃO DE POLUIÇÃO DA ÁGUA

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ABSTRACT

An innovative optical method for remote monitoring of water pollution was developed and tested in AMPERA ERA-NET Programme, project DEOSOM. The method is based on remote detection of laser-induced fluorescent radiation (LIF LIDAR). In the project, compact and light LIF LIDAR systems were developed, which can be operated by relatively unskilled personnel and used for early air- or shipborne pollution detection and evaluation, specifically for oil spill detection. The systems are provided with direct georeferencing, for exact localization of the oil spills, and artificial intelligence, for their automatic characterization. The paper presents the principles of the method and the results of tests carried out in the field and laboratory conditions.

Keywords: Laser Induced Fluorescence; Remote Detection; Pollution; Oil Spill.

RESUMO

Um inovador método óptico para a monitorização remota da poluição aquática foi desenvolvido e testado no âmbito do projecto DEOSOM financiado pelo programa AMPERA ERA-NET. O método é baseado na detecção remota de radiação fluorescente induzida por laser (LIF LIDAR). No projecto foram desenvolvidos detectores LIF LIDAR compactos que podem ser utilizados por pessoal sem qualificação específica para a detecção precoce e avaliação da poluição através de aeronaves e embarcações, especificamente na detecção de derrames de petróleo. Os sistemas são fornecidos com georreferenciação directa, para a localização exacta do derramamento, e inteligência artificial, para a sua caracterização automática. O artigo apresenta os princípios em que baseia o método bem como os resultados dos testes realizados em campo e em laboratório.

Palavras-chave: Fluorescência Induzida por Laser; Detecção Remota; Poluição; Derramamento de Petróleo.

JEL Classification: Q53

1. INTRODUCTION

Due to the increasing traffic of cargo ships and tankers in European waters, the risk of water pollution by accidental or criminal oil spillage is increasingly high. The same

situation occurs in the more than 1100 ports in the European Union. Ships and offshore installations are the most common sources of more than 500,000 tons of oil spilled into the marine environment every year.

Oil spillage monitoring includes three levels of surveillance. The first level is satellite-borne (range about 50 to 200 km); the second level consists of airborne inspection by visual analysis and IR/UV sensors (range about 100 to 500 m); the third level of surveillance is waterborne. For many years the attention of scientists and engineers was concentrated mainly on the development of detection methods and equipment for the first and second levels of surveillance. A number of active and passive optical methods were developed, mainly using complex and costly instruments. As a result, only very few detection methods are currently available for the 3rd level of surveillance, one of the most important, due to its flexibility and lower cost. In particular, the need for lightweight, low-cost detectors that can be widely used for watercraft borne as well as airborne coastal inspection remained unmet.

In response to this demand, in the end of 2008 a consortium of university, government and industry researchers listed in Table 1 launched a project aiming at developing an efficient system for shipborne pollution surveillance in harbourages, rivers, channels, and coastal waters. This three-year project, named DEOSOM (Detection and Evaluation of Oil Spills by Optical Methods) was funded within the European Coordination Action to Foster Prevention and Best Response to Accidental Marine Pollution (AMPERA, 2007). It had the following objectives:

1. Developing a low cost nanometre-spectral-range fluorescence LIDAR for early detection of oil spills in riverine and coastal waters and measurement of the hydrocarbon film thickness.
2. Developing a dedicated low-cost direct georeferencing system (GPS/GNSS+IMU) allowing for oil spillage mapping.
3. Benchmarking of the fluorescence lidar developed in the project against more sophisticated well established techniques.

Table 1: Consortium of the DEOSOM Project

Institution	Location	Principal role
INOV (INOV - INESC Inovação)	Lisbon, Portugal	Project coordination, general research and design, system integration
LDI (Laser Diagnostic Instruments AS)	Tallinn, Estonia	Development of optical detectors
CIIMAR (Centre of Marine and Environmental Research)	Porto, Portugal	Development of communication and positioning system
UVigo (University of Vigo)	Vigo, Spain	Planning and organisation of field tests and data processing
IH Instituto Hidrográfico	Lisbon, Portugal	Providing general methodology and conducting specific laboratory tests

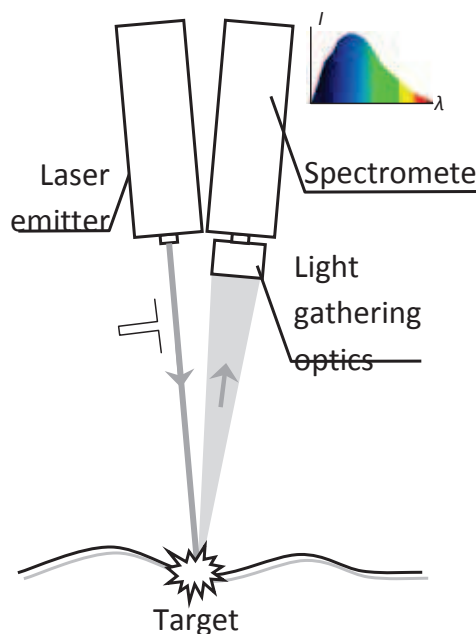
The present paper reviews the main results achieved during the project execution and discusses these developments in a market prospective.

2. THIRD-LEVEL WATER-POLLUTION SURVEILLANCE: AN OPTICAL APPROACH

The methods presently available for the third-level water pollution surveillance usually rely on ultraviolet (UV), visible or infrared (IR) imaging. Scanners are predominantly used as sensors in the visible region of the spectrum. These systems can detect oil under optimum conditions, but the inherent lack of positive discrimination between oil and some backgrounds limits their applicability. In addition, thin oil films on the water surface are often invisible even in daylight and good weather conditions (Fingas and Brown, 2007).

Detectors based on laser-induced fluorescence (LIF) light detection and ranging (LIDAR) are far more useful instruments due to the capability of this method to reliably detect and, in appropriate conditions, identify oil against soil, water, ice and snow backgrounds. The principles of LIF LIDAR are illustrated in figure 1.

Figure 1: Principal sketch of a LIF LIDAR detector



The radiation emitter, comprising a pulsed laser and beam-forming optics, produces short ($\sim 1 - 10$ ns) and intense radiation pulses, which propagate through the atmosphere. When the emitted beam hits a target, the laser radiation interacts with the target's molecules, leading, for many chemical compounds, to the emission of radiation with longer wavelengths via fluorescence. A fraction of this radiation, propagating back to the detector, is collected by a telescope and directed to a spectrometer for spectral analysis. The spectra are recorded in digital form in a computerized data-acquisition unit. The angular position of the emitted laser beam and the detection time of the return radiation pulse allow calculating the position of the target, while the spectrum gives the target chemical composition.

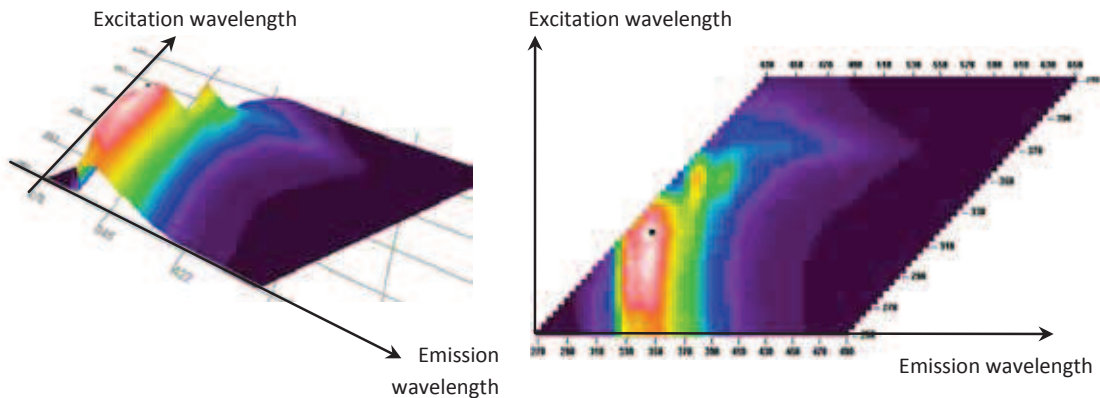
As air- and shipborne LIF LIDARs change their positions during measurements, the signals are time stamped and georeferenced to allow calculating the absolute location of the target for each measurement and, thus, mapping the pollutant distribution.

Water pollution monitoring can also be implemented by pumping water into the detector and irradiating it internally with a flashlamp, providing the complementary opportunity to vary the excitation wavelength. This variation adds one more dimension to

fluorescence spectra, turning them into two-dimensional spectral fluorescence signatures (SFS) akin to one illustrated in figure 2.

The choice of the detector strongly depends on the application, especially on the area under surveillance as well as on the promptness and reliability of pollution detection and characterisation (fingerprinting).

Figure 2: An example of spectral fluorescence signature represented as surface (left) and contour (right) plots



3. BASIC COMPONENTS OF LIF LIDAR WATER POLLUTION DETECTORS

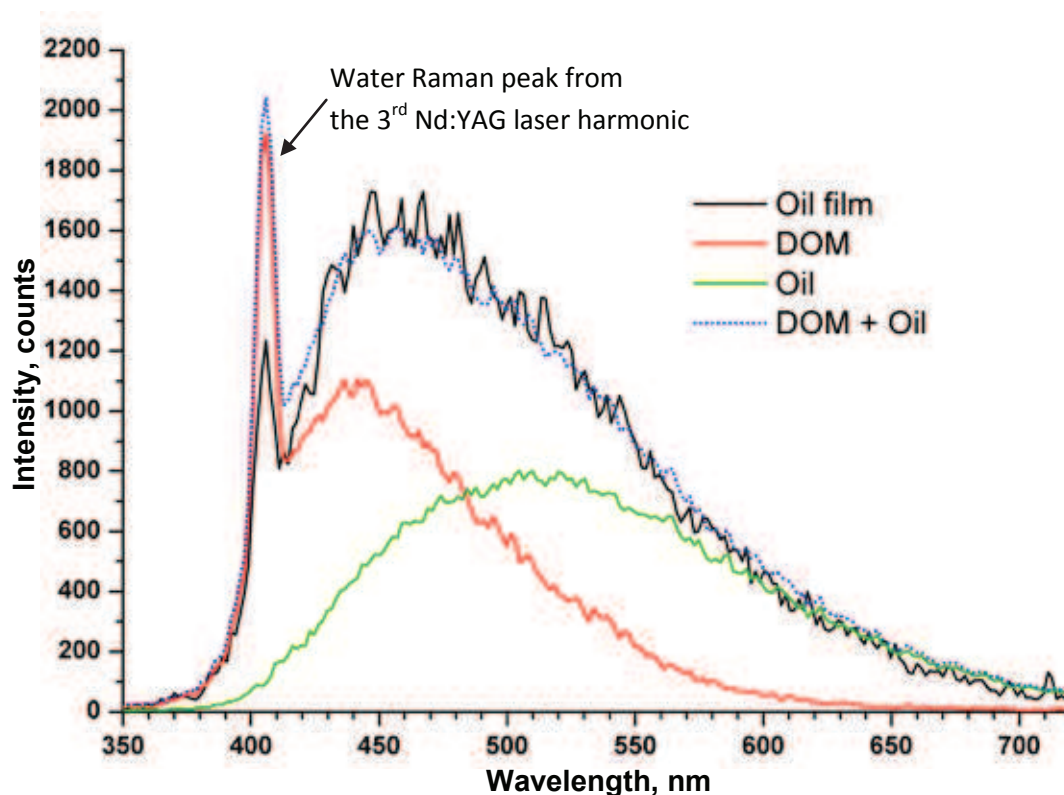
3.1 Radiation sources

The laser used as radiation source defines the excitation-pulse energy and wavelength - parameters that determine the detection range and the set of detectable pollutants.

Excimer XeCl lasers provide ultraviolet radiation at 308 nm wavelength. The main advantage of this solution is a good spectral separation of the principal spectral signatures to be detected: the peak due to water Raman scattering appears in the range 340-345 nm, the maxima of the fluorescence response of oils are in the 400-450 nm region, and the dissolved organic matter (DOM) fluorescence appears in between (at 350-400 nm). In addition, the laser beam penetrates deeply in water, allowing to detect submerged oil. The disadvantages include high acquisition and maintenance costs and the necessity of a gas supply, which increases the complexity of the instrument and reduces the ease of transportation.

Nd:YAG lasers emitting in the fundamental wavelength (1064 nm) are not suitable for the application, but the frequency duplication and triplication yields 532 and 355 nm radiation in the visible and ultraviolet ranges respectively, sufficiently energetic for efficient excitation of hydrocarbon fluorescence. The second harmonic of the Nd:YAG laser is less convenient for LIF LIDAR measurements due to lower quantum yield and eye hazard. For the 355-nm excitation, the water Raman peak lies at ~400 nm, the maximum of DOM emission in the region from 400 to 500 nm, and the oil fluorescence between 420 and 650 nm, thus making the separation these two signatures a more difficult task (see figure 3). Water penetration for 355-nm radiation is lower than for 308 nm, so this laser is preferably used for surface detection. On the other hand, the acquisition and maintenance costs for such instruments are significantly less than for XeCl excimer LIF LIDARs, and these lasers do not require gas.

Figure 3: LIF spectrum of a thin Marlin crude oil film on the water surface (black) plotted together with LIF spectra of water, predominantly composed by DOM (red) and pure Marlin oil (green). The oil film spectrum corresponds well to a combination of the DOM and oil spectra (dotted blue) taken, respectively, with the coefficients 1.01 and 1.001, found via the least mean squares method.



Recent developments in the optoelectronic industry brought the opportunity of constructing LIF LIDAR detectors on the basis of UV diode lasers. Producing weaker light and having far worse beam quality than Nd:YAG lasers, diode lasers are adequate for short-range detection. However, their low price, weight, dimensions and energy consumption, as well as long durability and minimum servicing requirements make these lasers extremely attractive for water-borne pollution monitoring. Of particular importance is their potential for autonomous operation using, for example, solar powering. By using one of these lasers and low-weight optical design, a LIF LIDAR instrument available for buoy-based maritime surveillance could be built.

3.2 Light gathering optics

The light gathering optics collects the radiation emitted from the target and focuses it in the entrance slit of the spectrometer. The radiation is usually collected by a telescope, and the power of the detected radiation is proportional to the area of its input pupil defined by the first lens. The choice of this lens diameter is a trade-off between sensitivity and compactness/weight.

Gathered radiation is usually transported to the spectrometer by optical fibre. In this case it is the fibre core that constrains the input aperture of the spectrometer, thus making unnecessary introduction of the optical slit unit. However, the schemes comprising a telescope rigidly connected with the spectrometer through an optical slit unit provide more efficient radiation conversion and an additional opportunity of establishing an ad

hoc trade-off between the spectral resolution and sensitivity though adjustment of the slit width.

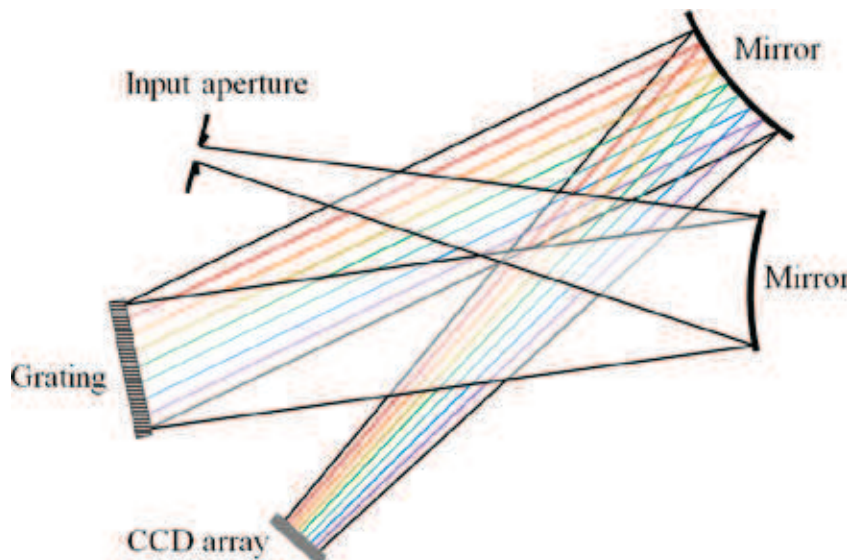
In general, an optical filter is introduced in the light pass to protect the spectrometer from retroreflected excitation radiation.

3.3 Spectrometers

As oil fluorescence emission spreads over a wide spectral range, the fluorescence oil-spill monitoring requires broadband spectral detectors. A great variety of detectors have been employed in the LIF LIDAR technique, including optical multichannel analyzers, photodiode array detectors, and nonintensified and intensified charge coupled devices, usually referred to as CCDs and ICCDs. The choice of the detector depends on many factors, including data acquisition rates and type of signal processing, sensitivity, spectral range, field deployability, and overall system cost (Carranza et al., 2003).

For portable low-cost instruments, palm-size Czerny-Turner CCD spectrometers price (figure 4) are often used.

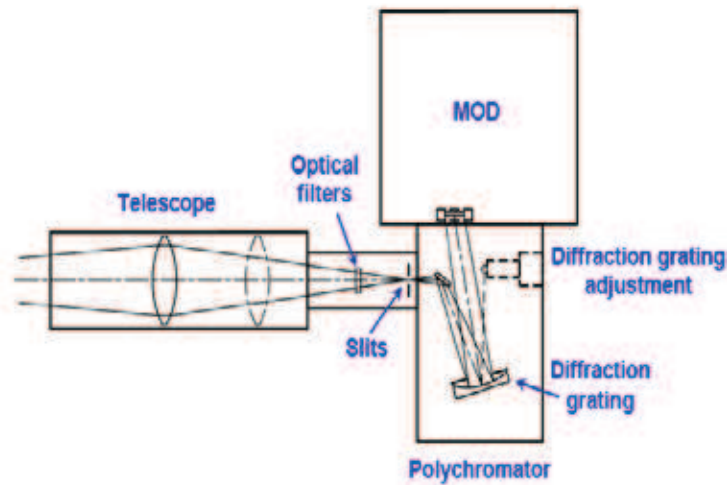
Figure 4: Czerny-Turner optical bench: a basis for compact mass-production CCD spectrometers



The ICCD spectrometers — despite of the higher cost, as compared to their CCD counterparts — provide much better sensitivity, with improvements in SNR ranging from a factor of 3 to greater than 1 order of magnitude (Carranza et al., 2003). This is especially important for long-range applications, such as the airborne surveillance, and for systems employing low-power sources.

In the LIF LIDAR technology, the contemporary global tendency of optimisation via integration is embodied in combining light gathering and spectral decomposition within the framework of a unique receiver system with lesser number of elements. An example of such a system, in which the diffraction grating plays an additional role of an imaging mirror is given in figure 5.

Figure 5: ICCD receiver with an adjustable telescope from Laser Diagnostic Instruments in which the diffraction grating plays an additional role of an imaging mirror (LDI, 2010)



3.4 Georeferencing

There are many global navigation satellite systems (GNSS) available in the market, from simple code navigation equipment to single or double frequency phase receivers, which range significantly in accuracy and price, operating in either the precise point positioning (PPP) or differential mode.

Totally autonomous inertial georeferencing system may be used as an alternative or as a complementary sensor. The inertial systems are categorised according to the type of their principal element, a gyroscope. Three types of gyroscopes are in wide use: MEMS (Micro-Electro-Mechanical Systems), fibre-optic (FOG), and ring-laser (RLG) ones. The MEMS are typically considered low cost gyroscopes, while FOG and RLG sensors represent medium to high cost systems. Some last-generation MEMS can compete with FOG systems, although the latter still have superior temperature stability.

Through the integration of GNSS measurements with inertial data the weaknesses of each system can be overcome. GNSS can be used to control the drift in the IMU solution and the IMU data can be used to bridge the gaps when there is loss of lock of the GNSS signal.

The final solution is the precise position and orientation of a moving platform/sensor at each instant.

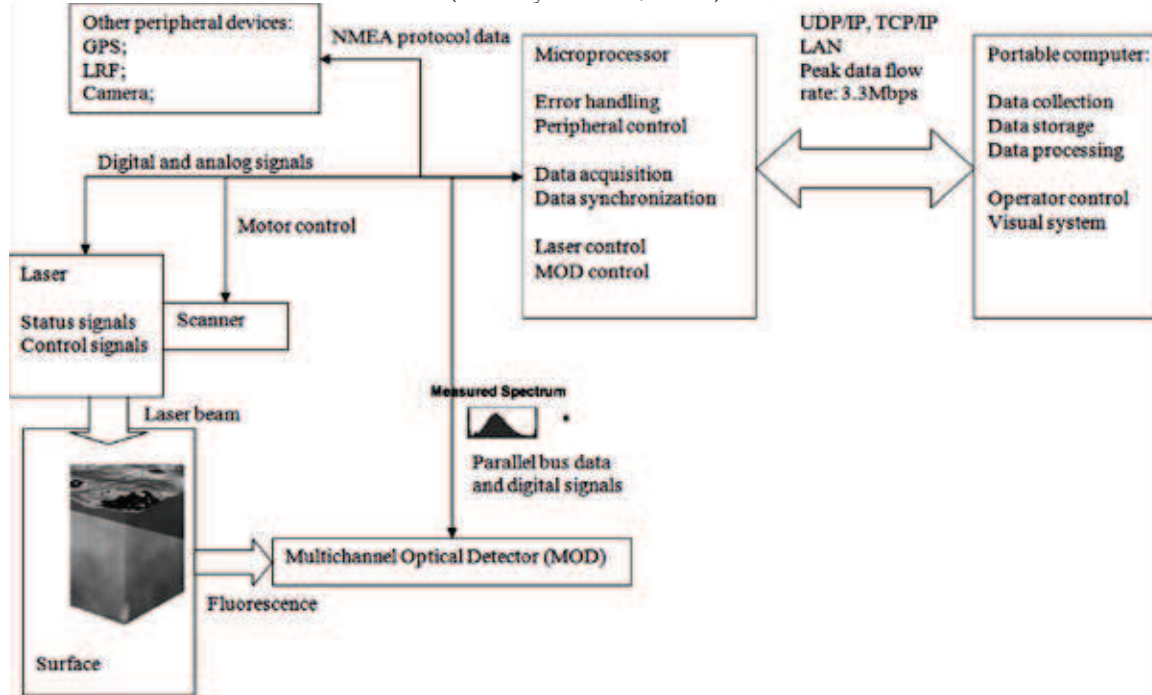
3.5 Control software

The top layer software controls data acquisition process and merges the spectra with the time stamp, necessary for synchronisation with the georeferencing data. The control involves a series of operations, such as the laser-beam positioning, initiating the laser pulse, background measurements, etc., and thus the control system is responsible for simultaneous operation of numerous peripheral devices, prompt error handling and providing a graphical user interface (GUI). Although Windows is not a real-time operating system (OS), it suits the present application because when the low pulse frequency lasers (~ 10 Hz and less) are used, the intra-pulse time is sufficiently long for the OS to finish the critical operations by the time of the next measurement.

The components can be controlled directly by the computer through the memory-mapped (MMIO) and/or port-mapped (PMIO) input/output (McDougall and McDougall, 2011). Such an approach used to be cost-effective as it does not require any extra processing

devices. However, with the widespread of cheap integrated circuits, today's dominating tendency is to provide the real-time data processing with the help of a microcontroller built-in in the data acquisition circuit, see, for example, (Ocean Optics, 2011) and a flow chart of figure 6. The most challenging task in developing such combined packages is to provide the reliable connectivity and simultaneous work of the built-in controller and PC software.

Figure 6: LDI detector for water- and airborne LIF LIDAR applications: schematics of the control (Aleksyev et al., 2008)



4. DEVELOPED LIF LIDAR DETECTORS

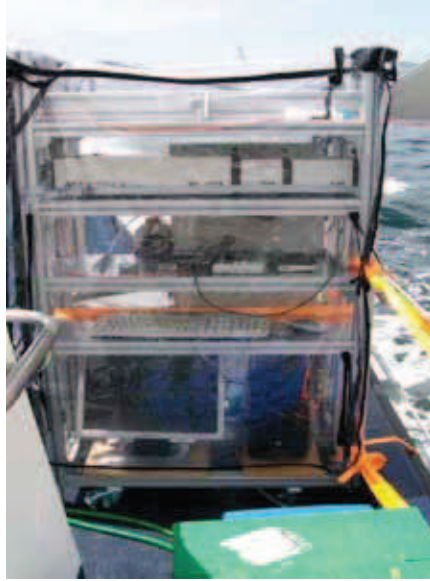
The LIF LIDAR detectors developed during the project include sufficiently wide range of instruments, differing in detection capabilities and prices. The most expensive instrument shown in figure 7, equally suited for water- and airborne applications, has the detection range of several hundred meters and possibility to detect submerged spills of hydrocarbon pollutants.

Figure 7: Compact LIF LIDAR detector based on a XeCl laser (excitation wavelength is 308 nm). The detector has dimensions of 60×50×40 cm³, isolated and waterproof case, and waterproof LAN and electrical connections



Similar LIF LIDAR instruments developed on the basis of frequency-doubled and tripled Nd:YAG laser is shown in figure 8. Producing the excitation radiation at the wavelengths of 532 and 355 nm correspondingly, this detector is unable to detect submerged oil spills, and here the separation of DOM and oil signatures is more challenging than in the case of shorter-wavelength 308 nm excitation. However, such a scheme may result in more compact and cheaper instruments.

Figure 8: LIF LIDAR detector prototype based on a Nd:YAG laser, producing the excitation radiation at 355 and 532 nm: operation during the field tests in Vigo (Utkin et al., 2011)



The chipset LIF LIDAR detector design is based on the cost-effective UV laser diodes (figure 9). The weak signal of fluorescence excited by low-energy laser diode is detected in a few number of wide spectral bands, resulting in sufficiently rough characterisation of the spectrum, but enabling the detection range to stay within acceptable limits of tens to hundred meters, depending on the pollutant type.

Figure 9: LIF LIDAR detector prototype based on a UV diode laser (Babichenko and Shchemelyov, 2011)



5. SIGNAL PROCESSING AND SPECTRUM CHARACTERIZATION

LIF signal processing includes the background elimination and accumulation of spectra from several laser pulses. In most cases the background elimination is performed by low-level microprocessor software, which, being switched into the pulse-synchronisation mode, forces the spectrometer to measure three spectra instead of one. The measurements are taken before, simultaneously with, and after the laser pulse, and the average of the first and third spectra is taken as the background level, to be subtracted from the main second measurement. The background spectra hold different constituents of noise like sun flares, temperature and electronic noise can be excluded from the LIF spectrum by subtraction.

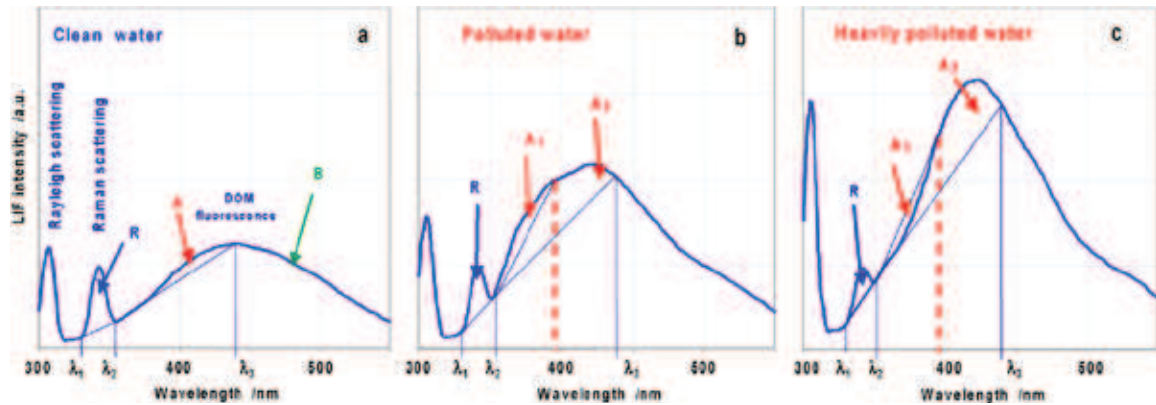
Oil fluoresces mostly due to its aromatic compound components and thus is strongly influenced by the chemical composition and physical characteristics (e.g., viscosity and radiation extinction coefficient) of the oil (Ryder, 2005).

The laser induced spectrum of oil films on water contains components not related to oil fluorescence, namely the water Raman scattering and LIF emission from dissolved organic matter (DOM). The Raman scattering peak of oil-contaminated water is attenuated by absorption of both the excitation and scattered radiation in the hydrocarbon film, so the attenuation factor can be used to estimate the oil-film thickness. DOM fluorescence complicates the spectral analysis and may prevent oil identification. On the other hand, the DOM signal can carry important information on the organic contamination of water. Since the intensity of water Raman scattering is an indicator of water transparency, the LIF intensities can be normalized by the Raman intensity to provide an absolute scale of the oil and DOM pollution emission.

Oil fingerprinting on the basis of the LIF spectra must be based on fast algorithms, which enable the user to change the vehicle trajectory in real time, in accordance with the current detection results. As a rule, such algorithms utilize reduction of information via feature extraction and perform a two stage analysis: (1) pollution detection and (2) identification of the pollutant(s).

An example of feature extraction for pollution detection is given in figure 10. The integral spectral intensities R , A , and B within the marked spectral ranges for a clean water spectrum (figure 10a) serve as a reference. The first range is defined by the inflections of the spectrum due to the water Raman peak (wavelengths λ_1 and λ_2), and the value of R is calculated as an integral of the spectral intensity above the line passing through the deflection points. The second spectral range starts at λ_2 and extends to the DOM fluorescence maximum λ_3 , and the integral intensity A is calculated by integration above the background line defined by the spectral intensities at λ_2 , λ_3 . The (λ_2, λ_3) range is further split into two equal width sub-ranges (by the red dashed line in figures 10b, c), yielding the integral intensities A_1 and A_2 . The case $A_1 > 0$ and $A_2 > A$ (figure 10b) corresponds to polluted water and that of $A_1 < 0$, $A_2 > A$ (figure 10c) indicates heavily polluted water. The value of B (figure 10a) can be applied to detect changes in DOM composition in the area of observation on condition that $A_2 = A$. An increase of the current value of B as compared to that of clean water often indicates a higher ratio of terrestrial DOM fractions, typically testifying a shore discharge (Babichenko et al., 2006).

Figure 10: Feature extraction for pollution detection based on spectral shape variation
(Babichenko et al., 2006)

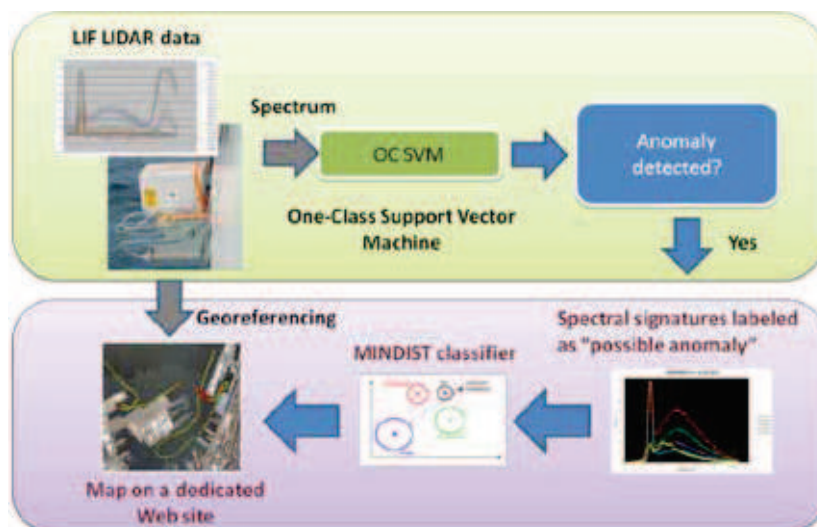


Identification of the pollutant oil is a more challenging task as one cannot predict a certain spectral signature or feature from the petroleum nomenclature based on empirical macroscopic properties (gravity, viscosity, etc.). It is therefore necessary to investigate the optical properties of a representative number of different oil types in the laboratory, and to analyze the spectral variability of their signatures. Obviously, it is impossible to investigate the optical properties of all different oils transported at sea. This has to be done with a number of representative oils, whereby the term “representative” does not necessarily have a global meaning. In most cases local or operational aspects should also be taken into consideration.

One of the earliest oil recognition method was proposed by Hengstermann and Reuter (1992). It is based on the principal component analysis. The eigenanalysis of the covariance matrix of 51 spectra of a representative catalogue of crude oils and refined products has shown that only four first basic spectral forms (eigenspectra) contain 99% of the information of the catalogue.

Another approach to oil detection and classification is based on the artificial-intelligence algorithms implemented via distributed systems with variable parameters, adjustable during a supervised learning procedure. One classification system developed within the DEOSOM project (Martín et al., 2011; Torres et al., 2011), is schematically represented in figure 11. The subsystem dedicated to pollution detection is based on a one-class support vector machine (OC SVM). It classifies the spectra into two classes, representing unpolluted water and water with some anomalous LIF emission. By means of OC SVM a classification model is trained using only unpolluted water data, and each new sample not fitting the unpolluted water spectrum is considered to be an anomaly.

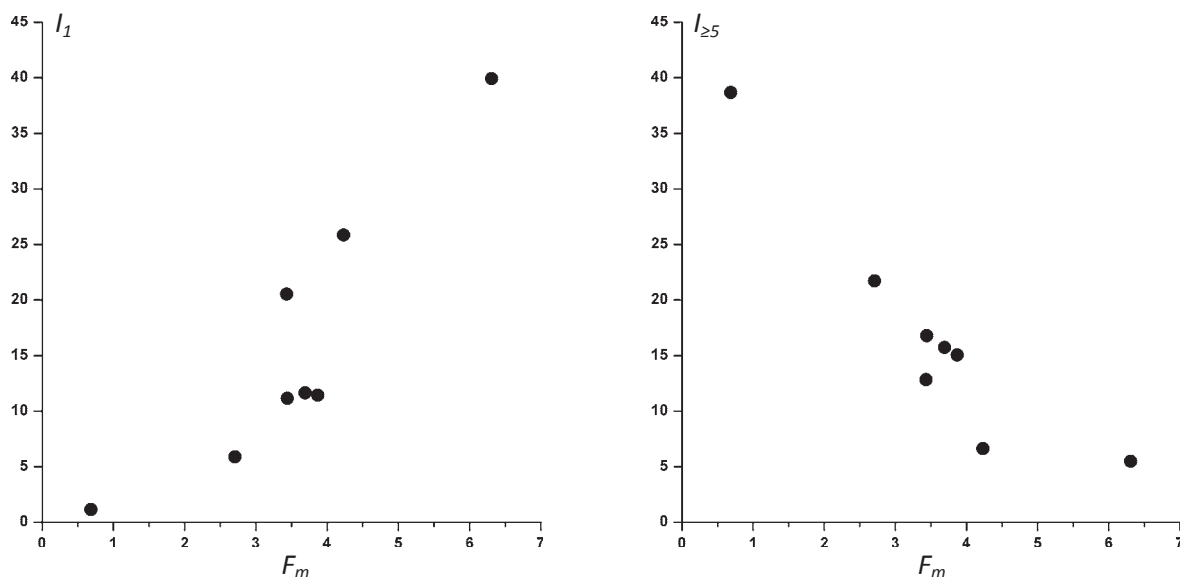
Figure 11: Pollution detection and identification algorithm developed within the framework of the DEOSOM project (Torres et al., 2011)



The subsystem dedicated to the pollutant identification is based on oil signature recognition. After analysis of the spectral signature variability of pertinent hydrocarbons, a database composed of 12 distinct oil products transported through and processed in Galicia was built. The LIF spectrum of each product is represented by a 512-points (wavelengths) reference vector. Anomalous LIF emission is also represented by a vector of the same dimension. The classification of these vectors is performed by comparing their Euclidian distances in the 512-dimensional space to each of the reference vectors. The signature is attributed to the oil product corresponding to the nearest reference vector (minimum distance, so-called MINDIST algorithm). The processing chain of the classifier contains a web server interface based on open source technologies: Google Earth engine, Open Layers java script and Map Server. The onboard software interacts with the server (additionally providing the georeferencing data) and receives the classification results promptly inserted into the electronic map of the locality.

Other important direction in the development of oil-recognition algorithms is developing software for subdivision of oils into common classes, like light, heavy and extra heavy, on the basis of their LIF emission. Since this classification is usually done on the basis of physicochemical parameters, such as the aromatic composition and specific, the correlation between these two parameters and specific features that can be extracted from the LIF spectra must be analyzed. The scattergraphs of the relative populations of hydrocarbon molecules containing only one aromatic ring I_1 and five or more aromatic rings $I_{\geq 5}$ (%) versus the relative LIF spectrum maximum F_m for eight chosen crude oil brands (Agbami, Asgard, Azeri Light, Brega, Marlin, Mellitah, Sahara Blend and Zafiro Blend) are shown in figure 12. The aromatic composition of the oil samples was assessed on the basis of laboratory fluorometric experiments carried out by Instituto Hidrográfico (Lisbon) using the methodology developed by Law (1980).

Figure 12: Scattergraphs of the relative aromatic-ring populations I_1 and $I_{\geq 5}$ (%) versus the relative LIF spectrum maximum F_m



The figure indicates strong correlation between the parameters under comparison; the quantitative results for the whole set of populations assessable with Law's method, $\{I_1, I_2, I_{34}, I_{\geq 5}\}$, are presented in Table 2.

Table 2: Correlation coefficients between the relative aromatic-ring populations $\{I_1, I_2, I_{34}, I_{\geq 5}\}$ and the relative LIF spectrum maximum F_m

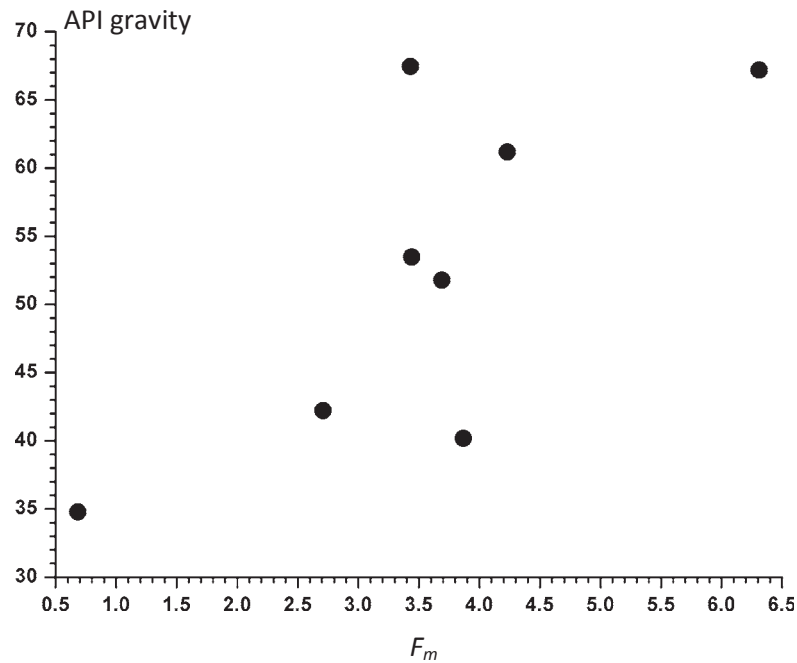
Aromatic-ring population	Correlation coefficient
I_1 (one aromatic ring)	0.90
I_2 (two aromatic rings)	0.71
I_{34} (three and four aromatic rings)	-0.91
$I_{\geq 5}$ (five and more aromatic rings)	-0.93

Another important parameter characterising the oil type is the American Petroleum Institute gravity, or API gravity. The API gravity is an inverse measure of the relative density of petroleum with respect to water (specific gravity),

$$\text{API gravity} = 141.5/(\text{specific gravity at } 15.6^\circ \text{ C}) - 131.5 ,$$

but it is used to compare the relative densities of petroleum liquids. If its API gravity is greater than 10, it is lighter and floats on water; if less than 10, it is heavier and sinks. The API gravity is one of the simplest and most wide-spread parameters used for classifying crude oils (Ryder, 2005). The measurements of this parameter for the 8 chosen oil samples demonstrated that it as well exhibits strong correlation with the relative LIF/LIDAR spectrum maximum F_m and thus can be assessed on the basis of *in situ* LIF/LIDAR spectra as well. The value of the corresponding correlation coefficient is 0.73, the data scattering is illustrated in figure 13.

Figure 13: Scattergraphs of the API gravity versus the relative LIF spectrum maximum F_m



6. FIELD TESTS

The methods developed were field tested in 2009-2011 in the Ria de Vigo and adjacent waters of the Atlantic Ocean with several LIF LIDAR oil detectors installed onboard Coastal Guard vessels (figure 14).

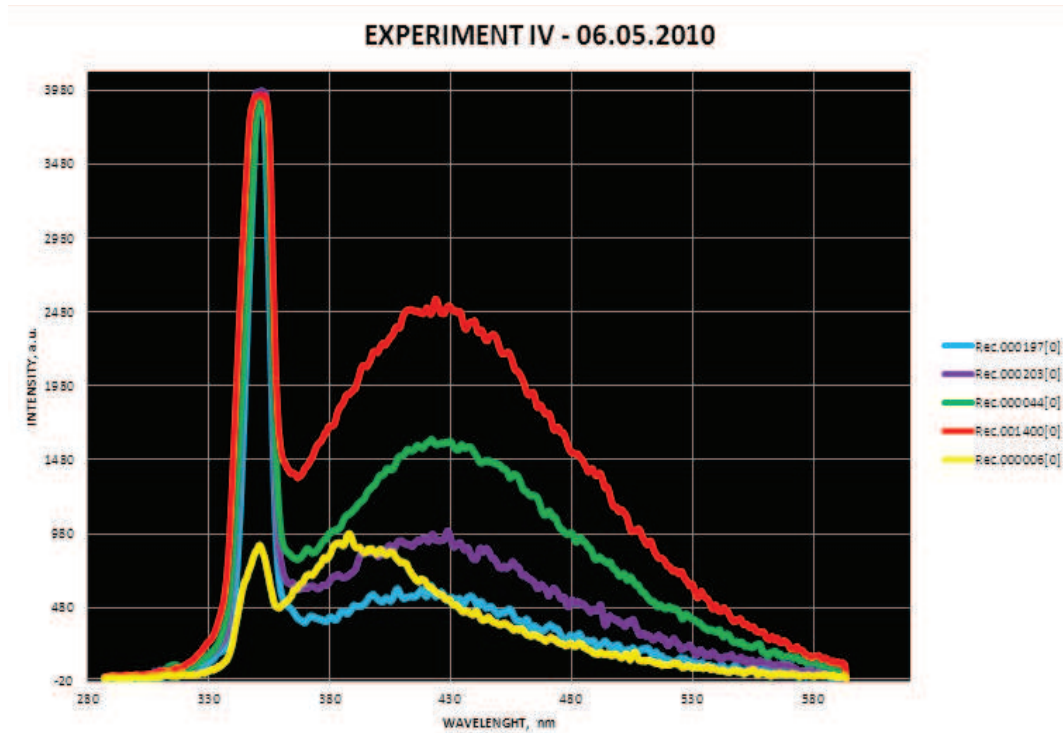
Figure 14: LIF LIDAR oil-spill detectors based on Nd:YAG-3 (a) and XeCl (b) lasers installed onboard of a ship provided by Galician Coastal Guard



Typical 308-nm-excited LIF spectra of predominantly clear waters in different locations of the above mentioned region are shown in figure 15. The curves present an intense and

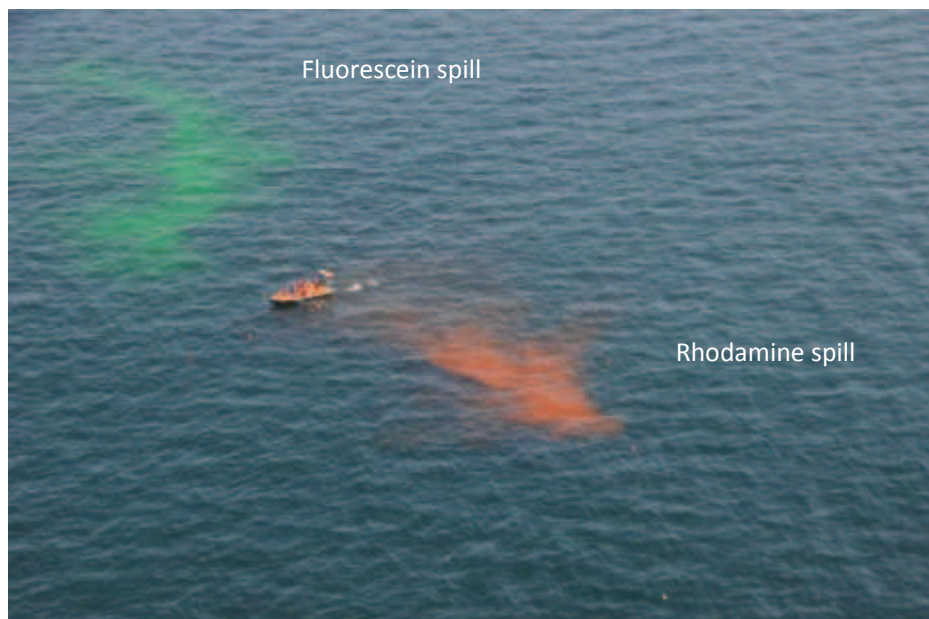
narrow water Raman peak at 344 nm and a wider peak in the 310-580 nm region due to DOM. The yellow curve corresponds to the only hydrocarbon pollution spot detected and presents specific features: the Raman peak intensity is low due to attenuation by the pollutant, while the pollutant fluorescence adds to the DOM spectrum, leading to a distortion of the broad peak and to a shift of its maximum to about 390 nm.

Figure 15: Typical spectra of unpolluted waters of the Ria of Vigo



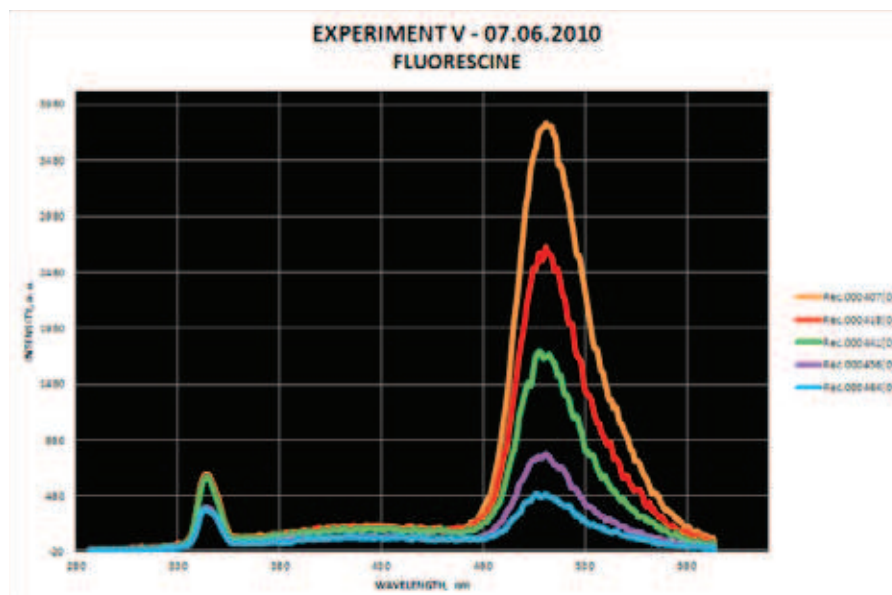
The detector performance for higher pollutant concentrations was tested on controlled experimental spills of rhodamine and fluorescein (figure 16).

Figure 16: Experimental spills of rhodamine and fluorescein



The recorded LIF spectra of waters contaminated by fluorescein are illustrated in figure 17. The spectra differ significantly from those of unpolluted water, with a strong decrease of the relative intensity of Raman peak at 344 nm and of the DOM fluorescence (with a flat maximum at about 430 nm) and present a very strong peak in the green region, which can be ascribed to the fluorescein emission.

Figure 17: Recorded spectra of waters polluted of the Ria of Vigo



7. CONCLUSION

Investigations carried out within the framework of the DEOSOM project showed great potentiality of the water pollution surveillance and, in particular, the oil spill detection using the analysis of the fluorescence light induced either by a laser (LIF LIDAR technology) or a lamp (SFS technology). It offers high sensitivity, good diagnostic potential, and relatively compact, robust, and simple instrumentation. Wide scalability of the LIF LIDAR technology can be achieved by application of different types of laser and detection units. With the detectors providing the range of more than 100 m, the LIF LIDAR method is suitable not only for the waterborne applications, but for the airborne applications as well.

This opens the prospect of step-by-step deployment of the effective third-level water-pollution surveillance network in the Atlantic-Mediterranean Maritime Cluster, whose elements are adapted to local conditions and scaled in accordance to the assessed accidental pollution risk, providing this way economically feasible and realizable solutions.

The accidents like the Prestige oil tanker disaster have clearly demonstrated especial vulnerability of the bio-environment of the region in question to the oil spills. As such, the prompt and reliable oil-spill monitoring is believed to compose an important part of further developments in the sphere of Sea economic activities. In this connection, it is worthwhile to note that the results of the described research may be applied to other areas of such activities. In particular, Nd:YAG based LIF LIDAR detector was successfully implemented for studying microphytobenthos biomass of muddy and sandy sediments of the Tagus Estuary, Portugal (Vieira et al., 2011) and assessment of water stress in typical plants of Mediterranean coastal zone (Lavrov et al., 2011).

Acknowledgements

This research has been supported in part by Fundação para a Ciência e a Tecnologia (FCT) in Portugal and the European Union within the framework of the European Coordination Action to Foster Prevention and Best Response to Accidental Marine Pollution, Program Accidental Marine Pollution ERA-NET (AMPERA), Project Detection and Evaluation of Oil Spills by Optical Methods (DEOSOM). The authors are grateful to GALP Energia for providing samples of the crudes.

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Page layout:

Paper size A4, 2,5cm left, right, bottom and top margins.

Document format:

Manuscripts should be submitted in Word file using font Times New Roman and single line spacing. The document should not have more than 25 pages, and a PDF version of the document must be provided.

Author(s) biographic note:

The author(s) biographic note must be in english, on a single page, with a text up to 100 words. The information given should include academic career, present professional position and research interests, if applicable. Should also mention affiliation and personal e-mail address. Use size 11, regular, justified.

Title:

Should be concise and informative, and must be given in portuguese and english with size 15, bold, left aligned and in capital letters.

After title add author(s) name(s) in size 11, italic, left aligned.

Abstract:

The abstract should have between 150 to 200 words and should not contain any undefined abbreviations.

It is necessary a portuguese and an english version, using size 11, regular, justified.

Keywords: up to 4 keywords separated by “,” at the end of the abstract.

An appropriate number of JEL code(s) must be provided with minimum of 2 digits, for example Q01. This classification system is prepared and published by the *Journal of Economic Literature*. For more information, please consult www.aeaweb.org/journal/jel_class_system.html.

Plain Text body:

For plain text body use size 11, regular, justified.

Subtitles 1st level - size 11, bold, capital letters, left aligned;

Subtitles 2nd level - size 11, bold, low case, left aligned;

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Table of Contents:

A Table of Contents should be provided at the beginning of the manuscript. Use size 11, regular, left aligned.

Abbreviations:

Abbreviations should be defined at first mention and used consistently thereafter.

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Footnotes can be used to give additional information. They should not contain any figures or tables and should be in size 8, regular, left aligned.

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Acknowledgments of people, grants, funds, and others, should be placed in a separate section before the reference list. The names of funding organizations should be written in full.

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After quoting a text extract, cite the reference giving only the author's name and publication year in parentheses. Ex: (Flores *et al.*, 1988; Winograd, 1986; Cunha and Cintra, 1996)

But if you are citing the author inside the text, add only the publication year between parentheses.

Ex: Winograd (1986) describes ...

References list:

The list of references should only include works that are cited in the text.

Do not use footnotes or endnotes as a substitute for a reference list.

Reference list entries should be alphabetized by the last name of the first author of each work.

To format reference list use size 11, regular, left aligned.

Ideally, the names of all authors should be provided, but the usage of *et al.* in long authors list will also be accepted.

Ex: Pierzynski, G. *et al.* (1994). *Soils and environmental quality*. Lewis Publishers. Florida.

Scientific article:

Last name of the author, First initial. (Publication year). Article title. *Title of the Journal or Review*.

Volume(Issue): first page-last page.

Ex: Sadiq. M. e Alam, I. (1997). Lead contamination of groundwater in an industrial complex. *Water, Air and Soil Pollution*. **98(2)**: 167-177.

Book:

Last name of the author, First initial. (Publication year). *Book title*. Additional information. Edition number, Publishing house. Publishing place.

Ex: Costa, J. (1995). *Caracterização e constituição do Solo*. 5th edition, Fundation Calouste Gulbenkian. Lisbon.

Book chapter:

Ex: Silko, L.M. (1991). The man to send rain clouds. In: W. Brown and A. Ling (eds.), *Imagining America: Stories from the promised land*. Persea. New York.

Online document:

Last name of the author, First initial. (Publication year). *Document title*. Accessed in: day, month, year, in: URL.

Ex: Chou, L., McClintock, R., Moretti, F. e Nix, D.H. (1993). *Technology and education: New wine in new bottles – Choosing pasts and imagining educational futures*. Accessed in 24th of August 2000, on the Web site of: Columbia University, Institute for Learning Technologies: <http://www.ilt.columbia.edu/publications/papers/newwine1.html>.

Dissertation:

Ex: Tingle, C.C.D. (1985). *Biological control of the glasshouse mealybug using parasitic hymenoptera*. Ph.D. Thesis. Department of Biological Sciences, Wye College, University of London. 375 pp.

Tables, Figures, Graphics and Boards:

All tables, figures, graphics and boards are to be numbered using Arabic numerals and should have a title explaining its components above the body, using size 9, bold, centred.

The source and year of the information given in tables, figures, graphics and boards should be included beneath its body, centred, size 8, regular. For tables and boards contents use size 8.

Figures and graphics must be in JPEG format (image).

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DISCUSSION PAPERS - SPATIAL AND ORGANIZATIONAL DYNAMICS

Com o objectivo de facilitar a publicação dos *Discussion Papers*, solicita-se ao(s) autor(e)s do(s) artigo(s) que, na elaboração dos seus textos, **siga(m) atentamente as normas adiante enunciadas**. Chama-se a atenção de que o artigo deve ser enviado na sua forma definitiva.

Assim, o documento final deve conter as seguintes normas editoriais:

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Os manuscritos devem ser entregues em formato *Word* com a fonte *Times New Roman* e espaçamento simples. O documento não deve ultrapassar as 25 páginas, sendo obrigatório entregar uma versão em PDF do mesmo documento.

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A nota biográfica do(s) autor(es) do artigo deve ser fornecida numa página única, obrigatoriamente em inglês, com um texto até 100 palavras. A informação incluída deve conter o percurso académico, a actual posição profissional e interesses de investigação, se aplicável. Deve também incluir a universidade a que está ligado e o seu endereço de e-mail. Para este texto usar tamanho 11, normal, justificado.

Título:

O título deve ser conciso e informativo em versão portuguesa e inglesa. Usar letras capitais com tamanho 15, negrito e alinhado à esquerda.

Depois do título adicionar o nome(s) do autor(es) em tamanho 11, itálico, alinhado à esquerda.

Resumo:

O resumo deve ter entre 150 a 200 palavras e não deve conter nenhuma abreviatura, sendo obrigatório uma versão em português e outra em inglês em tamanho 11, normal, justificado.

Palavras-chave: indicar até 4 palavras-chave separadas por “,” no fim do resumo.

Também deve ser indicada a classificação JEL que tem que ser específica a 2 dígitos no mínimo, por exemplo Q01. Este sistema de classificação é preparado e publicado pelo *Journal of Economic Literature*.

Para o efeito consultar www.aeaweb.org/journal/jel_class_system.html.

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Para o corpo de texto comum usar tamanho 11, normal, justificado.

Subtítulos 1º nível - tamanho 11, negrito, letras capitais, alinhado à esquerda;

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No início do documento deve constar um índice em tamanho 11, normal, alinhado à esquerda.

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As abreviações, aquando da sua primeira menção, devem ser escritas por extenso entre parêntesis e usadas coerentemente a partir desse ponto.

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As notas de rodapé devem ser usadas para fornecer informação adicional. Não podem conter imagens ou tabelas e devem ter tamanho 8, normal, alinhadas à esquerda, sendo sempre numeradas consecutivamente. Notas de rodapé relativas ao título devem ser indicadas com o símbolo (*).

Não é permitido o uso de notas de fim de texto.

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Agradecimentos e dedicatórias devem ser colocados numa secção separada antes do início das referências bibliográficas. Siglas de organizações e afins devem estar escritas por extenso.

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Ao citar excertos de texto, adicione as referências no fim do mesmo, mencionando apenas o último nome do autor e o ano de publicação da obra entre parêntesis.

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Artigo científico:

Último nome do autor, Primeira inicial. (Ano da publicação). Título do artigo. *Título da obra*.

Volume(Número): primeira página-última página.

Ex: Ramírez, P.M., Castro, E. e Ibáñez, J.H. (2001). Reutilização de águas residuais depuradas provenientes da ETAR de Albacete (S.E. Espanha) em campos hortícolas. *Tecnologias do Ambiente*. 44(2): 48-51.

Livro:

Último nome do autor, Primeira inicial. (Ano da publicação). *Título do livro*. Informação adicional. Nº da edição, Editora. Cidade da publicação.

Ex: Costa, J. (1995). *Caracterização e constituição do Solo*. 5ª edição, Fundação Calouste Gulbenkian. Lisboa.

Capítulo de livro:

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Dissertação de Mestrado ou Doutoramento:

Ex: Tingle, C.C.D. (1985). *Biological control of the glasshouse mealybug using parasitic hymenoptera*. Ph.D. Thesis. Department of Biological Sciences, Wye College, University of London. 375 pp.

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Todas as tabelas, figuras, gráficos e quadros devem ser numerados com numeração árabe e devem ter um título explicativo antes do seu conteúdo em tamanho 9, negrito e centrado.

A fonte e ano da informação fornecida deve ser colocada abaixo do respectivo corpo, centrado, com tamanho 8, normal.

Para o conteúdo das tabelas e quadros deve ser usado o tamanho 8.

Figuras e gráficos devem ser fornecidos em formato JPEG (imagem).

CIEO

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This special issue was produced with the support of KIMERAA project, co-financed by Atlantic Area Transnational Programme 2007-13 under the ERDF - European Regional Development Fund.