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DESENVOLVIMENTO SUSTENTÁVEL DO OCEANO: UMA UTOPIA ÚTIL

SUSTAINABLE DEVELOPMENT OF THE OCEAN: A NECESSITY

Editores

Maria João Bebianno
João Guerreiro
Telmo Carvalho
Maria Inês Gameiro

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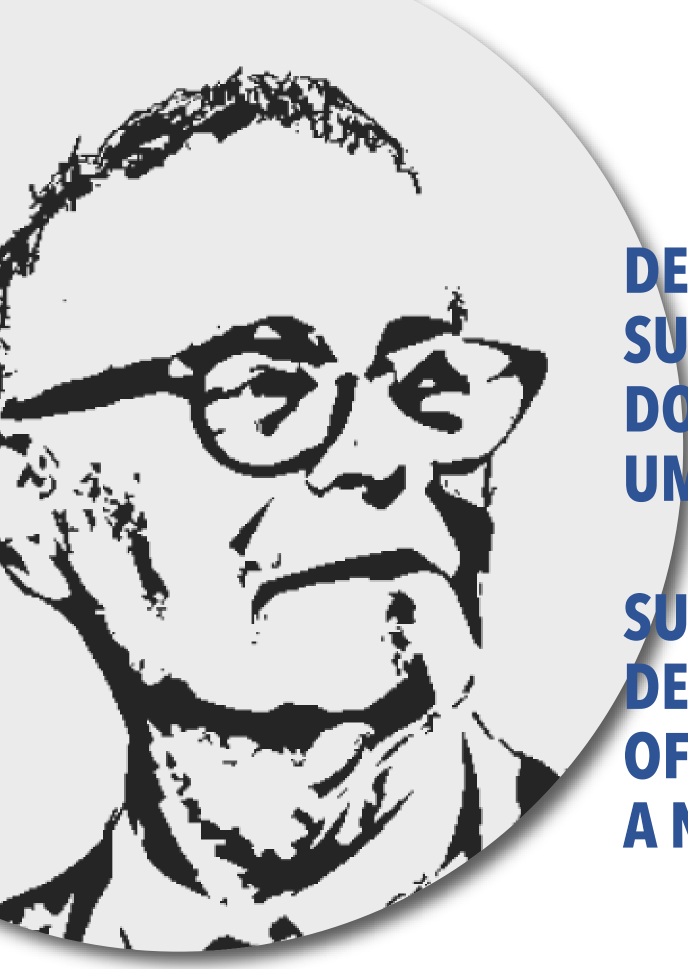

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NOTA DE APRESENTAÇÃO

O desaparecimento do Professor Mário Ruivo, após décadas de dedicação às problemáticas do oceano, representou uma perda para toda a comunidade científica. A dimensão do seu prestígio internacional e da sua capacidade de intervenção criou, com o seu desaparecimento, um vazio difícil de colmatar.

O Centro de Investigação Marinha e Ambiental (CIMA), da Universidade do Algarve, entendeu dinamizar uma reflexão abrangendo os temas do oceano e contribuindo, dessa forma, para honrar a memória de Mário Ruivo. Para tal, o CIMA desafiou os centros de investigação das universidades portuguesas que incidem as suas pesquisas nestas problemáticas, e que reconheciam a figura de Mário Ruivo como o grande impulsionador da investigação científica na área das ciências do mar, para se associarem a esta iniciativa.

O resultado deste desafio pode agora ser apresentado. Um conjunto de textos que refletem o "estado da arte" da investigação em ciências do mar realizada pelos centros de investigação das universidades portuguesas. A anteceder essas contribuições, recolhem-se as diversas intervenções destinadas a evidenciar a personalidade de Mário Ruivo, proferidas na primeira sessão da Conferência Internacional que recuperou um dos seus criativos pensamentos: "Desenvolvimento Sustentável do Oceano: uma Utopia Útil".

Mário Ruivo integra a galeria dos Doutores *Honoris Causa* da Universidade do Algarve.

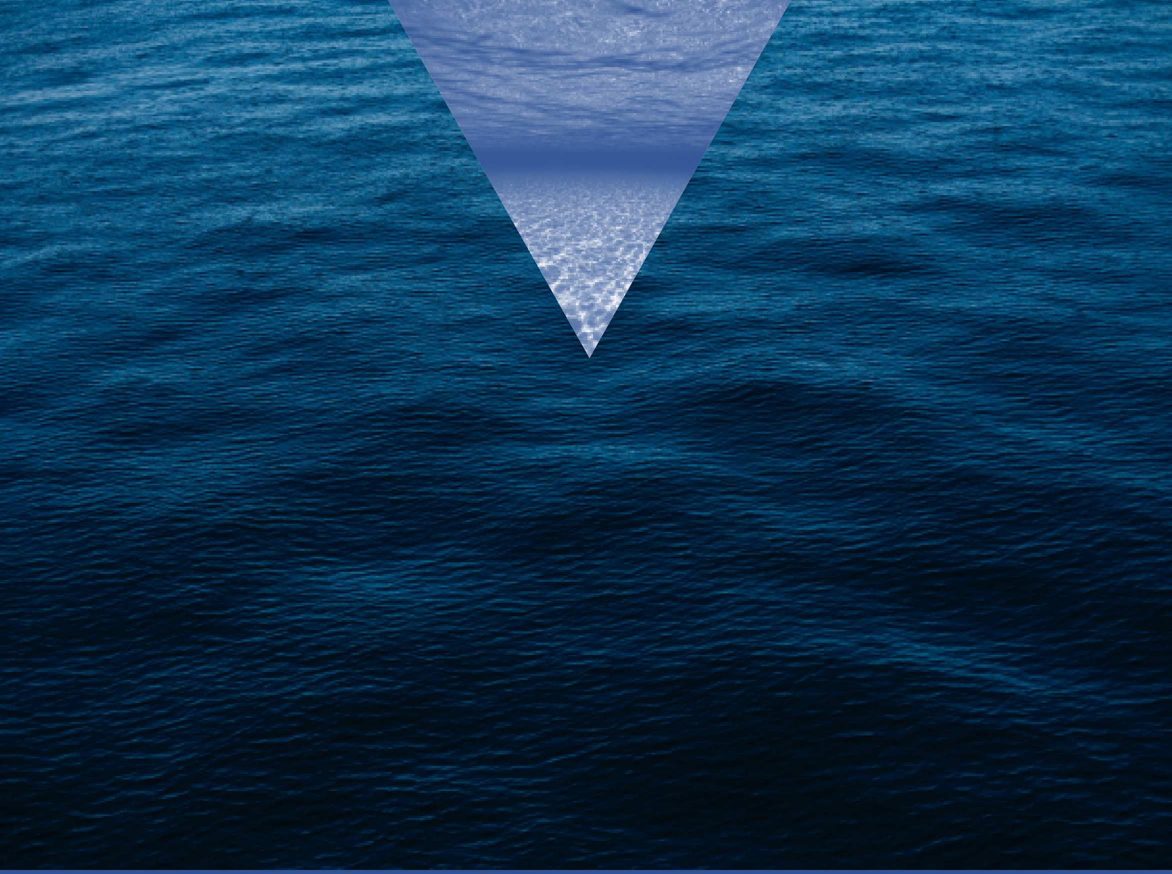
INTRODUCTORY NOTE

The disappearance of Professor Mário Ruivo, after decades of dedication to the problems of the ocean, represented a loss for the entire scientific community. The size of its international prestige and its capacity to intervene has created a vacuum that is difficult to overcome.

The Center for Marine and Environmental Research (CIMA), of the University of the Algarve, aimed to stimulate a reflection covering the ocean themes and thus contribute to honor the memory of Mário Ruivo. To this end, the CIMA challenged the marine research centers of the Portuguese universities that focus their research on these issues, and recognized the figure of Mário Ruivo as the great promoter of scientific research in the field of marine sciences, to be associated with this initiative.

The result of this challenge can now be presented in this e-book. A set of texts that reflect the "state of the art" of marine sciences research carried out by the research centers of the Portuguese universities. Prior to these scientific contributions, there were various interventions designed to highlight the personality of Mário Ruivo, during the first session of this International Conference, where and one of his creative thoughts has been taken up: "Sustainable Development of the Ocean: a Necessity."

Mário Ruivo is part of the *Honoris Causa* Doctors gallery of the University of Algarve.



SESSÃO DE HOMENAGEM AO PROFESSOR MÁRIO RUIVO

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HOMAGE SESSION TO PROFESSOR MÁRIO RUIVO

Mensagem de Sua Excelência o Presidente da República

Marcelo Rebelo de Sousa

Saúdo muito calorosamente a Universidade do Algarve, na pessoa do seu Magnífico Reitor, Professor Doutor António Branco, por esta feliz e oportuna iniciativa de promover uma Conferência de Homenagem a Mário Ruivo.

Falecido há cerca de um ano, o Professor Mário Ruivo é um nome pioneiro da salvaguarda dos oceanos e do património marinho, que se destacou na vida pública portuguesa pelo seu inestimável contributo para a defesa do ambiente e da qualidade de vida do nosso País.

Mário Ruivo, além disso, ou a par disso, um cidadão política e civicamente empenhado na condução dos destinos do Portugal que tanto amou, tendo exercido um papel notável na afirmação e na consolidação da democracia e das liberdades dos nossos concidadãos.

Aliava, como poucos, um espírito científico admirável e um compromisso firme e inequívoco com causas comunitárias, confluindo esses dois traços do seu carácter numa luta incessante pelos direitos dos portugueses e, mais especificamente, o direito a um ambiente mais sadio e mais vocacionado para proteger as aspirações legítimas das futuras gerações.

Pelo muito que nos deu num passado recente, a memória do Professor Mário Ruivo deve ser evocada nos tempos que vivemos, em homenagem ao cientista, ao homem público e ao cidadão, mas também como gesto de gratidão e reconhecimento das gerações presentes e vindouras.

Marcelo Rebelo de Sousa

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In memoriam de um grande humanista: a utopia e o desassossego

António Branco

Exma. Senhora Ministra do Mar, Engenheira Ana Paula Vitorino
Exmo. Senhor Presidente da Câmara Municipal de Faro, Dr. Rogério Bacalhau
Exma. Senhora, Professora Maria Eduarda Gonçalves
Exmo. Senhor Antigo Secretário Geral da Comissão Oceanográfica Intergovernamental da UNESCO, Dr. Patrício Bernal
Exmo. Senhor Diretor Executivo da EuroOcean, Professor Ned Dwyner
Exmo. Senhor Representante do Conselho Nacional do Ambiente e Desenvolvimento Sustentável, Professor João Guerreiro
Exmos. Senhores Membros da Equipa Reitoral
Exmos. Senhores Diretores de Unidades Orgânicas
Exmas. Autoridades Militares e Forças de Segurança
Exmos. Docentes, Investigadores e Funcionários
Exmos. Alunos
Minhas Senhoras e meus Senhores

Em dezembro de 2016, realizámos, na Universidade do Algarve, a cerimónia de atribuição do título de Doutor Honoris Causa ao Professor Mário Ruivo. E a rara grandeza dessa cerimónia não se ficou a dever apenas à especial solenidade desse elevado ritual de integração académica: também se deveu – e talvez sobretudo, neste caso – à grandeza intelectual, científica e pessoal do Professor Mário Ruivo, que tão generosamente aceitou fazer parte do nosso corpo de doutores. Por isso me pareceu não só natural como dever nosso a realização, na Universidade do Algarve, desta conferência de homenagem, menos de um ano depois do seu tão por nós sentido desaparecimento.

O tema da Conferência, «Desenvolvimento Sustentável do Oceano: uma utopia útil», tal como o desenho dos temas dos seus painéis de debate científico, obedeceu a dois princípios orientadores: em primeiro lugar, quisemos sublinhar a marca indissolúvel que a ação e o pensamento do Prof. Mário Ruivo deixou, ao longo de décadas, na definição estratégica do que deve ser a nossa relação com o Mar, sendo particularmente relevante o uso da palavra «utopia» nesse âmbito; em segundo lugar, pretendemos desdobrar esse tema principal em questões setoriais alinhadas com aquele pensamento e ação mas também com a estratégia nacional para a chamada Economia Azul, incluindo as preocupações com a questão da Plataforma Continental. O resultado foi um programa sucessivamente dedicado ao Direito do Mar; à Observação e Tecnologia no Oceano; aos Recursos Marinhos, à sua exploração, e à sua relação com a Biotecnologia Marinha; e, finalmente, ao problema grave e premente dos riscos das Alterações Climáticas e suas consequências para todos nós e para o planeta.

Para tal, pudemos contar com a colaboração de ilustres moderadores de painéis, a quem agradeço desde já a sua disponibilidade para nos acompanhar nestas jornadas. E gostaria, ainda, de destacar a presença, na sessão de encerramento, do Professor Luís Magalhães que, para além de ter sido presidente do Conselho Geral desta Universidade, foi testemunha privilegiada do percurso excecional do Professor Mário Ruivo.

Na realidade, ao desenharmos o programa que descrevi, em estreita colaboração com a Professora Eduarda Gonçalves – a quem aproveito para agradecer especialmente o apoio inestimável que nos deu –, obtivemos uma espécie de mapa das preocupações, das questões e das ideias centrais em que o pioneirismo devoto do Professor Mário Ruivo, associado à força do sonho de que sempre revestia não só os projetos de que foi responsável mas também os tantos outros que ajudou a desencadear, fez Escola.

E quando homenageamos o Professor Mário Ruivo é disso que falamos: de um legado que, repito, fez Escola no mais profundo sentido do termo. Uma Escola explícita alicerçada na relação de orientação e coordenação que manteve com centenas de investigadores, técnicos e, até, decisores políticos; uma Escola implícita no impacto indireto que teve em muitos que não tiveram o privilégio de contactar ou debater diretamente com ele sobre as questões que o desassossegavam.

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E assim cheguei aos dois conceitos que me parecem nucleares no exemplo indelével do Professor Mário Ruivo e que queria hoje destacar: o conceito de Utopia e o conceito de Desassossego.

O primeiro, a Utopia, muito desvalorizado por uma sociedade de consumo extremamente materialista, tem vindo a ser erroneamente conotado com a ideia negativa da «fantasia irrealizável»; o segundo, o Desassossego, tem vindo a perder a sua função impulsionadora, por ser bastas vezes preterido a favor de comportamentos de atividade *desenfreada e meramente reativa* ao curso do presente.

Ora, tanto a ancoragem da ação na Visão Utópica quanto a atitude de permanente Desassossego, que estavam tão presentes no Professor Mário Ruivo, emergem de uma região mais profunda do Ser, assim contribuindo para encorpar e densificar a atividade intelectual que está no cerne da atividade científica. Aliás, são essas as duas propriedades que fazem convergir um António Damásio, uma Sophia de Mello Breyner, um Albert Einstein, um Platão ou uma Marie Curie, entre muitos outros exemplos que poderia dar, são essas as duas propriedades intrínsecas, dizia eu, que fazem convergir essas personalidades maiores para um mesmo território em que, afinal, todos se colocam diante das mesmas grandes questões suscitadas pela Vida e pelo Meio em que ela se desenvolve.

E era igualmente nesse território comum a grandes cientistas, grandes filósofos e grandes artistas que se situava o pensamento e a intervenção do Professor Mário Ruivo, como pude testemunhar nos vários momentos em que, na qualidade de reitor, tive o privilégio de conversar com ele ou de presenciar as suas intervenções públicas, sempre muito simples, muito intensas e embebidas na visão utópica e desassossegada que tinha inscrita na sua matriz intelectual. E, por isso, o Professor Mário Ruivo foi, para mim, um exemplo de cientista humanista, na medida em que, àquelas duas qualidades a quem me referi, juntava uma visão integrada dos problemas na sua dimensão científica, tecnológica, económica, humana e social – o que faz com que o seu legado tenha que ser estudado, igualmente, no domínio da Cultura.

O motivo pelo qual quis sublinhar, na minha intervenção, estas vertentes do património que o Professor Mário Ruivo nos legou, foi porque, enquanto investigador da área das Artes e Humanidades, mas também no exercício do cargo de reitor, não me tenho cansado de chamar a atenção para a necessidade de nunca perdermos de vista o enquadramento dos problemas que tratamos e das respostas que lhes vamos dando numa *visão Humanística do Conhecimento*. É que essa visão, que compreendi ser aquela que orientava o Professor Mário Ruivo, tem a enorme vantagem de proporcionar uma perceção mais aguda dos próprios problemas, conferindo, assim, uma melhor adequação, utilidade civilizacional e longevidade às soluções encontradas para os resolver.

Oxalá, portanto, essa lição maior da vida e da intervenção do Professor Mário Ruivo continue a inspirar os cientistas, os técnicos e os pensadores desta e de outras Universidades e das instâncias de decisão económica e política em que se reflete sobre as grandes questões dos Oceanos, para as quais nos deixou tão lúcidas, visionárias e rigorosas orientações.

Desejo-vos duas excelentes jornadas de reflexão e debate, sob a influência da memória de tão grande Homem.

Mário Ruivo: um cientista com espírito livre e democrático

Rogério Bacalhau Coelho

Magnífico Reitor da Universidade do Algarve, Prof. Doutor António Branco
Exma. Sra. Ministra do Mar, Eng.ª Ana Paula Vitorino
Caros colegas da Mesa
Exmas. Autoridades Civis, Diplomáticas, Militares e Religiosas
Cumprimento, igualmente, todos os Membros da Comunidade Académica aqui presentes
Senhores palestrantes
Senhoras e Senhores

Em primeiro lugar, é para mim uma honra e um prazer estar com a comunidade académica, seja em que ocasião for.

Hoje, essa honra e esse prazer dão lugar a genuína emoção, em função da solenidade da ocasião que nos é dado participar.

Com efeito, a homenagem que hoje prestamos ao Prof. Mário Ruivo é daquelas cerimónias que não poderia ser mais justa, tão colossal foi o seu contributo no âmbito do conhecimento e da cidadania.

Devemos, por isso, antes de mais, saudar a Reitoria da UAlg, bem como o CIMA pela oportunidade do gesto, lembrando que, antes mesmo de o Prof. Mário Ruivo nos ter deixado, já a nossa comunidade académica lhe rendia um justo reconhecimento, acolhendo-o no seu seio através da concessão do Doutoramento Honoris Causa.

Estamos por isso, todos, particularmente confortáveis neste momento em que reiteramos o nosso agradecimento e admiração pela vida e pelo trabalho de Mário Ruivo.

Nesse memorável dia da Universidade de 2016, dizia o *novo doutor*, que o seu “interesse pelo Mar foi, em grande parte, motivado pelo desejo de melhor entender o comportamento da nossa espécie face à Natureza”.

E foi de facto isso que procurou, ao longo de uma vida dedicada à descoberta e preservação do "Mar / Oceano", imagem humanista que usava com muita frequência…

… Uma procura que começou quase desde o dia em que viu o mar pela primeira vez, aos 7 anos de idade.

Mas sobre o seu inigualável curriculum e sobre a vasta listagem dos feitos científicos realizados e das suas descobertas, haverá hoje quem possa produzir palavras mais autorizadas.

Hoje, é também o seu espírito livre e democrático, que nos interessa louvar.

Um espírito que se expressou em momentos difíceis – justamente quando a emissão de uma opinião livre podia ser severamente penalizada.

Foi assim, ainda como estudante, quando integrou o MUD.

Foi assim quando colaborou na Seara Nova, realizando a partir daí incontáveis serviços à causa das liberdades colectivas e individuais.

E tudo isso lhe valeu a penalização do regime de então, que insistia em não libertar um lugar nas universidades portuguesas, obrigando Mário Ruivo a um exílio pelo estrangeiro.

A defesa da democracia e da livre opinião era, por então, um crime severamente punido.

Também por tudo isso, homenagear Mário Ruivo é lembrar a sua coragem (até física) que contribuiu para a construção de uma consciência cívica, colectiva, moderna e esclarecida.

Foi, em resumo, um brilhante cientista consciente da contribuição da ciência para o bem-estar e justiça social.

Ficam, para usufruto de todos, estes exemplos, a que se somam uma elevada sensibilidade humanista e o alto valor do seu contributo para a investigação do seu "Mar / Oceano".

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Caras e caros Amigos,

O tema da conferência de hoje justifica que vos deixe uma última palavra.

As ciências do mar têm sido um dos sustentáculos das actividades da UAlg.

Nada mais consonante, tendo em conta o carácter costeiro da sua localização e, bem assim, a dependência histórica que a nossa Região tem do Mar.

Hoje, a generalidade dos cidadãos assumiu já que o futuro das nossas comunidades, quase todas elas, está ligado ao Mar.

Esta é uma primeira vitória da estratégia atlântica caucionada também pelo nosso Prof. Mário Ruivo.

Até há poucos anos, como se lembrarão, não era assim.

Faro, em particular, mantinha mesmo uma estranha atitude – que muitos designavam como "de costas voltadas para o mar".

Felizmente, estamos todos a empreender uma viragem decidida, de modo a que possamos estar finalmente preparados para abraçar a nossa condição ribeirinha.

Agora, há que consolidar os processos e andar mais longe em todos os âmbitos da Estratégia do Mar:

- dos Portos aos transportes,
- passando pela consciência do ambiente e da preservação dos recursos,
- sem esquecer a náutica de recreio, a pesca e, claro, a criação de condições para mais e melhor produção de conhecimento.

Os processos de reconversão dos espaços ribeirinhos, dos equipamentos e infra-estruturas náuticas são, nesse âmbito, prioridades que não devemos protelar.

São, na verdade, conquistas tão importantes para as comunidades algarvias como o são também para a universidade e seus centros de investigação.

Por isso, e bem no seio da nossa vibrante comunidade académica, eu deixaria um apelo para que possamos intensificar esta dimensão da nossa cooperação, permitindo que os cidadãos algarvios possam beneficiar ainda mais dos vossos valiosos contributos.

Emprestar o vosso know how a esta causa é robustecer o processo e tornar o espaço que vos acolhe um meio mais fértil para a vossa investigação e, também… para a continuação do desenvolvimento sustentado do prestígio da nossa Universidade.

O *Crescimento Azul,* que tantas e tão eloquentes intervenções ocasionou, tem mesmo que passar das bonitas palavras à realidade concreta dos actos, com expressão na vida de todos.

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Isto é, afinal, o que o nosso querido homenageado de hoje sempre procurou, com fervor científico e cidadão.

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Contributions of Professor Mário Ruivo to the Governance of the Global Ocean: an Unfinished Business

Patricio A. Bernal

Magnificent Reitor
Querida Maria Eduarda
Distinguished Authorities, Academics and guests
Colleagues and friends
Ladies and gentlemen

Sr Reitor, I sincerely thank your kind invitation to be with all of you on this special occasion to lend public recognition to the vision, dedication and service that Professor Mário Ruivo gave to the cause of a sustainable, just and equitable use of the Ocean and its resources.

At the end of last year, it was with great emotion that I witnessed through a photograph, the investment of Mário Ruivo as Doctor Honoris Causa of your University[1] the 14 of December 2016. That photograph was also the material confirmation of an image that I had of Mário as a genuine follower in the tradition of the *Grandes Navegadores Portugueses of the XV Century.* Wearing the traditional gown and hat, Mário looked unmistakably as *a Grande Navegador Português of the XX Century.* I will try to give today a brief account of the national and international navigations he made.

Allow me first tell you about my relationship with him. Mário was my friend, my colleague but also my mentor. During his tenure, as Executive Secretary of the Intergovernmental Oceanographic Commission (IOC), in the eighties, he delegated on me the responsibility of representing the Commission in several scientific and policy related

[1] Doutoramento Honoris Causa Mário Ruivo, Honoris Causa, Universidade do Algarve 2017, 42 p.

events around the world. I had returned to Chile, my country, after finishing my graduate studies of Oceanography in California. During those days Chile lived under the brutal military dictatorship of Pinochet and whenever we met with Mário, he inquired not only on my academic duties on the political situation and the work of the many Chileans that were fighting to recover democracy. Based on his own and very personal experience he offered counsel and advise that I always carefully considered.

Mário Ruivo was a scientist, but also a true humanist and democrat with a trajectory as a fighter against oppression from his early youth. He combined his broad knowledge of many subjects with a socio-political view of history and of the contemporary world. In fact, he had a sharp political instinct that often he had a hard time in taming it into political wisdom. When pushing forward a difficult initiative, he knew how to recognize when it was time to wait and when the time to act. Most of the time we agreed on what to do, but there were occasions where we did not. Those few instances of disagreement never put in danger our friendship.

I can call him unmistakable my mentor, since in my early career as a scientist, he called on me to represent IOC as an expert, something that gave me an opportunity to maintain and enlarge my research horizons. But he did play a key role in my later career, when he persuaded me to apply to the post of Executive Secretary of the IOC. He not only persuaded me, but also send me to Chile the application forms! He told me *"Patricio, you have the perfect combination of a strong recognition as a scientist, and experience as a politician"* since after recovering democracy in Chile, I had served in a cabinet post in the Government as Under Secretary of State for Fisheries. He became a staunch advocate and organizer of my successful candidature.

I want to share with you a reminiscence that reflects well our relationship. On one occasion, at the end of the Pinochet regime, when I expressed to Mário my optimism on the process of rebuilding democracy in Chile, after the plebiscite that Pinochet lost in 1988, to my surprise, he carefully warned me, to tone down my optimism, and recalling his experience in Portugal, told me that recovering democracy is a hard and often a harsh process, adding a phrase that I have never forgotten: "*Patricio, people after many years of living under dic-*

tatorship, carry a little "dictator" here in his occipital, touching the back of his head, *that is very difficult to remove*". I must say, with the benefit of hindsight, that he was profoundly right.

***

Mário was very active building new institutions to coordinate ocean related activities in Europe and Portugal, endeavours in which we also cooperated. They will be reviewed in detail by others participants in this Conference. I will restrict my comments to those initiatives that, in my view, had far reaching impact at the highest global level.

The Negotiations of the Law of the Sea

Having lead the Portuguese delegation to the discussions on the United Nations Convention on the Law of the Sea (UNCLOS), Mário actively participated and influenced especially the drafting of part XIII on Marine Scientific Research, in particular its Article 247, and Part XIV on the Transfer of Marine Technology. In the dynamic of the negotiations of a package with dissimilar contents like UNCLOS, during the Third Conference on the Law of the Sea '*quid pro quo*' transactions had to emerge. Parts XIII and XIV are a good example. With the aim of protecting the economic rights vested on the coastal states by the new Economic Exclusive Zone jurisdiction, Part XIII regulates the conduct of Marine Scientific Research inside the EEZ; in fact, one of the freedoms preserved in Part VII for the High Seas.

Since most developing nations did not have the capabilities to conduct scientific research in distant waters, the protections and guarantees in Part XIII affected predominantly research conducted by developed nations inside the EEZ of coastal states, research that could reveal or prospect for potential resources. On the other hand, Part XIV tried to build a legal arrangement to level the ground of capabilities for accessing to marine resources by exhorting all nations of the world to cooperate in the transfer of marine technology under *"fair and reasonable terms and conditions"* (Art. 266.1), and to *"foster favourable economic and legal conditions for the transfer..."* (Art. 266.3).

At the time of these negotiations, for developing countries, that had recently established the Group of 77, the context for Part XIV was

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provided by the larger discussion on equity in international economic affairs taking place under the UN Conference on Trade and Development (UNCTAD)[2]. Part XIV was drafted and was seen as a sort of promise of large country-to-country programs of transfer of marine technology that would open the access to marine resources, specially mining. Developed countries interpreted Part XIV, quite differently, as being part of the more general commitment to cooperate; something that they felt already did under multilateral and bilateral agreements.

After more than forty years from the UNCLOS negotiations, it is fair to say that in most cases it has been the private sector and not the states the key actor in negotiating the transfer of technology for the exploitation of marine resources, usually as a transaction in compensation for being granted access under favourable economic conditions to the resources of coastal states.

Most coastal nations do not have the specialized skills, expensive infrastructure and financial means to access the High Seas and its resources. Therefore, in practice, the effectiveness of the approach adopted in negotiating the Convention, giving states the main role of enforcing it, relies on the commitment and engagement of those nations that possess the assets and capabilities to do so. However, for this very same reason the treatment that UNCLOS does of the High Seas also raises basic questions of equity.

Having played a major role from FAO and from the IOC to put the Law of the Sea into practice, Mário was quite aware of these limitations. This is well reflected in all his career.

The big plot of two Mário's that change the general public perception of the Ocean

Next year is the 20th anniversary of the Lisbon Declaration and the launching of the Report of the Soares Commission[3] at the end of

[2] The UN General Assembly had adopted the 1st of May 1974 a strong Declaration containing a series of principles promoting a New International Economic Order (UN A/RES/S-6/3201, 1974).

[3] Created in 1995 its Report *The Ocean—Our Future*, released in 1998 (IWCO 1998) the Commission reviewed the existing situation of the order of the Ocean and reviewed future directions for improving its management.

the Lisbon EXPO-98, summarizing the work of 4 years of the Independent World Commission of the Ocean, presided by Mário Soares and organized and powered by the energy and vision of Mário Ruivo. The careful timing of these all these events *did not happen spontaneously*. They were the result of probably long brain-storming sessions between these two Mário's, that in an ambitious almost utopic vision, imagined a chain of parallel initiatives, that lead or promoted by Portugal, would eventually bear fruit and made all these things possible.

In 1989 the National Committee for the Commemoration of the Portuguese Discoveries had been requested by the Government[4] to come up with an idea for a World Expo in Lisbon after the Expo Seville. In 1992, the General Assembly of the *Bureau International des Expositions* finally endorsed the call for EXPO 98 to be held in Lisbon, the first World specialized exhibition on the Ocean, under the title *The Oceans: A Heritage for the Future.* EXPO 98 held in Lisbon, as we all know, was a resounding success with the participation of 143 countries, seeding in the Portuguese society a renewed interest for the Ocean, that we can see today reflected in the remarkable strength of Portuguese ocean sciences, among many other accomplishments.

Mário Ruivo, as the Portuguese delegate to IOC, proposed in Paris to Declare 1998 the International year of the Ocean, and to take this proposal to the General Assembly of United Nations. He also advocated the organization of the *Second Oceanographic Conference in Lisbon* in 1994[5]. The purpose of this Conference was to analyse the implications for the Ocean of recent technological progress and the new paradigms for development emerging from the Brundtland Report *Our Common Future* and from the 1992 United Nations Conference of Environment and Development in Rio de Janeiro, summarized in *Agenda 21*.

The Second International Conference on Oceanography - Lisbon 94[6] was convened, at the invitation of the Government of Portugal in

[4] Mário Soares was at that time the 17th President of Portugal.

[5] The First Oceanographic Conference, celebrated in the Danish Parliament in 1960, recommended to UNESCO the creation of the IOC.

[6] IOC (1995) Draft summary report of the Second International Conference on Oceanography - Lisbon 1994 - *Towards Sustainable use of Oceans and Coastal seas.* IOC-XVIII/Inf.3 Agenda item 6 Paris, 14 June 1995.

the Centro Cultural de Belém, almost simultaneously with the coming into force of the United Nations Convention on the Law of the Sea, a lucky and most likely not innocent coincidence. The Conference was opened by its Chairman Dr. Mário Ruivo in November 14, 1994. Two days later, thanks to the ratification of by Guyana one year before, UNCLOS came into force the 16 of November of 1994[7].

A few weeks later the United Nations General Assembly, acting on a suggestion from the IOC, on the initiative of Portugal, declared the year 1998 to be *The International Year of the Oceans.*

In parallel, to these events, the Independent World Commission of the Ocean (IWCO), under the Chairmanship of Mário Soares, was created in 1995 as a forum and a think-tank where the new and many emerging governance issues of the Ocean could be discussed openly, without the immediate and official participation of states. If the International Year of the Ocean and EXPO98 provided the theatre, the Commission was supposed to write the play.

Some Innovations in Ocean Governance that took root in 1998

Thanks to the work of Mário Ruivo during his tenure at the helm of the IOC, his successor Gunnar Kullenberg and many others working from within and outside of the UN system, *Chapter 17 of Agenda 21*[8]*,* approved in Rio at the level of head of States in 1992, contains a comprehensive scientific and technical prescription for the integrated development of the ocean environment

During the UN International Year of the Ocean in 1998, high-level national legislation with long-term management implications were initiated or promulgated, most notably in Australia, Canada, and

[7] Guyana was the 60th nation ratifying UNCLOS, the number needed for its entry into force.

[8] UN (1992) AGENDA 21. Chapter 17. *Protection of the oceans, all kinds of seas, including enclosed and semi-enclosed seas, and coastal areas and the protection, rational use and development of their living resources*. In: Report of the United Nations Conference on Environment & Development - Rio de Janeiro, Brazil, 3 to 14 June 1992.

the USA. (IOC, 2007). In a major Conference that took place in Monterrey, presided by Al Gore, the USA lay down a blueprint for its national Ocean Observing System and for improving its fisheries and coastal management. The majority of these texts introduce the concept of integrated management, defining standards that should guide policy development in a process leading to integration across sectors and jurisdictions.

Obtaining the agreement of states on all these initiatives was not easy. In an important but very little-known recognition, the delegate of the USA to IOC, Stanley Wilson, in a private reception at the American Embassy in Paris, recognized the farsighted vision of Mário Ruivo and Portugal, in proposing the International Year of the Ocean, despite the fact the USA delegation had questioned the idea and considered it with great scepticism.

The need to formulate integrated or at least coordinated policies for managing the ocean, originates from a basic fact: The ocean is much more than its boundaries, it is a huge three-dimensional body of fluid. Integrated policies are a consequence of the closely interconnected nature of ocean processes, that as Elizabeth Mann-Borgesse used to remind us, do not fit well with the traditional legal precepts of "*Westfalian*" sovereignty. Fish populations and pollutants do not respect borders. In a turbulent ocean, any particle that is here today, offshore Faro, has a non-zero probability to be in any other place of the ocean in the future. A molecule of CO_2 that sinks into the deep ocean around the Antarctic, can upwell in the Equatorial zone 100 years later. This was captured in the Lisbon Report and Declaration by meticulously using the word *Ocean* always in singular, never in plural. To make crystal clear this change of paradigm, with the intention of putting to rest geo-political theories of ocean spaces and sea-spaces, later at the IOC we came up with the lemma *"One Planet, One Ocean"*.[9]

[9] Although we tend to forget it, our Earth is the only planet in the known universe with water in liquid state on its surface, and 97% of all that water is in the Ocean. This is probably the main reason why there is life on Earth.

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The Lisbon Declaration

The Report of the Independent World Commission of The Ocean and the Lisbon Declaration provided a true *"roadmap"* for progressing on the Sustainable use of the Ocean. At the highest and most ambitious policy level, the Lisbon Declaration of 1998 stated "*If the ocean is to be governed in a democratic spirit, we must overcome the limitation of the present legal and institutional framework, in order to permit it to respond to changing conditions* ", although I have no direct evidence to say it, I can see the hand and feel the spirit of Mário Ruivo writing that paragraph of the Lisbon Declaration.[10]

In 2008, commemorating the 10th anniversary of the Lisbon Declaration, facing the slow movement of initiatives, working in a small drafting team lead by Mário, we added: *Problems emerge; circumstances change as the conditions in the use of the ocean evolve. However, the dynamics of adjustment to this process of evolution have been slow, uneven, and often dysfunctional. This disappointing record is due in part to a traditional sectoral approach, insufficient linkages between national, regional, and international institutions as well as their intrinsic weaknesses.*

Efforts to design horizontal integrated policies in ocean affairs had faced resistance from the strongly vertical structure of the political systems of management currently in place. Coordination of policies across national ministries is not regular nor standard practice in government. On the contrary, since the establishment of a ministry is a high level political decision, that reflects a division of power, or conversely reflects the new empowerment of a sector or constituency, Ministries and Ministers have an intrinsic drive to exert that power and are refractory to acquiesce into sharing part of that power through coordination.

Nevertheless, and despite the difficulties, a horizontal treatment across sectors of ocean issues, has made significant inroads in the institutional arrangements of nations.

[10] The Report also tackled more controversial and politically risky issues, like the recommendation, on page 17 of the English version, to enrol the navies of the world to enforce International law in the Ocean. The addition of this paragraph, forced the reserve and abstention of the USA Commissioner at the adoption of the Report, Representative Kennedy, since this was not official US policy.

Creating Ocean Citizenship, the pending task

I have called elsewhere[11] the relationship between The Ocean, UNCLOS and civil society, as a broken link. Ocean dwellers are a distinct, tiny minority of the human population. There are very few human activities that are truly oceanic in nature: national navies, and commercial shipping crews, mariners and long-distance fishermen are probably the human beings that spent most of their lives "out at sea", roaming in the High Seas. They constitute highly specialized, cohesive and isolated "guilds" that follow old "corporative" traditions. Sociologically and politically this fact has huge consequences both for our collective perception of the ocean and for the effectiveness of the institutions and jurisdictions created to provide governance and stewardship to the different ocean spaces. Mário Ruivo used to repeat me when confronting difficulties in rallying the political will of nations for the protection of the Ocean: *"Patricio the problem is that we are and we'll always be terrestrial animals*".

The rights and responsibilities that modern states give to citizens, closing the loop of accountability for elected and designated officials, for the Ocean, are certainly not embodied in these minority groups. There are no true citizens of the ocean empowered to exert that function.

Faced with this reality, and lacking the political will to create a body empowered with the authority to exert at least some of the functions of modern states for the high seas, the negotiators of the law of the sea entrusted these obligations collectively to nation-states. This fundamental decision is in stark contrast to the treatment that UNCLOS gave to the bottom of the sea in Part XI under the principle of "*the common heritage of mankind*".

Although the exhortation in UNCLOS is for the collective, cooperative, concerted action of all nations, in practice this responsibility is delegated in different circumstances to individual states: acting as coastal-states, flag-states and port-states. This means that is through

[11] Bernal, P.A. (2015) State Ocean Strategies and Policies for the Open Ocean. *Chapter 3*, in H. D. Smith, J.L. Suarez de Vivero & T.S.Agardy (Eds.) *Routledge Handbook of Ocean Resources and Management.* Routledge, Taylor and Francis; London, New York, 33-54 pp.

individual national-state strategies, policies and actions in marine affairs that the system is supposed to operate. However, until today few nations have evolved the institutions to deal with this challenge properly. Ocean Ministries or Departments, with sufficient power to oversight marine affairs across the board do not exist and relatively competent substitutes exist only in a tiny minority of nations. This arrangement *leaves for the weakest link to establish the minimum standard*. Individual nations are to provide the financial muscle and scientific know-how for the management of the marine environment as a whole and of the open oceans and deep seas in particular.

Nevertheless, the entities that extract benefits from the High Sea, with the exception of defence activities, generally are not public entities but rather private individuals or private corporations. Depending on the effectiveness of national policies, laws, and institutions and of the associated capabilities, this arrangement allows for a wide range of behaviours many of them at variance with international legal standards. We witness this kind of behaviour every day.

It is the weakness of these arrangements that make the wide promotion of the Blue Economy, as a new frontier for development a huge challenge.

In the text that we put together with Mário and others for the 10th anniversary of the Lisbon Declaration we said:

> All stakeholders – governments, economic actors and civil society – must base effective and equitable governance for the ocean on meaningful participation with increased transparency. In this process, public awareness and involvement will be essential to encourage and support governmental commitments.[12]

This is unfinished business. If we do not succeed in strengthening existing institutions, or better, if we do not find new ways, including totally new forms for legal institutions, to extend the protective mantle of democratic citizenship to the ocean, empowering every human being on land, to feel and genuinely care for our Ocean, we could face

[12] *A Lisbon Statement for Ocean Governance in the XXI Century*. Lisbon 2008.

a situation quite opposite to the Useful Utopia of the Sustainable use of the Ocean that Mário dream and so firmly fought for.

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Message à la mémoire de Mário Ruivo

Jean-Pierre Levy

Je voudrais avant tout exprimer ma reconnaissance aux organisateurs de cette manifestation pour l'hommage rendu en ce jour à mon grand ami Mário Ruivo.

J'ai été sensible à leur invitation et je regrette sincèrement de ne pouvoir être parmi vous à cette occasion.

Je suis actuellement sur un autre continent cependant toutes mes pensées sont avec vous car le départ de Mário me prive d'un collègue et ami de plus de 40 ans. Tout au long de notre amitié, l'esprit d'entreprise de Mário, son dynamisme et son optimisme, que les ans n'ont pas su diminuer, m'ont constamment encouragé et impressionné. Il en a été ainsi en particulier lorsque nous avons eu le plaisir et l'honneur ensemble de seconder Mário Soares lors de sa présidence de la Commission Mondiale Indépendante des Océans qui a culminé lors de l'Exposition sur les Océans tenue à Lisbonne en 1998.

Au-delà de la perte d'un humaniste pour tous ses intimes, la communauté scientifique dans son ensemble et le monde politique intéressés au devenir de notre planète ont perdu un phare international qui les a éclairés pendant plus d'un demi-siècle.

La recherche scientifique marine, les pêcheries, le droit de la mer, la préservation du milieu marin, ainsi que la place et le rôle politique du Portugal dans ces domaines, sont des sujets dont l'évolution et les progrès accomplis doivent énormément à Mário. Ces sujets seront certainement longuement évoqués au cours de cette réunion, et je voudrais, quant à moi, plutôt vous rappeler, si besoin en était, que Mário, outre ses qualités professionnelles et sa défense permanente des valeurs démocratiques, était surtout un homme de cœur et d'esprit.

Mário a toujours su porter sur le monde et les personnalités qu'il fréquentait un regard objectif teinté de bienveillance qui lui a permis d'être grandement apprécié par tous ceux qui l'ont approché.

A ce propos, une brève anecdote illustrera cet aspect de sa personnalité : au cours des quelque 40 années qui ont vu nos routes professionnelles se croiser régulièrement il nous est arrivé de partir ensemble en mission dans des pays lointains. Lors de l'une de ces missions en Asie, nous avons été amenés à avoir des entretiens répétés avec des fonctionnaires du gouvernement local. C'était une époque de très grande chaleur et Mário et moi transpirions abondamment. Nos chemises étaient trempées et les bureaux des fonctionnaires étaient tous climatisés. Nous avons constaté à notre grande surprise que plus les fonctionnaires étaient haut-placés, plus forte était la climatisation. Et finalement, lorsque nous avons été reçus par le Ministre des affaires étrangères, nous nous sommes mis à frissonner. Le lendemain nous étions tous les deux malades et alors que moi je m'emportais contre ces personnalités qui utilisaient tous les moyens, y compris la réfrigération, pour manifester leur pouvoir, Mário, lui, se contenta de mentionner qu'il nous aurait appartenu de prévoir une telle situation et d'emporter veste et cache-nez.

Cette illustration de l'aptitude de Mário à faire la part des choses était l'une des caractéristiques de sa personnalité. J'aurais de nombreuses autres anecdotes à vous conter cependant je m'en voudrais d'abuser de votre temps.

Qu'il me soit seulement permis de dire à la famille et aux proches de Mário ainsi qu'à ses collègues et à tous ceux qui l'ont apprécié que je ressens profondément le vide que son départ a entraîné. Il restera le meilleur exemple d'un esprit démocratique qui aura contribué à l'avancement des idées politiques et scientifiques de notre temps tout en maintenant les valeurs intellectuelles et humanistes qui font la grandeur de l'être humain.

Mário et son exemple resteront toujours avec nous.

Mário Ruivo, the "Lighthouse" of the Intergovernmental Oceanographic Commission of UNESCO

Vladimir Ryabinin

It is a great honour for me to write about Professor Mário Ruivo. And I will call him Mário. Using the first name for Mário Ruivo is nothing but a sign of respect, because everyone, when the name Mário was pronounced, would immediately understand that it was about Professor Mário Ruivo. And there was no need for a family name or title!

Mentioning Mário in a talk is an unfailing way to open a Portuguese heart. No matter to whom I speak about Mário, if this is a Portuguese person, I see clear signs of adoration and pride - and this nation is not known as prone to creating a "cult of personality". Such adoration is characteristic for so many Portuguese people to whom I have spoken recently, including Her Excellency Ana Paula Vitorino, Minister of the Sea; His Excellency Manuel Heitor, Minister of Science; His Excellency - Permanent Representative of Portugal to United Nations, Francisco António Duarte Lopes; Mário's close helper in UNESCO, Ms Teresa Salado; Professor Luis Pinheiro, representative of Portugal to the IOC; His Excellency Ambassador of Portugal to France and UNESCO José Filipe Moraes Cabral; and many-many others.

Mário passed to these people and many others his passion for the Ocean, and their respect to Mário gave all these people a very good cause of life – to serve Portugal and the Ocean. This makes their life noble. And now I am, as English say, trying to fill the big shoes of Mário by serving as Executive Secretary of the Intergovernmental Oceanographic Commission of UNESCO, or simply IOC. I am the ninth Executive Secretary of the Commission. Mário was the fifth, in

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post from 1980 to 1989. Many would agree that he was by far the most charismatic IOC Executive Secretary.

Mário attended all meetings of IOC Assembly and Executive Council from 1961 to 2015, in various capacities. No one else did so. In 2016 Mário missed the Executive Council because he broke his hip and could not move for some time. We all hoped that Mário would come in 2017 for the 29th Assembly, but he passed away. At the Assembly, we organised a tribute to Mário and we were blessed to have in attendance with us Madame Maria Eduarda Gonçalves, his widow.

Mário's devotion to IOC was exceptional. I would even state he loved IOC as a man could love a woman. In that connection, one can call Mário a Don Quichotte of IOC. This love and his unparalleled professionalism gave to IOC an incredible boost during Mário's tenure as the Executive Secretary and helped to keep the momentum in developing IOC after the end of his term. I also believe that Mário was instrumental in recommending Dr Gunnar Kullenberg as the Executive Secretary who followed him, and we are obliged to Mário for opening Gunnar's talent for serving world's oceanography. Mário really shaped IOC, morally and professionally.

The professional path of Mário is very well known, and it is impossible for me to discover anything new to add to his "Wikipedia" story. But what is important to describe, in my view, is his character and personality. Mário's professional work and life generated in him a unique alloy of traits, qualities and qualifications. He was an antifascist, a democrat, an intellectual, a scientist, a manager, a diplomat, and a politician. This very rare combination of highest professional qualifications and the highest ethical standard made his life so productive for serving, helping and coaching other people and for his profession. Most unfortunately, this is a rare, almost non-existent quality if one tries to find it in leaders of our days.

It is my job now to lead the IOC into the future. And I really feel it very strongly that I am helped in this work because I stand on the shoulders of giants. Mário is one of the most important of them.

In January this year, on the phone, we were discussing with Mário the future course of action for IOC. It was a very useful talk for me. As a part of it, we agreed that I should come to see Mário in Lisbon

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and continue that discussion "live". But Mário was weak. After some 20 minutes of the phone call, Mário got extremely tired and I barely heard his voice. And then the call dropped on his side and we got disconnected. I really did not know what to do. To call him again? Or to give him some rest? I decided to wait a little because I was supposed to come to Lisbon anyway. But this was not supposed to happen because on the 25th of January Mário passed away. Our phone talk remained not completed. I still have a lot of questions to Mário and would want his opinion on a number of important issues. And I feel orphaned without Mário. But, when I need to take an IOC-related decision, I try to imagine what Mário would think and do. I mentally speak to Mário. This helps.

We need to turn oceanography from a curiosity-driven and, to some extent, voluntary scientific discipline into a science-based technology of protecting the ocean and using it sustainably for the benefit of people and the Earth. Mário shared this vision and was very enthusiastic about it. Professor Peter Haugan, the IOC Chair, IOC Vice-Chairs, Secretariat, and representatives of many Member States fully share this vision, too. I think we in IOC are going to achieve this critical transformation of major importance for the world. One means of doing this would be an International Decade of Ocean Science for Sustainable Development, towards the ocean we need for the future we want. IOC agreed to conduct it and in September the United Nations 72th General Assembly started to discuss this proposal. Approximately 20 different organizations and many counties expressed their support to the idea. I think that we have real good chances to successfully implement our vision by the year 2030, when the ambitions Agenda of Sustainable Development will reach its final checkpoint. And, when we have done this, Mário will be happy, watching us from the skies. It is a good reason to keep trying. And if, or rather, when, we achieve this noble goal, I will myself feel that our interrupted telephone conversation with Mário is concluded.

Obrigado, Mário, for taking us where we are now and where we will be in the future. If there is a new lighthouse somewhere in Portugal, I would suggest that it is named after Mário, because he showed us the way!

Whose Ocean is it Anyway? How to Further Societal Engagement with the Ocean

Ned Dwyer

Abstract

The general public's understanding of the role of the ocean in our everyday lives and the challenges it is now facing from a myriad of natural and human induced pressures is limited. The Ocean Literacy movement is attempting to address these shortcomings by increasing understanding and engagement with ocean issues in order to lead to individual and societal changes that can address some of these challenges. As part of this movement it is important to re-evaluate what we mean by stakeholder engagement and move beyond what is considered the minimum necessary to what I argue is "real" stakeholder engagement where all interested parties come together to find realistic and acceptable solutions. Moreover, there is a need to look at the language used by experts, which is often alienating and resource focused, and reposition it so that it also addresses the intangible benefits of the ocean. Professor Mário Ruivo recognised the need for high quality information on the ocean and was one of the driving forces behind the creation of EurOcean – the European Centre for Information on Marine Science and Technology. The idea of creating EurOcean was to have a permanent structure that could focus on creating, maintaining and making permanently available information on marine science and technology, overcoming the then lack of visibility and difficulties of information access. Since then EurOcean has gone from strength to strength and is now made up of 12 members from 10 European countries and four cooperating members. And with the Professor´s support, in 2009 EurOcean established the Professor Mário Ruivo prize, which is awarded to young people who promote understanding and positive actions for the ocean.

Keywords: Ocean Literacy, Blue Society, Stakeholder Engagement

Resumo
A compreensão do público em geral sobre o papel do oceano no quotidiano das nossas vidas e sobre os desafios a que o mesmo se encontra exposto, devido a uma panóplia de fenómenos naturais e pressões induzidas pelo homem, é limitado. O movimento da Literacia do Oceano focam tais lacunas de conhecimento e pretendem aumentar a compreensão e o envolvimento do público de forma a serem alcançadas mudanças individuais e sociais que possa fazer face àqueles desafios. Como parte deste movimento, é importante reavaliar o que queremos pretendemos ao envolver as partes interessadas e ir mais além do que o mínimo necessário para o que esse envolvimento seja "real" e leve a algo em que todas as partes encontram conjuntamente soluções realistas e aceitáveis. Além disso, existe uma necessidade de olhar para a linguagem usada pelos especialistas, que muitas vezes age como uma barreira e tende a ser focada nos recursos naturais, e renová-la para que também atenda aos benefícios impalpáveis do oceano. O Professor Mário Ruivo reconheceu a necessidade de ter acesso a informação de alta qualidade sobre o oceano e foi essa uma das forças motrizes da criação do EurOcean - o Centro Europeu de Informação sobre Ciência e Tecnologia do Mar. O EurOcean doi assim criado com vista ao desenvolvimento duma estrutura permanente focada na agregação, manutenção e disponibilização de informação sobre ciências e tecnologias do mar, que superasse a anterior falta de visibilidade e as dificuldades de acesso. Desde então, o EurOcean não parou de crescer e é hoje composto por 12 membros de 10 países europeus e quatro membros cooperantes. Em 2009, com total apoio do homenageado, o EurOcean criou o Prémio Professor Mário Ruivo que premeia jovens Europeus que desenvolvam iniciativas que contribuam para o aumento do conhecimento e protecção do oceano.

Palavras-chave: Literacia do Oceano, Sociedade Azul, Envolvimento das Partes Interessadas

1. Public Perceptions of the Ocean

We have come here today to commemorate and celebrate the contribution that one man has made to our appreciation, understanding and knowledge of the ocean. Professor Mário Ruivo was a champion for the ocean during many years locally, nationally and internationally. Today, more than ever, we need to build on his legacy as the ocean faces unprecedented pressures and changes that are impacting on our lives and on the life of our blue planet.

Most of us in this room are working on issues related to the ocean or at least believe we are quite informed about the ocean. However, out there, in the wider world, the majority of people have a rather limited or narrow understanding of the role and importance of the ocean and of the threats it is facing.

In a recent study[1] commissioned by the U.K. branch of the Gulbenkian Foundation it is very revealing to read of the perceptions of the British public in regard to the ocean, and this from an island nation, I might add. When asked, "*what comes to your mind when you think about the ocean?*", some of the answers included " *Depth, beautiful lifeforms, fish that give us food*" or "*It's just alive, everywhere you look. All the way around the sea, or around the ocean, there's just … there's life.*" Such answers show us that there is an appreciation of the vastness and the wonder of the ocean.

Nevertheless, there is also a sense that the ocean is so huge, so enormous, and so untouchable, that we humans cannot affect it. When asked about any changes they believed had occurred in the ocean, one of the respondents said "*It's essentially untameable. It's totally wild. It's exactly as it was, I don't know, 1,000 years ago. What's changed? It's still – If you looked out on an ocean then, you'd look out on an [the same] ocean now.*"

This type of answer probably comes as a shock to us as "experts" on ocean matters. We are all too familiar with over-fishing, pollution, plastic litter, temperature rises, acidification, sea-level rise, dead zones, to name but a few. But should such an answer surprise us? In our current societies most of us are insulated from regular contact with the ocean. We pick up our processed fish at the supermarket (maybe not so much in Portugal!), we buy goods at the shop which we don´t realise were transported half way around the world by ship, we wash our clothes and flush our toilets without thinking about the possible nutrients, microfibers and polluted water which may enter the ocean. There is a need to address this lack of knowledge of the ocean and raise the level of awareness of its central, if sometimes hidden, role in our lives.

[1] Lindland, E. & Volmert, A. (2017). Getting below the surface: Mapping the gaps between expert and public understandings of ocean change and marine conservation in the UK. Washington, DC: FrameWorks Institute.

2. Ocean Literacy

"Ocean Literacy" is a term coined in the United States in the early part of this century to try and put on the school curricula material that would improve young people´s understanding of the importance of the ocean and help them to communicate about the ocean in a meaningful way. Moreover Ocean Literacy strives to encourage informed and responsible decisions about the ocean and its resources. Over the last 20 years, the Ocean Literacy movement has spread to other continents and countries. Here in Europe it has developed beyond being just focussed on schools to bring in wider society and improve awareness and knowledge of the ocean in general. The European Union´s Research and Innovation Programme, Horizon 2020 and its predecessor FP7 have been funding a number of projects in relation to Ocean Literacy with the objective of developing practical tools and methods that can be used to enhance Ocean Literacy across the continent. However this is a process that takes time. First of all we have to raise awareness of the relevance and importance of the ocean. Then we have to develop an understanding of how the ocean works and the challenges it faces. Finally, we have to promote individual and societal actions and changes that will lead to a healthier ocean and therefore a healthier planet.

Recently, as a member of the International Coastal Atlas Network project[2] of the IODE, I took part in an Intergovernmental Oceanographic Commission (IOC) organised training course on Ocean Literacy and story mapping held in Santa Marta in Colombia, South America. One of the participants was from the Dominican Republic. He told a story of how the local authorities in the area around the town of Nagua erected signage warning of the risk of tsunamis and giving practical advice on what to do in case of a tsunami warning[3]. One month later when representatives of the local authority returned they saw that all the signs had been cut down. Why they wondered? Were people using them for firewood? Were they obstructing people´s entrances? Did people not like the colour? What? So they spoke to

[2] http://ican.iode.org/

[3] http://arcg.is/1Cn50u

people in the area. *"You are scaring the tourists and driving them away"* they were told. "*We need the tourists to come here. It is our livelihood*". The last Tsunami in Nagua was in 1946. Many lives were lost, and 20,000 people were rendered homeless. However, most people living there now don´t remember this, didn´t live through it. The need to generate an income today is more important than the possible risk of a tsunami tomorrow.

3. "Real" Stakeholder Engagement

So when I ask – *"Whose ocean is it anyway?*, what I want us to reflect on is the need to involve all relevant and interested parties in decisions related to the ocean. In the last few years, we have seen a growing distrust of "experts" by the general public and also by a few politicians. This distrust is manipulated by some to promote a populist political agenda, the results of which we can now observe in a number of countries. This denigration of experts is dangerous. In relation to the ocean, as in many other areas, expertise is vital. How else will we know what the state of the ocean is, understand the challenges it faces and propose possible solutions? Nevertheless, we cannot ignore this distrust. We need to address it and find out what is at its origin. In part, I believe it is because experts and those in authority are often seen as those who come up with so-called solutions, which are then often imposed on people and their areas with minimal dialogue and discussion. The Dominican Republic story highlights in a very clear and simple way the need for real stakeholder engagement; not the stakeholder engagement many of us may be familiar with – which is often just sufficient to meet statutory requirements, to "tick-the-box" in other words. Real stakeholder engagement is a demanding and time-consuming process. It means brings everyone – the general public, local authorities, scientists and experts, civil society organisations, decision makers, industry and local businesses together around the table to tease out the situation in an open and respectful way in order to reach an agreement, a consensus or at least to start on the path towards a solution by building trust and confidence. Everyone has relevant experience and knowledge to contribute. What have we to lose

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by this approach? Maybe a little of our pride or some vested interest – but if we are serious about wanting a better ocean, then I believe it is an approach we really must adopt.

Figure 1: Real Stakeholder engagement is a demanding and time consuming process
Source: Drawing it out (Yolanda Liman)

4. A New Language for the Ocean

However taking this path will require a change of perspective from us all, and the willingness to try new things. We may also have to look at the language and words we use. The British journalist, George Monbiot wrote about this recently in an article[4] in "The Guardian" newspaper. At sea we experts talk about "no-take zones" when referring to areas where fishing is forbidden. We speak of "reference areas" for fully protected areas. Then we speak about "living and non-living resources" when we mean fish and minerals. "Natural capital" and "ecosystem services" are other phrases that are part of this vocabulary. We are reducing our concept of the environment and our ocean to something very dry, very sterile, very utilitarian. Monbiot asks what if we spoke of "places of natural wonder" instead of "protected areas" or even "living planet" instead of "environment".

[4] https://www.theguardian.com/commentisfree/2017/aug/09/forget-the-environment-new-words-lifes-wonders-language

Imagine for a moment if we spoke of the benefits of our family and friends in terms of the set of services they provide us with, if our only criteria for evaluating their value was in terms of services provided or requested. We would see this as a very reductionist view. Our families and friends mean much more to us than can be simply listed on a sort of balance sheet. In the same way, if we stopped referring to our living planet as a resource or in terms of natural capital to be exploited, but as something which is wondrous, vital and intertwined with our lives, then we might start taking the first steps towards a new approach to looking after it. We will never respect or love something if we only see it in terms of its monetary value. The phrase "Blue Growth" or "Blue Economy", which is currently so popular, also falls into this category of perceiving the ocean as strictly a resource or natural capital. It is premised on the idea that the ocean is there to be exploited. Through the European funded Sea for Society project[5], which EurOcean was involved in, we developed and are promoting the concept of a "Blue Society", a society that first and foremost respects and, dare I say, loves, the ocean. This is not a naïve or utopian idea, as it also acknowledges that we can use the ocean for human benefit. However, the concept of a Blue Society changes our perspective of the ocean and influences how we relate and interact with it. The words we use *are* important. Words are used to express our thoughts and beliefs, so how we refer to and speak about the ocean will influence how we interact with it.

Figure 2: A Blue Society is one in which the marine environment is sustainably managed, giving future generations the opportunity to enjoy and benefit from the many services and resources provided by the ocean, while also preserving ecosystem integrity and functioning.
Source: Nausicaá

[5] http://eurocean.org/np4/77.html

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5. A Heritage for the Future

Professor Mário Ruivo understood many years ago that knowledge and understanding were the pre-requisites for us to change our approach to the Ocean. He was one of the driving forces behind Expo ´98, held in Lisbon, which had the theme "The Oceans – a heritage for the future" (Os oceanos: um património para o futuro). One of my first ever visits to Lisbon was for Expo ´98. It was before I started working in marine sciences. I still remember how wonderful that exhibition was. In particular I remember visiting the Oceanário, and being awe-struck by the multitude of sea creatures, big and small that are there. I have been back to the Oceanário a number of times since I started working in Lisbon 3 years ago, and each time I still experience a frisson of excitement when I stand in front of the huge main tank of the aquarium.

As part of Professor Mário´s vision for spreading knowledge about the ocean, he was one of the main instigators behind the establishment of EurOcean, the organisation for which I now work. Its full title is "EurOcean - the European Centre for Information on Marine Science and Technology". Mário knew the importance of providing information on the ocean. He knew the importance of informing the world about the European scientific discoveries and advances in ocean science. Mário was promoting Ocean Literacy before the term itself was even created! In the two years I knew Mário, I enjoyed his visits to the Fundação para a Ciência e a Tecnologia (FCT) building. He had an office beside mine. When he visited he would always knock on my door and enquire about what EurOcean was doing. And he always said something meaningful and relevant that made me reflect and think, long after he had left. It is a privilege to have known him.

And with Mário´s support, in 2009 EurOcean established the Professor Mário Ruivo prize[6], which is awarded to young people who promote understanding and positive actions for the ocean. This year EurOcean submitted the next two editions of the prize as a voluntary commitment to the UN Ocean conference for the implementation of Sustainable Development Goal 14[7]. I believe that this is a fitting legacy

[6] http://eurocean.org/np4/2.html

[7] https://oceanconference.un.org/commitments/

Figure 3: Ricardo Serrão Santos MEP and former EurOcean President presents the Professor Mário Ruivo prize to Antoinette Atik and Laura Hutchinson, winners of the 2016 edition.
Source: VLIZ (Els Verhaeghe)

for a man whose heart was at one with the ocean and when we speak of a "heritage for the future", that future is our young people and our best legacy to Mário is that we do our utmost to guide our young people towards being better custodians of the ocean than we have been.

Mário Ruivo, um homem de cultura global

João Guerreiro

Magnífico Reitor da Universidade do Algarve
Senhora Ministra do Mar
Senhor Presidente da Câmara Municipal de Faro
Senhor membros de organismos internacionais na área do mar
Senhora Professora Maria Eduarda Gonçalves

O Senhor Presidente do Conselho Nacional do Ambiente e do Desenvolvimento Sustentável (CNADS), Professor Filipe Duarte Santos, pede-me para, em seu nome, pronunciar algumas palavras destinadas a associar este Conselho, o CNADS, à homenagem que esta Conferência Internacional dedica ao Professor Mário Ruivo.

A satisfação com que assumo esta tarefa é múltipla. Em primeiro lugar por evocar com estas breves palavras a uma personalidade do panorama científico internacional, na área dos oceanos, que é a referência desta Conferência. Desde os anos 50, porventura com maior ênfase a partir do período em que assumiu as funções de Diretor da Divisão de Recurso Aquáticos, da FAO, no início dos anos 60, que Mário Ruivo granjeou um enorme prestígio que o colocou num patamar único de reconhecimento internacional, traduzido pela forma como era solicitado, ouvido e comprometido na reflexão e ação em torno da problemática dos oceanos.

Mas foi igualmente uma personalidade que teve, no quadro nacional, um papel fundamental na dinamização da investigação e da extensão científicas na área do mar. A instalação do regime democrático, em 1974, permitiu o seu regresso a Portugal. E Mário Ruivo, desde logo, mergulhou no ambiente dos recursos e tecnologias do mar, impulsionando a criação do laboratório do Estado responsável pela investigação das pescas, fomentando os diversos programas da

Fundação para a Ciência e Tecnologia relacionados com o mar e dinamizando as várias iniciativas internacionais que se foram sucedendo com expressão maior, para Portugal, na Expo'98, na Comissão Independente dos Oceanos e no Relatório por esta elaborado sobre "O oceano, o nosso futuro".

Mas a satisfação com que me associo a esta Conferência prende-se também com a ligação de Mário Ruivo ao Conselho Nacional do Ambiente e do Desenvolvimento Sustentável, tendo assumido as funções de Presidente durante os primeiros vinte anos de existência deste órgão. Foi Presidente até que, há cerca de um ano, nos deixou, transmitindo a todos os seus membros um saber, uma estratégia, um exemplo, mas deixando também uma enorme saudade.

Permitam-me também evocar uma última razão que, do ponto de vista pessoal, me é particularmente grata. Tive a grata possibilidade de, nos últimos dez anos, conviver com grande proximidade com o Professor Mário Ruivo. E desse convívio beneficiei do seu saber, do seu entusiasmo e da sua estratégia nas diversas iniciativas que tive oportunidade de com ele colaborar. Beneficiei de longas conversas sobre os percursos complicados que abraçou, devido aos processos de exclusão que o regime fascista impunha, que o lançaram no convívio com organismos internacionais, com personalidades interessantes das redes científicas que frequentava ou com grupos de emigrantes políticos portugueses que lutavam pela introdução da democracia em Portugal. Acompanhei a sua reflexão sempre criativa em torno das possíveis iniciativas que deveriam ser tomadas para afirmar uma intervenção qualificada e exigente nos assuntos do mar.

Neste patamar da colaboração pessoal, poderei evocar a Conferência sobre o Mar Português, realizada nesta Universidade em 2011. Desta Conferência resultou a Declaração do Algarve que o Professor Mário Ruivo não se cansava de evocar e na esteira da qual pretendia, confiando nas suas próprias forças, revisita-la num curto prazo, avaliando o "estado da arte" do conhecimento e das tecnologias do mar seis a sete anos após aquela Conferência.

Gostaria finalmente de evocar o grau de Doutor Honoris Causa outorgado pela Universidade do Algarve, porventura a última manifestação pública em que Mário Ruivo participou, na qual, por decisão do Magnifico Reitor desta Universidade, tive a honra de proferir a respetiva *Laudatio*.

A sua vida, desde que abandonou Campo Maior, a sua terra natal, a escola em Borba e o liceu em Évora, não mais deixou de ser influenciada pelo fascínio do mar.

A Universidade do Algarve escolheu bem o lema desta Conferência Internacional, "Desenvolvimento Sustentável dos Oceanos: uma utopia útil". Recupera, assim, com enorme atualidade a referência à *utopia útil* com que Mário Ruivo gostava de se referir aos oceanos, esse mundo do qual ainda temos pouco conhecimento, mas que se pode antever como uma fonte de recursos variados, porventura a maior parte deles ainda desconhecidos. Mário Ruivo chamava, contudo, a atenção para os que pensavam explorar o mar baseando-se apenas na experiência terrestre que o homem acumulou ao longo dos anos. Afirmou, pouco tempo antes de nos deixar e numa entrevista à revista *Biblos*, de Coimbra, que "*sem conhecimento e sem tecnologia o bicho homem no meio marinho é cego, surdo e mudo*"[1].

Mas é o seu papel como Presidente do Conselho Nacional do Ambiente e do Desenvolvimento Sustentável que, nesta ocasião, gostava de evocar com maior detalhe.

O Conselho Nacional do Ambiente e do Desenvolvimento Sustentável (CNADS) foi criado em 1997, há cerca de 20 anos. E o Professor Mário Ruivo assegurou a Presidência do Conselho Nacional do Ambiente e Desenvolvimento Sustentável (CNADS) desde a sua constituição. Desempenhou esta função garantindo um equilíbrio ímpar no seu funcionamento e nas posições que este órgão foi assumindo ao longo do seu percurso. A intervenção direta de Mário Ruivo garantiu que tenha prevalecido neste Conselho não só um ambiente de enorme exigência científica, como também de convergência multidisciplinar, aspetos que todos reconhecerão não são fáceis de conciliar. Mas esta sua capacidade de orientar as atividades do CNADS permitiu que este órgão usufruísse de uma postura singular de acompanhamento crítico das iniciativas públicas e privadas com impacte no ambiente e no território.

[1] Entrevista com Mário Ruivo (2016) – *Biblos*, Imprensa da Universidade de Coimbra, nº 2, 3ª série, 185-197.

O CNADS desempenhou (e tudo indica que continuará a desempenhar) as funções de um autêntico *Conselho de Concertação Ambiental*!

Mário Ruivo demonstrava uma aptidão única para orientar os trabalhos deste Conselho. Recorde-se que este órgão é constituído por 36 membros, designados por entidades tão diversas como as associações representativas de setores económicos, as associações sindicais, as associações ambientalistas, as ordens profissionais relacionadas com as temáticas do ambiente e do território, as universidades portuguesas, para além de cinco personalidades nomeadas pelo Governo e de representantes das regiões autónomas. A aproximação de posições poderia antever-se difícil.

Mário Ruivo expressou, até ao momento em que nos deixou, uma permanente inquietação e apetência por novas iniciativas e novos projetos. Os que colaboraram de perto com ele testemunham o seu enorme dinamismo, a sua capacidade para multiplicar projetos, o seu entusiasmo por montar novas iniciativas, sempre com uma ideia de progredir na consolidação e disseminação do conhecimento. Reconhecia que tinha de aceitar momentos de espera quando o ambiente envolvente era pouco favorável ao desenvolvimento dos seus projetos. E avançava nos períodos mais favoráveis, nunca perdendo a linha segura do que se deveria fazer para valorizar os recursos, para preservar o meio e para melhorar a vida das comunidades.

Para se ter uma ideia do labor desenvolvido pelo Conselho Nacional do Ambiente e do Desenvolvimento Sustentável sob a presidência de Mário Ruivo, pode referir-se alguns indicadores.

Até final de 2016, o CNADS tinha elaborado um pouco mais de 120 Pareceres e Reflexões sobre temáticas variadas, destacando-se as seguintes: ambiente, agricultura, alterações climáticas, conservação da natureza, desenvolvimento, economia verde, economia circular, energia, ordenamento do território, pescas, resíduos, saúde, segurança alimentar, oceanos e zonas costeiras. Pareceres que resultavam de grupos de trabalho criados no seio do CNADS e que beneficiavam de audições externas diversas, estruturadas em função dos temas e da multiplicidade dos setores abrangidos pelos mesmos.

A elaboração dos Pareceres e Reflexões corresponde talvez à produção mais visível do CNADS. Obrigava e obriga ao trabalho conjunto de conselheiros com origens variadas, à pesquisa aprofundada sobre os temas em análise, à incorporação de valias e experiências alheias em resultado das audições e a um equilíbrio final nas conclusões e recomendações. Mas, perante a reflexão profunda associada a cada uma dessas iniciativas, pode afirmar-se que a decisão final raramente não foi tomada por unanimidade. Os Pareceres e Reflexões apontavam normalmente para avaliações e perspetivas de enorme valia prospetiva, não raras vezes pouco consonantes com as linhas de atuação então dominantes dos departamentos públicos ou dos consensos nacionais. Antecipam novas problemáticas e lançam recomendações inovadoras para as questões analisadas

Perante a diversidade de interesses representados no Conselho, pode considerar-se que o trabalho realizado, permanentemente acompanhado e beneficiando da orientação de Mário Ruivo, corresponde a terrenos desbravados com preocupações orientadas para a evolução crítica da nossa sociedade, para garantir o equilíbrio das intervenções do homem na exploração dos recursos, para defender alterações de comportamentos sociais predadores dos nossos ativos ambientais ou para defender modelos de sociedade que garantam a longo prazo a perenidade da vida humana.

Muitos destes Pareceres e Reflexões foram objeto de debates públicos. Mário Ruivo defendeu sempre a necessidade de afirmar publicamente o Conselho, pelo que as reflexões produzidas pelo CNADS deviam ser objeto de exposições e de confronto público. A prática de organizar Seminários e outras iniciativas públicas, associadas sempre que possível a organismos de investigação científica, a universidades ou a associações setoriais e/ou profissionais representadas no Conselho, assim como à própria Assembleia da República, permitia divulgar as recomendações emitidas pelo CNADS e influenciar, tanto quanto possível, o curso das decisões legislativas, regulamentares ou de impacte orgânico.

A projeção pública da atividade do CNADS foi sempre uma característica da presidência de Mário Ruivo, traduzindo uma postura de intervir sempre que possível de forma exigente e fundamentada nas problemáticas que afetam a nossa sociedade nos domínios do ambiente e do desenvolvimento.

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A designação do presidente do CNADS é da responsabilidade do Conselho de Ministros. Nos vinte anos durante os quais Mário Ruivo assegurou a presidência do CNADS, este seu desempenho foi acompanhado por nove primeiros-ministros. O funcionamento administrativo do CNADS está associado ao Ministério do Ambiente. E nestes vinte anos, Mário Ruivo conviveu com doze Ministros do Ambiente.

Neste mar de personalidades, influências, temáticas e de reflexões normalmente pouco ortodoxas não é fácil coordenar e orientar um órgão com 36 personalidades com interesses e visões próprias. Mas, para Mário Ruivo, o sentido de oportunidade e o reconhecimento de que o CNADS deveria assumir uma responsabilidade social conduziram a que o Conselho mantenha hoje uma capacidade única para opinar sobre as problemáticas nacionais nas áreas que são a sua vocação.

No campo da internacionalização, Mário Ruivo impulsionou igualmente a adesão do CNADS à rede europeia dos Conselhos de Ambiente e Desenvolvimento Sustentável. Desde 1999 que o CNADS participa nesta rede de partilha de informação e de experiências nas áreas das políticas do ambiente e do desenvolvimento sustentável, que reúne órgãos semelhantes de onze países europeus. É aliás no âmbito desta rede que o CNADS coordena o Grupo de Trabalho sobre os oceanos e integra ainda dois outros Grupos de Trabalho sobre energia e alterações climáticas e sobre economia circular. Estas participações permitiram também que o CNADS integrasse a direção desta rede e tivesse assumido, nos últimos anos, a função de Vice-presidente desta rede.

Como nota final poderei sublinhar que a afirmação do Conselho Nacional do Ambiente e do Desenvolvimento Sustentável está indiscutivelmente associada à personalidade de Mário Ruivo, ao seu espirito de acrescentar continuadamente conhecimento às iniciativas que desenvolvia ou que impulsionava, à sua capacidade de entender os benefícios da diversidade (resultante também da sua formação de biólogo), à sua enorme competência para, em órgãos colegiais, forjar plataformas de concertação e de consenso e, no domínio dos oceanos, do ambiente e do desenvolvimento sustentável, à sua sólida perceção, formação e antevisão.

Permito-me transmitir à Senhora Professora Maria Eduarda Gonçalves os cumprimentos do Professor Filipe Duarte Santos que, não

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podendo estar presente, me pediu que publicamente revelasse o enorme apreço que tem pela memória do Professor Mário Ruivo e a preocupação que tem de garantir a continuidade do seu trabalho no âmbito do CNADS.

Mário Ruivo, um homem de cultura global, merece ser recordado. A Universidade do Algarve, acompanhada pelos diversos Centros de Investigação na área do mar das universidades portuguesas, está de parabéns pela bonita e justa iniciativa que tomou.

Mário Ruivo: um homem nas graças do mar

Ricardo Serrão Santos

Antes de mais quero saudar a Universidade do Algarve, na pessoa do seu Magnífico Reitor Prof. António Branco.
Saúdo também todos os participantes nesta sessão.
Queria ainda deixar um cumprimento especial à Prof. Maria Eduarda Gonçalves.
Por estar a decorrer sessão plenária do Parlamento Europeu em Estrasburgo, é me impossível estar aí presente nesta sessão.
Agradeço, à Prof. Maria João Bebianno ter, desde o primeiro momento, mantido comunicação comigo sobre a realização desta sessão de homenagem ao grande amigo e mentor, Prof. Mário Ruivo, e de ter mostrado disponibilidade para receber o meu depoimento, ainda que gravado.

Tenho muita pena de não estar aí convosco e de em virtude disso não poder partilhar ao vivo, e entre amigos, a alegria da memória e do legado deste homem que marcou de forma irrefutável e única as ciências e as políticas dos Oceanos. Não só em Portugal mas no mundo.

Mário Ruivo é uma daquelas personalidades que aparecem na história de forma escassa.

Uma dessas raras personalidades que aliam um intenso, profundo e informado interesse pelas questões do mundo, a uma militância política corajosa e desassombrada. Um optimista que não vergava e mantinha sempre a esperança a flutuar mesmo quando as coisas não corriam de feição.

[Como ele dizia: "manter as jangadas a flutuar em porto seguro e esperar para nos fazermos ao largo"], atitude demonstrativa de uma capacidade de motivação e comunicação únicas e de uma paixão pelo

Oceano e pelo conhecimento científico, juntas num homem de grandes compromissos e amizades enraizadas e complexas.

Conheci o Mário Ruivo no final dos anos 80, início dos anos 90. A partir daí acompanhei o homem que tinha atrás de si uma longa e rica história. Fora um pioneiro em muitos aspectos. Mergulhou no célebre Batíscafo na campanha Luso-Francesa de investigação em mar profundo – em que participou em parceria com a Marinha portuguesa - com imersões ao largo do Cabo da Roca e de Sesimbra e também nas zonas centro e sul da costa portuguesa.

Foi pioneiro na reflexão relativa à sustentabilidade dos recursos pesqueiros, tendo estado dedicado como biólogo, ao estudo do bacalhau na zona a que actualmente chamamos NAFO e, de forma mais holística nos estudos sobre recursos halieuticos ao serviço da FAO em Roma.

Aí conheceu e privou com os melhores entre os melhores, como sejam Sir Sidney Holt e Brian Rothschild. Refiro apenas estes dois para partilhar dois episódios ilustrativos da personalidade do Prof. Mário Ruivo.

Quando Mário Ruivo recebeu o Grau de Doutor Honoris Causa pela Universidade dos Açores, Brian Rothschild fez questão de estar presente e veio aos Açores para o acompanhar, como amigo, nessa consagração.

Em 2015 Sir Sidney Holt esteve no Parlamento Europeu no âmbito de uma audição sobre gestão de pescas. Nessa ocasião, ao saber que eu conhecia e era amigo de Mário Ruivo quis aproveitar a ocasião para rever, através de conversa telefónica o seu bom e velho amigo, como disse. Os dois estiveram em "amena cavaqueira" recordando tempos idos e actualizando-se sobre os caminhos que entretanto cada um percorria.

Mário Ruivo, um homem do interior que abraçou as graças do mar, diz que escolheu dedicar a vida aos mares e Oceanos pela "curiosidade face a este meio simultaneamente misterioso e algo inatingível" - mas também pela percepção de que a pesca era na altura, uma das mais importantes componentes da economia nacional e que o seu desenvolvimento depende de um melhor conhecimento científico.

Não deixou o assunto por mãos alheias e meteu mãos à obra.

São conhecidas as suas viagens, como biólogo, nos velhos bacalhoeiros, nos mares da Terra Nova e da Gronelândia, no estudo do nosso "fiel amigo", o bacalhau.

Talvez menos falado, porque Mário Ruivo não era homem de gabar-se de prémios e reconhecimentos. No ido ano de 1951 foi-lhe atribuído o prémio D. Carlos I, pela Fundação da Casa de Bragança – imagine-se! – pelos estudos que fez sobre biologia da sardinha, depois de ter trabalhado dois anos, apesar de ser *persona non grata* ao regime, na Estação de Biologia Marítima. A sardinha! Esse outro fiel amigo em estranhas dificuldades de sustentabilidade nos tempos que correm.

Já no pós 25 de Abril teve grande influência na criação e instalação do "*Instituto Nacional de Investigação das Pescas*" e da entrega a Portugal, por parte da Noruega, do navio de investigação "*Noruega*", que ainda por aí navega…

Este navio resulta das grandes relações de reconhecimento e amizade, do persistente diálogo e da eterna procura de soluções de convergência, interesse mútuo e cooperação internacional que antes e após o 25 de Abril cultivou em nome da agenda do conhecimento e da governação internacional dos Oceanos.

Diga-se que logo no I Governo da República, Mário Ruivo foi encarregado pelo Ministério da Coordenação Económica, da reestruturação do sistema nacional de investigação de Mar.

Foi representante de Portugal na *Comissão Oceanográfica Intergovernamental* (COI) - e seu vice-secretário.

Ainda hoje, todos ali se recordam, do seu enorme contributo. Lembro-me de, já nos anos 2000, ter participado numa reunião da Assembleia Geral da COI em Paris e ver delegados de países "maiores", por assim dizer, entre os quais EUA, França e Reino Unido, virem à sua mesa para negociarem emendas. Facto revelador da influência que exercia e do respeito que outras delegações tinham pela sua opinião.

Mário Ruivo teve um papel fundamental na criação e consolidação do sistema de investigação em Ciências do Mar em Portugal, tendo sido durante vários anos coordenador das avaliações dos centros, contribuindo para a sua revitalização e modernização.

No final dos anos 90, e após um "debate" no seio de um alargado grupo trabalho de cientistas portugueses e estrangeiros, que coordenou ao longo de vários meses, criou o *Programa Dinamizador das*

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Ciências e Tecnologias do Mar, o qual, quanto a mim, constitui hoje, ainda, um marco maior do financiamento em ciências e tecnologias do mar em Portugal.

Corria então o ano de 1998, um ano marco na reflexão sobre os oceanos em que se celebrou o Ano Internacional dos Oceanos e a correspondente EXPO' 98, ambos impulsionados por Mário Ruivo. Assim como foi a Comissão Mundial Independente dos Oceanos, presidida pelo seu grande amigo e parceiro de luta Mário Soares e por si coordenada.

Por detrás da PDCTM esteve a criação Comissão Oceanográfica Intersectorial, a que Mário Ruivo presidiu na dependência da Fundação para a Ciência e Tecnologia.

O PDCTM estabeleceu cerca de 4 prioridades para uma primeira fase de implementação, que todos conhecem pelo que seria fastidioso aqui enunciar.

Infelizmente, e a despeito da vontade de Mário Ruivo, ficou por fazer a segunda fase que seria dedicada ao "desenvolvimento de serviços operacionais de gestão e difusão de informação em Ciências do Mar e dados Oceanográficos".

Mas se esta competência não chegou então a ser implementada, Mário Ruivo, que mantinha sempre jangadas em flutuação e prontas a partir, acabou por trilhar um caminho alternativo, envolvendo-se na criação do *European Marine Board* (cuja sede, contrafeito, não conseguiu trazer para Portugal) e o EUROCEAN: "O Centro Europeu para a Informação em Ciências e Tecnologias Marinhas" cuja sede é em Portugal.

Na minha perspectiva a componente científica, mas também grande parte da componente de governação da "*Estratégia Nacional para os Oceanos*" [presidida no início dos anos 2000 pelo jovem e dinâmico jurista Tiago Pitta e Cunha, que aliás conheci através do Mário Ruivo] assenta e inspira-se fortemente na dinâmica introduzida nos anos 90 pelo Mário Ruivo, que foi, aliás, membro do conselho consultivo da estratégia, como não podia deixar de ser.

Outra matéria que não posso deixar de focar é a criação do *Forum Permanente para os Assuntos do Mar* a cuja direção ambos pertencemos e à qual chegou a presidir.

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Este Forum teve uma importância muito relevante no contexto da intervenção da sociedade civil na afirmação do mar como desígnio de Portugal. Mas, infelizmente, no segundo mandato deste Fórum houve um secretário de estado que utilizou todos os meios possíveis para estrangular a voz deste forum presidido por Mário Ruivo, que no entanto nunca vergou no seu optimismo inabalável. Reconheceu que aquele era um momento para manter as jangadas em porto de abrigo, sem afundar, flutuando até reiniciar a navegação.

Quando se prolonga uma grande crise de sustentabilidade no mundo é pois imperativo exaltar o esforço e a combatividade daqueles que se destacaram na defesa e na promoção dos valores humanistas.

Mário Ruivo tem um lugar de destaque. Ao longo da vida contribuiu para o reforço dos valores ecológicos, lutando por uma sociedade cientificamente informada e pela conservação dos recursos naturais. Promovendo e liderando múltiplas iniciativas e projectos no âmbito do ambiente e do mar.

Num tempo em que a economia azul, a sustentabilidade dos ecossistemas e o combate às alterações climáticas são paradigmas de desenvolvimento, as ideias de Mário Ruivo e o seu legado não só mantêm uma perfeita clarividência, como são inspiradoras.

Dos inúmeros reconhecimentos que Mário Ruivo recebeu, que ele aceitava com humildade, porque achava que de alguma forma reforçam a couraça de resiliência dos ideais de agenda sobre o ambiente sustentável e os Oceanos, quero destacar apenas que dois me estão mais próximos: a "*Insígnia Autonómica de Reconhecimento*", atribuída pelo Governo dos Açores e pela Assembleia Legislativa Regional dos Açores, demonstrativa da elevada consideração que a RAA tinha por Mário Ruivo, que sempre apoiou e reconheceu a relevância do mar dos Açores no contexto do Atlântico.

E o grau de Doutor *Honoris Causa* em Ciências do Mar, atribuído pela Universidade dos Açores em 2010 cujo elogio esteve a cargo do seu grande amigo Mário Soares, e onde estiveram presentes quase todos os reitores das Universidades portuguesas.

Em 2016, Mário Ruivo, recebeu a mesma distinção nesta Universidade do Algarve. Na altura confessou-me o grande valor que dava a este grau, por ser desta universidade, pela qual tinha um especial carinho também.

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A Universidade do Algarve, onde estive mais do que uma vez com Mário Ruivo, não esquece os grandes valores e os grandes amigos e em boa hora organizou esta grande e muito justa homenagem.

Não posso deixar de fazer referência ao Prémio de Cidadão Europeu que lhe foi atribuído pelo Parlamento Europeu em 2016.

Por fim, reitero o meu agradecimento pelo convite para juntar-me a esta homenagem e faço votos de que tudo corra pelo melhor. O Programa é excelente. Parabéns e obrigado.

Mário Ruivo: saudade do futuro

Maria Eduarda Gonçalves

É para mim um prazer muito grande partilhar estes momentos com colegas e amigos do meu Marido presentes na mesa: a Engenheira Ana Paula Vitorino, Ministra do Mar, o Professor António Branco, reitor da Universidade do Algarve, o Professor João Guerreiro, que aqui representa o Conselho Nacional do Ambiente e Desenvolvimento Sustentável, o Dr. Ned Dwyer, diretor do EurOcean, o Dr. Patrício Bernal, antigo secretário da Comissão Oceanográfica Intergovernamental (COI) da Unesco, nosso amigo de há décadas, e o Senhor Presidente da Câmara Municipal de Faro; além dos muitos colegas e amigos que se encontram na sala.

Não quero deixar de agradecer em particular aos Professores Maria João Bebianno e João Guerreiro e ao Senhor Reitor a dedicação e a sensibilidade que colocaram na organização desta Conferência, lembrando do mesmo passo a memorável cerimónia de atribuição do doutoramento *honoris causa* a Mário Ruivo, neste mesmo local da Universidade do Algarve, há menos de um ano, em 14 de dezembro de 2016. Expressão desta sensibilidade e desse cuidado é agora também a edição do belíssimo caderno 'Doutoramento Honoris Causa Mário Ruivo' (Universidade do Algarve, Faro, Novembro de 2017), contendo os discursos proferidos nessa ocasião, o do Senhor Reitor António Branco, a "laudatio" do Professor João Guerreiro e o discurso de agradecimento do Novo Doutor Biólogo Mário Ruivo.

Compreenderão que me ocorrem, neste instante, sentimentos contraditórios, depois de escutar intervenções tão ricas e emotivas que fazem reviver Mário Ruivo: por um lado, saudade e comoção, e, por outro lado, contentamento por testemunhar o amplo reconhecimento e a inspiração que Mário Ruivo deixou nos muitos colegas com quem privou em Portugal e fora de Portugal, em particular em diversas instâncias das Nações Unidas, e, não menos importante do que isso, o reconhecimento do seu exemplo como pessoa. Ao longo de cerca de setenta anos de dedicação plena à investigação científica e à política científica no domínio das ciências e tecnologias do mar e às políticas do Oceano e do Ambiente, o Mário influenciou instituições e pessoas de sucessivas gerações, com quem construiu fortes amizades, que perduraram até hoje.

Esta é uma Conferência com um programa muito bem pensado, que espelha bem, desde o título, ideias-chave que nortearam a intervenção de Mário Ruivo nos domínios da política e da gestão da ciência e da tecnologia, do mar e do ambiente: *desenvolvimento sustentável*, nas suas múltiplas dimensões, ambiental, económica, social, institucional – como frisava regularmente; *utopia útil* - o sonho, sim, mas sempre orientado para a ação; e também *triálogo*, i.e. a comunicação e a concertação envolvendo comunidade científica, governo, empresas; a *participação dos cidadãos* apoiada num esforço de promoção da literacia científica e da informação.

Esta é também uma oportunidade muito especial de relembrar a ação e a visão estratégica e em muitos aspectos pioneira de Mário Ruivo no que respeita ao Mar-Oceano e ao Mar Português; visão e ação que desenvolveu ao longo de uma vida consagrada à ciência e à política dos oceanos em Portugal e em organizações internacionais, em especial no quadro das Nações Unidas. Uma visão integrada ("holística") e empenhada, apoiada num vasto conhecimento científico e numa profunda cultura histórica, e perspetivando sempre o futuro com optimismo e uma firme crença na capacidade do *homo sapiens sapiens* de mudar o mundo em prol do bem da humanidade.

É sendo felizes que podemos mudar o mundo, afirmou o filósofo francês Alain Badiou. O Mário era uma pessoa feliz.

Mário Ruivo ficaria feliz com a realização desta Conferência: não tanto pela homenagem à pessoa e à ação (pois encarava as homenagens como meios de reforçar os projetos em que estava envolvido), mas pela demonstração da riqueza e vitalidade da investigação científica em Ciências e Tecnologias do Mar que se faz hoje em Portugal, que nesta Conferência se evidencia, e da reflexão, que a acompanha, sobre as políticas do mar e do ambiente, num quadro de cooperação internacional. Se estivesse ainda connosco seria esta demonstração que ele certamente mais valorizaria.

A Conferência, que reúne investigadores de todos os centros de investigação em Ciências e Tecnologias do Mar do país – o que não é demais destacar -, oferece ainda uma excelente oportunidade de intercâmbio científico interdisciplinar e intersectorial, como Mário Ruivo procurou promover de modo persistente. Ficaria igualmente feliz por ver na assistência tantos jovens estudantes, como promessa do futuro que sempre mantinha no horizonte, ciente "como biólogo" da continuidade da espécie humana.

Mário Ruivo: pensar um oceano para todos

Ana Paula Vitorino

Magnífico Reitor da Universidade do Algarve, Prof Dr. António Branco
Senhor Presidente da Câmara Municipal, Rogério Bacalhau
Profª Maria Eduarda Gonçalves
Minhas Senhoras e meus Senhores

É um prazer estar nesta sessão de homenagem ao Prof. Mário Ruivo.

É um prazer por tudo o que o Prof. Mário Ruivo representou e representa para o nosso país, construindo e mantendo uma imagem de Portugal, pelo mundo fora, como líder na governação do oceano, mesmo em períodos em que dentro do nosso próprio país se dava pouca atenção ao mar, e portanto, remando contra a maré, solitário mas persistentemente.

Essa persistência marcou toda a sua vida, e todos aqueles que com ele se cruzaram. Foi uma personalidade reconhecida, democrata, opositor do regime fascista e grande defensor do Oceano como elo primordial de ligação entre os povos, e recurso fundamental para o futuro da Humanidade.

Foi profundamente empenhado na cidadania ativa, na valorização do conhecimento e do desenvolvimento sustentável, com particular interesse nas questões do "nosso grande recurso comum" o Oceano.

Por formação e por convicção foi um defensor da Ciência e da investigação como suporte para boas políticas públicas, incluindo a da Governação Sustentável do Oceano, que ele só via possível se executada de forma integrada, ou como ele preferiria dizer, *holisticamente*.

Foi esta forma de pensar o mundo e o Oceano que fizeram dele um dos Pioneiros da Governação Internacional dos Oceanos, ainda hoje reconhecidos e o Mário mais, porque foi profissional e intelectualmente ativo até ao fim da sua vida.

Essa visão foi muito alicerçada num percurso de vida "fora da caixa" e sobretudo fora da caixa do Portugal dos anos 50, 60 e 70, devido ao seu trabalho nas negociações nas Nações Unidas que dariam origem à Convenção da Lei do Mar, aos cargos dirigentes que assumiu na FAO e na Comissão Oceanográfica Intergovernamental da UNESCO, e que transportou para Portugal, mas também para a Europa. A vida do Mário foi tão inovadora que podemos até dizer que foi o pioneiro da exploração do mar profundo nacional, uma vez que foi o primeiro português em 1956 a mergulhar a 2.200 metros de profundidade ao largo do Cabo da Roca, no batiscafo francês FNRS III, rebocado até esse local pelo Navio da Marinha Portuguesa "Faial".

Nos anos 90 dedicou-se intensamente às "boas" políticas públicas, que advogava, precisavam ser alicerçadas num sólido conhecimento científico. Hoje a todos nós nos parece obvia esta carência, mas quando o Mário defendia esta necessidade, há umas décadas atrás, ainda vários setores, incluindo o político, viam a ciência como uma atividade de uns indivíduos que gostavam de ler muito e fazer experiências fechadas nos seus gabinetes e laboratórios, com pouca aplicação na nossa vida quotidiana. O Mário tinha muito esta noção de necessidade "alimentar" o poder político com informação correta e apropriada para a ação governativa! Se calhar derivada da sua própria experiência de governante, que iniciou em 1975, como Ministro dos Negócios Estrangeiros e continuou como Secretário de Estado das Pescas em três governos constitucionais.

E foi com esta preocupação que foi o grande conceptualizador e dinamizador, em 98/99 do PDCTM – Plano Dinamizador de Ciências e Tecnologias do Mar, que teve o condão de promover a interdisciplinaridade entre as diferentes ciências do mar, e de promover a ligação destas às tecnologias. Ainda hoje muitos dos projetos científicos de mar em Portugal, são feitos por redes que foram constituídas graças a este programa, que possibilitou inclusive criar massa crítica em Portugal para que algumas destas equipas se internacionalizassem com sucesso.

Mas a ciência só desempenharia o seu papel se chegasse aos atores sociais certos, e por isso foi fundador de iniciativas europeias como o European Marine Board (hoje considerada a voz da comunidade científica europeia em mar) ou o EurOcean (Centro Europeu de Informação de Ciências e Tecnologias do Mar) dedicadas à preparação e difusão para a sociedade de informação sobre os resultados da investigação em mar. Informação basilar para uma exploração racional e por isso sustentável dos recursos oceânicos.

Mas de todas as suas iniciativas, se calhar a que mais o encheu de orgulho foi o trabalho e o relatório "O Oceano o nosso futuro" da Comissão Mundial Independente para os Oceanos (CMIO), constituída por 42 especialistas mundiais de todos os continentes e presidida pelo seu amigo Mário Soares. Esta Comissão e este relatório, coordenados pelo Mário, teve o seu ponto alto na sua apresentação na Assembleia da Nações Unidas, que o celebrou com a aprovação do dia 8 de junho como o Dia Mundial dos Oceanos. Nesta e noutras iniciativas ficou demonstrado a sua enorme capacidade de gerar consensos, capacidade que o tornou famoso em vários cenários nacionais e internacionais.

Tudo isto é o que o Mário Ruivo deu a todos nós e ao seu país, e foi por este serviço público que foi condecorado por diversas vezes pelos presidentes Mário Soares e Jorge Sampaio, e até por outros países como a França, ou agraciado com o título de *Honoris Causa* por várias universidades, como a dos Açores ou, em dezembro passado por esta mesma casa, a Universidade do Algarve.

Mas há também a forma como tocou individualmente em cada um de nós! O Mário era um dínamo agregador, que nos fazia avançar em grupo num equilíbrio extraordinário em prol do bem comum, e por isso, sempre muito atento e lúcido à evolução da Humanidade e da sua relação com a Natureza.

Todas estas qualidades e sobretudo dinamismo, aliadas a uma natural simplicidade e alegria de viver, juntaram-se numa pessoa excecional, de maravilhoso convívio, que nos surpreendia constantemente, e que por isso permanece presente como figura tutelar em muitos de nós.

Prova disso é o empenho que o Mário empregou na última obra que coordenou, e para a qual teve a amabilidade de me convidar para o Conselho de Especialistas, o livro "Do Mar Oceano ao Mar Portu-

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guês", editado em 2015, no qual, tendo reunido um conjunto de especialistas, nos deixa, de certo modo o "estado da arte" e as suas convicções sobre o Mar forjadas nos diferentes textos (e fotografias que gostava de selecionar pessoalmente), sempre muito preocupado que fosse uma obra para o grande público, e sobretudo para os diferentes públicos! Ou seja uma obra de divulgação da ciência à Sociedade.

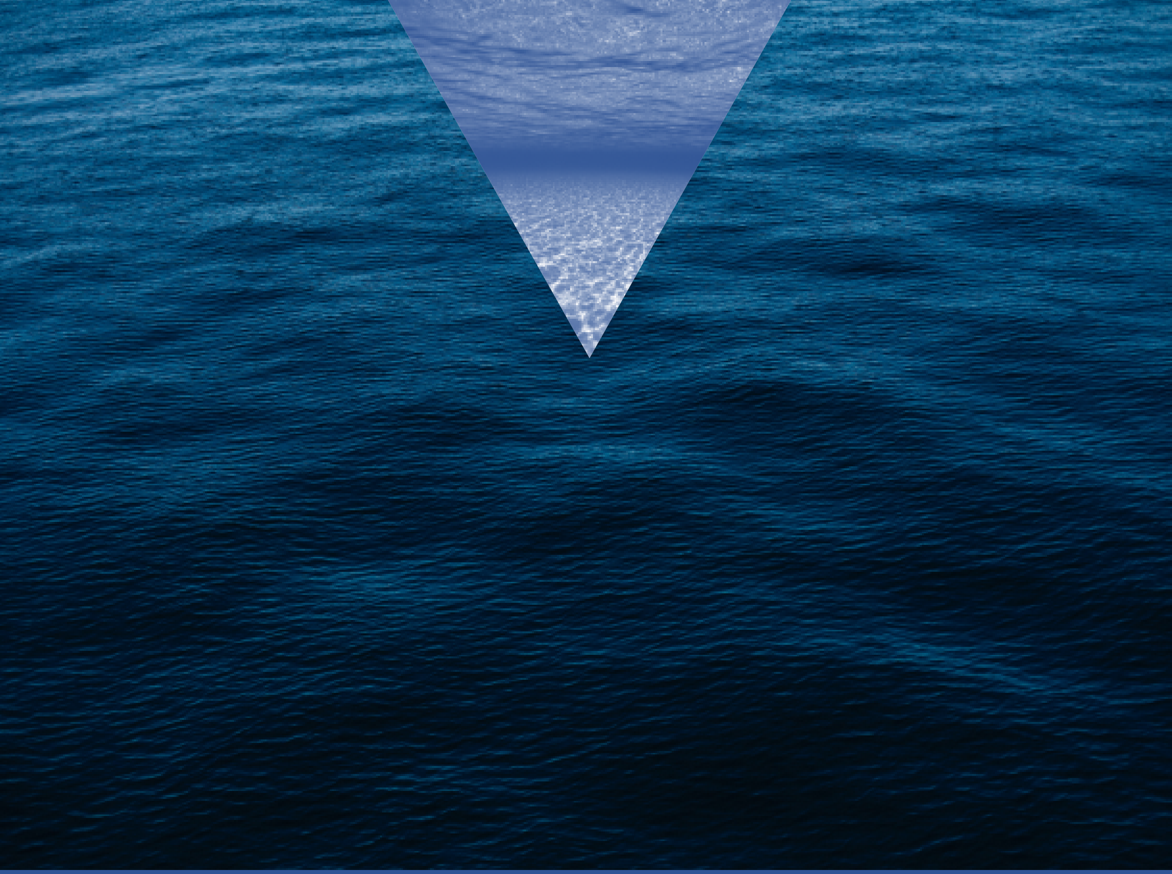
Como diria o Mário, quando não é a altura certa para atracar, "temos que lançar jangadas", porque de certeza alguma dará à costa quando a tempestade o deixar!

Referia-se à necessidade de criar estruturas que se projetassem e continuassem no futuro, como garante de uma ação coletiva, na qual, como biólogo, dizia ele, sabia não poder participar infinitamente.

Foi o que ele fez! Deixou-nos caminhos.

E portanto, também em honra do extraordinário trabalho e legado que o Mário nos deixou, e para que o Mar Salgado de Portugal não sejam lágrimas, como escreveu o poeta, temos todos que assumir uma militância ativa, e em conjunto "cumprir Portugal e o seu mar" como ativo estratégico porque é único e o nosso maior valor!

Obrigado a todos e parabéns à Universidade do Algarve por esta iniciativa.



DIREITO DO MAR E INVESTIGAÇÃO CIENTÍFICA MARINHA

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LAW OF THE SEA AND MARINE SCIENTIFIC RESEARCH

Professor Mário Ruivo played a noteworthy part in the design of the new law of the sea, and in its implementation both at the national, and the international level. As chairman of the Delegation of Portugal to the III UN Conference on the Law of the Sea (1974-78), Professor Ruivo helped shaping legal formulae meant to conciliate the interests of the international community and the specific interests of coastal states, together with emphasis placed on the relevance of international cooperation and of the role of international organizations for a better management and protection of the ocean, as well as for a more balanced distribution of marine science and technology at the world level. In Portugal, Professor Ruivo has chaired the Intersectorial Oceanographic Commission of the Ministry for Science, Technology and Higher Education (COI-MCTES) (1998-2017). Based on a preliminary analysis of data collected by COI-MCTES (2006-2016), interesting indications can be drawn regarding the dynamics of access by foreign research entities to the EEZ and the continental shelf of Portugal (Gonçalves and Gameiro).

Professor Ruivo has also been a pioneer at the world level in bringing environmental considerations into ocean science and ocean management. The proposal which underlay Law 17/2014, of 10 April, establishing the bases for a policy for the planning and management of the national maritime space, later on developed by Decree Law 38/2015, of 12 March, has been the object of a large public and political debate within and outside the Portuguese Parliament. In his quality as president of the National Council for the Environment and

Sustainable Development (CNADS), Professor Mário Ruivo was an active participant in this debate (Becker-Weinberg).

An illustration of a relevant international, multidisciplinary research project under the new ocean regime has been the IOC-sponsored Training Through Research (TTR) Floating University Program undertaken in the Gulf of Cadiz, focusing on large fields of mud volcanoes and other seafloor structures associated with gas seepage, hosting some of the most interesting deep-sea chemosynthetic ecosystems, and opening up potential alternative energy sources for the future, namely of methane release from depth, which may have had a significant impact on past climate change (Menezes Pinheiro).

Indeed, the deep ocean backs a wealth of supporting, provisioning, regulating and cultural functions and services, which hold benefits to mankind as a whole. Yet, a major contemporary challenge is managing the deep ocean sustainably. There is a risk that deep-sea mining will start without adequate environmental planning. Likewise, gaps in deep-ocean governance abound as most legal frameworks, both national and international, lack essential mechanisms to manage and protect ocean resources such as provisions for integrated, ecosystem-based and systematic planning and management. The legacy of Professor Ruivo for a sustainable use of the Ocean is especially relevant in this regard as he has always called for an integrated agenda combining scientific research, legal and policy tools, and awareness and global environmental justice (Hilário e Baker).

Maria Eduarda Gonçalves

Marine Scientific Research in the EEZ and on the Continental Shelf: Portugal's Input to UNCLOS, and Experience in Addressing Foreign Entities' Requests for Access

Maria Eduarda Gonçalves[1] & Maria Inês Gameiro[2]

Abstract

A basic feature of the law of the sea regime for marine scientific research is the jurisdiction of coastal states over such activity in their EEZ and on their continental shelf. Coastal states are entitled to regulate and authorise marine scientific research in these areas. Yet, according to UNCLOS, coastal states shall, in normal circumstances, grant their consent for research projects by other states or competent international organizations. Still, foreign entities may be required to accept local researchers in their cruises, and grant access to the research results.

An issue then is how the coastal states are exercising their rights under UNCLOS, to what extent foreign research entities are being allowed to have access to the EEZ and the continental shelf, and under what conditions.

In this paper, we start by reminding the main traits of the regime of Part XIII of UNCLOS and the salient role of the Delegation of Portugal, led by Professor Mário Ruivo, in the building up of this regime, before attempting some preliminary responses to the aforesaid issues on the basis of data collected by the Intersectorial Oceanographic Commission of the Ministry for Science, Technology and Higher Education (COI-MCTES) (2006-2016). We conclude that an effective mobilization is under way by both interested researching states, and Portugal as a coastal state, of their respective rights under Part XIII. Still, compliance by foreign entities with the pertinent UNCLOS provisions, as they apply for access to areas under the jurisdiction of the Portuguese state, in respect of deadlines for submission of their requests for access, and provision of final reports, looks unsatisfying. Ultimately, the role of COI-MCTES comes out as of critical importance to promote the required international cooperation.

Keywords: Marine scientific research, UNCLOS, Portugal

[1] Professora, ISCTE – Instituto Universitário de Lisboa; Researcher, Dinâmia'CET, ISCTE-IUL, mebg@iscte-iul.pt

[2] PhD in Law; Researcher, Dinâmia'CET, ISCTE-IUL; CEDIS, FDUNL, maria.ines.gameiro@gmail.com

Resumo
Um aspecto fundamental do regime da investigação científica marinha reside na jurisdição dos Estados costeiros sobre esta atividade quando exercida na ZEE e na plataforma continental. Os Estados costeiros têm o direito de regular e autorizar a investigação científica marinha nestas áreas. No entanto, de acordo com a CNUDM, os Estados costeiros devem, em circunstâncias normais, dar o seu consentimento à realização de projetos de investigação por outros Estados ou organizações internacionais competentes. Não obstante, às entidades estrangeiras pode ser exigido que aceitem incluir investigadores do país costeiro nos seus cruzeiros de investigação e que lhe dêem acesso aos resultados da investigação.
Neste quadro de referência, importa analisar como é que os Estados costeiros estão exercendo os seus direitos no âmbito da CNUDM, em que medida estão as entidades estrangeiras a ter acesso à ZEE e à plataforma continental e em que condições.
Neste capítulo, começamos por recordar os principais traços do regime da Parte XIII da CNUDM e o papel saliente da Delegação de Portugal, liderada pelo Professor Mário Ruivo, na construção deste regime, antes de procurar responder a algumas das questões acima mencionadas com base nos dados recolhidos pela Comissão Oceanográfica Intersectorial do Ministério da Ciência, Tecnologia e Ensino Superior (COI-MCTES) (2006-2016). Concluímos que está em curso uma mobilização efetiva dos direitos contemplados na Parte XIII, quer por parte dos Estados pesquisadores, quer por parte de Portugal, enquanto Estado costeiro. Ainda assim, o cumprimento pelas entidades estrangeiras das disposições relevantes da CNUDM aplicáveis ao acesso às áreas sob jurisdição do Estado português, no que respeita, em particular, aos prazos de submissão dos pedidos de acesso e à disponibilização dos relatórios finais, mostra-se insatisfatória. Em última análise, o papel da COI-MCTES revela-se de importância fundamental para a promoção da cooperação internacional requerida neste domínio.

Palavras-chave: Investigação científica marinha; CNUDM; Portugal

1. Introduction

The United Nations Convention on the Law of the Sea (UNCLOS) has profoundly changed the legal framework of maritime activities. Signed in Montego Bay, in 1982, following almost a decade of intense negotiations at the III UN Conference on the Law of the Sea (III UNCLOS), and in force since 1994, UNCLOS replaced the traditional law based predominantly on the freedom of the seas by a regime grounded on a partition of the ocean space. As a consequence of the establishment of 200-miles exclusive economic zones (EEZ) and the foreseen extension of the external limits of the continental shelves circa one third of the Ocean will fall under the jurisdiction of coastal states.

Yet the Ocean is, recognisably, a common. The distribution of sovereignty and jurisdiction rights and powers over the Ocean should not mean fragmentation, surely inappropriate and undesirable for waters and ecosystems that do not know physical boundaries, but rather the sharing of the responsibilities for research, management and protection of those spaces and their resources. One should recall, in this connection, the categorical statement of the Preamble of UNCLOS that "the problems of ocean space are closely interrelated and need to be considered as a whole". These principles should be revisited today in the light of international environmental law giving high priority to integrated management of the coastal areas, and of the seas and oceans generally.

For Portugal, UNCLOS triggered apparently contradictory effects: on the one hand, the reinforcement of the rights and powers of the state on the maritime spaces under national sovereignty or jurisdiction; on the other hand, the reduction of the opportunities of free access to areas which now fall under the jurisdiction of other states. While the new regime implied a considerable limitation of activities with a long tradition in this country such as distant fisheries, new and important opportunities for exploration have amplified in coastal zones. As a consequence of the new regime, the frontiers of the "Portuguese sea" ("Mar Português") moved, so to say, toward the coast (Gonçalves, 1997). Yet, today, Portugal is entitled to one of the largest exclusive economic zones in Europe (1 730 000 km2) encompassing an area 18 times bigger than the land, including the autonomous regions of the Açores and Madeira islands. The continental shelf of Portugal, whose extension is in the process of being endorsed by the Commission on the Limits of the Continental Shelf of the United Nations (c. 2 150 000 km2), approaches 40 times the land territory of Portugal, equalling land territory of the European Union, and around

4% of the Atlantic Ocean (Ruivo et al., 2015).[1] Is the identity of Portugal, traditionally epitomised as a maritime country, evolving towards that of a coastal state in the sense that the expression acquired under the UNCLOS, one might conjecture.

A basic feature of the new regime of marine scientific research under Part XIII of UNCLOS is the jurisdiction of coastal states over marine scientific research activities in their EEZ and on their continental shelf, so-called consent regime. Coastal states have the rights to conduct, as well as to regulate and authorize marine scientific research in those spaces. Yet, according to UNCLOS, coastal states shall, in normal circumstances, grant their consent for marine scientific research projects by other states or competent international organizations. Still, states have the power to oversee such research activities, which includes requiring that foreign entities accept researchers from the coastal state in their cruises, grant access to the research results, and assist in their interpretation. An issue then is how the coastal states, particularly those that are not the major seagoing research nations, are exercising their rights, which procedures are in place to address requests by foreign entities, what has been the scope of the participation of the local researchers in the research activities.

In this paper, we start by reminding the main traits of the marine scientific regime under Part XIII of UNCLOS and the salient role of the Delegation of Portugal, led by Professor Mário Ruivo, in the building up of this regime, before attempting a preliminary appraisal of the requests by foreign entities to undertake research campaigns in marine areas under the sovereignty or jurisdiction of Portugal (2006-2016), based on data collected by the Intersectoral Oceanographic Commission of the Ministry for Science, Technology and Higher Education (Comissão Oceanográfica Intersectorial do Ministério da Ciência, Tecnologia e Ensino Superior - COI-MCTES).[2]

[1] Resolução do Conselho de Ministros n.º 12/2014, Diário da República, 1.ª série N.º 30, 12 de fevereiro de 2014, p. 1313.

[2] Professor Mário Ruivo has chaired COI-MCTES from its inception till 2017.

2. Marine scientific research under UNCLOS: a compromise regime

In its preamble, the UN Convention defines as one of its key aims to establish a legal order for the seas and oceans, which ensures the equitable and efficient use of their resources, and the "study, protection and preservation of the marine environment". At the III UNCLOS, it was explicitly assumed that the attainment of this goal will contribute to a just international economic order.[3] UNCLOS considered that access to marine science and marine technology constitutes an essential condition for the effective exercise of the rights and the fulfilment of the duties assigned to states for the exploration, exploitation, management and conservation of marine resources, and, ultimately, for enabling them to take advantage of ensuing opportunities of economic and social development.

According to UNCLOS, all states shall "endeavour to adopt reasonable rules, regulations and procedures to promote and facilitate marine scientific research carried out in accordance with this Convention beyond the territorial sea and, as appropriate, to facilitate, subject to the provisions of their laws and regulations, access to their harbours and promote assistance for marine scientific research vessels which comply with the relevant provisions" (Article 255). Likewise, "states shall create

[3] Negotiations at the III UNCLOS started while the Charter of Economic Rights and Duties of States was being adopted by the General Assembly of the United Nations Resolution 3281 (XXIX), of 12 december 1974. The Charter, while establishing the general duty of States to engage in scientific and technological cooperation (Article 13 (2), first part) provides for a special obligation to facilitate access of developing countries to the achievements of modern science and technology, transfer of technology and the creation of indigenous technology for the benefit of the developing countries in forms and in accordance with procedures which are suited to their economies and their needs (Article 13 (2), second part). Without prejudice to the principle that the responsibility for the development of each country rests primarily upon itself (Preamble of the Charter), developed States are especially called upon to cooperate with developing countries in the establishment, strengthening and development of their scientific and technological infrastructure and their scientific research and technological activities so as to help to expand and transform their economies (Article 13 (3)). The interests of these countries should also be taken fully into account in formulating guidelines and regulations for the transfer of technology (Article 13 (4)).

favourable conditions for the conduct of marine scientific research in the marine environment and to integrate the efforts of scientists in studying the essence of phenomena and processes occurring in the marine environment and the relation between them" (Article 243). In addition, states shall "make available by publication and dissemination, information on proposed major programmes and their objectives as well as knowledge resulting from marine scientific research" (Article 244 (1)), and "actively promote the flow of scientific data and information and the transfer of knowledge resulting from marine scientific research, especially to developing States" (Article 244 (2)).

As pointed out, a basic feature of the marine scientific research regime under Part XIII of UNCLOS are the rights and powers assigned to coastal states over research activities in their EEZ and on their continental shelf. These include the rights to regulate, authorise and conduct marine scientific research (Article 246 (1)). However, the coastal state's right to consent to research activities by foreign entities is not absolute. In "normal circumstances", the coastal state has the duty to grant consent to projects that are "exclusively for peaceful purposes" and aim to "increase scientific knowledge of the marine environment for the benefit of all mankind" (Article 246 (3)). Coastal states shall endeavour to adopt rules and procedures for ensuring that consent will be granted within a reasonable time. Also, consent is implied if the coastal state does not respond within six months of the receipt of the communication of the proposed project (Article 252). The coastal state only enjoys a discretionary power to refuse its consent whenever research projects touch on certain recognised state interests enumerated in Article 246 (5). Article 246 (5)(b) provides the basis for a refusal of consent to research having potential environmental impacts, where the project involves drilling into the continental shelf, the use of explosives or the introduction of harmful substances into the marine environment.

Thus, accommodation of the potentially conflicting interests of the researching and the coastal states is sought by providing opportunities for these states to participate in research projects and to have access to scientific and technological knowledge and correlative external assistance as conditions to be fulfilled by the researching states or organizations, when applying for the conduct of research in areas under national jurisdiction (Gonçalves, 1983).

States or competent international organizations which intend to undertake scientific research activities in an EEZ or on a continental shelf shall, not less than six months in advance of the expected starting date of the marine scientific research project, provide the coastal state with a full description of: (a) the nature and objectives of the project; (b) the method and means to be used, including name, tonnage, type and class of vessels and a description of scientific equipment; (c) the precise geographical areas in which the project is to be conducted; (d) the expected date of first appearance and final departure of the research vessels, or deployment of the equipment and its removal, as appropriate; (e) the name of the sponsoring institution, its director, and the person in charge of the project; and (f) the extent to which it is considered that the coastal State should be able to participate or to be represented in the project (Article 248).

Furthermore, when undertaking the project, the researching states or organizations shall: (a) ensure the right of the coastal state if it so desires to participate or to be represented in the project, specially on board of research vessels and other craft or scientific research installations, when practicable, without payment of any remuneration to the scientists of the coastal State and without obligation to contribute towards the costs of the project; (b) provide the coastal state at its request with preliminary reports as soon as practicable, and with the final results and conclusions after the completion of the research; (c) undertake to provide access for the coastal state at its request to all data and samples derived from the marine scientific research project and likewise to furnish it with data which may be copies and samples which may be divided, without detriment to their scientific value; (d) if requested, provide the coastal state with an assessment of such data, samples and research results or provide assistance in their assessment or interpretation (Article 249 (1)).

At the time of the III UNCLOS, major distant-water research nations – namely, the United States, the then Soviet Union, France, Japan, the United Kingdom – expressed fears about uncertainties inherent to "creeping jurisdiction" by coastal states, and the ensuing risks for research freedom, including possible publication restrictions (Scholz, 1980). A "regulatory paradox" has been evoked to the extent that advances in scientific knowledge necessary for improving ocean management and protection might be hindered by regulatory measures that restrict marine research activities (Hubert, 2011). The new regime, in particular the discretionary powers conferred to the coastal states, was received with some reservations by such nations. While reproaching the pertinent UNCLOS provisions of ignoring important operational aspects of marine research, fears were expressed that coastal states might prevent research in the EEZ simply by interpreting the obligations placed on researching states in such a way as to impose obstacles to their projects (Scholz, 1980). In this connection, calls were voiced for drawing international standards regarding the scope of these obligations, as well as mandatory dispute settlement.

Yet, it was also admitted, developing states "may not have the sophistication and competence to judge marine scientific research, except in a very narrow way". Accordingly, UNCLOS was also viewed as a "significant improvement" since it would provide increased legal certainty, and it would be in the interest of coastal states "to work with other governments to develop cooperative programs of mutual interest" (Walsh, 1983).

As a matter of fact, UNCLOS envisages the creation of legal and institutional conditions for a balanced distribution of marine science and technology at the world level. The search for compromise pervaded the negotiations throughout, including those on the marine scientific research regime.[4]

[4] In its report on the negotiations of the Third Committee at the 8th Session of III UNCLOS, the Chairman underlined the "need to keep a viable and equitable balance between the interests of all States", a balance that he qualified as "delicate". United Nations, Third Conference on the Law of the Sea, Report of the Chairman of the Third Committee, A/CONF.62/ L. 41, 23 August 1979, p. 2. Opportunities for access to marine technologies, though extensively formulated in Part XIV of UNCLOS, appear, however, to be juridically of less far-reaching scope because of the vagueness of the wording of the respective provisions. The provisions look rather more wishful claims by states than subjective rights properly speaking.

The question then is how countries, especially the less developed ones, can acquire the necessary means to exercise their rights in an effective way. Under the present circumstances, the industrialized states are most likely to contribute the largest share of the effort to acquire new knowledge (Walsh, 1983). Hence the conciliation of the diverse interests involved is to a large extent dependent upon co-operation among the states concerned. Ultimately, the actual pursuit of the objectives of UNCLOS in ocean science and technology rests on the will of the states, and to a significant extent also on adequate operation of international institutions having responsibilities in research and technological development in respect to the sea.

In this light, the conflict between the interests of coastal and of researching states could be regarded as more apparent than real. The overall emphasis placed by UNCLOS on international cooperation in marine scientific research and the transfer of marine technology confirms the spirit of compromise that underlies the regime.

3. International cooperation in marine scientific research, and the role of the Delegation of Portugal at the III UNCLOS

The duty to cooperate is indeed a central trait of the marine scientific research regime under UNCLOS. Section 2 of Part XIII deals specifically with "international cooperation" in marine scientific research. All states and international organizations shall promote international cooperation in marine scientific research for peaceful purposes and on the basis of mutual benefit (Article 242).

International cooperation, as provided for by UNCLOS, can be analysed as follows: (a) Cooperation to facilitate marine scientific research in the interest of research itself or of the state that undertakes the research, and indirectly, of the international community as a whole; (b) Cooperation specifically aimed at expanding the opportunities for coastal states to participate in marine research and have access to its results, as well as to promote their capabilities for research through training and education.

In the first case, the duty to cooperate is incumbent upon all states. Such duty is interpreted without prejudice to the rights and

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powers explicitly assigned to coastal states. In the second case, the explicit reference to developing states as the preferential beneficiaries of the actions foreseen implies that the duties are to be considered as primarily incumbent upon industrialized states (IOC, 1984). UNCLOS explicitly refers to "programmes to provide adequate education and training of their technical and scientific personnel in order to strengthen their autonomous marine scientific research capabilities" (Article 244 (2)). Reference should be made in this connection to the Resolution on development of national marine science, technology and ocean service infrastructures approved by III UNCLOS at its 11th session.[5] This resolution, which resulted from a proposal submitted by Peru on behalf of the Group of 77 indeed relied on an initiative by Mário Ruivo, then secretary of IOC/UNESCO (Jayewardene, 2001).[6] The resolution recommends, "international organizations within their respective fields of competence [assist] developing countries in the field of marine science, technology and ocean services."[7]

The drafters of UNCLOS were conscious that participation in scientific research activities, as well as access to technology, should not be seen as an endeavour separate from the development of national scientific and technological capabilities. This should enable developing countries to make their own choices, adapt imported technologies to local conditions, and participate as partners in the universal process of research and development related to the oceans (Gonçalves, 1982). The jurisdiction which is granted to coastal states with regard to marine sci-

[5] UNCLOS, Annex VI, Resolution on Development of National Marine Science, Technology and Ocean Service Infrastructures, https://treaties.un.org/doc/source/docs/A_CONF.62_121-E.pdf. See also Resolution on the development of national marine science, technology and ocean service infrastructures adopted by the Conference at the 182nd meeting on 30 April 1982, Doc. A/CONF.62/120, http://legal.un.org/diplomaticconferences/1973_los/docs/english/vol_16/a_conf62_120.pdf

[6] Doc. A/CONF 62/L.127, 19 April 1982.

[7] The initiative by the IOC in adopting a Comprehensive Plan for a Major Assistance Programme to Enhance Marine Science Capabilities of Developing Countries provided an important illustration of the response by UN bodies to the new circunstances, doc. IOC/INF-612, Paris, 4 January 1985, http://unesdoc.unesco.org/images/0006/000630/063061eo.pdf; Ruivo, 2010.

entific research may be understood in this perspective as a means to enable them to accede to knowledge on the characteristics of marine resources and ecosystems of those zones, such knowledge being decisive for their proper exploitation, management and utilization.[8]

It should be admitted, however, that the opportunities opened to coastal states to participate in research activities carried out by foreign entities in their EEZ or on their continental shelf are limited to a certain extent. In fact, it does not follow that the coastal states intervene necessarily in the formulation of the research project in order to introduce adjustments, which would virtually make it more consistent with their needs and interests. Technical assistance to be furnished in connection with foreign research projects could, however, be part of the arrangement to facilitate access.

At the III UNCLOS, the Delegation of Portugal played a salient role in helping to build up legal formulae meant to conciliate the interests of the international community and the specific interests of coastal states, together with emphasis placed on the relevance of international cooperation and the role of international organizations for a better management and protection of the ocean. The Portuguese diplomacy was intelligent and realistic enough to anticipate the evolv-

[8] Today, a new legally binding agreement is sought to provide an effective mechanism and institutional arrangements to implement transfer of marine technology and capacity-development in relation to Biodiversity in areas Beyond National Jurisdiction (BBNJ). See http://www.unesco.org/new/en/media-services/single-view/news/transfer_of_marine_technology_and_capacity_building_unesco/. IOC Chair Mr. Peter Haugan (Norway) recently emphasized that the new IOC Capacity Development (CD) Strategy provides a strong framework, which when supported by dedicated funding (IOC's Capacity Development Fund) can provide a clearing-house mechanism for transfer of marine technology (TMT). The question now remaining is how a new legally binding instrument under UNCLOS can provide an effective mechanism and institutional arrangements to implement CD and TMT in relation to BBNJ. This new agreement could provide a much-needed mechanism for enhanced implementation of Part XIV of UNCLOS, something states agreed to do during the Rio+20 UN Conference on Sustainable Development. The new agreement would also complement efforts to implement the recently approved 2030 Agenda for Sustainable Development, through Sustainable Development Goal 14 (SDG14) – "Conserve and Sustainably Use Oceans, Seas and Marine Resources for Sustainable Development" (IOC, 2016).

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ing trends, and the opportunities emerging for Portugal, as a coastal state.

Article 247 UNCLOS deserves being underlined specifically.[9] Based on an original proposal by Portugal at the 6th session of III UNCLOS, this provision is designed to facilitate the consent by coastal states to the conduct of scientific research activities in areas under their jurisdiction whenever the research project has been approved by the states involved within the framework of a competent international organization.[10] This provision has taken particular importance for the activities of the Intergovernmental Oceanographic Commission (IOC, 1981). The IOC Assembly eventually approved Resolution XXIII.8 on a special procedure for the application of Article 247 (IOC, 2007; Jarmache, 2010).[11]

Likewise, the Delegation of Portugal became noticed by its leading action in respect of institutional arrangements, a position informed by the Delegation's true recognition of the critical importance of international cooperation in the furthering of the objectives of UNCLOS, particularly in the scientific and technological domains, and the need for adjustments in the competent international organizations' structures,

[9] Article 247 states: "A coastal State which is a member of or has a bilateral agreement with an international organization, and in whose exclusive economic zone or on whose continental shelf that organization wants to carry out a marine scientific research project, directly or under its auspices, shall be deemed to have authorized the project to be carried out in conformity with the agreed specifications if that State approved the detailed project when the decision was made by the organization for the undertaking of the project, or is willing to participate in it, and has not expressed any objection within four months of notification of the project by the organization to the coastal State."

[10] Doc. A/CONF.62/WP.10/Add.1, Memorandum by the President of the Conference on document A/CONF.62/WP.10, Marine Scientific Research, Third United Nations Conference on the Law of the Sea 1973-1982, Official Records, Volume VIII (Informal Composite Negotiating Text, Sixth Session), 1977, para. 69; see also Relatório da Delegação de Portugal, III Conferência do Direito do Mar. Sexta Sessão – Nova Iorque, Maio/Julho 1977, p. S.5/29.

[11] Another key IOC decision has been Resolution XX-12 of the IOC Assembly approving guidelines, criteria and standards for the transfer of marine technology under Article 271 of UNCLOS within the framework of the IOC's activities and programmes.

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competences and powers to facilitate the implementation of the new regime.[12]

Part of this effort found expression in specific initiatives undertaken by the Delegation of Portugal, led by Professor Mário Ruivo, at the III UNCLOS between 1976 and 1978.[13] This Delegation promoted the holding of a series of informal meetings of around 30 delegations chosen in keeping with a balanced geographical distribution and participation of diverse interest groups, to discuss and recommend action on international institutional arrangements.[14] Indeed, since its initial drafts, UNCLOS included numerous references to the roles of "competent international organizations". International organizations are not mentioned nominally with the exception of the references to participation of experts of the organizations in the special arbitration commissions in the dispute settlement mechanisms (Article 2, Annex VIII) or, in the case of the IOC, in the workings of the Commission on the Limits of the Continental Shelf (Annex II, Article 3).

As a backup document for the said meetings, the Delegation of Portugal prepared and circulated the "Annotated Table on references to institutional mechanisms contained in the Revised Single Negotiating Text (Fifth Session)" (New York, 24 August 1976, Rev. 1), together with a paper entitled "Trends in Ocean Uses and Related Institutional Aspects". Following a proposal from the Delegation of Portugal[15], the United Nations Secretariat ultimately published the "Annotated directory of intergovernmental organizations concerned with ocean affairs".[16]

[12] See Declaration by M. Ruivo (Portugal), United Nations, Third Conference on the Law of the Sea, A/CONF. 62/SR. 96, 9 May 1978, prov., p. 3. In a somewhat similar vein, the Delegation of Portugal remarked that the application of UNCLOS to the European Economic Community (EEC) required a special reference in the final clauses of the Convention.

[13] Professor Mário Ruivo, who was the president of the Delegation of Portugal to the III UNCLOS from 1974 to 1978.

[14] Cf. Nota sobre as Iniciativas da Delegação de Portugal na III CNUDM em Assuntos Institucionais, documento informal, 1978.

[15] Third United Nations Conference on the Law of the Sea 1973-1982, Doc.A/CONF.62/SR.70, 7 May 1976, 70th Plenary meeting, Official Records of the Third United Nations Conference on the Law of the Sea, Volume V, 7 May 1976.

[16] Doc. A/CONF.62/L.14, 10 August 1976. See also A /CONF.62/121, Final Act of the Third United Nations Conference on the Law of the Sea, 27 October 1982, p. 142.

An intent behind the initiatives of the Delegation of Portugal was to render the Conference duly aware of the role that international organizations, especially those part of the United Nations system, must play in furthering peaceful international cooperation and a balanced development in ocean affairs, and the critical importance for Member States to provide the means required for the organizations to comply with their responsibilities under UNCLOS.[17] However, these initiatives were also part of a strategy to create an atmosphere favourable to the acceptance of the location in Portugal of an United Nations organisation competent in ocean affairs. This was indeed the case for the International Tribunal on the Law of Sea.[18] Among the arguments put forward with the proposal of the Government of Portugal to offer Lisbon as the seat for the International Tribunal on the Law of the Sea were the long-lasting maritime history of the country, the recent return of the country to democracy, and the desire of Portugal to contribute to enhancing the dialogue among countries having different social and economic regimes and levels of development, within the principles of a new international economic order in an interdependent world.[19]

Following up from the said initiatives, a formal proposal was submitted to the III UNCLOS for a declaration or resolution on international institutional arrangements in ocean affairs, co-signed by Bulgaria, Cape Verde, Chile, Egypt, France, Indomesia, Iran, Kenya, Liberia, Mexico, Morocco, Nepal, Netherlands, Poland, Portugal, Senegal, Spain and Uruguay.[20] The proposal propounded the es-

[17] In Negotiating Group 5 on the settlement of disputes, Portugal advanced an informal suggestion for a new paragraph of Article 296, admitting the possibility to have recourse to compulsory conciliation in case of controversies over a state's violation of international norms imposing the conservation of marine living resources (Suggestion officieuse du Portugal – Article 296, NG5/14, 27 avril 1978).

[18] Letter dated 8 July 1977 from the representative of Portugal to the President of the Conference, Doc. A/CONF.62/55, 12 July 1977.

[19] Idem.

[20] Doc. A/CONF. 62/L. 30, 18 May 1978, Bulgaria, Cape Verde, Chile, Egypt, France, Indonesia, Iran, Kenya, Liberia, Mexico, Morocco, Nepal, Netherlands, Poland, Portugal, Senegal, Spain and Uruguay: draft declaration or resolution on international institutional arrangements in ocean affairs, http://legal.un.org/diplomaticconferences/dtSearch/Search_Forms/dtSearch.html

tablishment by the Secretary General, in consultation with Member States and on a broad geographical basis, of an ad hoc study group of 14 to 20 members with expertise in ocean affairs to review and identify gaps in the current institutional system, evaluate institutional implications of UNCLOS and come up with suggestions to improve the system's effectivity.

In the same spirit, the Delegation of Portugal submitted a proposal for the holding of periodic conferences on international affairs concerning the oceans justified by the continuous technical progress raising new issues of environmental protection, and the ensuing need to promote scientific knowledge and reinforced international cooperation.[21] When presenting this proposal, the Delegation of Portugal explained:

> "In undertaking the review mentioned in paragraph 1, the conference shall take into account major trends in ocean uses, new technologies, progress in scientific knowledge, management and protection issues of international significance, institutional and legal developments and other relevant aspects of international ocean affairs."[22]

One should underline the pioneering nature of both these proposals. The launching, in 2000 (Resolution 54/33 of the UN General

[21] Portugal: proposal regarding periodic conferences on international ocean affairs, Doc. A/CONF. 62/L. 23, Official Records of the Third United Nations Conference on the Law of the Sea, Volume IX, http://legal.un.org/docs/?path=../diplomatic-conferences/1973_los/docs/english/vol_9/a_conf62_l23.pdf&lang=E; see also Declaration by M. Ruivo (Portugal), United Nations, Third United Nations Conference on the Law of the Sea 1973-1982, Doc. A/CONF.62/SR.60, 8 April 1976, Official Records of the Third United Nations Conference on the Law of the Sea, Volume V, p. 28.

[22] Declaration by M. Ruivo (Portugal), United Nations, Third Conference on the Law of the Sea, Doc. A/CONF. 62/SR. 96, 9 May 1978. Prov., p.4. The Delegation of Chile supported this proposal by the Delegation of Portugal, in particular, at the final session of UNCLOS, cf. Third United Nations Conference on the Law of the Sea 1973-1982, Doc. A/CONF.62/SR.98, 98th Plenary meeting, Official Records of the Third United Nations Conference on the Law of the Sea, Volume IX, p. 43. The Delegation of Chile stressed the importance it payed to "Portugal's proposal concerning the co-ordination of international organizations which undertook activities relating to the sea". (Idem, p. 44). On the importance of this matter, and of the action by the Delegation of Portugal, see Kingham and Mc Rae (1979).

Assembly), of the United Nations open-ended informal consultative process in order to facilitate the annual review by the Assembly of developments in ocean affairs; current work under the United Nations Preparatory Committee for the Development of an international legally binding instrument under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction; and, ultimately, the holding, under the UN General Assembly, of the Ocean Conference (2017) all illustrate the early vision of the Delegation of Portugal.[23]

The Intergovernmental Oceanographic Commission (IOC) is the main body within the United Nations system with competences in the field of marine scientific research and related transfer of marine technology. The IOC has been a central focus of the strategy of the Delegation of Portugal at the III UNCLOS, and in other related instances of international cooperation until today. Action by the IOC in recent decades, based on work of its Advisory Body of Experts on the Law of the Sea (ABE-LOS) is particularly relevant in this regard since it has sought to develop international standards for cooperation in marine scientific research and the transfer of marine technology following up from UNCLOS (Jarmache, 2010).

Ultimately, the need was felt, specifically, to clarify the regime of so-called "operational oceanography" under IOC major programmes jointly led with the World Meteorological Organisation (WMO), and to Argo floats. The IOC Executive Council adopted Resolution EC/XLI.4 on Guidelines for the implementation of Resolution XX-6 of the IOC Assembly regarding the deployment of profiling floats in the high seas within the framework of the Argo programme (Jarmache, 2010; Dexter and Treglos, 2010). These floats, which are launched

[23] One can read, in the report of the Delegation of Portugal to the 6th Session of III UNCLOS (1977): "*Como balanço final, consideramos que os interesses substantivos de Portugal podem considerar-se salvaguardados. A posição de Portugal tem-se afirmado e pode considerar-se hoje que a nossa Delegação faz parte daquelas que têm um efectivo impacto na evolução das negociações na Conferência, tendo adquirido uma posição de liderança em relação aos aspectos institucionais*." Relatório da Delegação de Portugal, III Conferência do Direito do Mar, Sexta Sessão – Nova Iorque, Maio/Julho 1977, p. S.2/4 e S. 2/5.

in the high seas, may, however, drift into a state's exclusive economic zone. The key legal issue here is whether the rules to apply to such data collection should be regarded as distinct from scientific research, and therefore exempt from Part XIII of UNCLOS (Hubert, 2015). Some delegations at the IOC (i.e. USA, UK and Belgium) have argued that a distinction should be kept between "marine scientific research" and "operational oceanography". In this case consent by the coastal state would not be required. Other delegations (Argentina, Peru, Portugal) disagree with this view, and have argued that states should express their interest in being notified. The IOC Guidelines recognize the right of coastal states to be notified about activities that involve the launching of floats in the high seas, which may enter areas under national jurisdiction. The Delegation of Portugal had the opportunity to remind the IOC Assembly that the application of Article 247 could facilitate the development of operational oceanography.[24]

The critical importance of international cooperation in marine research, as well as the importance to clarify applicable rules and standards, is nowadays involved in a sense of even more urgency in view of "the many natural and man-made issues concerning the ocean", and "the need to understand better the role that ocean science can play", requiring the development of "stronger ocean governance mechanisms to profit from the knowledge obtained" (Holland and Pugh, 2010; Bernal, 2010). Indeed, new challenges emerge, which need to be taken into account in the context of implementation of the marine research regime. Technological innovation is opening up many more possibilities to explore and better understand the oceans, including observation from space, and use of sensors such as those of profiling floats mentioned above. The potential for conflicts has increased due to intensified and expanding uses of the oceans, such as renewable energy production, bioprospecting and marine geoengineering. Besides, human action has impacted on the ocean through habitat destruction, biodiversity loss, overfishing, pollution, climate change, and ocean acidification (Hubert, 2015). Also, the recognition

[24] IOC, Twenty-third Session of the Assembly, Paris, 21–30 June 2005, UNESCO, IOC-XXIII/3, p. 26.

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has grown that marine scientific research itself is bringing about environmental threats, and of the need to address this issue. One may recall that states can justify certain restrictive measures aimed at preventing damage to the marine environment, even if their actions have the effect of limiting the conduct of marine scientific research, but only where such restrictions are necessary and reasonable (Arts 194(4) and 240(d) UNCLOS).

At the IOC, these concerns have been raised together with the call for ABE-LOS to consider and help address emerging legal issues relating to scientific research, keeping the dialogue between science and technology, and the law (Kullenberg, 2010: 87). Yet this group of experts has not met since 2009.

4. Requests by foreign research entities for access to areas under the jurisdiction of Portugal: an overview (2006-2016)

As pointed out, Portugal played a remarkable part at the III UNCLOS, helping to shape some of the legal formulae reached by the Convention, in a spirit of compromise. Specifically, the participation of the Delegation of Portugal in the negotiation of Part XIII of UNCLOS was guided by some major leit-motivs: supporting a moderate version of the consent regime alongside the recognition of the importance of furthering marine scientific research in the common interest of mankind; highlighting the key role of international organizations as means to enable marine scientific research and related transfer of technology, while facilitating dialogue between coastal states and researching states; guaranteeing the peaceful implementation of the regime through an appropriate dispute settlement system.[25]

The fact that Portugal waited for 1997 to ratify the Montego Bay Convention did not prevent the country to apply basic principles and rules of UNCLOS before its entering into force. Considerations of political pragmatism led the Portuguese government – while the III UNCLOS

[25] Relatório da Delegação de Portugal, III Conferência do Direito do Mar. Sexta Sessão – Nova Iorque, Maio/Julho 1977, p. S.5/28.

was still at an early stage - to adhere to the reformist trends furthered by Afro-asiatic and Latin American countries seeking the enlargement of areas under national jurisdiction. This attitude looked rather eloquent to the extent that the maritime policy of Portugal had traditionally been characterised by the defense of the freedoms of the sea.[26] As a matter of fact, Portugal was one of the first European states to implement the emerging regime for the EEZ with the adoption of Law 33/77, 28 May, extending the limits of the territorial sea and establishing the exclusive economic zone in the continent and in the archipelagos of Açores and Madeira. Portugal assumed, so to speak, its identity as a "coastal state" in the sense that the expression assumed under UNCLOS. Portugal took part in the Group of Coastal States, an informal group formed for the negotiating process at the III UNCLOS.

Portuguese policy-makers have increasingly acknowledged the critical relevance of science and technology as a prerequisite for an effective exploration and exploitation of the natural resources of the marine areas under national sovereignty and jurisdiction. An objective of the National Strategy for the Sea (Estratégia Nacional para o Mar 2013-2020) (following up from the Estratégia Nacional para o Mar 2006-2016) consists in "reinforcing the national scientific and technological capability, by stimulating new fields of action that promote knowledge of the Ocean and may enhance in an effective, efficient and sustainable manner its resources, uses, activities and ecosystems services."

The establishment of the EEZ, whose limits are presently defined by Law 34/2006, 28 July, entails the reinforcement of the duties of the Portuguese state with respect to the protection of the marine environment and the conduct of scientific research required. Following

[26] It will not be a surprise that the Delegation of Portugal to the UN Conferences on the Law of the Sea of 1958 and 1960 argued strongly for the freedom of the seas principle, affirmed by the Convention on the High Seas (1958), while expressing reservations vis-à-vis the proposal already put forward at the time by some Latin American delegations for the extension of the limits of the territorial sea well beyond 3 miles. Accordingly, the Delegation of Portugal did propose the introduction in the Convention on the High Seas of the principle of the freedom of research, which was ultimately rejected.

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UNCLOS, domestic law relating to the EEZ has been permeated with references to the "protection of the marine environment and the sustainable use of marine living resources", and the duty to comply with applicable international law (Articles 1-A; Articles 3, 10 and 15-A, Decree Law 287/87, 7 July, amended by Decree Law 383/98, 27 November, and by Decree Law 40/2017, 4 April). This legislation also requires that conservation and management of the living resources be based on the "best scientific information available on the species and or the stocks" (Article 2-A (1) of Decree Law 287/87, 7 July). Ecological considerations pervade the EEZ regime: fishing catches may be limited even in the face of "levels of uncertainty of scientific knowledge" "for precautionary reasons", an early illustration of the precautionary principle (Article 1-A, Decree Law 287/87).[27]

As a state party to UNCLOS, Portugal must inherently comply with the regime applicable to marine scientific research under Part XIII. Decree Law 52/85, 1 March, did establish a specific regime, including an authorization procedure applicable to research activities by foreign entities in marine areas under Portuguese sovereignty and jurisdiction, reproducing the main provisions of UNCLOS in this respect, namely Article 248. Noticeably, according to this legislation, the authorization would depend on acceptance by the foreign entities of the right of "governmental observers, scientists or technicians" to join the implementation of the project (Article 19, Decree Law 52/85). Uncertainty remains, however, with regard to the current status of Decree Law 52/85.[28]

[27] 1986, accession to the European Economic Community, now the European Union, has also shaped the maritime policy of Portugal with regard to exploration and conservation of the sea and its resources falling under the EU's common fisheries policy. It is worth underlining that according to Framework Directive on the Maritime Strategy (Directive 2008/56/EU), the EU promotes the integration of environmental considerations in all relevant policies.

[28] Decree Law 278/87, of 7 July, establishes the regulatory framework for the exercise of fishing and marine cultures in marine areas under the sovereignty and jurisdiction of Portugal, and derrogates Decree Law 52/85 (Article 35 (1)). Nevertheless, Decree Law 278/87 also states, "As far as regulations to which the present legislation remits have not been published, the present legal norms remain in force in relation to the respective matters, provided that they do not contradict this legislation" (Article 35 (2)).

Now, according to Law 17/2014 (Article 21) and Decree Law 38/2015 (Article 57), while requests by national entities are subject to prior authorisation of the competent authorities (Article 51, Decree Law 38/2015), requests by foreign entities should be submitted to the Ministry of Foreign Affairs.

Foreign entities wishing to undertake marine scientific research in areas under national jurisdiction should submit their requests to the Unity of Overflights and Naval Scales (Unidade de Sobrevoos e Escalas Navais) of the Ministry of Foreign Affairs (USEN/MNE). This unit is competent to "analize the requests for entry and use of maritime areas and Portuguese harbours by military, oceanographic and other foreign vessels and propose their authorization to higher authorities" (Article 7 (1)(b), Portaria 31/2012, 31 January). The Directorate for International Economic Organizations (Direção de Serviços das Organizações Económicas Internacionais) is competent to "analize and follow-up sea and ocean affairs in particular under the United Nations Convention on the Law of the Sea, together with the General Directorate for European Affairs" (Direcção-Geral dos Assuntos Europeus) (Article 5 (b), Portaria 31/2012, 31 January).

USEN/MNE forwards the requests received to both: i) the Foundation for Science and Technology, which in turn forwards them to COI-MCTES; and ii) the General Directorate of the Maritime Authority (Direção-Geral da Autoridade Marítima - DGAM).[29]

COI-MCTES is competent, among other missions, to give advice on matters relating to the regime, and to evaluate, from a scientific and technical perspective, the requests for research in marine areas under national jurisdiction received from foreign entities.[30] COI-MCTES prepares its advice on the basis of the analysis of the documents received and of consultation of the scientific community in the

[29] Decree Law 43/2002, 2 March, amended by Decree Law 263/2009, 28 September (defines the Maritime Authority System and creates the National Maritime Authority) and Decree Law 44/2002, 2 March, amended by Decree Law 121/2014, 7 August (defines the National Maritime Authority and creates the Directorate-General of the Maritime Authority).

[30] Resolução do Conselho de Ministros nº 88/98, Diário da República I Série-B, Nº 157, 10-7-1998.

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sciences and technologies of the sea. Let's recall that oceanographic vessels seeking to undertake research in marine areas under the jurisdiction of Portugal should submit their requests, through their respective embassies (the "appropriate official channels", according to Article 250 UNCLOS), with all information and data concerning the planned research (Article 248 UNCLOS). COI-MCTES also explores the possibilities for involvement of Portuguese researchers in the campaigns on board the research vessels. One might note that this is also the sole opportunity to raise environmental issues, since no specific institutions with specific competences on environmental matters are heard.

In turn, the DGAM leads the process within the Navy, including the Hydrographic Institute, requiring the advice of the General Directorate of Marine Resources (Direção-Geral dos Recursos Marinhos - DGRM), presently a department of the Ministry for the Sea.[31] DGAM compiles and integrates the opinions received, and sends out a single advice to USEN/MNE.

When the research project is to be located in the marine subdivisions of Madeira or Açores (Article 5 (2), Decree Law 108/2010, 13 October), the competent bodies of the government of the Autonomous Regions are consulted. Whenever the research campaign is carried out in the subdivision, a special request for authorization must be submitted to the Regional Government. A database on these research requests has been set up.[32]

In the end, USEN/MNE transmits its final decision by the means of a verbal note to the corresponding embassy.

Once the research campaign is over, the resulting report and the data should be provided to USEN/MNE, which forwards them to the entities from which the initial opinions have been obtained, in accordance with Article 249 (1)(b) UNCLOS.

A preliminary overview of data collected by COI-MCTES between 2006 and 2016 offers interesting indications, specifically, about the

[31] Arguing for the establishment of a specific entity in charge of foreign research in the marine areas under the jurisdiction of Portugal, see Ferreira da Silva, 2015.

[32] Information obtained verbally from USEN/MNE; Legislative Regional Decree 9/2012/A, 20 March.

number of requests received, their national origin and the scientific domains covered, the information provided with the requests, their timing, and the extent to which there is participation of researching institutions and researchers from Portugal in the campaigns. From this overview some questions come out, which deserve further scrutiny.

In the period considered, 297 requests, a significant amount, we might say, were received at COI-MCTES, distributed among the subdivisions of the Continent (around 190) and Açores (around 82) and Madeira (around 25), as follows (Figure 1):

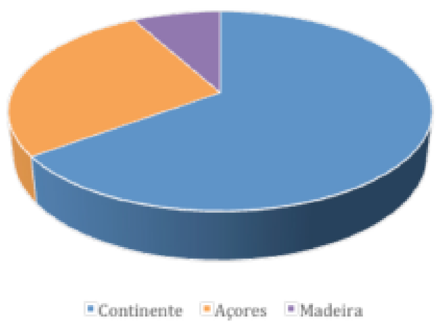

Figure 1. Distribution of the campaigns by subdivision.
Data collected from COI-MCTES (2006-2016)

A remarkable fact, all the requests have been authorized with just one exception, resulting from the refusal of the Autonomous Region of the Açores (Figure 2).

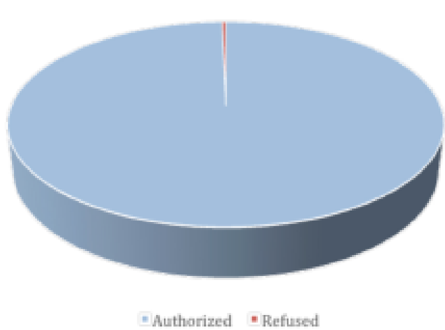

Figure 2. Research campaigns 2006-2016
Data collected from COI-MCTES (2006-2016)

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The states of origin of the research vessels were: Germany (80); France (74); Spain (49); the United Kingdom (31); the United States of America (15); the Netherlands (12); Belgium (5); Denmark (4); Italy (4); Russia (3); and a few other countries or organizations. Remarkably, research campaigns by Spanish teams have been increasing in recent years. The average duration of the campaigns has been 31 days.

The research campaigns have been focused on the following research domains: deep sea, genetic resources and cetacean ecology, mainly in the Açores; fishing stocks and seismic and tsunami studies, particularly on the Continent; and ocean and climate interactions and ocean modelling, thourough all the subdivisions (Figure 3).

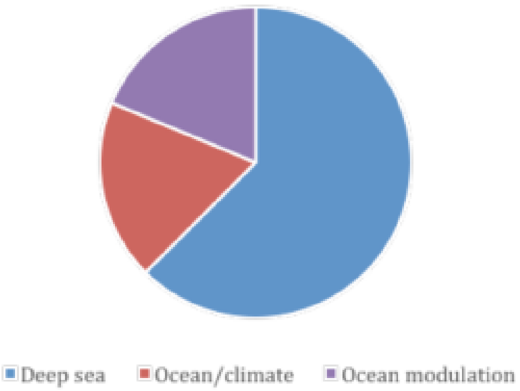

Figure 3. Distribution of the campaigns by research areas.
Data collected from COI-MCTES (2006-2016)

Some of the research campaigns have had as an explicit goal the training and capacity building of young students and researchers. This is the case with most of the campaigns from the USA, but also with several campaigns from Germany.

Remarkably, circa three quarters of the requests were submitted to the Ministry of Foreign Affairs without compliance of the deadline of six months required by UNCLOS (around 190 from a total of 297) (Figure 4).

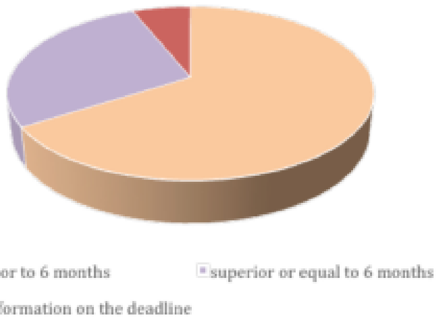

Figure 4. Requests submitted to the Ministry of Foreign Affairs – deadline compliance. Data collected from COI-MCTES (2006-2016)

Indeed, COI-MCTES has sent out regular recommendations requesting the Ministry to inform the Embassies of the importance of submitting the requests in due time. The less abiding countries are Italy, Russia, France, the United States of America, Denmark, Spain, the United Kingdom, Belgium, the Netherlands and Germany (Italy (4/4); Russia (3/3); France (74/60); United States of America (15/12); Denmark (4/3); Spain (49/32); United Kingdom (31/20); Belgium (5/3); Netherlands (12/7); Germany (80/46).

Also, the final reports, which are mandatory under Article 249 (1)(b) UNCLOS, have not been submitted by the research teams in a considerable number of cases (Figure 5). Formal notifications have also been sent to the institutions in charge calling for the reports to be made available.

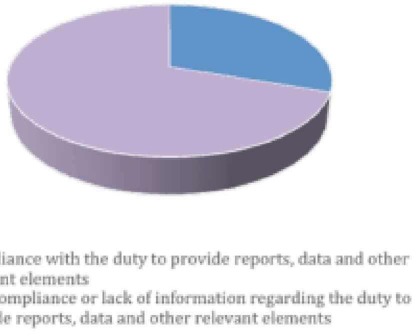

Figure 5. Requests submitted to the Ministry of Foreign Affairs – compliance with Article 249 (1)(b)(c). Data collected from COI-MCTES (2006-2016)

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Moreover, data have frequently been made available later than the conclusion of the project, which may, however, be justified in view of the time required to process the data.

Available data from COI-MCTES suggest an intermitent improvement in compliance with the deadline for submissions and in the provision of reports, data and conclusions (Figure 6). It should be pointed out, though, that the absence of data reported to COI-MCTES does not necessarily mean that no report has been produced, but just that COI-MCTES has not been informed.

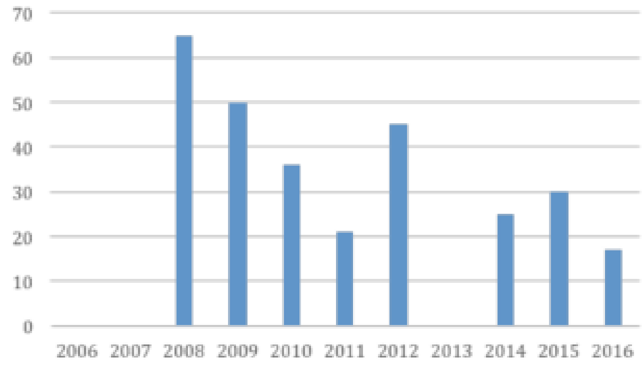

Figure 6. Requests submitted to the Ministry of Foreign Affairs – compliance with Article 249 (1)(b)(c). Data collected from COI-MCTES (2006-2016)

In some instances, the information provided with the requests for access did not reveal the equipment used. This has been the case with campaigns by research vessels from the USA, the Netherlands or the United Kingdom, contradicting Article 248 (b) UNCLOS.

Between 2006 and 2016, from the 297 research campaigns undertaken, 143 foresaw the participation (on board or not) of Portuguese researchers, most of them from the University of Açores (around 40 campaigns), the University of Lisbon (around 27), the University of Aveiro (around 21) and the University of Algarve (around 20) (Figure 7).[33]

[33] Other research institutions involved have been: LNEG – 13; IPIMAR- 12; IPMA – 11; INETI – 10; IH – 8; University of Madeira – 6; EMEPC – 3; University of Évora – 2; ICNF – 1; EMAM – 1

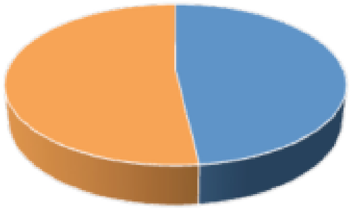

Figure 7. Participation of Portuguese researchers – 2006/2016. Data collected from COI-MCTES (2006-2016)

The role of COI-MCTES comes out as of considerable relevance for the assessment of the nature of the proposed campaigns, discriminating research and commercial campaigns, and detecting potential environmental impacts; in targeting information about the planned research campaigns to appropriate local research institutions or individual researchers, and paving the way for their possible involvement; in making researchers aware of potential synergies between the envisaged research campaigns and projects going on in related areas and subject-matters (an example of the impact of this role is the association between two large projects, MoMAr and InterRidge, besides the numerous suggestions put forward by COI-MCTES regarding the participation of researchers or possible links with other projects or research areas provides an ilustration); and in keeping a database concerning foreign research campaigns in areas under the jurisdiction of Portugal.

6. Conclusion

As signalled, UNCLOS triggered apparently contradictory effects for Portugal: on the one hand, the reinforcement of the rights and powers of the state on the marine spaces under national sovereignty or jurisdiction; on the other hand, the reduction of the opportunities of free access to areas, which now fall under the jurisdiction of other states. Indeed, the identity of Portugal, traditionally epitomised as a maritime nation, evolved towards that of a coastal state in the sense that the expression acquired under the UNCLOS. This regime change seems to have had a considerable impact on the conditions for the country to pursue marine research activities. Indeed, as a consequence of UNCLOS, Portugal is now entitled to one of the largest exclusive economic zones in Europe, including the autonomous regions of the Açores and Madeira, and to a continental shelf whose extension (in the process of being endorsed by the UN) approaches 40 times the land territory of Portugal.

Against this background, the role played by the Delegation to the III UNCLOS is worth emphasizing. The Delegation of Portugal, led by Professor Mário Ruivo (1974-1978), helped in the effort to reconcile the overall interests of the international community and the specific interests of coastal states, while underlining the need for UNCLOS to duly acknowledge the critical role of international organizations to further the required international cooperation in marine affairs.

A preliminary analysis of available data relating to foreign research in the EEZ and on the continental shelf of Portugal (2006-2016) provides interesting indicators about the actual mobilization by both interested researching states, and Portugal as a coastal state, of their respective rights under Part XIII of UNCLOS. Still, compliance by foreign research entities with the pertinent provisions of Part XIII as they apply for access to areas under the jurisdiction of Portugal, particularly in respect of deadlines for submission of the requests for access, and the provision of the final reports, looks somehow unsatisfying.

Ultimately, the role of COI-MCTES emerges as of considerable importance to evaluate the interest of the proposed campaigns for national research institutions and researchers, and fostering the necessary cooperation, and in maintaining a very useful information source about the campaigns by foreign research entities in marine areas under national jurisdiction. This role should in our view be duly reinforced.

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Mud Volcanism and Hydrocarbon-rich Fluid Seepage in the Gibraltar Arc System: 9 Years of IOC-sponsored Training through Research Investigation

Luís M. Pinheiro[1] & Vítor H. Magalhães[2]

Abstract

Extensive areas of mud volcanism and gas seepage occur at continental margins in all kinds of geodynamic settings. In the deep S. Iberia and Northwestern Moroccan margins, an area often described as the "Gulf of Cadiz", and in the Alboran Sea, extensive multinational and multidisciplinary research allowed the discovery of vast fields of mud volcanoes and other seafloor manifestations of hydrocarbon-rich fluid seepage: pockmarks, mud diapirs, diapiric ridges and fields of methane-derived authigenic carbonates. These two areas are part of the Gibraltar Arc System, located at the Africa-Eurasia Plate Boundary and formed due to the Africa-Eurasia SE-NW directed oblique convergence, in particular since the late Miocene. 63 mud volcanoes of various sizes, reaching more than 3 km in diameter and a few hundred meters high, were identified in this area by geophysical surveys and confirmed by coring and underwater video surveys. These structures mainly concentrate in the Gulf of Cadiz compressional accretionary wedge and in the W. Alboran Sea back-arc basin. Recently, mud volcanoes were also found west of the accretionary wedge along the Azores-Gibraltar Fracture Zone. Thermogenic gas hydrates were recovered from several mud volcanoes and a large diversity of chemosynthetic communities, including new species for the science, were identified. Vast fields of methane-derived authigenic carbonate crusts and chimneys, precipitated through anaerobic methane oxidation by consortia of archaea and bacteria, record significant past episodes of methane release from depth. Such episodes of methane release, in particular associated with gas hydrate dissociation in deep sea sediments,

[1] Departamento de Geociências and CESAM, Universidade de Aveiro, Aveiro, Portugal, lmp@ua.pt

[2] Instituto Português do Mar e da Atmosfera (IPMA) and IDL, LA, Lisboa, Portugal, vitor.magalhaes@ipma.pt

may have had an impact on past climate change. In this paper, we provide a brief review of mud volcanism and gas seepage in the Gibraltar Arc System, and discuss the origin of the fluids, the tectonic control, migrating pathways and the surface and sub-surface expressions of fluid flow in this major tectonic province.

Keywords: Mud volcanoes, pockmarks, gas hydrates, Gibraltar Arc, Gulf of Cadiz, Alboran Sea, MDAC

Foreword

The inclusion of this short review paper in this volume in tribute to Prof. Mário Ruivo is fully justified, as a significant part of the Portuguese and Spanish led investigations of mud volcanism and other hydrocarbon-rich fluid escape structures in the Gulf of Cadiz and in the Alboran Sea reported here, were possible thanks to the Intergovernmental Oceanographic Commission (IOC) Training Through Research (TTR) Floating University Program, coordinated by Moscow State University, a Program strongly promoted and supported by Prof. Mário Ruivo, both in his capacity as IOC Executive Secretary and as the Portuguese Representative at the IOC. In the scope of the TTR program, a large number of Portuguese and Spanish scientists and students, together with students and colleagues from Russia, Morocco, several European countries and the USA, shared for many years the great opportunity to carry out research together, on board the RV Prof. Logachev, in a spirit of multicultural friendship, knowledge sharing and capacity building. Many of the young students and researchers that participated in this Program are today outstanding scientists.

Mário Ruivo was a true humanist, a strong defender of the world's Ocean and its biodiversity, and a unique personality of our time at the national and international highest level in marine science and global ocean governance. Mário Ruivo firmly believed that scientific knowledge and international cooperation are essential and the key for informed decisions and policies concerning the Ocean, the sustainable use of its resources, and the protection of its environment, biodiversity and health, critical for our survival. Mário Ruivo was a true friend, a passionate human being, always ready to stand up for his ideals and causes. He was an extremely generous person, with an enormous curiosity and an amazing vast culture, a clear and extremely sharp mind and a prodigious memory, and a wide perspective and a deep knowledge of all major matters concerning the ocean. He was also a passionate observer of the human nature and aspirations. His ideals and long term vision will continue to deeply inspire and guide all of us who had the privilege to have been his friends and had the opportunity to have worked closely with him.

1. Introduction

Extensive areas of mud volcanism and gas seepage occur both onshore and in the ocean in all kinds of geodynamic settings (e.g. Kopf, 2002; Mazzini et al., 2017; and references therein). These mud volcanoes (MV) expel a hydrocarbon-rich fluidized mud breccia and form volcanic edifices that frequently exhibit a conical form, with diameters at their base that can reach a few km and a height that can attain a few hundred meters. The offshore mud volcano provinces also host highly interesting deep-sea chemosynthetic ecosystems with a large biodiversity. The deep S. Iberia and Northwest Moroccan margins, an area often described as the "Gulf of Cadiz", together with the Western Alboran Sea, form an area generally known as the Gibraltar Arc System (Figure 1). In this area, extensive multinational and multidisciplinary research, a significant part of which was carried out in the scope of the Training Through Research program of UNESCO-IOC, has allowed the discovery of numerous seafloor hydrocarbon-rich fluid escape structures. These include a large number of mud volcanoes, sometimes with gas hydrates (Figures 1, 2 and 3), and other seafloor manifestations associated with gas seepage, such as pockmarks, mud diapirs, diapiric ridges and fields of methane-derived authigenic carbonates (MDAC; Figure 4), observed on sidescan records, high resolution multibeam bathymetry, seismic reflection profiles and bottom photos, from the continental shelf to water depths in excess of 4500 m (Figure 1).

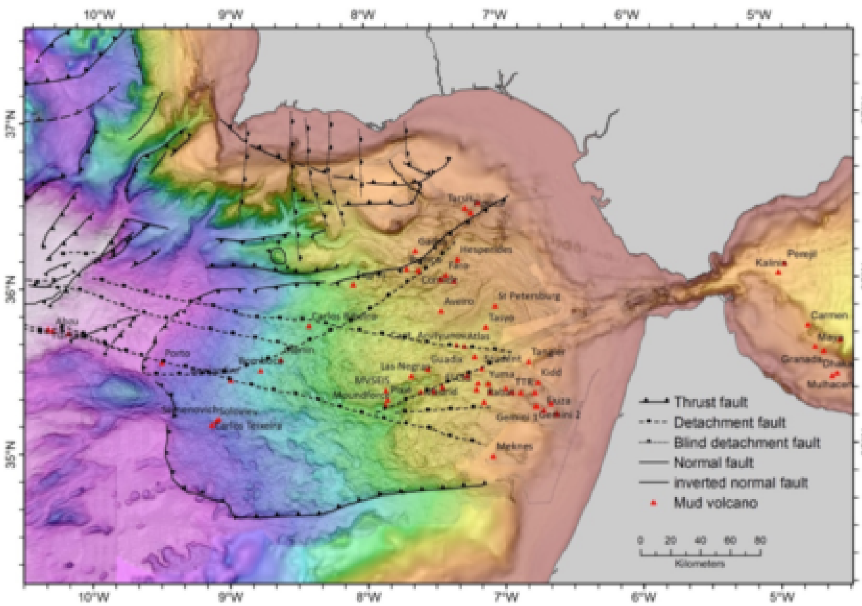

Figure 1: Occurrence of mud volcanoes in the Gibraltar Arc System (red triangles). Also shown major structural features and trends. The curved thrust in the central part of the figure shows the limit of the Gulf of Cadiz accretionary wedge.

The dewatering processes in the Gulf of Cadiz accretionary wedge (fossil and active) provide a mechanism for generating deep, overpressured fluids that drive the observed superficial fluid escape processes and manifestations (Pinheiro et al., 2003; Somoza et al., 2003; Hensen et al., 2007; 2015; Medialdea et al., 2009; Hensen et al., 2015). Active gas seepage/venting in the Gulf of Cadiz, has only been observed so far at the Mercator MV (Van Rooij et al., 2005; Akhmetzhanov et al., 2007). However, fossil pockmarks identified on the upper continental slope of the Gulf of Cadiz and in the Alboran Sea (Somoza et al., 2003; Blinova et al., 2011; León et al., 2014), suggest extensive fluid flow may have occurred during the late Quaternary. Besides pockmarks, past fluid flow episodes have also been recorded by the widespread occurrence of methane-derived authigenic carbonates (MDAC; Fig. 4) found in association with mud volcanoes, mud diapirs, diapiric ridges and faults (Díaz-del-Río et al., 2003; Magalhães et al., 2012). MDACs on the Guadalquivir Diapiric Ridge, the Formosa Ridge and on the mud diapirs and mud volcanoes located at water depths between 800 and 1400 meters water depth in the northern margin of the Gulf of Cadiz have been interpreted as evidence of enhanced gas seepage episodes, most probably related to periods of destabilization of gas hydrates (Gardner et al., 2001; Díaz-del-Río et al., 2003; Pinheiro et al., 2003; Magalhães, 2007). Episodes of significant methane release from the deep sea, in particular associated with gas hydrate dissociation in deep sea sediments, may have had an impact on past climate change.

2. Geological and geodynamic setting of the Gibraltar Arc System

The Gibraltar Arc region (Figure 1) is located at the gateway between the Mediterranean and the Atlantic, along the complex Africa-Eurasia Plate Boundary. The formation mechanism and the tectonic processes responsible of the shape and evolution of the tectonic arc are still poorly understood and controversial. Proposed models include: (1) westward movement of the presente Alboran microplate between Africa and Iberia; (2) westward roll back of a subduction slab; (3) extensional collapse of the earlier collisional Betic–Rif orogen caused by convective removal of deep lithospheric roots; slab detachment; or delamination of lithospheric mantle (see e.g. Mattei et al., 2006 and references therein). This area is characterized by shallow and intermediate seismicity, but high magnitude earthquakes occurred near Granada (Buforn et al., 1991; Urchulutegui et al., 2006).

3. Hydrocarbon-rich fluid escape manifestations in the Gibraltar Arc System

Hydrocarbon-rich fluid migration, accumulation, escape and surface manifestations in the Gibraltar Arc system (Figure 1) include numerous *mud volcanoes*, a large number of which have been confirmed by coring, *pockmarks*, in the S. Spanish margin of the Gulf of Cadiz and in the Alboran Sea, extensive areas of *methane-derived authigenic carbonates* off S. Portugal and Spain, *gas fields*, some of which are being exploited off S. Spain and that likely continue to the west into

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the S. Portuguese Margin, numerous *gas chimneys* visible on seismic reflection sections, *diapiric ridges* and *gas hydrates*. These are addressed below in some detail.

3.1 Mud volcanoes, mud diapirs and diapiric ridges

63 mud volcanoes of various shapes and sizes (most of them conical, a few hundred meters to 3 km wide at their base, and with a height that can attain a few hundred meters) have been identified in this area by geophysical surveys (reflection seismic profiles, sidescan and multibeam bathymetric surveys (Figures 1 and 2). Most of them have been confirmed by coring and underwater high-resolution video surveys: 55 concentrate in the compressional accretionary wedge of the Gulf of Cadiz and 8 are located in the Alboran Sea extensional back-arc basin (Gardner et al., 2001; Pinheiro et al., 2003; Somoza et al., 2003; 2012; Blinova et al., 2011; Hensen et al., 2015); both these areas were formed due to the Africa-Eurasia convergence since the Cenozoic, the formation of the Gibraltar Arc and the roll-back of a subducting slab. Recently, similar structures were found west of the accretionary wedge along the Azores-Gibraltar Fracture Zone (Hensen et al., 2015). Some of these mud volcanoes show a clear "Christmas-tree" structure, visible on seismic profiles (Somoza et al., 2003; Medialdea et al., 2009; Somoza et al., 2012), indicating recurrent eruptions.

Mud diapirs and diapiric ridges, in which acoustic blanking likely associated with gas is observed, but without any indications of mud extrusion, have been found in various areas of the Gibraltar Arc system; often, fields of MDAC are found in association with these diapiric ridges (e.g. Diaz-del-Rio et al., 2003; Somoza et al., 2003; Magalhães et al., 2012).

3.2 Gas hydrates

Thermogenic gas hydrates, with C2+ values as high as 19%, have been recovered from several mud volcanoes in the Gulf of Cadiz, and their presence has been inferred for many MVs located at depths

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greater than 1500 m (Mazurenko et al. 2002; Pinheiro et al., 2003; Magalhães, 2007). Although gas hydrates have not yet been recovered in the Alboran Sea, there is strong evidence for their existence, in particular in the Carmen MV (Blinova et al., 2011). Until present, gas hydrates in the Gulf of Cadiz were only recovered from the Michael Ivanov, Porto, Bonjardim, Capt. Arutyunov and Ginsburg mud volcanoes (Mazurenko et al., 2002; Pinheiro et al., 2003; Nuzzo et al., 2009; Hensen et al., 2015). However, strong indications of their presence were found for most of the deep mud volcanoes in the South Portuguese Margin (Figures 2 and 3). Indicators of the presence of gas hydrates found outside of mud volcanoes edifices are restricted to a few areas in which not very clear and discontinuous bottom simulating reflectors (BSRs) are observed locally on the Iberian slope, often associated with pockmarks (Somoza et al., 2000; Casas et al., 2003). A BSR has also been interpreted in the Mercator mud volcano, in the NW Moroccan margin (Depreiter et al., 2005).

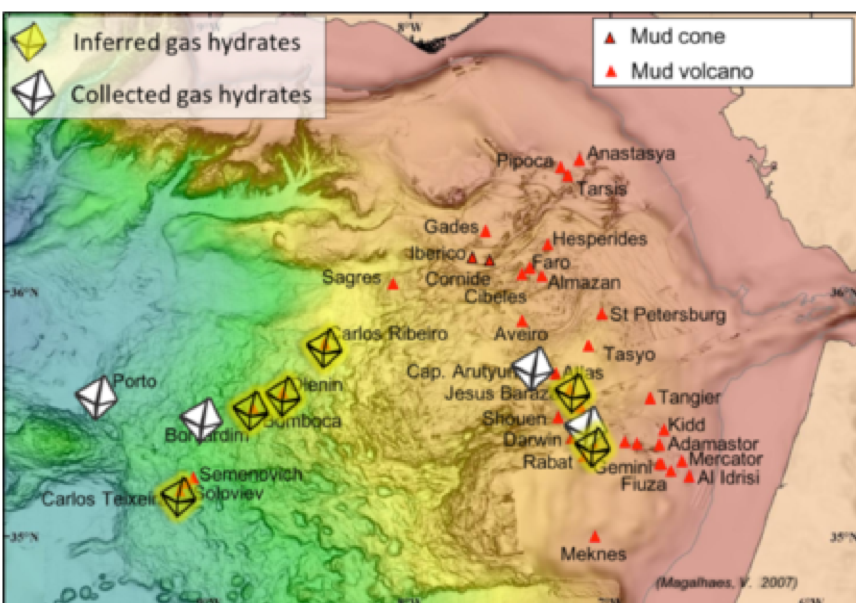

Figure 2: Porto Mud Volcano, in the Deep South Portuguese margin of the Gulf of Cadiz. Approximate depth: 4100m. The approximate location (A), a sidescan sonar image (B) and the corresponding 5kHz seismic profile (C) are shown, as well as images of retrieved gas hydrates from gravity cores (D-G), during the TTR-16 cruise (Akhmetzhanov et al., 2008).

The collected gas hydrate samples and the mud volcano mud breccia and fluid compositions are variable but characterized by high concentrations of light hydrocarbons (methane through butane), indicating a complex biogenic, thermogenic and mixed origin (Mazurenko et al., 2002; Stadnitskaia et al., 2006; Nuzzo et al., 2008; 2009).

Mud volcanoes conduits are preferential pathways for dewatering fluids of the accretionary wedge sediments. Besides a microbial source for the methane, through degradation of organic matter at shallow levels, thermogenic carbon sources were also identified in samples collected from the Gulf of Cadiz mud volcanoes (Blinova and Stadnitskaia, 2001; Mazurenko et al., 2003; Stadnitskaia et al., 2006; Hensen et al., 2007; Nuzzo et al., 2009). As such, the most active fluid escape structures in the Gulf of Cadiz have sufficient amounts of methane and other light hydrocarbons to form gas hydrates wherever the thermodynamic conditions are favourable.

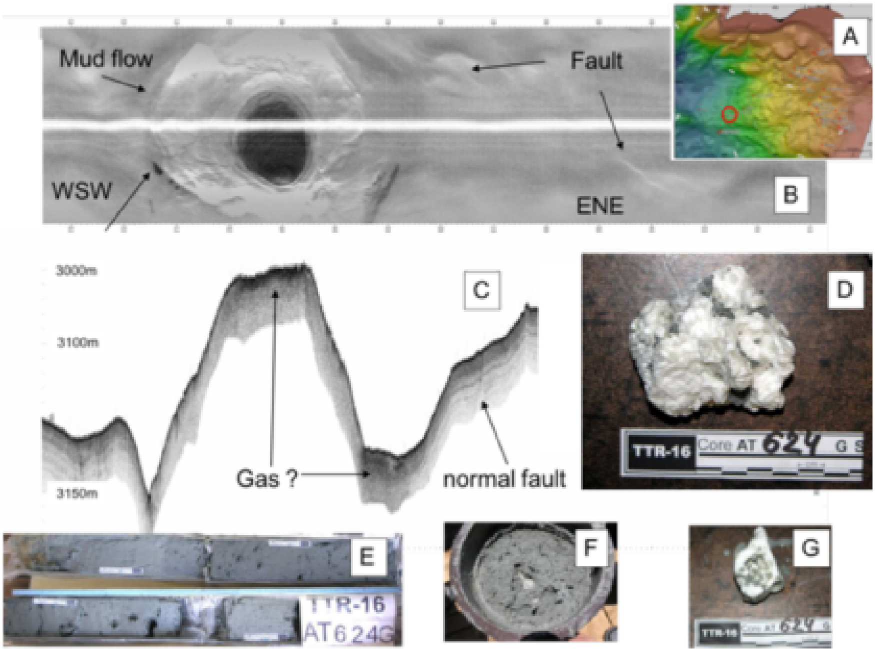

Figure 3: Gas hydrates recovered from mud volcanoes (red triangles) in the Gulf of Cadiz. White octahedra indicate mud volcanoes from which gas hydrates have been retrieved; yellow octahedra indicate mud volcanoes for which the presence of gas hydrates is inferred based on geochemistry of fluids.

3.3. Methane-derived authigenic carbonates

Evidence of major past episodes of methane release from depth have been recorded by the occurrence of vast fields of methane-derived authigenic carbonate (MDAC) crusts and chimneys (Figure 4), some of which composed of dolomite, precipitated through anaerobic methane oxidation, a process mediated by consortia of archaea and bacteria (Pinheiro et al., 2003; Blinova et al., 2011; Magalhães et al., 2012; Wang et al., 2014). The occurrences of MDAC in the Gulf of Cadiz are restricted to mud volcanoes, mud cones, diapiric ridges, fault scarps and along some of the channels of the Mediterranean Outflow (likely controlled by deep faults, given their orientation), indicating that these structures are the preferential pathways for fluid escape at the seafloor. MDAC have also been collected in the W. Alboran Sea associated with MVs and pockmarks (Blinova et al., 2011).

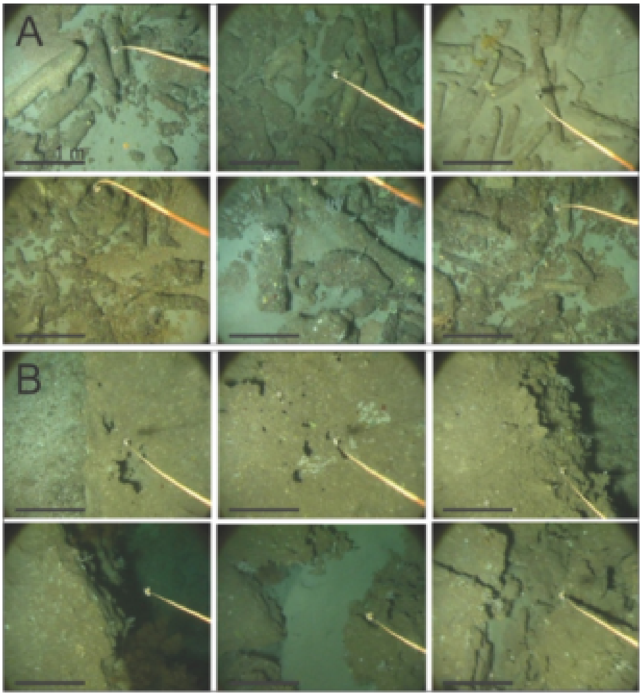

Figure 4: Underwater video images from Iberico (A – 6 top figures) and Hesperides (B – 6 lower figures) mud volcanoes showing: (A) the dolomite-dominated carbonate chimneys (the scale bar is of about 1 m wide); (B) the aragonite-dominated carbonates (scale bar is 1 m long).

The MDAC from the Gulf of Cadiz occur as two main lithologic types: (I) dolomite-dominated chimney-type carbonates and (II) aragonite-dominated carbonates (Figure 4). The chimney-type carbonates (Figure 4A) exhibit a wide variability of shapes and sizes, ranging from pipe-like, linear tubes, curved, helicoidal, conical and branched, to nodular and massive irregular shapes. These chimneys are mostly broken, sometimes intensely fragmented, forming carbonate rubble, and they are generally observed lying on the seafloor (Magalhães et al., 2012). The aragonite-dominated carbonates (Figure 4B) occur as: (1) mounds of various dimensions, some up to 4-5 m high and several meters long; (2) rough hard-grounds that can pave the seafloor for several square meters, with a thin or absent sediment cover; (3) crusts and slabs, similar to the pavements; and (4) carbonate concretions of a few cm in size within the superficial sediments.

Geophysical seafloor mapping and underwater video observations show that MDAC are extremely abundant and form extensive fields paving large areas of the seafloor in the Northern Margin of the Gulf of Cadiz (Magalhães, 2007; Magalhães et al., 2012), as illustrated by the seafloor video images of the Hesperides and Iberico MVs (Figure 4). MDAC collected from MVs and pockmarks from the Alboran Sea are aragonite-dominated carbonates (Blinova et al., 2011, López-Rodríguez, 2015), similar to the carbonate concretions from the Gulf of Cadiz.

The MDAC are formed as a product of anaerobic oxidation of methane and other light hydrocarbons (Magalhães et al., 2012) coupled with seawater sulphate reduction. Petrographic and stable isotopic characteristics of the MDAC suggest that their formation, at least in some samples, is correlated with episodes of formation and dissociation of gas hydrates (Magalhães et al., 2012; Magalhães et al., Submitted). The ages of the MDAC indicate that their formation occurred in short discontinuous intervals of time, not during the lowest sea levels, but when sea level was changing most rapidly. The ages obtained point to their precipitation during: (1) the onsets of glacial/interglacial cycles (terminations 2 and 3), contemporary with rapid sea level rises; (2) at the transition from stadial to interstadial, also corresponding to rapid sea level rise; and (3) at the transition from interglacial (MIS 5.5) to stadial MIS 5.4 or from interglacial (MIS 5.3) to stadial 5.2, associated with periods of progressive sea level lowering (Magalhães, 2007).

In the Gulf of Cadiz, macro-scale chemosynthetic organisms and patches with chemosynthetic microbial communities were found at several MVs and areas of cold seepage (Rodrigues, 2009; Hilário et al., 2010; Cunha et al., 2013; Ramalho et al., 2018). The chemosynthetic fauna in the Gulf of Cadiz include host invertebrates with bacterial symbionts such as the Calyptogena, Acharax and pogonophora tube worms. They were observed only in small areas correlated with recent or more intense active hydrocarbon venting sites. The microbial communities in the Gulf of Cadiz include archaea, sulphate reducing bacteria, methanogenic bacteria, sulphide and methane-oxidizing bacteria and bacteria that oxidize heavier hydrocarbons (Niemann et al., 2006). The microbial communities are critical to carbon cycling in intermediate to slow seepage environments as they have an important role in the precipitation of the MDAC. Small patches of probable bacterial mats were also identified in the Faro MV, indicating a present-day state of low fluid venting at the seafloor of this MV. The low- to mid-range microbial methane turnover and Anaerobic Methane Oxidation (AOM) activity that was measured at most of the MVs from the Gulf of Cadiz (Niemann et al., 2006) also indicates a present-day state of low fluid venting to the seafloor. This is also corroborated by the limited observation of active gas bubbling, only at two locations in the Mercator mud volcano crater, in areas of highly gas-saturated mud breccia (Van Rooij et al., 2005; Akhmetzhanov et al., 2008).

The number of chemosymbiotic species present in the Gulf of Cadiz MVs is remarkably higher than in other cold seeps. Their diversity and distributional patterns appear to be related to the variability in biogeochemical conditions within and between MVs (Rodrigues, 2009; Hilário et al., 2010; Cunha et al., 2013; Ramalho et al., 2018).

3.4 Pockmarks

Pockmarks have been found mainly through multibeam bathymetry in the upper slope of the Gulf of Cadiz (Baraza and Ercilla, 1996; Somoza et al., 2003) and in the Western Alboran Sea (Blinova et al., 2011: León et al., 2014). Until present, no active seepage has been observed at these pockmarks. The pockmarks in the Alboran indicate higher and more recent seepage activity, as demonstrated by the presence of live chemosynthetic fauna (Blinova et al., 2011, López-Rodríguez, 2015).

4. Tectonic control and origin of fluids

The integrated interpretation of high resolution multibeam bathymetry and numerous seismic reflection profiles (both high resolution Sparker, conventional and deep multichannel) show that a significant number of the mud volcanoes that occur in the Gulf of Cadiz area are located along faults, mainly strike-slip faults, or at the intersections of strike slip faults with the arcuate thrusts associated with the formation of the Gibraltar Arc (Pinheiro et al., 2003; 2006; Somoza et al., 2003; Medialdea et al., 2009). The MVs in the Alboran Sea are mainly associated with deep normal faults in this back-arc setting (Maldonado et al., 1999; Comas et al., 1992; Blinova et al., 2011; Somoza et al., 2012). Deep multichannel seismic sections show that major faults associated with fluid escape structures at the surface can be traced down to several km below the seafloor (Medialdea et al., 2009; Pinheiro et al., in prep.) and suggest that fluid migration pathways can reach a depth of several km below seafloor. Geochemical analysis and modelling have shown that mud volcano fluids are, on average, highly enriched in CH_4, Li, B, and Sr and depleted in Mg, K, and Br, and that clay mineral dehydration at depths of about 5 km below seafloor, most likely within Mesozoic and Tertiary shales and marls, is the major source of fluids for the Gulf of Cadiz area (Hensen et al., 2007; Nuzzo et al., 2009). Dehydration may be induced primarily by overburden and tectonic compression but, in some cases, like in the Captain Arutyunov MV, pore fluids with very high concentrations of Li and B indicate additional leaching at temperatures above 150°C, which could be explained by the injection of hot fluids along deep penetrating major E–W strike–slip fault systems. This is also supported by the occurrence of thermogenic, but significantly CH_4-

enriched, light volatile hydrocarbon gases at Captain Arutyunov MV, which cannot be explained by shallow microbial methanogenesis. A similar deep origin for the mud volcano fluids has also been proposed for the mud volcanoes in the Alboran Sea, based on the analysis of the pore fluids from the Carmen MV, suggesting that the water in the mud volcano fluids likely originates from clay mineral dehydration in the thermal zone of the smectite to illite transformation (Sautkin et al., 2003; Blinova et al., 2011, Gennari et al., 2013). An additional contribution of methane from serpentinization at deep crustal/upper mantle levels, via the Fischer-Tropsch reaction, may also be postulated but yet to be confirmed.

5. Conclusions

The Gibraltar Arc System, which includes the Gulf of Cadiz and the West Alboran Sea mud volcano provinces, is characterized by extensive evidence of hydrocarbon-rich fluid seepage, manifested at the sea bottom by a large number of mud volcanoes, mud diapirs, diapiric ridges, pockmarks and fields of methane-derived authigenic carbonates. The fluids composition is complex and often mixed, with a clear thermogenic signature in places, but with a significant contribution also from shallow biogenic methane. The potential contribution of methane from serpentinization processes at deep levels cannot also be ruled out but requires further investigation. The fluid origin is likely at deep levels in excess of 5 km and involves mobilization of the deep sedimentary clayey section of the Gulf of Cadiz accretionary wedge and deep sedimentary sections in the Alboran Sea, and the input of water from dehydration processes at temperatures of around 150ºC, likely related to the smectite-illite transformation. These fluids migrate to the surface along major deep faults (essentially along arcuate thrusts, strike-slip and normal faults) that root at depths in excess of 5 km, and the major manifestations of the fluids migration at the sea bottom occur along these faults or at fault intersections. The anaerobic oxidation of methane and higher hydrocarbons in the shallow sedimentary section is mediated by consortia of sulphate-reduction bacteria and archaea, that promote the precipitation of methane-derived authigenic carbonates (MDAC), often in the form of crusts and chimneys. These MDAC record important episodes of past fluid escape in the study area; their detailed study, in particular including accurate U-Th dating, can provide crucial information on major past episodes of methane expulsion from deep levels in the crust to the shallow sedimentary section and possible also to the hydrosphere and the atmosphere.

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The Deep Ocean – A New Stewardship Frontier

Ana Hilário[1] & Maria Baker[2]

Abstract
Technological advances in recent decades underpin the massive progress in the exploration and characterization of deep-sea ecosystems, revealing highly diverse deep-sea floor habitats and a realm that is vulnerable to disturbance. Nonetheless, the deep sea remains mostly unknown. Likewise, gaps in governance abound as most legal frameworks, both national and international, lack essential mechanisms to manage and protect ocean resources such as provisions for integrated, ecosystem-based and systematic planning and management. A significant challenge here is that management needs to keep pace with fast-growing industries. This communication focuses on three main aspects of the legacy of Professor Mário Ruivo for sustainable use of the deep oceans 1) scientific discovery and observation; 2) legal and policy tools; and 3) awareness and global environmental justice.

Keywords: Conservation; Human Impacts; Management

1. Human impacts in the deep ocean

The deep sea, the largest biome on the planet, is often described as Earth's "last frontier". Since the beginning of deep-sea exploration, in the late 19th century, major technological developments led to amazing discoveries that challenged our way of understanding life on the planet and revealed a wealth of resources resulting from high biodiversity and habitat heterogeneity (Figure 1). Nevertheless, the deep ocean is still mostly unknown: only five percent of it has been explored with remote instruments and less than one percent of the deep

[1] CESAM and Department of Biology, University of Aveiro, Portugal. Email: ahilario@ua.pt

[2] Ocean and Earth Sciences, University of Southampton, UK. Email: mb11@noc.soton.ac.uk

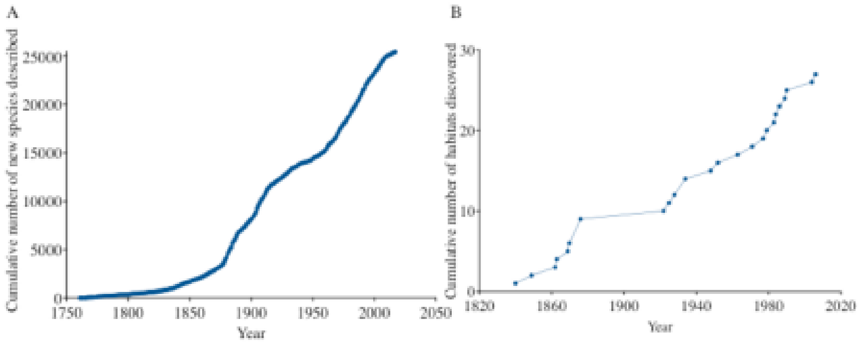

Figure 1. Cumulative number of species described (A) and habitats discovered in the deep-sea (B). A. Data courtesy Dr. Tammy Horton, The World Register of Deep-Sea Species; B) From Ramirez-Llodra et al. (2010).

seafloor has been sampled or monitored (Ramirez-Llodra et al. 2010), thus we remain largely ignorant of how deep-ocean ecosystems change in space and time, both naturally and in response to human activities.

One of the greatest challenges of the 21st century is managing the deep ocean sustainably, i.e., achieve appropriate protection while enabling use of living and non-living resources (Barbier et al. 2014). With increasing population and raising demands for food, raw materials and energy, and as resources become depleted on land and in shallower areas of the oceans, we have begun to extract them from deeper water (Ramirez-Llodra et al. 2011). Further, raising demands for new technologies, including for green energy, are leading industries to seek access to mineral deposits in remote and difficult to exploit regions, such as the seabed, where these resources are comparatively abundant (Petersen et al. 2016). Although humans have used the oceans for millennia, technological developments now allow exploitation of fisheries resources, hydrocarbons and minerals below 2000 m depth, from where our knowledge on the resilience of ecosystems is still extremely limited (Cunha et al. 2017) and, in most cases, with poor or non-existent management strategies in place.

The impacts from fisheries and hydrocarbon exploitation are well documented (Morato et al. 2006, Cordes et al. 2016) and include stock depletion, endangering species via bycatch, total destruction of vast areas of the ocean floor by trawling and pollution. No full-scale seabed mining has currently taken place, but equipment tests and scientific experiments that have been carried out since the 1970s suggest long-term negative effects in mining vicinities (Vanreusel et al. 2016). Further, as pH and oxygen concentration decline as a consequence of climate change, the cumulative impacts of all human activities in the deep-sea is expected to increase in the future (Figure 2) compromising the resilience of deep-sea ecosystems and the services they provide.

2. A complex governance framework

The deep ocean supports a wealth of supporting, provisioning, regulating and cultural functions and services that hold benefits to mankind as a whole. As such, it should be managed from a global and multi-sectorial dialogue and interdisciplinary research must occur at the intersection of biodiversity, resource economics, climate science, law and policy (Mengerink et al. 2014). However, governance in the deep ocean is currently fragmented and constrained by complex legal boundaries: there are 148 coastal nations with exclusive economic zones, several claims for the extension of the continental shelf and

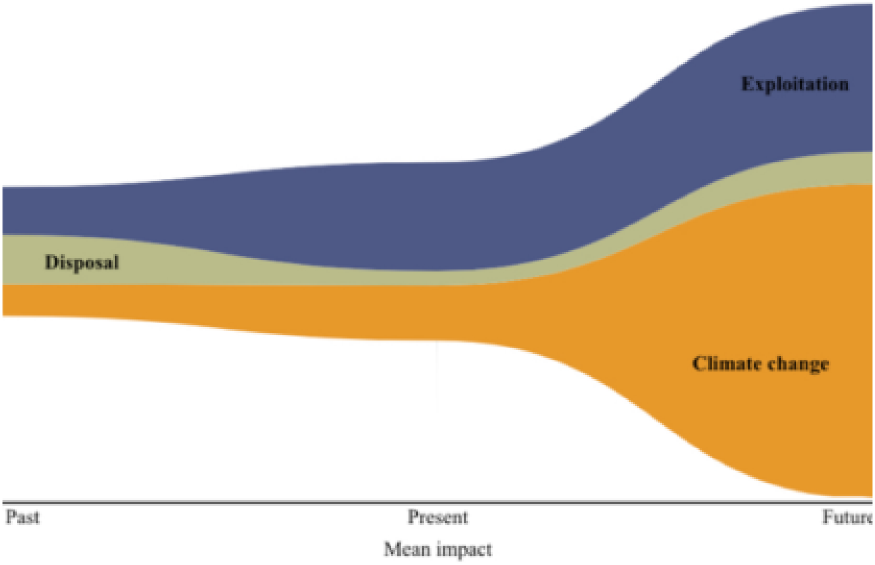

Figure 2. Evolution of the dominant impacts on deep-sea habitats. Modified from Ramirez-Llodra et al. 2010.

64% of the ocean lies in areas beyond national jurisdiction and is therefore common heritage of the mankind and managed by the United Nations Convention on the Law of the Sea (UNCLOS).

Many countries with deep-water resources lack the expertise to support sustainable management and protection while in international waters, there is no consistent application of environmental assessment approaches. Under the umbrella of UNCLOS, multiple single-sector organizations manage and regulate the different activities that affect the deep ocean (Figure 3): regional fishery management organizations regulate commercial fisheries; the International Maritime Organization manages shipping; the International Seabed Authority regulates mining of the international seabed; etc. This single-sector approach, although necessary for managing specific activities, is not sufficient to ensure balanced resource use and sustainability. Instead, deep-ocean management requires flexible approaches to international cooperation, informed by scientific evidence and supported by practical scientific partnerships.

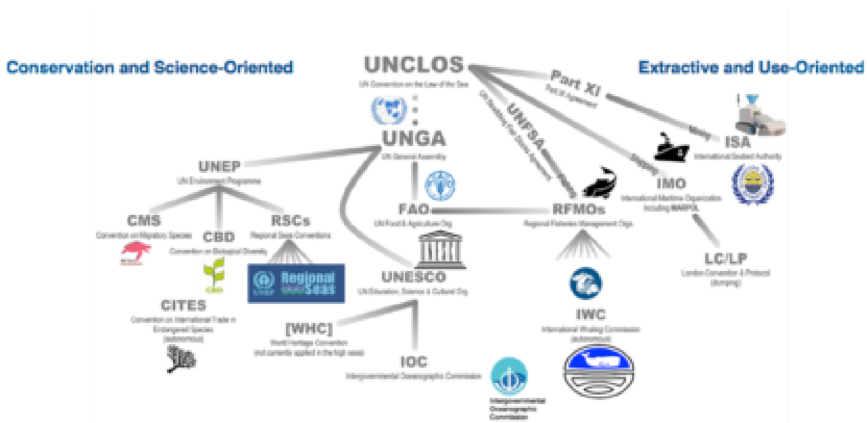

Figure 3. International organizations responsible of managing human activities on the ocean under the umbrella of UNCLOS.Adapted from Ardron and Warner (2015).

3. The Deep Ocean Stewardship Initiative

The Deep Ocean Stewardship Initiative (DOSI; www.dosi-project.org) seeks to integrate science, technology, policy, law and economics to advise on ecosystem-based management of resource use in the deep ocean and strategies to maintain the integrity of deep-ocean ecosystems within and beyond national jurisdiction. DOSI operates in different ways and at different levels through multi-stakeholder workshops, briefings, publications, surveys, assessment contributions, online resources and engagement. DOSI works with national, regional and global policy makers, educators and civil society to:

1. Identify priority management needs for resource use in our deep ocean;
2. Develop best practices for human activities in the deep sea;
3. Raise awareness and develop expertise;
4. Centralize and promote observation and knowledge of the deep sea.

As an interdisciplinary network of over 550 experts from 45 countries dedicated to maintaining the integrity and functions of deep-ocean ecosystems, DOSI provides a unique platform for deep-sea science-policy engagement that is fundamental to define humankind's relationship with the deep sea for future decades.

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Future Developments and Challenges in the Law of the Sea: the New Implementation Agreement of UNCLOS on Marine Biodiversity in Areas Beyond National Jurisdiction

Sérgio Alves de Carvalho[1]

Abstract

Applicable to areas beyond national jurisdiction, the future UNCLOS Implementation Agreement offers a unique opportunity to explore solutions that go beyond those that traditionally stem from the strict concept of "territoriality" that so significantly shaped the development of the Convention. Although it is inevitable and desirable that this concept continues to structure the Law of the Sea, it will be necessary to ensure that it is accompanied by elements that, in a more robust way, create avenues of enhanced cooperation, shared responsibility and joint governance of the Ocean and of the different ways we use it, particularly in the areas usually dubbed as 'global commons'. In this sense, the Implementation Agreement can be seen as an exceptional and timely chance to update and reform certain aspects of the Law of the Sea without disrupting the delicate balance enshrined in UNCLOS. Just like the last one of its kind, the United Nations Fish Stocks Agreement of 1995, the BBNJ Implementing Agreement – through the development of new rules, processes, and principles – can influence the existing legal infrastructure and the way it is implemented. If naming UNCLOS "the Constitution of the Oceans" can sometimes be seen as a curse, by what it suggests in terms of how difficult (or virtually impossible) it is to even attempt to modify it, a process like the one we are about to embark on can provide us the tools with which we can interpret and implement the Convention in a way that is more attuned to the many and complex challenges we face today and more likely to bringing about to the kind governance we need in order to effectively address them.

Keywords: Ocean; governance; law

Resumo

Aplicável às áreas além da jurisdição nacional, o futuro Acordo de Implementação da UNCLOS oferece uma oportunidade única para explorar

[1] Head of Unit in charge of Oceans Affairs and Law of the Sea at the Directorate-General for Foreign Policy, Ministry of Foreign Affairs – sergio.carvalho@mne.pt

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soluções que vão além daquelas que tradicionalmente decorrem do conceito estrito de "territorialidade" que acabou por moldar de forma significativa o desenvolvimento da Convenção. Embora seja inevitável e desejável que este conceito continue a estruturar o Direito do Mar, será necessário assegurar que o mesmo é acompanhado de elementos que, de forma mais robusta, criem vias de cooperação reforçada, responsabilidade partilhada e governança conjunta do Oceano e seus diferentes usos, particularmente nas áreas geralmente denominadas por "global commons". Nesse sentido, o Acordo de Implementação pode ser visto como uma via excecional e oportuna de atualizar e reformar certos aspetos do Direito do Mar sem perturbar o delicado equilíbrio consagrado na UNCLOS. Tal como o último acordo de semelhante natureza a ser aprovado, o Acordo das Nações Unidas sobre as Populações de Peixes de 1995, o Acordo de Implementação do BBNJ – através do desenvolvimento de novas regras, processos e princípios – poderá influenciar a infraestrutura jurídica existente e a forma como esta é implementada. Se apelidar a UNCLOS de "Constituição dos Oceanos" pode não raras vezes ser visto como uma maldição, pelo que sugere em termos do difícil (ou praticamente impossível) que é promover a sua alteração, um processo como o que estamos prestes a embarcar é suscetível de proporcionar as ferramentas com as quais podemos interpretar e implementar a Convenção de uma forma mais adaptada aos muitos e complexos desafios que hoje enfrentamos e mais em linha com o tipo de governança que necessitamos para ultrapassá-los de forma eficaz.

Palavras-chave: Oceano; governação; direito

Let me start by greeting everyone present, many of whom happen to be friends and colleagues, and by thanking the kind invitation that was addressed to me and which honours me very much. It is with great pleasure that I join this initiative organized to celebrate the life and work of Professor Mário Ruivo in a way that I believe he would himself appreciate: by promoting a broad and interdisciplinary reflection on the various challenges associated with the Ocean and its governance.

Professor Mário Ruivo was not only a singular personality who has shaped the national and international agenda on ocean affairs; he was not only a pioneer of the cause of the Ocean, highlighting the fundamental role that it plays in the present and future of humanity; he was not only one of the most vocal and energetic promoters of Portugal's return to the Sea. He was that and also something particularly relevant to what I plan to speak to you about today: a tireless promoter of a political and legal order capable of bringing about a new relationship between the human species and the Ocean, based on knowledge, solidarity among peoples and respect for the importance that the Sea has in our lives.

This is an ambition that today gets renewed importance and relevance, in the face of what can be seen as a gradual shift in the political understanding that drives the decisions regarding how States manage the Ocean and the activities therein. A shift that, while making its way slowly and sometimes hesitantly, has the potential to stimulate an evolution also in the legal framework that underpins the way the Ocean is governed.

This is not the time to set out in detail the origin and nature of this transition, but it should be stressed that the report "The Ocean: Our Future" by the Independent World Commission on the Oceans, coordinated by Professor Mário Ruivo, was a significant piece of a puzzle that – together with others, put in place by personalities such as Elisabeth Mann Borgese or through the work of international organizations and intergovernmental processes, such as the UNESCO Intergovernmental Oceanographic Commission or the United Nations Informal Consultative Process – helped to inspire and inform a new perception of the role the Ocean plays in our lives and a new conception about its governance.

This evolution has as one of the most important recent expressions the inclusion, in the 2030 Agenda for Sustainable Development, of a stand-alone goal dedicated to the Ocean and marine resources. Although the more cynical may see this novelty as a hollow declaration of intent so typical of the UN universe, it does contain something profound: the recognition by the international community that the health of the Ocean is indispensable for the sustainable development of peoples; that taking care of the Ocean and its resources is a universal responsibility; and, not least, that this achievement seems impossible without a new form of governance characterized by shared responsibilities and a permanent exercise of cooperation between the various international actors.

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At this point I should stress that the change we have been witnessing over the last couple of decades or so in terms of the political understanding of the challenges of the Ocean and in the kind of response these require is far from a revolution. It is rather a slow evolution that to a large extent is grounded, like in the past, on important developments impacting the way we use the Sea – and, for the first time, on an increased knowledge of how those uses influence ocean health (and of how ocean health is, in turn, indelibly linked to human wellbeing).

What developments am I talking about?

It is incommensurable the distance that separates our world from the world of Hugo Grotius and his *mare liberum*, which amounted to one of the first moments where the relationship between the economy and the law of the Sea gained tangible expression.

In the early seventeenth century, when the only industries with significant size were shipping and maritime trade, it is fair to argue that an open Ocean with almost unlimited freedom of navigation fitted perfectly the needs of the time and the centuries that followed.

And if the Law of the Sea began to change dramatically in the middle of the twentieth century, this was largely due to the fact that the economic uses of the Sea also started at that same time to change substantially, starting to take the shape prevalent up until today.

The Truman Proclamation is, in this respect, a particularly relevant moment. When in 1945 President Henry Truman declared that the resources of the continental shelf contiguous to the United States belonged to this country, this was to a significant degree the reflection of the technological advances that allowed the exploration and exploitation of living and non-living resources of the Ocean seabed and subsoil thereof – which, together with the consolidation of the modern fishing industry and, in the political realm, the waves of decolonization, set in motion the wheels of the process which would lead to the Third United Nations Conference on the Law of the Sea.

And even though voices such as those of Arvid Pardo had sought to temper this evolution with the proposition of a philosophy of common management of the Ocean (particularly with regards to the re-

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sources of the seabed), the truth is that the second half of the 20th century gave way to a regime reflecting a reality that radically departed from the one that had characterized the previous period. That is, for the first time (at least, in such an obvious fashion), the exploitation of the Ocean and its resources required territory, demanded stable boundaries, required a division of the ocean space.

While the legal regime that emerged in this political and economic landscape lives on, today we are confronted with new and different kinds of challenges that require us to think not so much (or not solely) about how we should divide the Ocean, but more about how we can manage the different activities that take place within and across different ocean territories.

Over the past few years, we came to realize ever more clearly that the Oceans and Seas are key elements in the global economy and that they harbour immense potential for innovation and growth. The so-called blue economy today comprises a set of sectors (from offshore oil exploitation to tourism, from fisheries to marine biotechnology) that are largely interdependent, increasingly competing for the same ocean space and whose long-term sustainability depends on the sustainable use of Ocean by each and every one of these sectors and by all users alike.

The Ocean is the world's largest source of protein, it contains resources with enormous potential that can be found in the seabed and subsoil, but also vital ecosystemic services whose disruption may impact not only on coastal communities but also on different regions of the world. Equally significant, healthy oceans are essential for thriving marine ecosystems, livelihoods and economies, for fighting extreme poverty, and for strengthening food security and building resilience to climate change.

Moreover, the maritime space is increasingly made up of shipping routes, choke points, ports, and other critical infrastructures such as pipelines, oil and gas platforms, submarine cables whose disruption can seriously impact the whole international community.

The point I would like to stress is that this diversification of uses of the Ocean and its resources, along with – crucially – the parallel development of the knowledge we have about its potential, state, and the functions it performs, has slowly led to the materialization of a new and broader concept of "stability."

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That is, it has become increasingly clear for many that we need stability not only in terms of guaranteeing stable boundaries (which no doubt is important for long-term investment and economic exploitation), but also through the form of a governance framework that unlocks the potential of the economy of the Sea while providing effective and long-term responses to the different challenges arising from an increasing use of the Ocean, growing competition for maritime space, and the mounting association between our wellbeing and ocean health and resilience.

And it is this new "stability structure" (or a call for it) that is now gradually beginning to emerge, as a result of what I earlier named a transition in the political understanding of the challenges of the Ocean and how we should collectively address them.

This change is to some degree already reflected in many governance tools, particularly on a national level (marine spatial planning being one obvious example) and on a regional level (like the EU Integrated Maritime Policy and the African Union's 2050 Africa's Integrated Maritime Strategy). However, on a global level this seems to be much more challenging. The question is: to what extent can this shift be reconciled with, or built in (or reflected in), a global legal framework designed almost 40 years ago?

Firstly, we need to understand the philosophy that governed the development of the legal infrastructure that we have today. That is, we must see the development of the Law of the Sea within the larger post 2nd World War trend to build an inclusive and structured international relations framework, regulated by the moderating and shaping force of international law which were to provide us with an organized, peaceful and universal multilateral public order.

In this context, the codification of the Law of the Sea that emerged in the second half of the 20th century, and whose main achievement is the adoption of the United Nations Convention on the Law of the Sea (in 1982), is to a significant degree a by-product of this new reality and, in this sense, it is largely informed by those very principles which have marked the development of a new world order.

With almost universal acceptance (168 parties) and with a regime that establishes a solid legal framework within which all activities in the oceans and seas must be carried out, the Convention is a virtually unparalleled success in the development of international law.

But let this not prevent us from mobilizing analytical reasoning and looking at some aspects of the legal structure created by the Convention with the necessary critical sense, including to recognize that the codification efforts of the Law of the Sea have been influenced to a large extent by concepts that today puts us some difficulties.

This is the case of what, in a very simplistic way, we can call the application of terrestrial concepts to the way we think about the Sea. I am not only talking about the legal translation of the principle (which we now accept as peaceful) that "the land dominates the sea ". I am also referring to the fact that the new legal order of the Ocean was based on a certain notion of territory, of defined spaces within which the States exercise their powers of sovereignty or jurisdiction, an evolution which – as I said before – was closely linked to the quantity and quality of knowledge about the Sea and its resources that was being made available at the time, as well as the advances in the technology that could exploit them.

The new public order of the Ocean that emerged, with an important territorial character, based on a clear division between spaces subject to State sovereignty and jurisdiction, on the one hand, and those subject to the freedoms of the High Sea and the *sui generis* regime of the Area, on the other, fed by tools that allowed a definitive delimitation of maritime frontiers, served well the circumstances of the time by providing the stability and legal certainty necessary for the economy of the Sea to develop and thrive in that period.

However, at about the same time when the United Nations Convention on the Law of the Sea (UNCLOS) finally entered into force (1994), the world was already a different place, with a changing political landscape, and with an emerging notion that there was a new set of environmental pressures (different from the major oil spills that influenced the drafting of UNCLOS) that ought to be addressed and which the idea of territory and sovereignty (and even flag-state jurisdiction) alone had trouble to effectively solve.

It is not that UNCLOS fails to provide us with tools to respond to environmental challenges or to incorporate these concerns into the

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decision-making process; or that it has not left us with instruments to manage these challenges in order to reach solutions that go beyond the national borders of each coastal State. Part XII of the Convention (Protection and Preservation of the Marine Environment) is a living proof of this legacy, and the same can be said about the case law which, in the meantime, has added substance to that infrastructure.

But the truth is that these foundations the Convention has left us with provide objectively less developed tools for managing emerging threats, especially beyond national borders, where the nature of problems faced therein require answers that differ from those usually available within areas of national jurisdiction.

The existing configuration leaves us particularly vulnerable to issues that need to be dealt with in a "non-territorialized" way, that are not confined to an area of sovereignty or jurisdiction; issues that, on the contrary, require an effort of cooperation and coordination between and across jurisdictions – reflecting the fact that, such as the Convention so well describes, "the problems of ocean space are closely interrelated and need to be considered as a whole".

In a nutshell, problems such as ocean acidification, marine pollution, the impacts of climate change, the destruction or serious threat of destruction of several fish stocks (many of them highly migratory species), the slow degradation of vast and important marine ecosystems, will not and cannot be solved only by means of an approach which is based on sovereignty and jurisdiction over a maritime space.

It is in this context that a new Implementation Agreement of the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biodiversity in Areas Beyond National Jurisdiction (BBNJ) can, based on the fundamental structure provided by the Convention, not only develop tools to respond to emerging problems, but also to forge a new governance approach, tailored to the specificities of areas beyond national jurisdiction but whose solutions and informing principles can spillover to the management of other areas.

At the very moment that we are celebrating Professor Mário Ruivo, who headed the national delegation in the negotiations of the United Nations Convention on the Law of the Sea, discussions are being held in New York on the General Assembly's resolution that will

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launch the negotiation of the BBNJ Agreement within the framework of an Intergovernmental Conference, starting in 2018.

Considering the magnitude of the national maritime space and the obvious interface between the maritime territory under Portuguese jurisdiction and the areas beyond national jurisdiction (in particular, in the extended Continental Shelf, whose superjacent water column constitutes High Seas), the adoption of a regime that enhances the conservation and sustainable use of biodiversity in areas beyond national jurisdiction is in principle aligned with our national interests.

In fact, given that the Ocean is a complex and interdependent whole, where ecosystems do not recognize borders and often extend themselves across different jurisdictions, the marine environment and the biodiversity of areas under national jurisdiction are directly linked to – and depend on – the environment and biodiversity of areas beyond national jurisdiction.

As a result, better management of areas beyond national jurisdiction (to where the greatest anthropogenic impacts have been transferred as coastal States have progressively enforced their jurisdictions and restricted third party access) that contributes to improving the health and resilience of its marine environment will certainly have a beneficial impact on the marine environment and living resources of our own territory.

At the same time, however, the same relationship of interplay between the national maritime territory and areas beyond national jurisdiction (especially the delicate situation of overlap or continuity between the extended Continental Shelf and the High Seas) requires that the development of the new regime be closely followed, particularly in order to ensure that new rules for the conservation and sustainable use of biodiversity in areas beyond national jurisdiction do not result in provisions hampering or constraining the exercise of sovereign rights of a coastal State over its maritime territory.

For the above reasons, Portugal has been one of the most vocal supporters of a new BBNJ Agreement, but – more than that – a vocal supporter who has been, and wants to be, directly involved in the discussions about its content. With respect to the four different components of the future Agreement (Area-based Management Tools,

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including Marine Protected Areas; Marine Genetic Resources; Environmental Impact Assessments; Capacity Building and Technology Transfer), we have ideas and legitimate concerns that we want to see reflected in the future agreement.

In addition, issues such as the legal nature and management of marine genetic resources (including the sharing of benefits arising from their utilisation) or the adoption of area-based management tools in areas that are not subject to the jurisdiction of a single State pose significant legal challenges whose resolution we intend to monitor and influence, including the impacts these will have in the further development of the Law of the Sea.

This is therefore a very interesting period from the point of view of the evolution of the Law of the Sea. We cannot, should not, and do not want to undo in any way the legal regime created by UNCLOS 40 years ago; but we have the obligation to seize this opportunity to seek to improve our legal framework and to adapt it, as far as possible, to the knowledge that exists today about the Ocean and its present and future challenges.

Being applicable to areas beyond national jurisdiction, the new Implementation Agreement offers us a unique opportunity to explore solutions that go beyond those that traditionally stem from the strict concept of "territoriality." Although it is inevitable and desirable that this concept continues to structure the Law of the Sea, it will be necessary to ensure that it is accompanied by elements that, in a more robust way, create avenues of enhanced cooperation, shared responsibility and joint governance of the Ocean and of the different ways we use it, particularly in the areas usually dubbed as 'global commons'.

In this sense, the Implementation Agreement can be seen as an avenue that offers us an exceptional and timely chance to update and reform certain aspects of the Law of the Sea without disrupting the delicate balance enshrined in UNCLOS. Just like the last one of its kind, the United Nations Fish Stocks Agreement of 1995, the future BBNJ Implementing Agreement – through the development of new rules, processes, and principles – can certainly influence the existing legal infrastructure and the way it is implemented.

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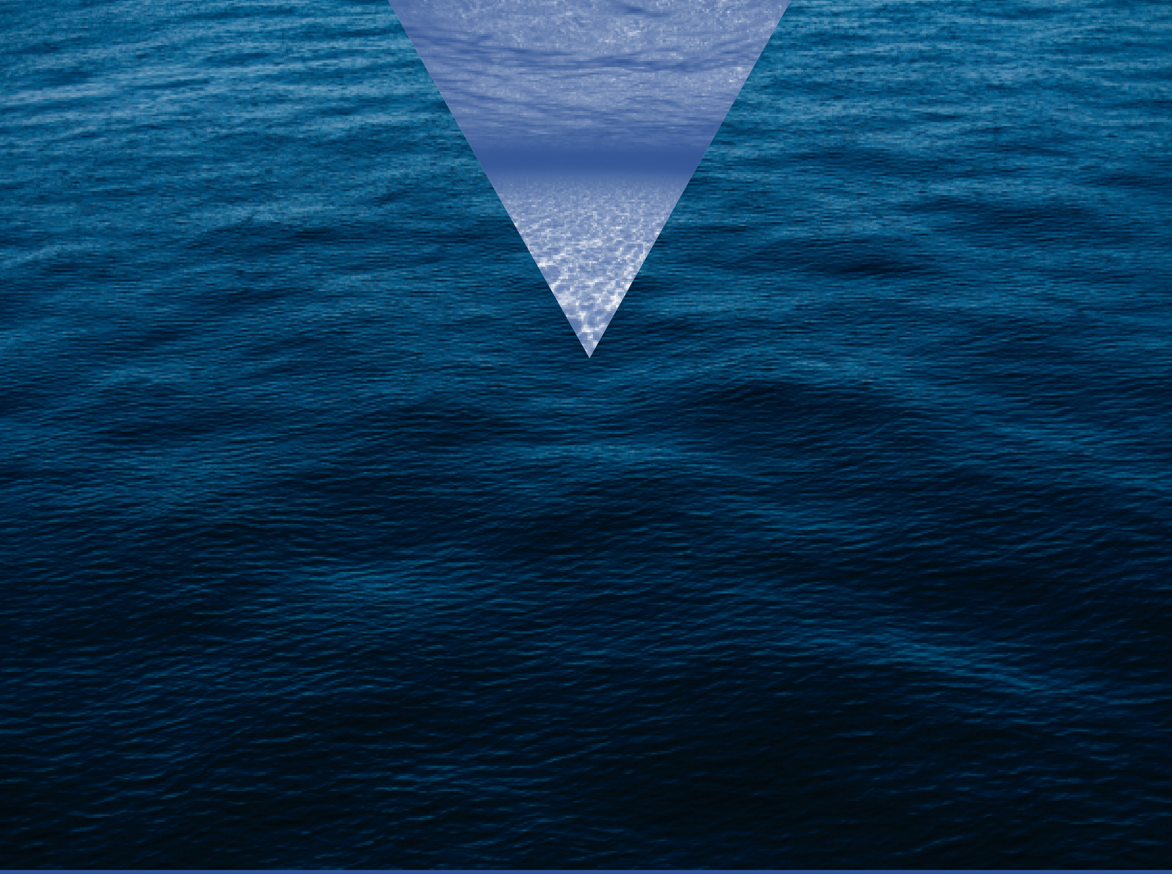
If naming UNCLOS "the Constitution of the Oceans" can sometimes be seen as a curse, by what it suggests in terms of how difficult (or virtually impossible) it is to even attempt to modify it, a process like the one we are about to embark on can provide us the tools with which we can interpret and implement the Convention in a way that is more attuned to the problems we face today and more likely to bringing about to the kind governance we need in order to solve them.

This is a huge challenge. The development of the Law of Sea is no longer asked to simply reduce the prospect of conflicts and guarantee the conditions for the optimal economic exploitation of the Sea. It is also tasked with structuring the relationship between humanity and the Ocean in way that allows us to continue to harness its immense potential while ensuring that ocean conservation is not hampered – and, on the contrary, is promoted and advanced in tandem.

This is not an easy task. But it is one that is vital and urgent if we want to forge a new and lasting relationship with the Ocean that, as Professor Mário Ruivo advocated, is truly respectful of the importance it has for people, for the planet and for our collective prosperity.



OBSERVAÇÃO E TECNOLOGIA NO OCEANO

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OBSERVATION AND TECHNOLOGY IN THE OCEAN

The Session on "Observation and Technology in the Ocean" helped to emphasize how important is for a better understanding of the ocean dynamics and marine ecosystems not only the development of technology for continuous and long-term systems of ocean observations but also the collaborative analysis and interpretation of the collected data. These goals are well within the scope of GOOS (Global Ocean Observing System), which is a programme implemented by the UNESCO Intergovernmental Oceanographic Commission (IOC) which involves contributions of people and organizations worldwide. The idea of implementation of GOOS was supported at the IOC 16th General Assembly in 1991, and the Intergovernmental Committee for GOOS (I-GOOS) was formed in 1992 with the sponsorship of IOC, WMO (World Meteorological Organization) and UNEP (United Nations Environmental Programme) aiming at the coordination between governments for carrying out GOOS. Professor Mário Ruivo had always a prime role in the Portuguese involvement in GOOS, in particular in its regional alliance EUROGOOS, and he has spent much energy and effort to make possible the development in Portugal of marine technology and ocean observations.

The themes of this Session were: "The Marine Robotics: Tools for the Study and Exploration of the Ocean", "Unmanned Vehicle Systems for Ocean Observation: Lessons Learned and Future Applications", "Ocean Observation: a Useful Activity for the Society?", "Deep Sea - from Unknown to Intended- Deep Sea Observatories, a Tool to Monitor the Human Activities", "Cetacean Ecology and Health in Continental Portugal" and "Hydrological Characterization of the

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Olhos de Água Submarine Groundwater Discharges – Projects FREEZE and TROANTE". In the first two themes, the difficulties arising in ocean observation in an operational way were focused and state-of-the-art techniques developed in Portugal, such as marine robotic vehicles, were reviewed. In the third theme, the problem was raised of how to ensure proper coverage of the ocean (using in situ, airborne and satellite systems), good enough to allow the understanding and forecasting of the ocean behavior. The fourth presentation pointed out the importance of the existence of observatories in the deep sea and their contribution to monitoring climate change and deep-sea mining. The fifth presentation was centered on the monitoring of marine environment conditions through the study of marine vertebrate populations off the Portuguese mainland coast. The sixth presentation has exemplified how satellite and airborne remote sensing conjugated with *in situ* observations can be used to detect ocean surface signature phenomena, namely offshore freshwater springs.

The discussion panel brought up several questions and comments from the audience, some regarding the problems and difficulties of a proper coverage of the ocean given the need for a much stronger collaboration between countries and between scientific teams.

Isabel Ambar

Deep Sea - From Unknown to Intended - Deep Sea Observatories, a Tool to Monitor Human Activities

Ana Colaço & Marina Carreiro-Silva[1]

Abstract:

The deep-sea environment is the largest ecosystem on earth and poorly study. The lack of affordable technology and the immense size of this ecosystem, with all its different environments and habitats, such as the pelagic realm, the benthos with abyssal planes, ridges, vents, seamounts, cold seeps, sponge aggregations, cold-water corals gardens and reefs, to name just a few, contribute to the lack of knowledge.

With the increase technological development, and with the overexploitation of land and shallow water resources, humanity is migrating deeper in the sea, by extracting oil and gas, fishing on deeper grounds, extracting minerals from the continental slopes and discussing the possibility to mine seafloor massive sulphides (SMS), nodules and cobalt crusts.

In order to understand human impacts on deep-sea ecosystems and to propose strategies to mitigate these impacts, we need to comprehend the nature of the environment. Time series are crucial, for the continuous measurement of the environmental characteristics of the deep. However, studying the deep-sea is expensive. There is the need of oceanographic vessels, underwater vehicles and sensors that cannot be continuously at sea.

To bridge this gap, the scientific community has been working together with engineers to develop continuous observation systems that will allow to have time series, and to understand the natural fluctuations of the environment. Fixed-point observatories exist in several key places around the globe. They can be cabled, tethered or autonomous, measuring continuously or at a high frequency, and sending the data to shore, to warn about potential tsunamis, seismic crises at the bottom of the ocean, or even an increase in the deep-water turbidity.

[1] IMAR-Institute of Marine Research. MARE- Marine and Environmental Sciences Centre. OKEANOS-Universidade dos Açores.
maria.aa.colaco@uac.pt
carreirosilvamarina@gmail.com

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Portugal has been involved in this effort, through the participation and usage of a fixed-point observatory installed as part of the EMSO network, Like the EMSO-Azores in the Lucky Strike hydrothermal vent(maintained by EMSO-France) , and raising funds to install other nodes at the Gulf of Cadiz and on the Condor seamount (Azores). Observatories are used to detect climate change, monitor mining and contribute to Global Ocean Observation System.

Keywords: Deep-sea; observatories; impacts

1. The deep-sea:

The deep-sea is the largest ecosystem on earth, with more than 90% of the ocean being deep-sea. More than 50 % has depths greater than 3000 meters, and only 5% is explored (Ramirez-Llodra et al 2010).

Until recently, the deep-sea has been seen as a stable cold dark environment, with low productivity, highly diverse and biomass poor. It was believed that the immense water volume that forms the deep-sea, was a huge diluted environment that no pollutants, no warming or acidification could affect (Colaço et al, 2017).

However, in the last decades, with technology improvements, new and diverse habitats were discovered (Ramirez-llodra et al, 2010), some of them with the highest productivity on earth, like the chemosynthetic environments (Levin et al, 2016).

The deep-sea environment lays below 200 meters, where the energy from the sun cannot feed photosynthesis. In general, the life beneath those depths depends on the energy produce in the surface waters and that enters the deep-ocean by sinking, biogeochemical cycles or through trophic webs (figure 1).

The immense deep-sea is mainly pelagic, with an immense water volume, however being the least known (Sutton et al, 2017). This vast pelagic habitat contains the mesopelagic (200–1000m depth) and bathypelagic (water column > 1000m depth) zones with imprecision on the transition depths zones, due to connectivity processes at large spatial and temporal scales (Sutton 2013). Taken as a whole, the bathypelagic biome is by far the planet's largest biome; 79% of the volume occupied by life on earth lies at depths >1000 m (Sutton, 2013).

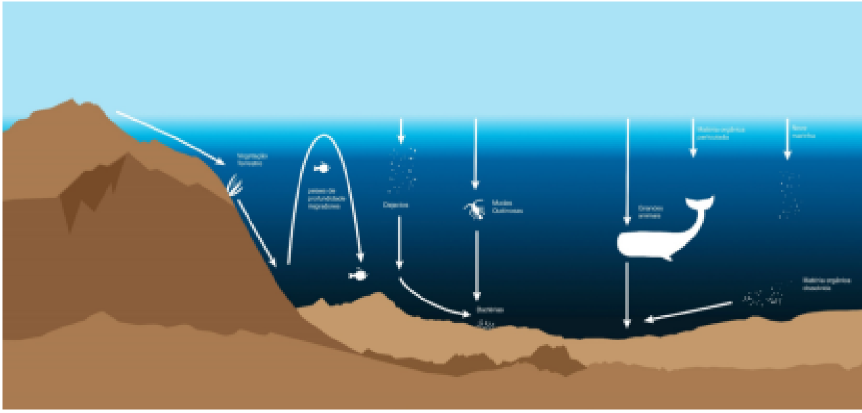

Figure 1. The deep-sea environment lays below 200 meters. The life beneath those depths depends on the energy produce in the surface waters and that enters the deep-ocean by sinking, biogeochemical cycles or through trophic webs. ©Pedro Mesquita.

This pelagic ecosystem provide supporting ecosystem services, such as carbon and nutrient cycling, and trophic exchange, which are still poorly understood (Colaço et al, 2013; St. John et al, 2016). When reaching the seafloor, the knowledge we have on several features and the associated communities increases. There are several biodiversity hotspots like the seamounts with cold-water corals reefs and gardens, sponge aggregations, canyons, and high productive environments such as the hydrothermal vents and cold seeps.

Seamounts are hotspots of species richness (Morato et al., 2010). Their high productivity can support high densities and biomass of benthic suspension and filter feeders, such as corals and sponges, together with demersal fish populations (Porteiro et al, 2013; Fock et al, 2002; Shcherbachev et al, 1985). Many seamount taxa are long-lived and slow-growing, like many cold-water coral species than can attain ages of centuries to millennia (Carreiro-Silva, et al 2013). Habitats formed by these benthic fauna are ecological complex, structured and can harbour a more diverse and abundant biological diversity than the sedimentary environment (e.g. Porteiro et al, 2013; Buhl-Mortensen et al, 2010; Gomes-Pereira et al, 2017). CWC and sponges are what we call bioengineering species, because when the environmental conditions are favourable, they form dense 3Dimensional structures. These special environments provide significant habitat for invertebrate species (Henry and Roberts, 2007), and fishes (Pham et al 2015; Gomes-Pereira et al, 2017) and may have nursery and recruitment functions (Baillon et al, 2012).

Deep-sea sediments cover around 65% of the world's surface. Sedimentary environments alike the margins and abyssal plains are low in fauna biomass, but high in biodiversity. The microbial biomass is very large, and the microbial processes that occur inside the sediments play an extremely important functional role on nutrient recycling, promoting the biogeochemical cycles that are essential to sustain primary and secondary production in the oceans (Danovaro et al 2007).

Chemosynthetic environments, like hydrothermal vents and cold seeps, were just discovered in late 70's. However, due to their uniqueness, they have been the focus of several studies, most of them multidisciplinary, since the energy source that fuels the primary productivity in loco is geothermic (a few exceptions on cold seeps). This chemosynthetic production provides nutrition to a high biomass, either as symbiotrophic species, or to benthic or planktonic heterotrophic species. Although these ecosystems were thought to be isolated oases for a long time, they are now acknowledged to interact with the water column and seafloor, exchanging elements and energy with the surrounding deep-sea environments.

Today it is commonly accepted that the deep sea plays a key role in ecological and biogeochemical processes at a global scale (Danovaro et al 2017).

However despite its remoteness and importance, several habitats are already affected by the men (Ramirez et al, 2011) (figure 2).

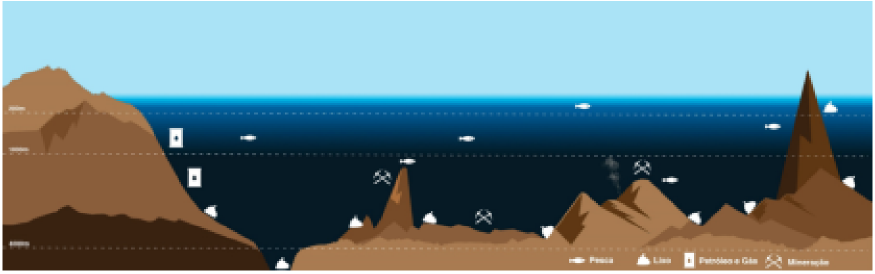

Figure 2. Humans impact on the deep-sea. ©Pedro Mesquita. Adapted from Levin & LeBris, 2105

2. The impacts and understanding the changes

In order to understand the array of processes that occur in the deep-sea, it is essential to have long-term time series studies. The processes can vary at different time scales (daily, seasonal, inter-annual, decadal or even at centennial or millennial scale). Long term time series are even more important in the deep-sea, as we know that most of the species are long-lived and slow growing. For instance, black corals can attain more than 2000 years (Carreiro-Silva et al, 2013), the orange rough maximum age has been estimated at 149 years (Fenton *et al.*1991) with a high age of first maturity (>30 years) (Bell *et al.* 1992). Several deep-sea patterns and processes are unknown. Also the responses of the biological communities to anthropogenic stressors and climatic shifts lack basic knowledge. That knowledge is essential to identify which biogeochemical or other environmental parametres can be good proxies of changes in the deep-ocean.

With the increase technological development, and with the over-exploration of land and shallow water resources, mankind has migrated their activities to deeper sea areas, by extracting oil and gas, fishing on deeper grounds, extracting minerals from the continental slopes and discussing the possibility explore the high seas to mine seafloor massive sulphides (SMS), nodules and cobalt crusts.

Fisheries

Morato et al (2006) showed that global landings of demersal marine fishes have shifted to deeper water species over the last 50 years. They suggested that depletion might be occurring in deep-water fish stocks. This is particularly serious, since their life histories render them highly vulnerable to overfishing with little resilience to over-exploitation. Deep-sea fisheries impacts are even more severe, when the fish operations contact the seabed and cause severe environmental impacts, by killing, smothering or damaging benthic animals like the CWC, sponges, which due to their life history traits are considered vulnerable marine species or ecosystems (Clark et al, 2016).

Oil and gas

Due to the decrease of oil reserves in shallow ocean margins, there is an increase in the exploration and exploitation activities for oil and gas extraction in deep waters. However, there is a huge gap on the baseline environmental data, which makes the management of such activities challenging from the environmental point of view (Cordez et al, 2016), despite the existence of several regulatory regimes under different jurisdictions (Mazor et al, 2014; Katsanevakis et al, 2015). The activity has several impacts (see revision from Cordes and co-authors 2016), from the infrastructure installation, to the daily operations water discharges and potential accidents, to the end of operations. The impacts might be persistent or not, and the severity depend on the environment and species resilience. For vulnerable species the impact might be longer or irreversible.

Mining

Until the humankind is able to recycle and have a circular economy, the need for metals for day-to-day equipment will keep rising. The seafloor hosts potential mineral resources for these needs in the form of polymetallic manganese's nodules (nodules), polymetallic sulphides (SMS) and ferro-manganese and cobalt crusts (crusts). The different resources lay on different environmental settings, each one with different characteristics (nodules on abyssal plains; SMS on active and inactive hydrothermal vent fields; cobalt crusts on the summit or slopes of seamounts at a certain depth range). All of them vulnerable to extraction activities (Van Dover et al, 2017). The vulnerability to impacts includes direct impacts on the species and on the life history of organisms, like the habitat destruction, creating barriers to connectivity and recruitment. The impacts can be more severe due to the fact that: in the case of the nodules the activity can be very extensive (in surface); the case of SMS, the environments are unique ; in the case of crusts, the habitat hosts vulnerable marine species that support other extraction activities (CWC and fisheries). The extent of impact is not known. The impact can not be extrapolated from one area to another (destruction of habitat and species). The indirect impact of the plumes, noisy and metals are yet to be determine. Thresholds can only be determined if we understand the natural variations of the environment, and be able to assess the baseline values of physical, biogeochemical and environmental parameters (Miller et al, 2018).

While densities and diversities of some taxa can recover to or even exceed pre-disturbance levels, community composition remains affected after decades. The loss of hard substrata or alteration of substrata composition may cause substantial community shifts that persist over geological timescales at mined sites (Golnner et al, 2017).

Climate change

The deep-sea plays a key role in regulating Earth's climate by absorbing excess heat and carbon dioxide from the atmosphere. Through this process the deep ocean is becoming warmer, more acidic, less oxygenated and with altered food inputs with potential impacts on deep-sea ecosystems (Levin and Le Bris 2015). Recent studies suggest the Atlantic Ocean is already facing changes in seawater chemistry and is predicted to be one of the most impacted oceans in the future (Mora et al 2013; Sweetman et al 2017). Projections for 2100 suggest temperature (T) increases between 1-4ºC, a decrease in pH of up to 0.4 pH units, declines in oxygen concentrations up to 3.7%, and 40% loss of the food supply to the ocean seafloor (Mora et al 2013; Sweetman et al 2017). Such changes can significantly affect deep-sea organism physiology, life history traits (e.g. growth and reproduction) and recruitment, with concomitant changes in biodiversity and provisioning of living resources by deep-sea ecosystems (Levin and Le Bris 2015).

Climate change will likely reduce the resilience of species and ecosystems to anthropogenic stressors, and slow rates of recovery (Sweetman et al 2017). For example, slowed CWC growth under ocean acidification will reduce recovery of habitats from fishing disturbance, and delayed larvae development under hypoxic conditions and nutritional stress with low food could impact communities recovering from mining impacts, which will further compromise ecosystem structure and function in the deep sea.

ÍNDICE

3. The observatories

To understand the human impacts and mitigate them, we need to understand the environment, how it changes naturally, to identify how human action is affecting the normal function of the system. It is crucial to be able to have time series, and ideally continuous measurement of the environmental characteristics of the deep (figure 3).

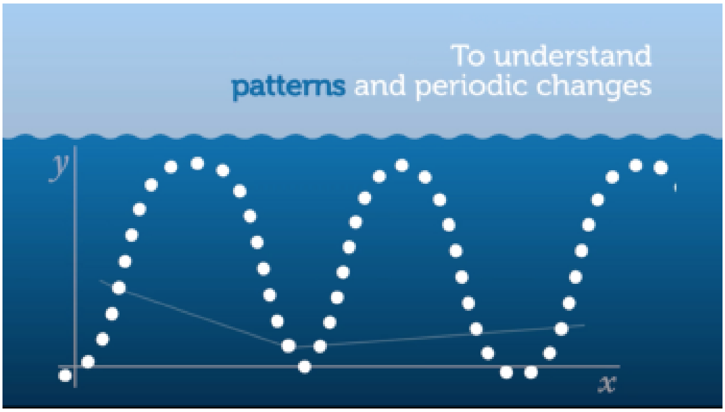

Figure 3. Time-series and continuous measurements are needed to understand the natural patterns. Snapshot can give a distorted pattern of reality. ©Aurora Ribeiro @http://www.fixo3.eu/

Studying the deep-sea requires oceanographic vessels, underwater vehicles and sensors that cannot be continuously at sea, which is not a trivial task. The instruments are expensive, ships are scarce and expensive and cannot be permanently on one spot, and vehicles just now are starting to go deep and increasing the temporal and spatial coverage.

Data collected with oceanographic vessels generally correspond to a constrained time interval, giving only a snapshot of the reality. Often the trends observed are just the effect of the lack of continuous monitoring, and not the result of natural fluctuations. Moreover, due to operational constrains, most of the data are collected during the spring and summer seasons when the weather is better, with cold seasons being undersampled.

Moorings have been used as a means to collect time series data from a specific location, and although being a delayed mode of observing the environment, they have shown the importance of temporal variations and time series (Glover et al, 2010). With technological improvements, multidisciplinary moorings and platforms were developed and left at sea for long periods of time. Nevertheless, the energetic constrains do not allow for frequent measurements and sensor synchronization (the same time stamp). Due to this fact sampling frequencies of can not be homogenized (Matabos et al, 2016).

The deep-sea is a very complex system that faces different types of disturbances, from regular cycles to chaotic behaviour that might vary from days to geological time. How those phenomena are linked is not well understood. Scientists are missing key elements of a multidisciplinary understanding of marine ecosystem functioning, including species and community level responses to environmental change (Matabos et al, 2016).

In 2000, the United States National Research Council established the definition of a seafloor observatory : "… unmanned system, at a fixed site, of instruments, sensors, and a command module connected to land either acoustically or via a seafloor junction box to a surface buoy or a fibre-optic cable …" (NRC 2000).

From more than 20 years, the scientific community has been working together with engineers to develop continuous observation systems that will allow to have time series, and to understand the natural fluctuations of the system. Fixed point observatories were created in several key places around the globe. They can be cabled, tethered or autonomous, measuring continuously or at a high frequency, and sending the data to shore, to warn about potential tsunamis, seismic crises at the bottom of the ocean, or even an increase in the deepwater turbidity.

Seafloor observatories do not replace seagoing investigations. Not all variables of interest to scientists can be measured with sensors, specially, because there are no metrics developed for most of the biological and ecological sciences (biodiversity changes; ecosystem function and services changes). Observatories give access to complementary information at temporal scales not previously available (Matabos et al, 2016) (figure 4).

With the improvement of communications, in some parts of the globe, the observatories are fed energetically and use real time data acquisition throughout fiber optical cables. This advance has given an

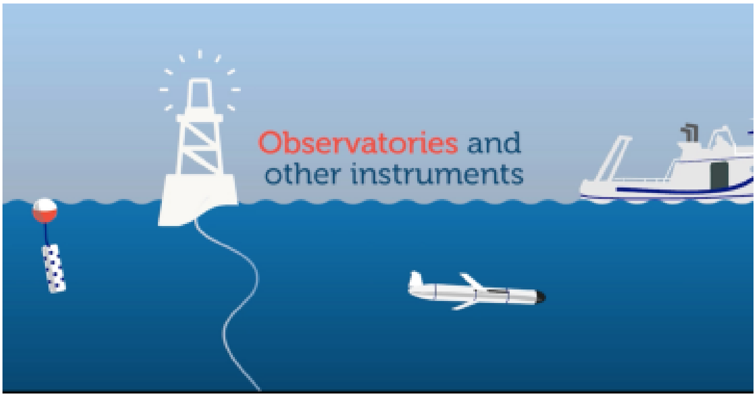

Figure 4. Seafloor observatories are complement of seagoing investigations. ©Aurora Ribeiro @http://www.fixo3.eu/

all-new way of promoting science, with millions of gigabytes of data that need to be ground-truth, quality control and analysed.

However, the story does not end here. In order to understand the changes globally, there is the need to develop best practices, homogenize the acquisition, the instrument errors, and develop the algorithms that can upgrade the new data on charts, and maps, geo-referencing on time. Also the operational costs and the price of equipment and sensors needs to be reduced so that they are accessible to all countries, including the underdeveloped ones, as well as make them operational from smaller and less "high tech" vessels.

There is the need of coexistence in land, in the sea, and on science.

There are several initiatives that develop deep-sea observatories. In Canada, the *Ocean Networks Canada Observatory* (ONC) created by the University of Victoria (Canada), oversees the management, development and operation of the VENUS and NEPTUNE Canada cabled networks. At the ONC observatory, ocean research and technology development is enhanced through a cabled infrastructure that supplies continuous power and internet connectivity to a large set of instrumentations and experiments, from geophysical to biological behaviour studies (Tunnicliffe et al. 2008; Best et al. 2012; Matabos et al 2016). In the USA, the *Ocean Observatories Initiative* is a project funded by the National Science Foundation that promotes the installation of a network of ocean observatories that will continuous measure near real-time chemical, geological, biological, and physical oceanographic data on coastal, regional, and global scales.

In Europe the EMSO network (formerly ESONET) is a co-ordinated chain of deep-sea observatories around Europe from the Arctic Ocean to the Black Sea (Best et al, 2014; Pearson, et al, 2015). ESONET was funded to integrate researchers for a marine component of GMES (Global Monitoring for Environment and Security), the GOOS (Global Ocean Observing System), comprising a network of long-term, multidisciplinary seafloor observatories at key locations around the European margin for long-term monitoring advancement in geophysics, chemistry, biology, oceanography, geochemistry and fisheries. The observatories can contribute by measuring essential ocean variables, agreed by the ocean observing community.

With the development of seafloor observatories, scientists are offered unique opportunities to study multiple, interrelated processes over different timescales (seconds to years) to conduct comparative studies of regional processes (Juniper et al., 2007).

4. Portugal and the deep-sea observatories

Portugal has been involved in the creation of deep-sea observatories, through the participation and usage of the fixed-point observatory EMSO network, and raising funds to install other nodes at the Gulf of Cadiz and on the Condor seamount (Azores).

Portugal, hosts in the Azores region two fixed-point observatories. The EMSO Azores (at the Lucky Strike hydrothermal vent field), installed and maintained since 2010 by EMSO France and the Condor Seamount observatory. Portugal's involvement in the EMSO Azores observatory includes participation on seismic surveys with standalone OBS, colonization experiments to understand connectivity patterns among different hydrothermal vent fields, and monitoring the communities physiological condition as a proxy of changes in the environment. The Condor Seamount integrated multidisciplinary scientific observatory, implemented in 2009 with funding from an EEA grant, promotes an integrated ecosystem approach for studying seamounts. It is not yet connected to shore (it will be in the near future), but it has been recording data on … in a semi- continuous long time series point. It will be expanded during the EMSO-PT infrastructure implementation phase, with, among other instruments, sediment traps, optical or acoustic plankton counter and ADCP's. The relevance of the Condor seamount infrastructure for the scientific and stakeholder community has granted a protection regime from commercial fisheries at least until 2020, but it was also designated as a Marine Protected Area as part of the Azores Marine Park.

As part of the EMSO network, the recent developed platform of multisensors (EGIM) that measures temperature, conductivity, pressure, dissolved oxygen, turbidity, ocean currents, and passive acoustics (just some frequencies) needs to be deployed in all of the nodes of this network in order to make the same measurements and at the same frequency. The EGIM prototype is now at the Lucky Strike observatory, but it is foreseen to acquire an improved EGIM with new sensors (related to climate change, nutrients, and imagery) to be deployed at Condor seamount, in a area with important biological communities between 900 and 1200 meters, to study benthopelagic coupling processes and climate change alterations.

The observatory will include several Essential Ocean Variable (EOV) measurements, including in a first phase physical variables (temperature, salinity, velocity /ocean currents), and in a later phase the carbon and biogeochemistry variables (dissolved oxygen, dissolved organic carbon, POM), which are still in the concept phase but could be tested in this observatory. In what regards biological and ecological EOVs, despite primary productivity beinga a mature EOV (as a proxy of available POM in the bottom), it is a challenge to identify other EOV's to measure change on a hard substrate environment, for deep-sea environments. Another key challenge, is the lack of mature EOV's targeting the benthic–pelagic coupling, manifested as the exchange of energy, mass, or nutrients between benthic and pelagic habitats. Benthic-pelagic coupling plays a prominent role in aquatic ecosystems, and it is crucial to functions from nutrient cycling to energy transfer in food webs. Sustained regional observations are necessary to characterize the spatial, seasonal and inter-annual variability in bathypelagic flux characteristics of a given site. Remineralization of POM as it sinks through the water column modifies both the concentration and composition of carbon in sinking particles. Oceanographic mooring with sediment traps at different water depths (from bathyal to the abyssal), with optical sensors for *chl-a* fluorescence and, assessment of flux quantities and particle character including size- and type-distributions are needed. This experiment could be coupled with sensors to measure physical and climate EOV, which are scarse on depths greater than 2000 meters, contributing to understand the variations of Meridional Overturning Circulation at global change level.

Conclusion

Monitoring of deep seafloor condition is a current global priority. The society is in need of a network of in situ multidisciplinary observation systems around the world. They will improve our understanding of the impacts of climate change, anthropogenic activities, and geo-hazards (Ruhl et al, 2011), allowing early warning in case of geohazards, which , like weather forecasting, might prevent human losses.

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Cetacean Ecology and Health in Continental Portugal

Catarina Eira[1] & Sílvia Monteiro[2]

Abstract

The Coastal and Marine Vertebrate Conservation team at CESAM is dedicated to cetaceans, although part of the work is also dedicated to seabirds and sea turtles. Within several projects it was possible to evaluate cetacean and seabird abundances and also the main threats that represent conservation problems for cetaceans, seabirds and marine turtles in Continental Portugal. One of the most important achievements is the contribution for the proposals of new marine Natura 2000 areas and their management plans for cetaceans and seabirds in Portugal.

Keywords: Conservation, threats, large marine vertebrates

Editorial

The increase of human populations and activities in coastal areas led to escalating pressures on marine and coastal ecosystems. Consequently, there is an increasing need to understand the impact of anthropogenic activities in marine populations. The Coastal and Marine Vertebrate Conservation team (CMVC) at CESAM is dedicated to the study of cetaceans, seabirds and shorebirds, marine turtles and their environment. Among cetaceans, particular importance is given to Harbour porpoises, Bottlenose dolphins, Striped dolphins and Common dolphins. Harbour porpoises (Figure 1) have a particular importance in terms of conservation needs due to their Vulnerable status in Portugal.

The team has been involved in several projects, including the LIFE MarPro project, which allowed for a large-scale evaluation of abundance and distribution of cetaceans and seabirds using airplane

[1] CESAM & Biology Department, Aveiro University. mail: catarina.eira@ua.pt
[2] Sociedade Portuguesa de Vida Selvagem. mail: silvia.sm.monteiro@gmail.com

Figure 1: Harbour porpoise (*Phocoena phocoena*): mother-calf pair.

census for the first time in Portugal. In turn, the obtained data was the basis for the proposal of important areas for cetacean conservation, within the Habitats Directive framework, especially concerning the conservation of harbour porpoises. The proposed areas are pSCI Costa de Setúbal and pSCI Maceda - Praia da Vieira accompanied by the enlargement of two existing areas SCI Costa Sudoeste and SCI Estuário do Sado (Figure 2). The proposed areas would represent an enormous contribution to the Natura 2000 network extension to the marine environment.

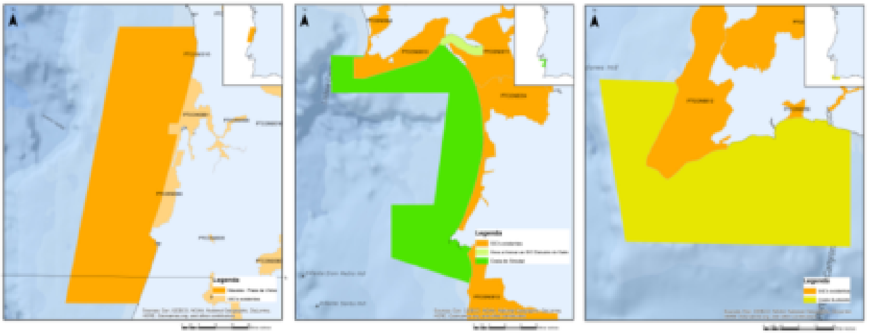

Figure 2: Proposed protection areas for cetaceans within the LIFE MarPro framework: new pSCI Maceda - Praia da Vieira, new pSCI Costa de Setúbal showing the proposed enlargement for SCI Estuário do Sado, and proposed enlargement for the SCI Costa Sudoeste.

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With respect to seabirds, within the same project, the team has contributed to the definition of two new SPAs for seabirds (Cabo Raso and Aveiro/Nazaré, Decreto Regulamentar n.º 17/2015) and to the enlargement of two already exiting SPAs (Cabo Espichel and Costa Sudoeste, Decreto Regulamentar n.º 17/2015). Also, the aerial census methodology was revealed to be of the utmost importance to detect annual variations in Balearic shearwater abundance and habitat use (Araújo et al. 2017) in the Portuguese continental coast.

Over the past years, within the framework of several projects, the team has participated in the national marine animal stranding network (coordinated by the ICNF). As such, cetaceans, turtles and seabirds stranded dead in coastal areas are collected and analysed in order to determine their cause of death and to allow for an evaluation of the activities that threaten their conservation. Together with project LIFE MarPro, samples were also collected from stranded individuals within project CETSENTI specifically to evaluate cetacean populations' health status, by integrating data on life history, contaminant loads, bacteria and fungi, virus prevalence, parasites, etc. In general, sampling marine stranded animals contributed to increasing the number of archived samples at the marine animal tissue bank at ECOMARE.

The samples collected over the years along the Portuguese continental coast allowed evaluating toxic element concentrations in tissues of Bottlenose dolphins (Monteiro et al. 2016a), Harbour porpoises (Ferreira et al. 2016), Common dolphins (Monteiro et al. 2016b), Pilot whales (Monteiro et al. 2017), Loggerhead turtles (Nicolau et al. 2017) and Balearic shearwaters (Costa et al. 2017). Considering the 4 different dolphin species, bottlenose dolphins presented the highest concentrations of mercury. Also, a high prevalence of Dolphin morbillivirus was found in striped dolphins in Portugal (Bento et al. 2016) and potentially zoonotic bacteria were found in striped dolphins (Godoy-Vitorino et al. 2017).

The identification of cetacean cause of death indicated that accidental catch by fishing gear is an important threat that must be mitigated. Therefore, within project LIFE MarPro, specific acoustic alert systems were offered to fishers to make their nets more detectable to

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Common dolphins (cetacean species presenting the highest mortality value due to accidental capture) and Harbour porpoises (small cetacean species with high conservation status in the continental Portugal).

The stranding network and the projects that support it also allowed collecting important data concerning marine turtle strandings (Nicolau et al. 2016a), demonstrating for the first time that waters off the Portuguese mainland coast represent an important pathway for loggerheads and leatherbacks in the North Atlantic region.

The project team is presently working on the characterization of marine litter (Sá et al. 2016) and its prevalence on marine megafauna. Considering loggerhead turtles, marine litter was detected in the digestive system of 56% of the already sampled turtles (Nicolau et al 2016b).

With respect to live strandings, marine animals are brought to the Ecomare rehab center. Rehabilitation attempts to mitigate the effect of some threats, for example marine litter, in the case of turtles and seabirds presenting ingested or entangled litter. It also mitigates bycatch impacts, since a large proportion of the admitted animals present evidences of interactions with fishing and sport fishing. These animals are properly treated at the Ecomare rehab center (see figure

Figure 3: Rehabilitation area for marine animals at ECOMARE.

3) and then returned to the marine environment as soon as possible.

Indirectly, the results obtained help monitoring marine environment conditions. Our objective is to further monitor marine vertebrate populations on the Portuguese mainland coast by integrating data on toxicology and microbiology with various population parameters. Only then will we be able to properly assess the effects of threats in the marine environment (well-known and emerging threats) and propose further mitigation measures.

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Hydrological Characterization of the Olhos de Água Submarine Groundwater Discharges - Projects FREEZE and TROANTE

Fátima M. Sousa (1,2) & Helena Frazão (1)

Abstract

The name of the small village Olhos de Água, in Algarve, is associated with the existence of freshwater springs visible at the beach, during low tide. These springs have also been identified on the continental shelf, just in front of the beach, because they were already observed from shore in days of calm seas. If these submarine discharges have high flows, they have a surface signature characterized by the reduction of roughness due to the sharp salinity contrasts between the freshwater discharges and the seawater. In the frame of the R&D project "FREEZE – Submarine Freshwater DischargEs: characteriZation and Evaluation study on their impact on the Algarve coastal ecosystem", three oceanographic surveys took place in November 2012, April 2013 and November 2013 in the Olhos de Água region, to study the thermohaline characteristics of the Submarine Groundwater Discharges (SGDs). The analysis of the hydrological data gathered in the whole set of 196 CTD stations carried out during the three surveys, allowed the identification of the SGDs sources, based on the low salinity values found near the bottom.

In the frame of the RD&I project "Desenvolvimento de Tecnologia UAV para Utilização de Âmbito Conjunto e Dual – TROANTE", running in the period January 2016-January 2019, an infrared radiometer will be mounted on board an Unmanned Aerial Vehicle (UAV) to measure sea surface temperatures over the continental shelf off Olhos de Água. The UAV flights will take place in different seasons of the year to detect surface temperature anomalies that could be associated with the location of the SGDs.

[1] MARE – Marine and Environmental Sciences Centre, Faculdade de Ciências da Universidade de Lisboa (FCUL), Campo Grande, 1749-016 Lisboa, Portugal. fsousa@fc.ul.pt; hcfrazao@fc.ul.pt

[2] Departamento de Engenharia Geográfica, Geofísica e Energia, DEGGE/FCUL, Campo Grande, 1749-016 Lisboa, Portugal.

Keywords: Submarine Groundwater Discharges (SGD); Olhos de Água; Algarve

Resumo

O nome atribuído à região dos Olhos de Água, no Algarve, está associado à existência de nascentes de água doce na praia, que ficam a descoberto durante a maré vazia. Estas nascentes também já foram detectadas na plataforma continental, mesmo frente à praia, pois são visíveis da costa e facilmente identificadas em dias de mar calmo. Se o fluxo das descargas for elevado, dão origem a um alisamento da superfície do mar provocado pelo forte contraste entre as salinidades da água doce proveniente das descargas submarinas e da água do mar. No âmbito do projeto de I&D "*FREEZE - Submarine FREshwater DischargEs: characteriZation and Evaluation study on their impact on the Algarve coastal ecosystem*", realizaram-se três campanhas oceanográficas em Novembro de 2012, Abril de 2013 e Novembro de 2013 na região dos Olhos de Água, com o objectivo de estudar as características termohalinas das Descargas de Águas Subterrâneas (DAS). A análise dos dados hidrológicos obtidos nas 196 estações CTD realizadas durante as campanhas permitiu localizar as DAS a partir dos baixos valores de salinidade encontrados junto ao fundo.

No âmbito do projeto de ID&I "Desenvolvimento de Tecnologia UAV para Utilização de Âmbito Conjunto e Dual – TROANTE", a decorrer desde Janeiro de 2016 e por um período de 3 anos, irá utilizar-se um radiómetro de infravermelhos a bordo de um UAV (Veículo Aéreo Não Tripulado), com o objetivo de medir a temperatura da superfície do mar e assim, detectar a assinatura térmica das DAS à superfície. Irão realizar-se vários voos sobre a plataforma continental da região dos Olhos de Água, em diferentes épocas do ano, para identificar as anomalias da temperatura à superfície que possam estar associadas à localização das DAS.

Palavras-chave: Descargas de Águas Subterrâneas (DAS); Olhos de Água; Algarve

1. Introduction

The existence of freshwater springs at the Olhos de Água beach (Algarve, south coast of Portugal) has been known for a long time, being the name of the small fishermen village historically related to these "water eyes" (in Portuguese, *olheiros*) still observed nowadays at the beach during low tide. One of these springs, located near the Barranco das Belharucas beach, was known as "the goats' spring" because, in the past, the goats usually came down the hills to drink freshwater at the beach. Figure 1a shows a picture of one of these freshwater springs at the Olhos de Água beach, observed during low tide.

These springs have also been identified on the continental shelf, just in front of the beach, because they were already observed from shore during days of calm seas. When the outflows are very strong, they can drift the small boats of the local fishermen. These high flow submarine discharges have a surface signature characterized by the reduction of roughness due to the sharp salinity (density) contrasts between the freshwater discharges and the seawater (UNESCO, 2004). Due to this smooth aspect of the sea surface, the submarine springs at the Avola site, in SE Sicily, are locally called "bubble" (*bugli* in Povinec *et al.*, 2006). The smooth surface caused by one submarine groundwater discharge (SGD) just in front of the Olhos de Água beach is presented in Figure1b.

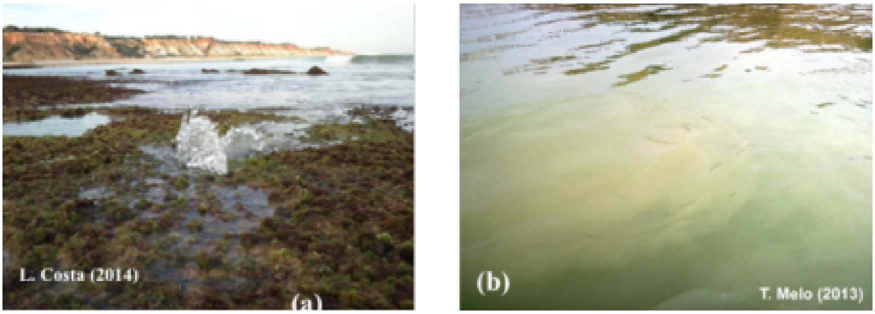

Figure 1: a) Freshwater spring at Olhos de Água beach visible during low tide; b) smoothed surface signature caused by an SGD offshore Olhos de Água (FREEZE, 2014).

The hydrological characterization of the freshwater SGDs was achieved in the frame of the R&D project "FREEZE – Submarine FREshwater dischargEs: characteriZation and Evaluation study on their impact on the Algarve coastal ecosystem". This project took place in the period January 2010–December 2013 and one of its objectives was the study of the Submarine Groundwater Discharges (SGDs) at sea in the Olhos de Água region.

In the frame of the RD&I project "Desenvolvimento de Tecnologia UAV para Utilização de Âmbito Conjunto e Dual – TROANTE", running since January 2016 until January 2019, an Unmanned Aerial Vehicle (UAV) will be used to collect data in the coastal area off Olhos de Água. Sea surface temperatures will be measured with an infrared radiometer on board the UAV, to detect the thermal signatures of the SGDs at the surface.

Some results obtained in the frame of the project FREEZE will be presented here as well as the activities planned to be conducted under the project TROANTE.

2. Project FREEZE

2.1. Data and Methodology

Satellite data

In the frame of the FREEZE project, ten SAR (Synthetic Aperture Radar) images obtained during the period 2000-2010 were processed and analyzed to look for patterns of sea surface roughness that could be associated with the potential location of the SGDs over the continental shelf off Olhos de Água. These patterns, usually called slicks, identify areas where capillary and small gravity waves are attenuated, and the sea surface roughness is reduced, due to light shimmering effects caused by sharp salinity contrasts. The smoothed areas appear darker on SAR imagery compared with the wind-roughened surrounding ocean, which appears brighter on those images. These slicks could represent the surface signature of the SGDs, where less dense water discharging from the submarine springs reach the surface.

One SAR image obtained on 9 February 2010, at 10:43 UT, during a particularly rainy winter, is presented in Figure 2. This image, with a 75-m ground resolution, shows one slick, with a diameter of about 3.5-4.0 km, located just in front of Olhos de Água beach. The slick is identified by a white circle in Figure 2.

The geographical location of the slick was crucial for the planning of the station array to be occupied during the CTD surveys, because it was essential to cover not only the areas where the SGDs could be found but also the surrounding waters with coastal oceanic thermohaline properties.

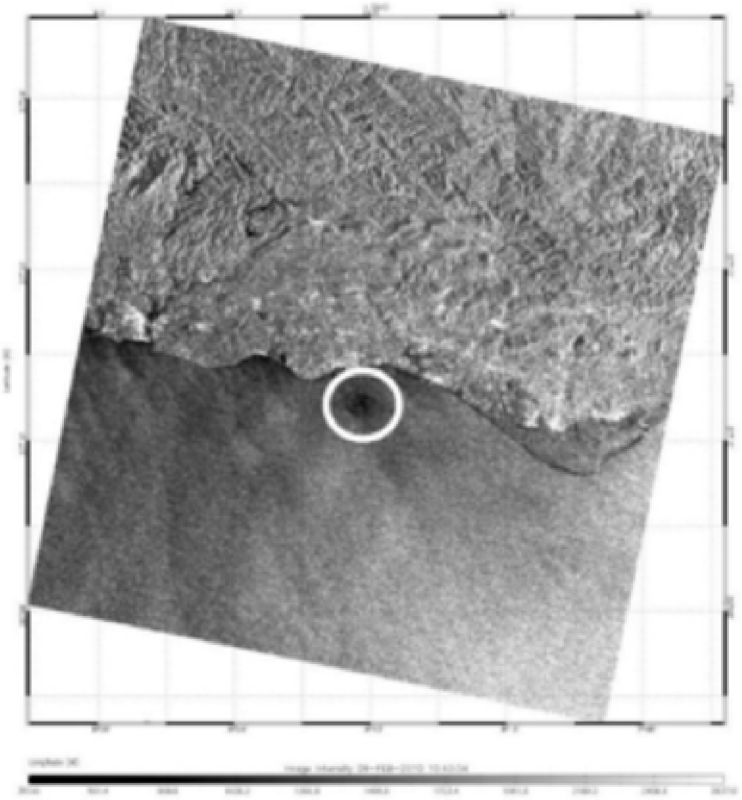

Figure 2: SAR image obtained on 9 February 2010, at 10:43 UT, showing a slick (inside the white circle) offshore Olhos de Água (de Sousa et al., 2014).

CTD surveys

Three CTD (Conductivity, Temperature, and Depth) surveys were conducted in November 2012, April 2013 and November 2013, in the Olhos de Água region, on board the boat "Ecorecursus I", belonging to the Centro de Ciências do Mar da Universidade do Algarve (CCMAR/UAlg). The depths of the stations ranged from 2 to 30 m, being the study area restricted to 3 n.m. from the coast (≈ 5.6 km) due to the small dimensions of the boat.

The CTD data were collected with a relatively high-density station array, with an average distance between stations of about 500 m. During the 3 surveys (from now-on identified as Nov/2012, Apr/2013 and Nov/2013), a total of 166 CTD stations were carried out in the Olhos de Água area (59+42+65). In the last survey, 30 stations were also carried out, located in two areas considered as “non-SGDs referee places” (Albufeira and Falésia), thus helping in the identification of waters with a coastal oceanic origin contrasting with the waters influenced by submarine springs over the continental shelf off Olhos de Água. The location of the whole set of 196 CTD stations, carried out during the 3 surveys, is presented in Figure 3.

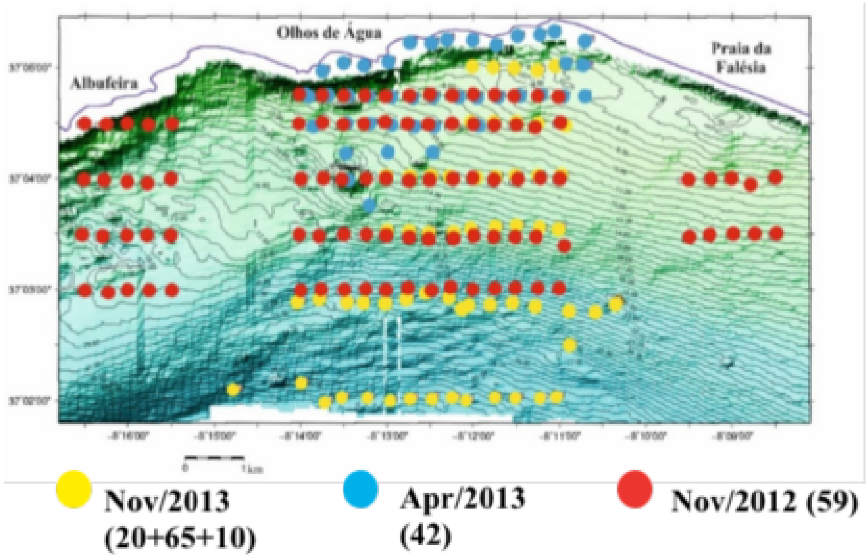

Figure 3: Location of the 196 CTD stations carried out during the 3 surveys conducted in the Olhos de Água area: (59) Nov/2012, (42) Apr/2013 and (20+65+10) Nov/2013 (adapted from Frazão, 2016).

The positioning system used during the first survey was a Garmin GPSMAP® 60CSX without differential correction, but in the second and third surveys, a combined GPS positioning system and depth controller (GPSMAP® 421s) was installed on board.

In the three campaigns, temperature, conductivity and pressure data were collected with one NXIC (Non-eXternal Inductive Conductivity) CTD of Falmouth Scientific, Inc. (FSI, USA).

2.2. Hydrological analysis

The salinity, temperature and sigma-t (density) profiles, as well as the temperature/salinity (T/S) diagrams were drawn and analyzed for the whole set of 166 CTD stations carried out in the Olhos de Água area. The scatter T/S diagram with all the stations is presented in Fig. 4a.

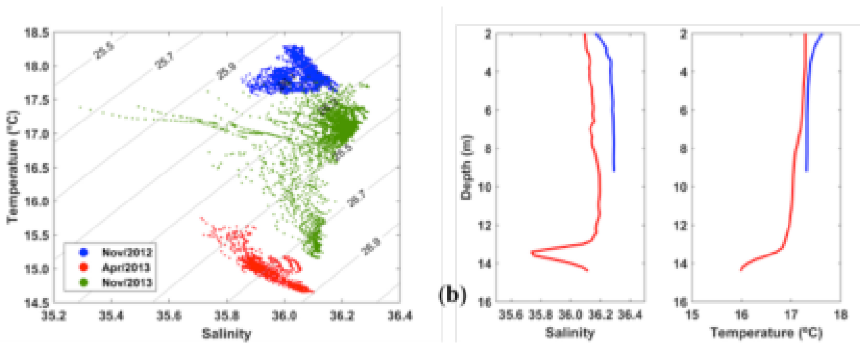

Figure 4: a) T/S diagram with all the 166 (59+42+65) stations carried out during the 3 surveys in the Olhos de Água area; b) salinity and temperature profiles obtained in an oceanic coastal station (in blue) and in one station influenced by SGD (in red) during the Nov/2013 survey (adapted from Frazão, 2016).

Figure 4a shows that each survey is characterized by different thermohaline properties reflecting the time of the year when each campaign took place. The survey Nov/2012, represented in blue in Figure 4a, was conducted during a summer-winter transition situation of a relatively hot and dry year and presents the highest values of temperature (17.5 ºC £ T £ 18.3 ºC) reached in the whole period of observations.

Temperatures ranging between 14.5 ºC and 16.0 ºC were obtained during the Apr/2013 survey (represented in red in Figure 4a), which took place right after a rainy winter (precipitation values were almost twice the ones of the previous winter), with the sea temperatures reaching the lowest values observed in the whole period. Since all the stations were located very close to the coast (very shallow waters with maximum depth of 14 m), they reflect the interactions with the winter cold air temperatures.

The salinity values obtained during both surveys were very similar (35.7 £ S £ 36.2) presenting only a difference of 0.1 higher observed during the "hot and dry" Nov/2012 survey.

The last survey (Nov/2013, represented in green in Figure 4a) took place also in the summer-winter transition but after a relatively wet year and presented the largest variations in temperature and salinity.

It is interesting to note that the temperature values were much lower (15.0-17.7 °C) than the ones obtained exactly in the same month but one year before. Salinity values presented the highest variation, ranging between 35.3 and 36.3.

The analysis of all the T/S diagrams reveals that the stations are grouped in two different patterns; this is perhaps more evident in the stations carried out during the Nov/2012 and Apr/2013 surveys, represented in blue and red, respectively, in Figure 4a. The stations with a coastal oceanic behaviour present a small increase in salinity, with the corresponding small decrease in temperature, and a gradual increase in density with depth. T/S diagrams of the stations influenced by SGDs present a completely different shape from the ones mentioned above. They reveal instabilities in the water column showing sigma-t inversions, probably due to vertical mixing with waters coming out from the submarine springs. The lowest salinity values reached in these stations could also indicate that they are under the direct influence of the SGDs waters.

T/S diagrams of the stations carried out during the Nov/2013 survey (represented in green in Figure 4a) do not show, in a clearly visible way, the two patterns mentioned above, but only the SGD influenced station pattern. As this last survey took place after a particularly rainy year, the large number of submarine springs in the area off Olhos de Água, associated with higher discharges, could be responsible for the predominant SGD pattern in the T/S scatter diagram, thus masking the presence of a few stations with a coastal oceanic behaviour.

Examples of salinity and temperature profiles of coastal oceanic and SGD influenced stations are represented in Figure 4b, in order to show the behaviour in depth of a coastal oceanic station (blue profiles in Figure 4b) compared with the one showing an SGD signal in the water column (red profiles in Figure 4b). The coastal oceanic station presents a small increase in salinity and a small decrease in temperature with depth. The SGD station presents a salinity minimum (S » 35.7) at about 13.5 m depth, relative to the constant value S » 36.2 registered along the whole water column. This high variation in salinity ΔS = - 0.5, is also combined with a relatively high temperature variation of ΔT » - 1.0 ºC. These sudden salinity and temperature decreases are due to waters with other hydrological characteristics corresponding to the presence of the SGD signal affecting the water column of the station (see Figure 4b).

Vertical sections of salinity, temperature and sigma-t, were drawn along lines parallel and perpendicular to the coast in order to establish a tight net to be able to identify the potential location of the submarine groundwater discharges.

The analysis of the whole hydrological dataset allowed the identification of two major types of SGD sources: ones with a strong signal in the entire water column and others where the SGD signal occurred near the bottom. The location of the SGDs identified through CTD data, and the schematic representation of the slick observed on the SAR image (Figure 2) are represented in Figure 5.

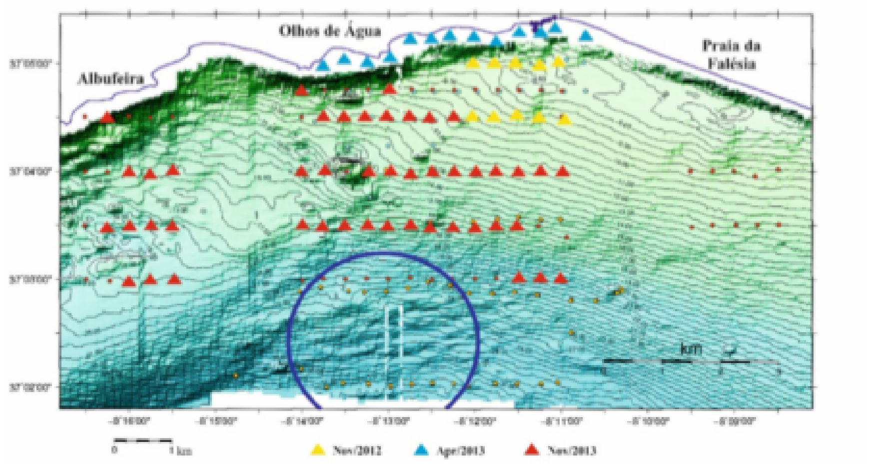

Figure 5: Location of the SGDs identified through CTD data collected during the surveys: Nov/2012 (yellow), Apr/2013 (light blue) and Nov/2013 (red). The dark blue circle is the schematic representation of the slick identified on the SAR image (adapted from Frazão, 2016).

Frequently, the signal of the freshwater discharges was detected, at any depth in the water column and at the surface, thus indicating that the station was under the influence of an SGD. The waters coming out from the submarine springs may be subjected to both local vertical mixing and advection processes. As the submarine discharges occur in shallow waters, they propagate horizontally like plumes which could be affecting partially or totally the water column of the stations located in the direction of the plume trajectory.

The presence of the SGDs seems to be recurrent as they were detected in the same locations during rainy and dry years, being stronger the signal of the first ones.

3. Project TROANTE

In the frame of Project TROANTE, an Unmanned Aerial Vehicle (UAV) was built and got ready by the end of August 2017, being now able and ready to do the flight tests.

The infrared radiometer which was acquired in January 2017 will be mounted on board the UAV to measure sea surface temperatures (SSTs) during the flights off the Olhos de Água. Several flights are planned to cover different situations along the year. Pictures of the UAV and the infrared radiometer are presented in Figures 6a and 6b, respectively.

During each UAV flight, SSTs will be measured along several legs (see the blue lines in Figure 6c) covering the location of the SGDs revealed by CTD data and the slick observed on the SAR image (red dots and dark red line in Figure 6c, respectively) to detect at the surface, the thermal signature of the submarine groundwater discharges. The location of the SGDs identified through the analysis of high-resolution seismic data (FREEZE, 2014) is also represented in Figure 6c (green triangles).

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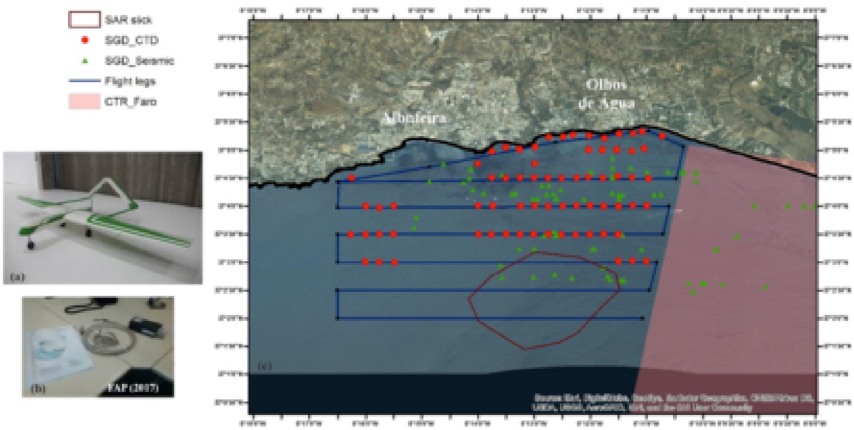

Figure 6: a) Unmanned Aerial Vehicle (UAV) built in the frame of Project TROANTE; b) infrared radiometer to be mounted on board the UAV to measure SST; c) flight legs (in blue) to accomplish during each UAV flight. The location of the SGDs detected with CTD (red dots) and with seismic data (green triangles) are also represented as well as the slick identified on the SAR image (dark red line).

(IPMA), Laboratório Nacional de Energia e Geologia (LNEG), the former Centro de Oceanografia/Faculdade de Ciências da Universidade de Lisboa (CO/FCUL), Universidade do Algarve (UAlg) and Instituto Superior Técnico (IST), Lisboa. Thanks to Gabriela Carrara from IPMA, Judite Fernandes from LNEG, Dmitri Boutov and Ana Machado from CO/FCUL, and Francisco Leitão and Pedro Range from UAlg, who also participated in the surveys.

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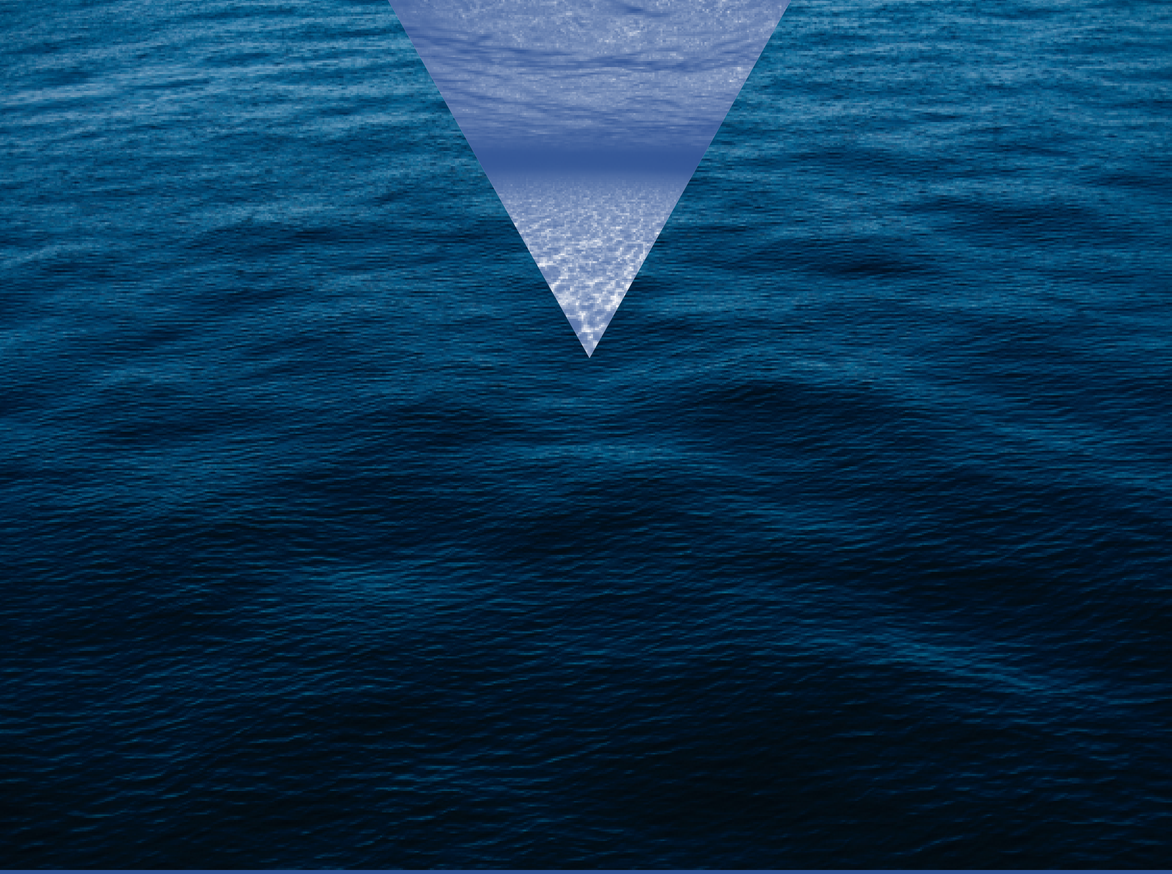

RECURSOS MARINHOS

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MARINE RESOURCES

In the Marine Resources session several themes have been presented in different research fields: the importance and preservation of migratory diadromous fishes, several of them threatened; the social and economic importance of small-scale fisheries, too big to be ignored, with the discussion focused mainly on the sardine stock sustainability; the problems related with the climatic changes, overfishing and sea rejections and to find solutions that do not pass by aquaculture or re-stock.

The importance of links between scientists, political and decision-makers was discussed and should be encouraged to deal with environmental sustainability. The tropicalization of marine ecosystems in Portugal has also been emphasized.

All the researchers, the chairman and the chairwoman spoke about the importance that Mário Ruivo had in the Portuguese Marine Research and the support that he gave to several generations. Although independent from government his contribution was always to put marine research and technology in the political agenda, referring several times in public that the Marine Sciences and Technology Community should assume its responsibility as an active social actor. Until his death he has been concerned with supporting and helping the younger generations of marine researchers.

We can say that in the Portuguese sea we had a before and after Mário Ruivo in Science.

Maria José Costa & Telmo Carvalho

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Diadromous Fish in Portugal: Status, Threats and Management Guidelines

P.R. Almeida[1, 2]*, B. R. Quintella[1,3], C. S. Mateus[1], C. M. Alexandre[1] & S. Pedro[1]

Abstract

Diadromous fish evolved in a way to use two completely different environments during their life-cycle (i.e. river and sea), being divided in anadromous (e.g. sea lamprey, shads) and catadromous (e.g. eel, thin-lipped grey mullet) species, if their reproduction occurs, respectively, in freshwater or marine environments. In Portugal, the high commercial value associated with these species makes them primary targets for traditional fisheries, which need proper management to avoid overfishing and guarantee the long-term survival of their populations. Loss of river connectivity, caused by the construction of dams and other hydraulic infrastructures, also contributes to the decrease in population numbers of diadromous species, a scenario that is often exacerbated by the associated river flow regulation, water scarcity and the climatic changes occurring at a global level but with special intensity in the Iberian Peninsula. The high complexity and territorial scope of these threats demand the development of suitable and integrated measures for the conservation and management of diadromous fish. The scientific component can act as a link between all the stakeholders involved in these processes, namely the local and central administration managing rivers basins and fisheries, commercial fishermen, private promotors and general public. The work being developed in the Mondego river basin for the past 20 years, and which recently begun to be replicated in the Vouga river basin, represents a valuable and decisive contribution to the recovery of diadromous fish populations in Portugal. Habitat rehabilitation and management of com-

[1] MARE – Centro de Ciências do Mar e do Ambiente, Universidade de Évora, Évora, Portugal

[2] Departamento de Biologia, Escola de Ciências e Tecnologia, Universidade de Évora, Évora, Portugal

[3] Departamento de Biologia Animal, Faculdade de Ciências da Universidade de Lisboa, Lisboa, Portugal

* Corresponding author - E-mail: pmra@uevora.pt

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mercial fisheries can act in synergy, allowing a sustainable exploitation of these valuable resources.

Keywords: Diadromous fish; habitat rehabilitation; fisheries management

Resumo
Os peixes diádromos evoluíram no sentido de utilizarem dois meios completamente distintos durante o seu ciclo de vida (i.e., o rio e o mar), subdividindo-se em anádromos (e.g. lampreia-marinha, sável) e catádromos (e.g. enguia, muge), consoante a sua reprodução se realiza em água doce ou em ambiente marinho, respetivamente. Em Portugal, o elevado valor comercial que estas espécies atingem faz com que sejam o principal alvo de pescarias artesanais, estando documentados fenómenos de sobrepesca, a par de uma intensa atividade furtiva. A implementação de medidas apropriadas de gestão da pesca é por isso fundamental para garantir a sobrevivência destas populações a longo prazo. A perda da continuidade longitudinal nos rios, com a construção de barragens e outras obras hidráulicas transversais, contribuiu igualmente para o declínio dos efetivos populacionais das espécies diádromas, situação agravada pela regularização de caudais e pela escassez de água associada às alterações climáticas que se fazem sentir a nível global, mas com particular intensidade na Península Ibérica. A complexidade e abrangência territorial destas ameaças exige a implementação de medidas integradas de gestão e conservação. A componente científica pode servir como elo de ligação entre todos os agentes intervenientes no processo, designadamente, a administração local e central responsável pela gestão das bacias hidrográficas e da pesca, os pescadores profissionais, os promotores privados e o público em geral. O trabalho que tem vindo a ser desenvolvido ao longo dos últimos 20 anos na bacia hidrográfica do rio Mondego, e que recentemente começou a ser replicado na bacia do Vouga, no que respeita ao restauro do habitat e o acompanhamento da pesca comercial realizada numa lógica de tornar esta exploração sustentável, serão um contributo determinante para a recuperação das populações de peixes diádromos em Portugal.

Palavras-chave: Peixes diádromo; reabilitação do habitat; gestão das pescas

1. Introduction

Diadromy (from the Greek *"dia"*, through, and "*dromos*", running) refers to the need of certain fish species to use both marine and freshwater environments to complete their life cycle, thus having separate feeding and reproduction areas in saline and freshwater, and migrating between them. Diadromous species are divided into anadromous (Greek: "*ana*", up) and catadromous (Greek: "*kata*", down), depending on whether the reproduction occurs in rivers or the sea, respectively. Anadromous species occurring in Portugal include the sea lamprey, *Petromyzon marinus* L., the European river lamprey, *Lampetra fluviatilis* L., the allis shad, *Alosa alosa* L., the twaite shad, *Alosa fallax* (Lacépède 1803), the sea trout, *Salmo trutta* L., and the Atlantic salmon *Salmo salar* L. The Atlantic sturgeon, *Acipenser sturio* L., is another anadromous species which once occurred in Portuguese waters, but is now classified as Regionally Extinct, with the last specimens being caught in the early 1980's, in the Guadiana river (Cabral *et al.*, 2005). Catadromous species include the European eel, *Anguilla anguilla* L., the thin-lipped grey mullet, *Liza ramada* (Risso, 1827) and the European flounder, *Platichthys flesus* L.

2. Species life cycle, distribution and conservation status

Sea lamprey

The anadromous sea lamprey (*P. marinus*) is a semelparous species (a single reproductive episode before death) with a life cycle divided in two distinct phases: a freshwater larval phase and a post-metamorphic marine phase. After 3-7 years burrowed in fine sediment deposits of rivers and streams in freshwater (Beamish & Potter 1975; Quintella *et al.*, 2003; Dawson *et al.*, 2015; Silva *et al.,* 2016), the ammocoetes (larvae) undergo a metamorphosis that prepares them for life in the marine environment (Youson, 1980). This stage ends with downstream migration and the onset of feeding. In Portuguese rivers, the metamorphosis and downstream migration of *P. marinus* extend from late summer (August/September) to mid-winter (January/February) (Quintella *et al.*, 2003). The parasitic phase lasts approximately 13 months to two years (Renaud, 2011; Silva *et al.*, 2013), before the spawning migration to continental waters begins – in the Iberian Peninsula, this happens in December and peaks between February and March (Almeida & Quintella, 2013; Araújo *et al.*, 2016), with spawning occurring between April and June (Almeida *et al.*, 2000; Silva, 2014).

Sea lamprey is a native species, occurring in the main Portuguese river basins (Table 1). It is considered a delicacy and can reach considerable prices in Portugal, having a high commercial importance in several river basins (Stratoudakis *et al.*, 2016). Conservation status along the distribution area diverge, with the species being considered a pest in North America (landlocked populations) and listed as Vulnerable (VU) in Portuguese river basins (Table 1). Insufficient background knowledge and conservation concerns in Western European countries, particularly in Portugal, led to an increasing number of studies and monitoring efforts emerging in the last two decades (*e.g.* Almeida *et al.*, 2000; 2002; 2008; Quintella *et al.*, 2003; 2006; 2007; Andrade *et al.*, 2007; Mateus *et al.*, 2012; Pedro *et al.*, 2014).

European river lamprey

The European river lamprey (*L. fluviatilis*) is a semelparous species with a larval freshwater phase and an adult marine/estuarine (feeding) phase. The ammocoetes live buried in fine sediment deposits of rivers and streams for 4-5 years (Hardisty & Potter 1971), followed by a metamorphosis that precedes the downstream trophic migration and the onset of feeding. The trophic (downstream) migration occurs in the autumn, and the marine phase may last 14 to 22 months. The spawning migration to continental waters takes place between January and April, with reproduction occurring between March and May.

The European river lamprey is not commercially exploited in Portugal, unlike in some other countries within its occurrence range. The species historic distribution was described for the rivers Minho, Mondego and Tagus (Baldaque da Silva, 1891), but presently the species is only found in the latter, more specifically in the tributary Sorraia river (Mateus *et al.*, 2012; 2016), leading to serious conservation concerns (Table 1).

Table 1. List of the diadromous fish species occurring in Portuguese river basins: scientific and common names, national distribution and conservation status

Species	Minho	Lima	Cávado	Douro	Vouga	Mondego	Tagus	Sado	Mira	Guadiana	IUCN Red List	Red List (PT)[1]	Habitats Directive	Bern Convention	Bonn Convention	OSPAR	HELCOM	CITES
Petromyzon marinus Sea lamprey	x	x	x	x	x	x	x		?	x	LC	VU	II, 8 SCI	III	✓	✓	VU	
Lampetra fluviatilis European river lamprey							x				LC	CR	II, V, 1 SCI	III			NT	
Alosa alosa Allis shad	x	x		*	x	x	x			x	LC	EN	II, V	III		✓		
Alosa fallax Twaite shad	x	x		*	x	x	x	?	x	x	LC	VU	II, V	III				
Salmo trutta Sea trout	x	x	x	?	?	x	?				LC	CR					VU	
Salmo salar Atlantic salmon	x	?									LC	CR	II, V	III	II	✓	VU	
Anguilla anguilla European eel	x	x	x	x	x	x	x	x	x	x	CR	EN			II	✓		II
Liza ramada Thin-lipped grey mulet	x	x	x	x	x	x	x	x	x	x	LC	LC						
Platichthys flesus European flounder	x	x	x	x	x	x	x	x	x	x	LC	DD						

1 Cabral et al., 2005; *In the Douro there are occasional records, but the population is not viable due to the several dams that exist in this basin (Cabral et al. 2005).

Shads

The allis shad (*A. alosa*) is a semelparous species that spawns in the spring, in shallow waters over gravel substrate (Baglinière *et al.*, 2003). Downstream migration to the estuaries occurs in the autumn and the juveniles enter oceanic waters before completing their first year of life.

The twaite shad (*A. fallax*), on the other hand, is a predominantly iteroparous species (reproduction occurs several times in life). Spawning takes place between the spring and the beginning of summer, with juveniles migrating towards the sea in the autumn.

Both species occur in several Portuguese river basins (Table 1) and are considered extinct in the Douro and Ave rivers - despite the occasional observations in the Douro river basin, the populations are not considered viable due to the cascade of dams along the river main stem (Cabral *et al.*, 2005). Some landlocked populations of allis shad occur in the Portuguese territory, namely in the Alqueva (Guadiana river), Castelo de Bode (Zêzere river) and Aguieira (Mondego river) reservoirs.

The allis shad population associated to the Minho river basin, with important commercial and heritage values (Mota & Antunes,

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2011), was one of the largest in the southern part of the species' distribution, after the collapse of this species in France (ICES, 2015). Presently the populations from central Portugal (*i.e.* rivers Vouga and Mondego) have been increasing their numbers, representing the most important stock harvest in Portugal. The twaite shad is also subject to fishing mortality, but usually not as a target species (Mota *et al.*, 2011). Exception to this is the Guadiana river basin fishery, where twaite shad is captured instead of allis shad due to restrictions and the small population size of the latter.

Shads are generally caught when they migrate from their marine feeding areas to the upstream freshwater spawning grounds, but there are also captures recorded at sea or along the coast throughout the year (Stratoudakis *et al.*, 2016). These catches have recently become more expressive, with coastal landings of allis shad reaching an average of 30 tons per year in the last 20 years (10-70 tons) (ICES, 2015).

At the European level, the conservation status of both species in the Atlantic region and for the 2007-2012 period, is 'unfavourable-bad' with declining (*A. alosa*) and deteriorating (*A. fallax*) populations.

Sea trout

The sea trout is the anadromous form of the brown trout (*S. trutta*), and usually both forms co-exist as part of the same breeding population. Spawning migration takes place between May and July, although some migrating adults are also caught in the autumn. Reproduction occurs between December and February in rivers and smaller streams, often in the upper reaches or in smaller tributaries, in cold and well oxygenated waters. Juveniles (parr) can stay in river stretches for 2 to 5 years, migrating to the sea (smolts) afterwards, where they stay for 1 to 4 years. Reproduction takes place several times during their lifespan.

The sea trout is a native species in Portugal, with an occurrence limited to the northern and central regions of the country (Table 1). The population from Minho river is considered the largest one in Portuguese territory (Cabral *et al.*, 2005), but quantitative data is still lacking to properly evaluate the population size. The sea trout is targeted by both commercial and recreational fisheries, with catching periods and size limits regulated for the river basins where the species occurs. Data from professional and recreational fishermen operating in rivers Minho and Lima indicate that the number of sea trout adults in these two river basins is extremely low (*i.e.* reduction may have affected 98% of sea trout adults in the past 10-15 years) and that population effectives of the anadromous trout seem to be in a marked decline in most of its occurrence area (Cabral *et al.*, 2005).

Atlantic salmon

The Atlantic salmon (*S. salar*) is a native anadromous species with historically low abundance in Portuguese waters. Currently, the species occurs regularly only in the Minho river and less frequently in the Lima river (Table 1) (Cabral *et al.*, 2005). Historical distribution included the rivers Cávado and Douro (Baldaque da Silva, 1891). Spawning migration occurs in summer and early autumn, and spawning takes place in the autumn and winter in the upper stretches of rivers, in unpolluted, cold and well-oxygenated waters with moderate speed currents. Salmons remain in fresh water for 1 to 8 years, before migrating to the sea, where they stay for 1 to 5 years. Commercial and recreational fishing for Atlantic salmon is forbidden in river Lima but allowed, and properly regulated, in river Minho from March to June.

European eel

The European eel (*A. anguilla*) is a semelparous catadromous species that spawns in the Sargasso Sea. The larvae drift with the oceanic currents to the continental shelf, where they metamorphose into glass eels and enter continental waters (McCleave *et al.*, 1987; Tesch & Wegner, 1990). The growth stage (yellow eels) may take place in marine, brackish (transitional) or fresh waters, and lasts from 4 to over 20 years, after which they metamorphose again into silver eels, the maturing phase. As silver eels, they begin their migration back to the Sargasso Sea.

The European eel occurs in all Portuguese river basins from Minho to Guadiana (Table 1), and in coastal waters of the Azores and Madeira archipelagos. Commercial fishing operates from glass eel stage up to silver eels. In Portugal, glass eel catches are regulated and only allowed in the international stretch of the Minho river for a reduced time span in late winter, but forbidden elsewhere. Nonetheless, illegal fisheries occur frequently, as this is a highly valuable delicacy in several countries (in 2015, glass eel catches were sold up to 400€ per kilogram, the same year where one of the greatest seizures took place - *ca*. 300 kg of glass eels). Currently, under the EC Council Regulation 1100/2007 (European Eel Management Plan), both commercial and recreational fishing of adult eels are forbidden in the Minho river and a restriction to 3 kg/day/fisherman of glass eel was imposed during the operational period. A marked decrease in silver eel populations (up to 75 %) over several decades led to the classification of this species as Endangered (EN), according to the last assessment of the Portuguese Red List of Threatened Vertebrates (Cabral *et al.*, 2005).

Thin-lipped grey mullet

The thin-lipped grey mullet (*L. ramada*) is a native, catadromous species. The spawning period takes place in coastal areas from late autumn to early winter. Recently, a fish pass installed at the Açude-Ponte dam in the Mondego river registered a peak in downstream migrating adults during August and September (more than 350 000 in 2013 and more than 450 000 in 2014) (Almeida *et al.*, 2016a). Upstream migration occurs in the spring (Almeida *et al.*, 1995), although recent observations have showed that this may continue during summer. Annually, the monitoring of the fish pass at the Açude-Ponte dam registers more than one million thin-lipped grey mullets migrating upstream. The success of this species is likely related to its remarkable euryhalinity and the highly plastic, opportunistic trophic behavior (Almeida *et al.*, 1993; Almeida, 2003, Cardona, 2015). The maximum length reported is approximately 70 cm, and longevity *ca.* 10 years.

This species occurs in all the main Portuguese estuarine systems, from the Minho to the Guadiana river basins (França *et al.*, 2011) (Table 1). Despite its importance in commercial fisheries in other regions (*e.g.* Mediterranean Sea), the thin-lipped grey mullet is not commercially exploited in Portugal, apart from minor, local fisheries in some estuaries (*e.g.* the Tagus estuary).

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European flounder

The European flounder (*P. flesus*) is a catadromous fish that spawns during winter and early spring in marine waters. The post-larvae drift with the currents and have the capacity to detect brackish water signals coming from coastal areas, which triggers the onset of the metamorphose (rearrangement of the internal organs and migration of the left eye to the right side of the body, thus losing bilateral symmetry). The juveniles use estuaries, coastal lagoons and lower freshwater stretches of rivers as nursery areas where they remain for 2 to 3 years, before migrating to the sea to spawn.

This species is found primarily in coastal and estuarine waters, throughout the entire Portuguese coast (Table 1), but can be found in fresh water stretches in some river basins. It is, nonetheless, more abundant in the river basins north of Tagus river (Cabral *et al.,* 2005), and estuaries like Ria de Aveiro, Mondego, Douro, Lima and Minho were identified as important nursery areas for this species (Cabral *et al.*, 2007; Vasconcelos *et al.*, 2008; Freitas et *al.*, 2009; Ramos *et al.*, 2010). The European flounder is targeted by commercial fishing, with greater importance in local artisanal fisheries. Recent captures of *P. flesus* in the northern Portuguese estuaries have shown a slight increasing trend (Teixeira & Cabral, 2009), but, notwithstanding, a decrease in the commercial landings in the Minho river led to the suspension or restrictions to specific fishing gear.

3. Main Threats

One of the main life cycle requirements of diadromous species is to move between freshwater and marine habitats. The construction of barriers that prevent migration represents the main threat for these species, as it blocks migration routes essential for the completion of their life cycle. The presence of anthropogenic barriers to fish passage can result in partial or complete loss of the upstream habitat, both for spawning/nursery (*i.e.* anadromous species) or growth (*i.e.* catadromous) areas. In Portugal, during the second half of the 20th century, upstream migration became blocked at the lower stretches of all major rivers with the building of the first large dams in the main stem. Mateus *et al.* (2012) concluded that before the building of unsurmountable dams, lampreys were present at the headwaters and tributaries of all the major Iberian river basins. About 80% of the habitat that was estimated to be available in Iberian river basins for sea lamprey is now inaccessible due to the construction of these infrastructures (Mateus *et al.*, 2012; Figure 1). Habitat loss is also related to river flow regularization, discharge reduction, gravel extraction and pollution (water contamination can also create a barrier to migrations). Most of the

Figure 1. Distribution range of diadromous fish species in the main Portuguese river basins and location of the respective first unsurmountable barriers. * Distribution limits presented in this map apply to all occurrent diadromous species except for European eel, whose presence, although in lower abundance, has been detected upstream of some of the described barriers. Except for Raiva and Grela dams (Author: Carlos M. Alexandre) presented photos were obtained from public WEB sources.

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times, all these factors are acting in synergy on the same river, being related and/or magnified by the others. Dams and weirs usually lead to artificial flow regimes in the downstream stretches, with strong alteration of water levels and river flow. Low discharges can reduce attraction flow cues to which upstream-migrating fish usually respond. River engineering and channel cleaning/maintenance that alter the channel cross section, thereby impacting on sediment accumulation, will have effect on the type of habitats found along the river continuum, usually reducing the diversity and quality of habitats, and destroying spawning, nursery, feeding and refuge areas. In fact, besides maintaining access to spawning and feeding grounds, other habitat features need to be maintained, as for example deep pools where adult shads can congregate prior to spawning, or the appropriate sandy substrate for larval lampreys (Maitland *et al.*, 2015).

Other threat to diadromous fish, which can also relate to habitat loss, is overfishing of commercially targeted species. In Portugal this is the case of the sea lamprey and the allis shad. The high economic value of these two species in Portugal makes them a preferred target of both commercial fishermen and poachers, creating a major threat to the sustainability and conservation of their Portuguese populations (Almeida *et al.*, 2002; Andrade *et al.*, 2007; Mateus *et al.*, 2012; ICES, 2015; Stratoudakis *et al.*, 2016).

Climate changes will increase the vulnerability of aquatic ecosystems to the threats mentioned above, being particularly stressful in rivers located in regions highly influenced by the Mediterranean climate. The reduced water availability, due to rising air temperature and reduced annual precipitation, will contribute to extreme hydrological changes, namely more frequent occurrence of extreme events like drought or floods (Filipe *et al.* 2013). But these climatic events go beyond the increased prevalence of floods and droughts and their direct effects. They can change the composition and structure of fish communities, as they lead to increases in water temperature, reduction of water availability and, consequently, habitat loss. Besides a direct reduction of the species' distribution area, climate changes (especially the high variation in water temperature) can affect ecological processes, including physiological tolerances and ecosystem dynamics, such as the timing of migration, reproduction, and other behaviors.

4. Conservation and Management of Diadromous Species in Portugal: the Mondego case study

In the last decades, there have been great advances in the knowledge and awareness of the threats and ecological requirements of diadromous fish species, like lampreys, shads and eels. Throughout the distribution range of these species, several important sites for their conservation have been identified and several habitat recovery and population management actions were conducted, including a growing effort to involve and inform the general public and major stakeholders on necessary conservation actions within a perspective of compatibilization of the multiple uses associated with these natural resources (Mateus *et al.*, 2015).

In Portugal, of the nine diadromous species whose occurrence is confirmed, three are classified as Critically Endangered (river lamprey, Atlantic salmon and sea trout), two as Endangered (allis shad and European eel) and two as Vulnerable (twaite shad and sea lamprey) (Cabral *et al.*, 2005). Adding to this high risk of regional extinction, some of the described species are also considered very important from cultural and socioeconomic standpoints, supporting a variety of activities related with the use and exploitation of goods and services provided by aquatic ecosystems (Stratoudakis *et al.*, 2016), such as commercial (*i.e.* sea lamprey, allis shad and European eel) and recreational (*i.e.* Atlantic salmon and sea trout) fisheries, and strongly contributing to the overall economic income and cultural activities of local populations. Consequently, in past years these diadromous species have been targeted by several conservation and management programs, most of them focused on the development of habitat rehabilitation actions and the implementation of fishing regulations that guarantee the sustainable exploitation sustainability of these fisheries.

4.1. Habitat recovery actions

A successful case study of conservation and management program directed to diadromous fishes started 20 years ago in the Mondego river basin. The Mondego river represents an important stronghold for diadromous species, most of them with a notorious conservation status and a high socioeconomic value. More specifically, sea lamprey and allis shad are particularly interesting and valuable as gastronomic delicacies in this region, promoting the development of an important commercial fishery (Stratoudakis *et al.*, 2016). However, since the beginning of the 1980's, this river has become highly impounded after the construction of two large hydroelectric power dams, the Aguieira and Raiva dams (located 86 and 80 km upstream the river mouth, respectively), and of several smaller weirs throughout its main stem (APA, 2016). The Açude-Ponte dam built at Coimbra, 45 km upstream from the river mouth, for irrigation and industrial water uses, was until recently considered the first unsurmountable obstacle for diadromous fish species occurring in this river basin, contributing to a significant reduction of the available habitat for these species, together with the consequent ecological and socioeconomic losses (Almeida *et al.*, 2000).

The downward scenario faced by diadromous fish species within the Mondego river basin changed in 2011, with the development of several mitigation actions specifically focused on habitat rehabilitation for these species (Mateus *et al.* 2015; Almeida *et al.*, 2016a; Almeida *et al.*, 2016b). Habitat recovery for these species began with the construction of a vertical-slot fish pass at the Açude-Ponte dam in Coimbra (Figure 2), an infrastructure managed by the Portuguese Environment Agency (APA), whose efficiency and effectiveness for the target migratory species is being evaluated since then through a set of distinct but complementary methodologies, namely visual counts, bio-telemetry, electrofishing surveys and enquiries to local commercial fishermen (Almeida *et al.*, 2016a). Results obtained from this extensive monitoring program revealed that this fish pass was not only suitable for the successful passage of the target species for which it was designed (*i.e.* particularly sea lamprey and shads), but was also contributing, in a matter of just a couple of years, to significantly increase the abundance of some of the most important diadromous species in this region, such as sea lamprey, especially in the upstream river stretches where it was almost absent (Pereira *et al.*, 2017).

Visual counts reveal that, annually, *ca.*1.5 million fish successfully use the fish pass during their upstream and downstream migrations

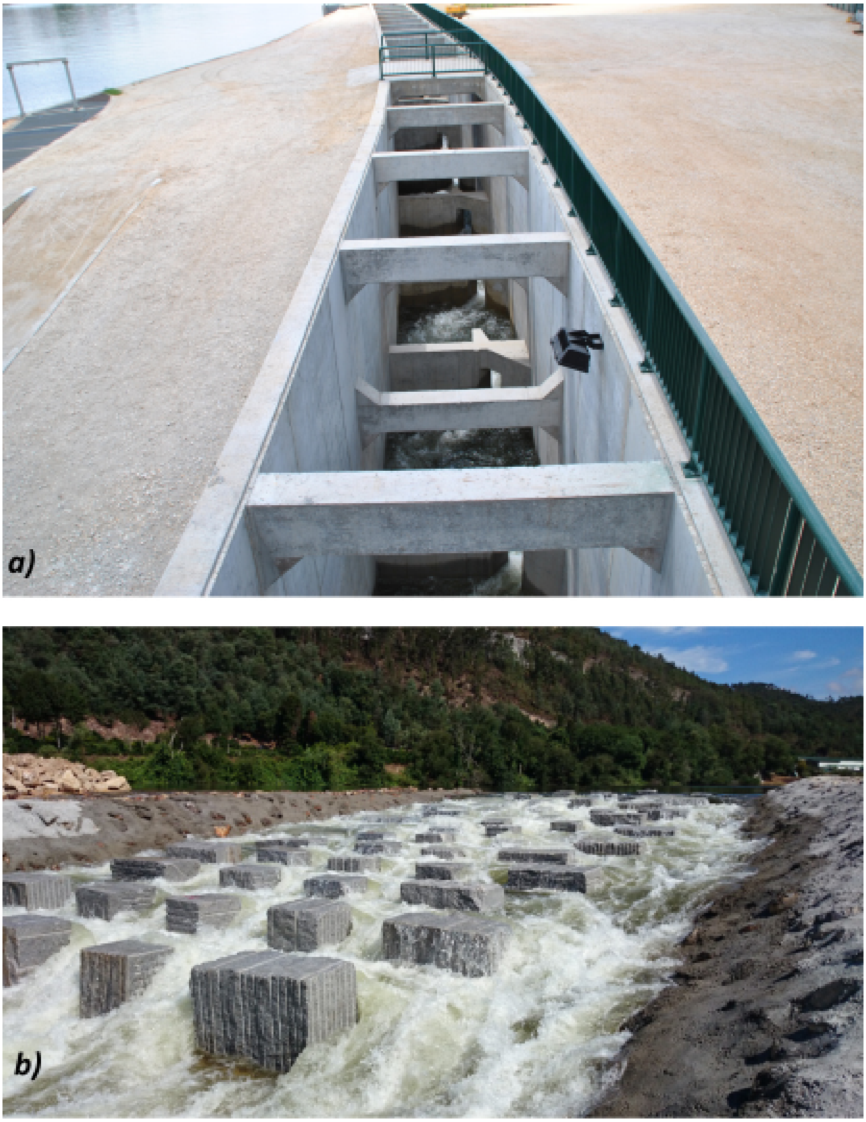

Figure 2. Fish passes constructed within the habitat restoration projects developed in the Mondego river basin: a) vertical-slot fish bass built at the Açude-Ponte dam; b) example of a nature-like fish pass built in one of the smaller weirs (Penacova fishing track) located in the Mondego main stem. Photos by Pedro R. Almeida (a) and Carlos M. Alexandre (b).

(*i.e.* reproductive or trophic), including several diadromous fishes such as sea lamprey, allis and twaite shads, and thin-lipped grey mullet. Due to their local importance for commercial fisheries, sea lamprey and shads are being monitored in more detail, and results obtained so far indicate that, between 2011 and 2017, a total of nearly 50 000 lampreys and 27 000 shads successfully used this fish pass to reach upstream spawning areas in the Mondego river. Studies for monitoring the fish pass efficiency also include the use of a PIT-tag antenna system installed at the infrastructure, and the use of conventional and physiological sensor transmitters (*i.e.* muscle activity measurement), to analyze high definition data concerning sea lamprey behavior and muscular effort before, during and after fish pass negotiation. The set of applied bio-telemetry methods reveal that, of the sea lampreys that reach the Açude-Ponte dam during their spawning migration, *ca.* 30% successfully use the fish pass to reach upstream areas and do it without a significant muscular effort that could impair their migratory and reproductive success (Pereira *et al.*, 2017). The passage efficiency value obtained for sea lamprey at the Açude-Ponte dam fish pass may seem low when compared with results obtained for other species from the same family (Pacific lamprey, *Lampetra tridentata* Richardson, 1836) in similar infrastructures (38-82%; Moser *et al.*, 2002) but, in the end, it seems to be sufficient to significantly boost the recover in abundance of upstream populations of this species. Electrofishing campaigns conducted before and after fish pass construction detected a one hundred-fold increase, between 2011 and 2017, in the relative abundance of sea lamprey larvae at the upstream stretches of the Mondego river (unpublished data).

Boosted by the apparent success of the fish pass constructed at the Açude-Ponte Coimbra dam, which enabled diadromous fish migrations to upstream areas in the basin, habitat recovery actions in the Mondego river were continued through the development of the project "Habitat restoration for diadromous fish in River Mondego", coordinated by the University of Évora with the technical-scientific advice of MARE – Marine and Environmental Sciences Center, and funded by the Ministry of Agriculture and Sea and the European Fisheries Fund through PROMAR 2007-13 (Almeida *et al.*, 2016b). The project followed an integrated management approach, aiming to ensure the compatibility between the conservation of diadromous fish and all the other water uses in this watershed, namely, hydropower production, water supply, commercial fisheries and different recreational purposes (*e.g.* recreational fisheries and aquatic sports like kayaking). This goal was only possible through the involvement of a strong and diverse network of interested stakeholders, including several entities with responsibilities in the management of aquatic ecosystem resources, such as the Portuguese Environment Agency (APA), the Mora Freshwater Aquarium, the Portuguese Sea and Atmosphere Institute (IPMA), the Energies from Portugal (EDP), the Portuguese Fisheries Authority (DGRM), the Portuguese Institute for Nature Conservation and Forests (ICNF), the Sea Lamprey Brotherhood, and the municipalities of Penacova, Vila Nova de Poiares and Coimbra. The main action of this project involved the construction of nature-like fish pass facilities in five smaller weirs, one of which located downstream of Açude-Ponte Coimbra dam, and the remaining four located upstream (Figure 2), as well as the complete removal of another weir. These tasks included a pre- and post-operational monitoring program to evaluate the suitability and success of the interventions implemented at these smaller weirs, using a similar methodological approach to the one previously developed for the Açude-Ponte dam fish pass.

This project also included some tasks specifically focused on the European eel, mainly through the construction of the first passage device in Portugal entirely devoted to this species at the Açude-Ponte dam in Coimbra (Almeida *et al.*, 2016b). The aim of this device is to promote dispersion of eels over a wider area, thus avoiding the bio-ecological constraints that usually result from density increases immediately downstream of riverine obstacles (Acou *et al.*, 2008), like: i) decrease of body condition; ii) impairment of growth and sexual maturation; iii) changes of sex-ratio, with the decrease of female proportion; and iv) mortality increase. Effectiveness of this infrastructure is currently being monitored at a regular basis, with periodic counts of the number of eels that completely negotiate the eel pass and reach a monitoring station located at its end (Almeida *et al.*, 2016b). Since its takeoff, in 2015, *ca.* 2 500 juvenile eels have successfully used this device to negotiate the previously unsurmountable Açude-Ponte dam and reach upstream growing areas.

Monitoring of both habitat restoration programs described in this section, the respective evaluation of operational constraints identified at the constructed fish passes and the definition of suitable solutions to enhance the performance of these infrastructures, is a permanent and ongoing work. However, in general, results obtained so far are very positive, indicating that the complementary nature and development of these rehabilitation programs successfully contributed to provide access to additional 45 km of freshwater habitat for diadromous fish species at the Mondego river basin, which represents an increase of restored habitat for these species of 300% and 5% at local and national levels, respectively.

4.2. Complementary conservation and management efforts

Habitat restoration actions like the ones described in the previous section can have their potential success impaired if they stand alone for the conservation and promotion of diadromous fish populations, without the complementary development of suitable and effective management guidelines. In the Mondego river basin, for example, several of these diadromous species (*i.e.* sea lamprey, shads and eels) are targeted by intense fishing, especially in the lower reaches of the river basin (Figure 3). As much effective as the upstream restoration actions can be in providing new habitat for diadromous fishes, if they are overfished or captured illegally (*e.g.* illegal capture of glass eels and poaching) downstream, the number of fish that reach upstream areas and can take advantage of implemented habitat rehabilitation measures becomes significantly reduced, jeopardizing the expected ecological benefits.

Considering this, habitat restoration projects in the Mondego river basin directed to diadromous fish species were accompanied by a set of complementary conservation and management actions particularly focused on the engagement of local commercial fishermen to the conservation and management problematic of this group of species. This approach promoted the interplay between fishermen, scientists and authorities responsible for freshwater and estuarine fisheries regulations, towards the sustainable exploitation of these resources.

Within the previously described restoration projects, almost 50 local commercial fishermen were approached and, annually, an aver-

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Figure 3. Examples of fishing gear used in commercial fisheries directed to diadromous fish species: a) fyke and b) drift nets. Photos by Ana F. Belo.

age of *ca.* 50% of them are actively providing their capture data, especially of sea lamprey and shads, but efforts are continuously being made to increase this number (Mateus *et al.* 2015; Almeida *et al.*, 2016b). Moreover, since restoration efforts were set in place in this region, annual meetings are held between local commercial fishermen, researchers involved in the conservation of diadromous fish populations and authorities responsible for the management of fishing activities, both in sea/estuary (DGRM) and in freshwater environments (ICNF). In these meetings, monitoring results are presented and fishing regulations discussed, promoting a joint effort towards the sustainable management of the main species targeted by fishing activities (Almeida *et al.*, 2016b; Stratoudakis *et al.*, 2016).

Within the framework of mentioned actions, efforts have been made to implement, for the first time in Portugal, an intermediate fishing closure for sea lamprey and shads. This innovative pilot management action has a strong potential to be replicated in other river basins with similar scenarios (Almeida *et al.*, 2016b; Stratoudakis *et al.*, 2016). Commercial fisheries regulations in Portugal define the official fishing season for sea lamprey between the beginning of January and the end of April. In the Mondego river, a 5 to 10-day complete fishing closure (usually at mid-March) is being annually implemented during the peak of the sea lamprey spawning migration. For shads, in the same watershed, fishing season runs from February to mid-March, with a 5 to 10-day closure in March of all fishing activities. The pilot intermediate fishing closure at the peak of the sea lamprey and shads spawning migration is being implemented in the Mondego river since 2012 with the agreement of all involved stakeholders. Results obtained so far are promising, since it is common to observe an increase in the number of sea lampreys and shads that reach and use the upstream fish passes only a few days after the beginning of the intermediate fishing closure (Almeida *et al.*, 2016b; Stratoudakis *et al.*, 2016).

5. Conclusions and Future Perspectives

The conservation and management of diadromous populations in Portugal should be pursued using an integrative approach coupling habitat restoration, with focus in the reestablishment of the longitudinal continuity for migrations, with regulations and monitoring actions that assure sustainable fisheries. The methodological approach to accomplish this can be based on the successful pilot projects described previously for Mondego river. Since it is not feasible to perform simultaneously the habitat rehabilitation in every river basin and in all the river stretches that were once used by diadromous species, a strategical plan is needed to spatially prioritize the rivers/stretches that should be recovered in the first place.

Despite the auspicious results collected so far, the work done in the Mondego river basin is not finished, since the developed habitat measures were only directed to the main stem. Important habitat for this species can still be found in main tributaries, like rivers Ceira and Alva, which should also be the aim of restoration action that could ensure fish migrations. The Vouga river basin, also in the central region of Portugal, is presently the target of a European funded project entitled "LIFE AGUEDA – Conservation and management actions for migratory fish in the Vouga river basin - LIFE16 ENV/PT/00041" that will take action from 2017 to 2022. In this case, the main rehabilitation actions (nature-like fish pass construction) are first being directed to an important tributary of this basin, the Águeda river, which is less subjected to hydromorphological pressures (*i.e.* obstacles to migration created by large dams and flow regulation) such as the identified in the main stem of the Vouga river. Both Mondego and Vouga rivers are already receiving a special attention regarding their diadromous fish species but a tremendous amount of conservation and management work is still lacking to recover and protect fish populations and related habitats in the remaining Portuguese river basins (*i.e.*, Minho, Lima, Cávado, Douro, Tejo and Guadiana rivers).

For what concerns fisheries management, the work performed so far in the Mondego river basin aiming to contribute to a sustainable fishery of sea lamprey, allis and twaite shad by introducing a management scheme that links the administrative governmental agencies responsible for fisheries regulations in marine environment (DGRM) and freshwater stretches (ICNF) with fishermen's, with the concomitance and advice of research institutions working with diadromous species, is exemplificative of what can be done at a national level to guarantee the longevity of the stocks and associated fisheries. In fact, funding to replicate this approach to the remaining river basins is already secured under the framework of a project entitled "Operational plan for monitoring and management of anadromous fishes in Portugal" (funded by Programa Operacional Mar 2020) and will be pursued between 2018-2020.

After 20 years of dedication to the study of diadromous fish in Portugal, a group of researchers is finally managing to put in practice what they have learned with a double objective of improving the state of the populations of these species but also preserving the traditional fishing activities targeting these valuable resources. If we look strictly to the national panorama, in particular to what is happening in the Mondego river, future prospects are encouraging, but this group of species have a wide distribution area and concerted efforts at a European level are also necessary to guarantee the global recovery of the stocks.

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Tropicalization of Temperate Marine Systems in a Context of Global Changes

Emanuel J. Gonçalves[1,2]

Abstract

The effects of climate change are now visible in different systems of the planet, and the ocean is not an exception. On the contrary, these effects are often more pronounced and have larger impacts on the ocean than on land. Here we present some results about the study of coastal fish communities in the west coast of Portugal and discuss the trends observed in light of a growing tropicalization pattern of these communities. A much faster change than expected in the coastal fish community is observed in response to the main fluctuations observed in the North Atlantic Oscillation, and the community can change its composition in more than a third of the species. Through modelling techniques, it was possible to corroborate that these changes are accelerating, the last two decades being clearly distinct from the previously observed patterns. The impacts of these changes on the fish, as well as on the uses we make of them, are discussed.

Keywords: Tropicalization, Temperate systems, Climate change

Resumo

Os efeitos das alterações climáticas são hoje visíveis em diferentes sistemas do planeta, não sendo o oceano uma exceção. Pelo contrário, esses efeitos são muitas vezes mais pronunciados e como impactos de maiores dimensões no oceano do que em terra. Aqui apresentam-se alguns resultados sobre o estudo de comunidades de peixes costeiros na costa oeste de Portugal e discutem-se as tendências observadas à luz de um padrão de tropicalização crescente destas comunidades. Observa-se uma alteração muito mais rápida do que o esperado na comunidade de peixes costeiros em resposta às principais flutuações observadas na Oscilação do Atlântico

[1]MARE – Marine and Environmental Sciences Centre, ISPA – Instituto Universitário, Rua Jardim do Tabaco 34, 1149-041 Lisboa, Portugal | emanuel@ispa.pt

[2] Oceano Azul Foundation, Oceanário de Lisboa, Esplanada D. Carlos I, 1990-005 Lisboa, Portugal | egoncalves@oceanoazulfoundation.org

Norte, podendo a comunidade alterar a sua composição em mais de um terço das espécies. Através de técnicas de modelação, foi possível aferir que estas alterações estão a acelerar, sendo as últimas duas décadas claramente distintas dos padrões observados anteriormente. Os impactos destas alterações para estas comunidades e peixes, bem como para os usos que delas fazemos, são discutidos.

Palavras-chave: Tropicalização, Sistemas temperados, Alterações climáticas

Changes in marine systems are widespread and become news in the last two decades both on the scientific literature (Ripple et al. 2017), but also increasingly in the public domain. Society is more aware of global warming consequences than ever before in history, but consequences of the effects on marine systems are still largely a scientific issue with much less awareness by the general public.

These global warming consequences are the basis for a great deal of research effort directed at studying the responses of marine organisms to changes in ocean temperature (Beaugrand et al. 2002, Schiel et al. 2004, Pörtner & Peck 2010, Heath et al. 2012). A number of founding studies during the last decades of the last century have established that coastal fish assemblages displayed clear shifts associated with long-term patterns of sea temperature changes (Southward et al. 1995). Marine fish and other organisms are expected to show changes in growth rates, reproductive behaviour and outputs, physiology, habitat requirements, feeding habits and movement patterns (Perry et al. 2005, Caputi et al. 2010, Pörtner & Peck 2010). One visible effect of ocean warming in marine communities is a shift in species abundance and distribution ranges towards the poles, which may cause significant changes in assemblage structure and dynamics and on marine trophic webs (Perry et al. 2005). These latitudinal range shifts in marine species have been widely described (Perry et al. 2005, Cheung et al. 2009, 2012, Hawkins et al. 2009, Figueira & Booth 2010, Nicastro et al. 2013, Wernberg et al. 2013) and have been shown to affect ecosystems and fisheries (Sumaila et al. 2011, Cheung et al. 2013).

These climatic changes follow quite complicated processes in the ocean that are only slowly being comprehended (Speth & Kohne 1983, Levitus et al. 2000, Jones et al. 2001, Ottersen et al.2001). A sequence of several warming and cooling periods can follow one another, spanning several decades each. For instance, in the British Isles, a cooling trend was detected up to about 1930, followed by a warming phase that lasted until the late 1950s, a new cooling phase that persisted until the early 1980s, and a new warming phase that still persists today (Paeth et al. 1999, Hawkins et al. 2003, Woehrling et al. 2005).

In the North East Atlantic, climatic oscillations are largely related to the North Atlantic Oscillation (NAO) (Hurrell 1995, Ottersen et al. 2001, Saunders & Qian 2002, Hurrell et al. 2003). This oscillation is particularly active during the winter (Rodwell et al. 1999) and may be quantified through the NAO index calculated by the difference in atmospheric pressure between, for instance, the Azores high pressure zone and the Iceland low pressure zone (Hurrell 1995). Rapid changes in sea surface temperature may occur when there is a change from a period of consecutive years of positive NAO to a period when the NAO becomes negative, as was the case of the 1996-98 winters along western European shores (Kushnir 1999, Greene & Pershing 2003).

These differences in the NAO are characterised by extremes in weather conditions for instance in Europe. In years when the NAO is strongly positive, storms crossing the Atlantic travel through northwest Europe where southwest winds become prominent, winters are mild and rainy and sea surface temperature tends to be higher. In contrast, in southwest Europe and in the Mediterranean, winters are sunny, dry and cold, and northern winds tend to be prominent. Sea surface temperature is lower and upwelling events may even occur, further cooling nearshore waters. When the NAO is negative, on the contrary, the situation is much the reverse. Storms are displaced to the south, meaning that southwest Europe and the Mediterranean receive considerable amounts of rain, warmer southwest winds blow and sea surface temperature is higher. In these same years, northwest Europe experiences extremes of cold air and water temperature and fewer storms (Hurrell et al. 2003).

Particularly in biogeographic transition zones, as is the Portuguese western shore, faunas are expected to change in response to these changing conditions where an acceleration of the warming patterns may have strong impacts on the composition and abundance of fish communities. Thomson & Lehner (1976) have found several decades ago that, in Baja California, cold water events in the winter could temporarily but drastically affect the tropical and subtropical components of the littoral fish fauna. In 1996, an exceptional climatic transitional year, this type of effects could be detected in several marine animals in Europe (Stenseth et al. 2002). Similar dynamics occur on the western coasts of North America, South America (Bakun et al. 2010), northwest Africa (Belvèze & Erzini 1984), South Africa (Hutchings et al. 2009) and New Zealand (Chiswell & Schiel 2001), and have been shown to drive recruitment dynamics, predator-prey relationships and assemblage structure (Menge & Menge 2013).

These oscillations in fauna composition in response to climate change provide marine biologists with a unique natural experiment to test the ways marine fauna and flora respond to fluctuations related to global warming. Here, we present results of studies that have been conducted in the last decades on the west coast of Portugal (Arrábida Marine Park). Underwater visual census (Figure 1) allow us to register the occurrence and estimate the abundance and biomass of fish

Study methods to assess coastal fish communities

Figure 1 – Visual census methods to assess the abundance and distribution of marine fish faunas in the study areas (photo credits: Andy Mann / National Geographic, Emanuel Gonçalves).

species using quantitative and qualitative approaches. Fish species are grouped by their climatic affinity as tropical, warm-temperate, temperate, cold temperate and eurythermic, based on species distributions (Henriques et al. 2007, Horta e Costa et al., 2014).

Sea surface temperature (SST) data and information on wind direction and intensity were based on ICOADS (International Comprehensive Ocean-Atmosphere Data Set, available at: www.cdc.noaa.gov/coads/), using cells of 1° latitude and longitude (38° N, 10° W). NAO data were obtained from the Climate Analysis Section, National Center for Climate Research (NCAR), Boulder, Colorado, USA, available at: www.cgd.ucar.edu/cas/jhurrell/.

During this study, a sequence of cold and warm periods was observed in the study area, which allowed to monitor the climatic effects on the nearshore fish fauna. The oceanographic and climatic parameters used are presented in Figure 2. Associations reveal close relationships involving the tropical and warm-temperate biogeographic affinity groups on one end and the cold-temperate group, with an opposite sign, on the other end. In the temperate group, the patterns of interannual variation are poorly correlated with the other groups (Figure 3).

Fluctuation of environmental parameters during the study period

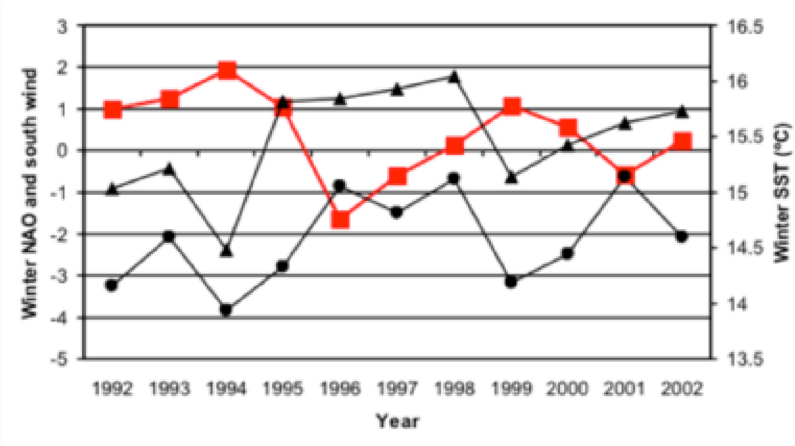

Figure 2 – Variation in NAO conditions during a 11-year period in western Portugal (adapted from Henriques et al. 1997).

Fauna similarities during the warming and cooling periods

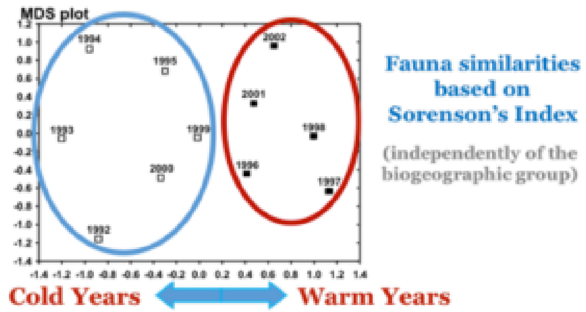

Figure 3 – Multidimensional scaling (MDS) on the similarity matrix (based on Sorenson's index) of all 11 yr (adapted from Henriques et al. 1997)..

Similarities among years were computed based on Sorenson's index. The cold years are clearly grouped on one side of the x-axis and the warm years on the other. One-way ANOSIM revealed that differences between these two groups were significant (Global $R = 0.46$, $p = 0.004$). Sorenson's similarity values between consecutive years, reveal two main changes in assemblage composition: one between 1995 and 1996 and a second one between 2000–2001 and 2001–2002. Kendall's tau correlations between the two principal components derived from the PCA on oceanographic conditions and the two components derived from faunistic data showed a significant correlation between winter conditions and tropical, warm-temperate and cold-temperate groups ($r = 0.60$, $p = 0.01$) but not with summer conditions.

The temperate group, on the other hand, was not correlated with winter conditions ($r = 0.35$, $p = 0.14$). These data show that the tropical, warm-temperate and cold-temperate faunal groups co-vary with winter conditions, with warm-temperate and tropical species following a similar trend, while the cold-temperate fish follow an inverse relationship.

Using both an observational and model approach, we have developed a Tropicalization Index (TI) adapted from Wernberg et al. (2013). This Tropicalization Index was calculated as the ratio between the sum of the tropical and cold temperate species occurring in each year. We used these two groups, since their northern and southern range limits are most likely to occur in our transition zone, and they were shown to contribute to distinctive warm and cold fish assemblages among years (Henriques et al. 2007). The Tropicalization Index was calculated using the observed and modelled annual assemblage data for the local-scale (9 km) datasets of the best predictive model for the short-term period (1993–2011, Figure 4) and for the related regional-scale (1°) datasets for the long-term period (1960–2012, Figure 5) (Horta e Costa et al., 2014).

Tropicalization index in the short-term high-resolution period

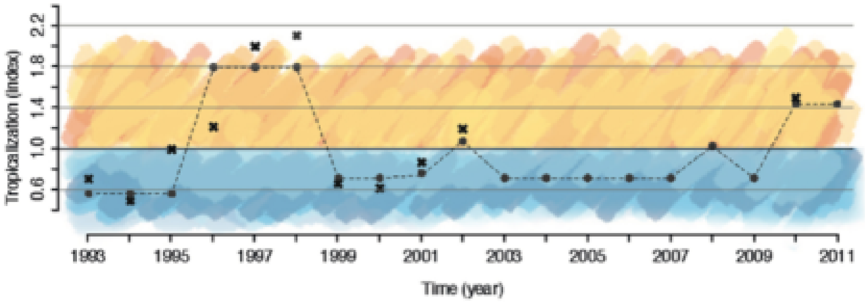

Figure 4 – Tropicalization index = tropical sp./ cold-temperate sp. (adapted from Wernberg et al. 2013). Short-term (1993-2011) and high spatial resolution (9km) (adapted from Horta e Costa et al. 2014).

The Tropicalization Index obtained from predictive models was very similar to the index calculated from observed assemblages (Figure 4). The highest values were found during the 1996–1998 and 2010

Tropicalization index in the long-term period and regional scale

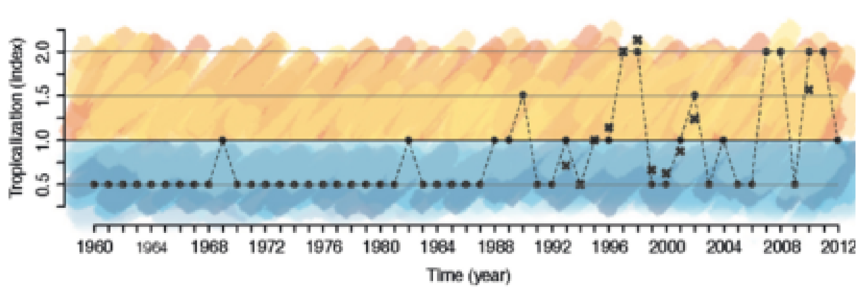

Figure 5 – Tropicalization index = tropical sp./ cold-temperate sp. (adapted from Wernberg et al. 2013). Long-term (1960-2012) and regional scale (1-degree grid) (adapted from Horta e Costa et al. 2014).

and 2011 periods. After the first peak, it decreased over two years and showed a small increase again in 2001 and 2002. The higher values of the index were associated with warmer years. Looking at the long-term patterns of mean winter NAO (range = −1.32 to 1.18), the index also showed inter-annual variability with a period of strong positive NAO at the beginning of the 1990s, with these temporal patterns suggesting an inverse relationship through time. The long-term prediction of fish assemblage structure revealed higher values of the Tropicalization Index since the mid-1980s, but especially after the mid- 1990s when the largest index (TI = 2) was reached for the first time in 50 years (Figure 5).

During these studies, the first record of a tropical surgeonfish in continental Europe was observed at our study area (Horta e Costa & Gonçalves, 2013) (Figure 6). This and other subtropical and tropical species have been increasing registered in the west coast of Portugal, associated with warmer years.

The tropical *Acanthurus monroviae* at the Arrábida Marine Park

Figure 6 - Acanthurus monroviae (Monrovia doctorfish) observed on 30 December 2007 at the Arrábida Marine Park, Portugal. Photography credit: Cláudio Dias.

Taken together, these results show a clear trend in warmer years in the last two decades, correlated with significant changes in the composition and structure of coastal fish communities. The surface waters along the Portuguese shore are dominated by the Canary current, which brings cold water from the north (Bischof et al. 2003), and likely also brings eggs and young fish. In some years, namely if the NAO is positive, this current will prevail in all seasons. When the winter NAO is negative and strong, south and southwest winds become predominant, and this current may be temporarily reverted, being replaced by a poleward flow (Frouin et al. 1990). These oceanographic conditions seem to explain the strong faunistic variations observed.

Monitoring programs of fish assemblages need to be accompanied by detailed surveys of oceanographic and meteorological variables, if one wants to disentangle the relative contributions of the different climatic factors. This view of temporal variations in fish assemblages as a series of oscillations will have important implications for the delimitation of what constitutes natural populations of fish. A given area may alternate between being a source and a sink of eggs, larvae and juveniles (Pulliam 1988), depending on the conditions in specific years and the mean duration of the surviving populations.

Our studies suggest that a tropicalization of the coastal fish assemblage structure is underway along the Portuguese west coast, due to more frequent warming events over the last 50 years corresponding to a period of accelerated warming worldwide (Rosenzweig et al. 2008). These conclusions are supported by the strong influence of local oceanographic variables on assemblage shifts, which show patterns consistent with warming.

The Tropicalization Index detected relevant patterns of change in this assemblage. Range edges of species expand and contract in response to environmental variations, but are difficult to assess—particularly in the marine environment. This Tropicalization Index is an important tool to detect responses of marine assemblages to climatic variations.

We show that rocky reef fish assemblages changed among years with contrasting climatic features, and winter conditions were the most important drivers of variability in assemblage structure. The winter NAO showed considerable influence on inter-annual variability in species with distribution limits in this region and is the main large-scale predictor of changes in fish assemblages. Despite this, the relationship between winter NAO and local-scale wind stress and sea surface temperature was weak, suggesting that local patterns of change in oceanographic variables have a strong influence on assemblage variation. Fish assemblage composition differed between years in association with mean winter wind stress.

One puzzling question was how did the composition of the fish assemblages changed so rapidly? Hawkins et al. (2009) found that warm water species increased in warmer years despite the persistence of cold-temperate ones, possibly due to higher competitive ability and occasionally massive recruitment during spring blooms of this group. Nevertheless, after a period with several warm years and consecutively poor recruitment events, cold-temperate species are likely to retreat rapidly.

Temperate transition zones, like the one on the Portuguese west coast, are often considered 'hotspots' of biodiversity since they are typically characterized by complex and diverse habitats, and contain species adapted to dynamic oceanographic conditions. Here, northern and southern distribution ranges of warm and cold species change with temporal cyclic fluctuations (Henriques et al. 1999). The most likely pattern for a future warmer ocean is the rapid advance of tropical species polewards and the simultaneous, but slower, gradual retreat of cold-water species (Hawkins et al. 2009).

Our findings illustrate the important role of this area as a barometer for the study of the effects of climate change on marine communities (Horta e Costa & Gonçalves 2013). In these temperate regions, if cyclic fluctuations of climatic conditions remain and cold years return after a warm period, there is a chance that cold species persist as they can move deeper and the southward currents transport their propagules from the north. These temporal fluctuations, typical of temperate transition zones, may alleviate some of the effects of warming oceans. This highlights the potential resilience of temperate transition areas to climatic shifts when compared to tropical or polar regions, where high rates of extinctions and invasions are very likely (Cheung et al. 2009, Sumaila et al. 2011) and possibly irreversible.

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On top of these consequences, synergistic and additive effects are likely to impact marine communities since climate change is interacting with other human-induced stressors such as overfishing (Griffith et al. 2011). Such human-induced impacts may decrease ecosystem resistance and resilience, and accelerate the disturbance of marine communities and species interactions (Ling et al. 2009). Intensively fished populations were found to be the most susceptible to ocean acidification, revealing that stressed populations show higher vulnerability to climate change (Griffith et al. 2011). Networks of marine protected areas (MPAs) have been suggested to increase the resilience of ecosystems in relation to future warming scenarios, while reducing the impact of fishing and other human uses (Ling et al. 2009, McLeod et al. 2009), possibly mitigating non-linear and unpredictable responses of species and ecosystems in this changing world (Munday et al. 2008). In particular, large-scale strongly protected MPAs and well placed networks of marine reserves act as climate resilient areas which may help populations better resist the detrimental effects of a warming world (Roberts et al., 2017).

The tropicalization of coastal fish assemblages could lead to large environmental and socio-economic impacts in the near future (Sumaila et al. 2011, Cheung et al. 2012, 2013). With the tropicalization of transition areas becoming more frequent worldwide (Hawkins et al. 2009, Cheung et al. 2012, 2013, Wernberg et al. 2013) and the current rate of human-induced impacts, structural changes to marine assemblages could be very large in the future, disrupting ecosystems.

The first occurrence of *Acanthurus monroviae* (Monrovia doctorfish) on the Atlantic coast of Europe registered during our studies exemplifies one puzzling question that remains unanswered: what are the mechanisms by which these vagrant individuals reach such far locations as adults? In fact, the sightings of vagrant adult tropical fish from different species in the west coast of Portugal raises the question about the mechanisms by which these species colonize areas outside their natural home ranges. Some degree of habitat connectivity and/or viable dispersal mechanisms such as transport by currents in association with drifting materials (natural or artificial), may favour the direct dispersal of adults to areas outside their natural home range. Luiz et al. (2012) showed that rafting is a key mechanism for species crossing the mid-Atlantic barrier in the tropics, providing strong evidence that reef fish can overcome large oceanic distances by associating with drifting material. Winters with strong south winds and waves bring warm temperatures nearshore in the western Portuguese shore and are known to be linked with an increase in the occurrence of species with warm temperate and tropical affinities in this region (Henriques et al., 2007).

This makes the western Portuguese coast, in particular the region around the Arrábida Marine Park an important barometer for studying the effects of more frequent environmental changes associated with a warmer ocean, with possibly permanent expansions of the geographical ranges of these warm water species.

The effects of climate change on marine communities was a topic of great interest to Professor Mário Ruivo and one with which we had many conversations through time. The information here presented is part of a number of papers we have published related to the impacts of climate change in marine systems (Henriques et al. 2007, Horta e Costa & Gonçalves 2013, Horta e Costa et al., 2014) and intent to honour Mário Ruivo's life work and memory for future ocean enthusiasts, a topic he has championed all is life.

As many today agree, Professor Mário Ruivo believed that without environmental sustainability, there is no economic nor social sustainability. For him, it was clear that without knowledge there is no Human development and, as he many times said, in the Ocean, Man is deaf, dumb and blind. We may then conclude that investing in knowledge and protecting the natural capital and two of the most important tasks of modern society – are we up to the task of Mário Ruivo's vision?

Acknowledgements

I would like to acknowledge the co-authors of the papers which are the basis of this text, namely (in alphabetical order): Bárbara Horta e Costa, Gustavo Franco, Jennifer E. Caselle, Jorge Assis, Karim Erzini, Miguel Henriques, Vítor Almada. Many PhD and MSc students, re-

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search technicians and other colleagues were instrumental for all the research we have been developing about the effects of climate change on marine communities, which have now acquired a new approach with studies on the effects of climate-related stressors such as temperature and acidification on the early life stages of temperate fish co-lead by my colleague Ana Faria.

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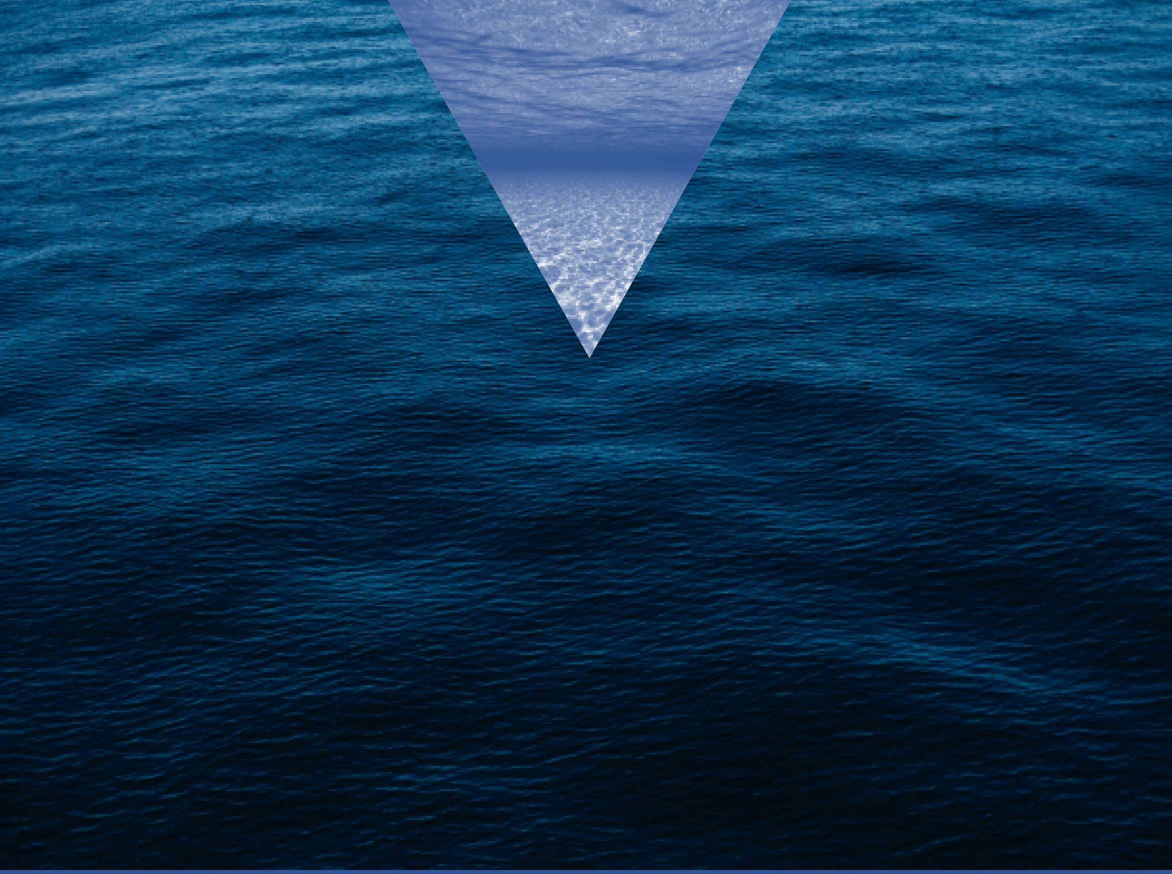

EXPLORAÇÃO DE RECURSOS E BIOTECNOLOGIA MARINHA

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RESOURCE EXPLORATION AND MARINE BIOTECHNOLOGY

The session was a lively one, with the preservation of ecosystems, especially with the deep sea, in the background. The moderator argued that deep sea mining will soon be a necessity, which can be met through a responsible "blue mining",, combining scientific knowledge and technological practices based on that knowledge, and adequate governance. Nélia Mestre was less optimistic, emphasizing that current knowledge is still insufficient.

Then Adelaide Almeida presented an interesting methodology to preserve the sanity of aquaculture systems through viruses (bacteriophage) capable of effectively combating the pathogenic bacteria.

André Pacheco argued that it is possible to extract (renewable) energy from small-depth lagoon systems, using Ria Formosa as a paradigm. If the project succeeds the consequences could be highly beneficial.

Marine biodiversity was presented by João Varela and Sara Raposo as essential and determinant for the sustainable production of food, for humans and nonhumans, energy, and also for the promotion of human and animal health. Ana Paula Mucha pointed out that marine bioremediation could be the solution for the recovery of marine and coastal ecosystems.

In short, the future is full of potential resources. As always, it is necessary for industry to respect nature.

Fernando J.A.S. Barriga

Deep-Sea Mining: a Manageable Necessity or a Curse?

Fernando J.A.S. Barriga[1]

Abstract

The dependence of modern societies upon critical raw materials (nearly all metals) is overwhelming. Some believe that demand is growing faster than offer, not only because of geological availability but also for political and economic reasons.

For these reasons it is imperative to consider new sources for raw materials. The seafloor stands as a likely candidate. We must create readiness now to be prepared when the need comes.

One of the greatest fears is the environmental cost involved in mining the deep seafloor. However, the mining industry no longer deserves its partially not favorable reputation. We need both the resources and the environment. And NIMBY (Not In My Back Yard) will not help.

Keywords: Seafloor mining, recycling, circular economy, Mar Mineral exhibition

Resumo

A dependência das sociedades modernas sobre matérias-primas críticas (quase todas metais) é esmagadora. Alguns acreditam que a procura está a crescer mais rapidamente do que a oferta, não apenas em função da disponibilidade geológica, mas também por razões políticas e económicas.

Por estas razões, é imperativo considerar novas fontes de matérias-primas. O fundo do mar é um candidato provável. Devemos criar prontidão agora para estarmos preparados quando a necessidade vier.

Um dos maiores receios é o custo ambiental envolvido na mineração do fundo do mar. No entanto, a indústria mineira não merece a sua reputação por vezes não favorável. Precisamos dos recursos e do ambiente. E NIMBY (não no meu quintal) não vai ajudar

Palavras-chave: Mineração do fundo do mar, reciclagem, economia circular, Exposição Mar Mineral

[1] Fac Ciencias Univ Lisboa.Instituto Dom Luiz (IDL. FCUL, Edificio C6, Campo Grande, 1749-016 Lisboa, Portugal. f.barriga@fc.ul.pt

Introduction

Population growth and rising standards of living are placing new, extremely high levels on the demand of many mineral resources. These circumstances, and newly available technological developments, produced renewed interest in deep-sea mining. However, environmental concerns, with variable degrees of justification, are raising opposition to the concept. The forecast for the behavior of consumption versus availability of many raw materials, nearly all critical metals, arguably show that consumption will grow much faster than resource discovery onshore. Finding new sources of raw materials seems inescapable. The deep seafloor stands out as a likely candidate. There is great need of public support to the concept, and this can only be achieved through a global effort involving not only science, industry, and governance but also information of the public at large. Modern mining, properly implemented, is no more problematic than other large scale industrial operations, including agriculture and fisheries, as described further in this text. The supply of mineral resources, onshore or offshore, must be footprint-free, or nearly so, and it is essential that the public understands this. The "Not in my Back Yard" (NIMBY) attitude has a price, often a heavy environmental price.

Sea Floor Mining and the Ecosystem

Marine mining has already started, decades ago, for diamonds, currently up to depths in excess of 200 metres. Although the industry recognizes there is a footprint, it considers the footprint quite minor, because the area mined is small: in Namibia, where offshore diamond mining is now 70% of the country's total, only 3% of the concession of 3,700 sq. miles (9600 km^2) have been mined. As plans to mine deep-sea massive sulphide deposits and polymetallic nodules progress, the environmental concerns grow. Some of these concerns are as follows:

- The deep-sea ecosystems are composed of long-lived species, with low rates of reproduction. The environment may not recover from mining on a human time scale;
- The dynamics of tailings plume dispersion must be defined, tailings must be returned to the seafloor with the least possible effect on the ecosystem;

- Protected, non-mining areas must be created adjacent to mining areas;
- Mining must involve scientists, industry and governance. Research must focus on the ecosystem and on new technology; knowledge must flow and be incorporated in the production process. Governance must create adequate rules, and enforce them;
- New consumption habits must be fostered;
- There must be ample investment for the above tasks, scientists must sail and have access to state of the art tools.

(after Ana Colaço, in interview for Mar Mineral exhibition, MUHNAC, Lisboa).

The Circular Economy

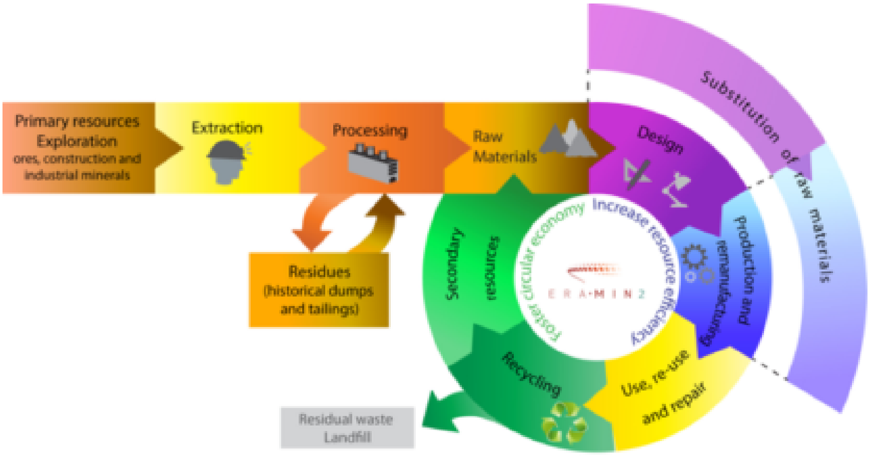

Figure 1. The circular economy (D. Carrilho, FCT (Portugal). In www.era-min.eu, retrieved January 201.

Partly because of its name, many people and organizations think that the circular economy will soon render the exploitation of primary resources obsolete. However, a truly circular economy, in this sense, will not be possible for a long time yet, because (a) losses are inevitable; (b) consumption will continue to grow for many decades. Using the name "Circular Economy" conveys the false notion that we can do without primary production. A more appropriate designation would be "Feedback Economy".

There can be no doubt that recycling, secondary resources, and the like are important (see Figure 1). However, their ability to replace the exploitation of primary resources in a planet with a population expected to grow to about 10 billion people by 2050 is implausible (United Nations Department of Economic and Social Affairs, Population Division. July 2015. Retrieved 30 May 2017). Rare Earth Elements (REE) are a good example as, in many applications (e.g. phosphor layers for flat screen for computers, TV's and smartphones) the REE concentrations are significantly lower than in natural REE ores. The economic and energy costs of recycling REE from these devices is clearly unfavourable, rendering it next to unfeasible.

Green Mining, Blue Mining

Mining no longer needs to be the culprit. The modern technological development and economic terms have allowed use of the term "green mining", on land-based mining operations. Countries like Finland and Canada, and organisations such as the MIT in the USA are pioneering the concept. Modern mining is no worse, on the contrary, than other essential industries, including fisheries and agriculture, both with a heavy load of problems. Agriculture claims about 50,000 km^2 of new arable land per year, due to topsoil loss, largely a result of agriculture. Many years ago, the Worldwatch Institute called this "… the quiet crisis in world economy" (LR Brown, EC Wolf, 1984, Worldwatch paper 60, September 1984). Recently, a senior UN official reinforced this view warning that we may have "…only 60 years of farming left if soil degradation continues" (C Arsenaut, 2017, Reuters, in Scientific American). Clearly new farming methods, less soil-destructive, must be developed and brought to generalized use. Mining is not the only industry that has to preserve the environment.

With an appropriate set of rules and their proper enforcement, mining can be "green". Many rules apply to onshore green mining, but the first is universal: Illegal and unregulated mining operations must be shut down. Figure 2 (Google Earth image retrieved 2018) shows the effect of nearly 30 years of large scale mining, limited to the mine itself, and the tailings impoundment, surrounded by a landscape identical to the pre-mining situation.

If responsible mining onshore is "green mining" the offshore counterpart can be called "blue mining". We need to be able to de-

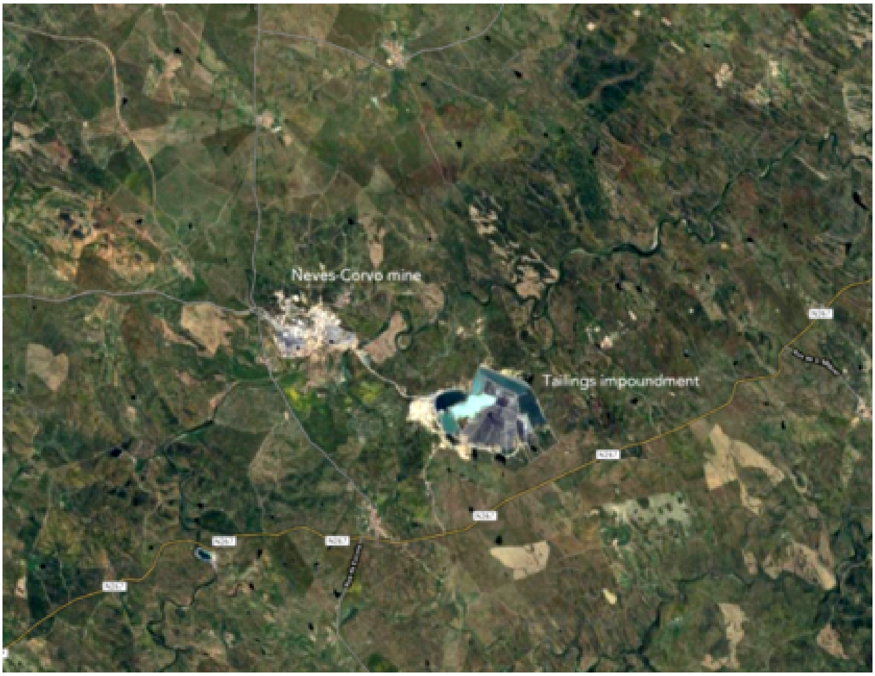

Figure 2. Google Earth image of the Neves-Corvo area in Southern Portugal. Distance between mine and impoundment about 3 km.

scribe examples of blue mining, to persuade the general public that the deep seafloor ecosystems will survive seafloor mining. A powerful statement comes from the Clarion-Clipperton Zone (CCZ). The potential area for mining in the CCZ is 12.5 million km^2. The existing concessions, mined for 20 years, will extract nodules in about 4000 km^2 of each concession, or about 0.5% of the CCZ potential area.

The Norwegian Example

Norway went through a nationwide effort, since the 1960's, to implement the offshore oil industry (http://www.norskpetroleum.no/en/ retrieved January 2018). This included a lot of apt exploration, but far more than that. Proper and careful relations with foreign oil companies, establishment of a legal framework, creation of Statoil, and a great education effort, with two main components: training young geologists, geophysicists, engineers and lawyers, and developing among the general public the notion that an oil industry could be properly established, with minimal environmental cost and great economic advantage. Fifty years later it is clear that the Norwegian oil industry is a success. The importance of education is well expressed in a simple statement: "… common causes of social conflict in the [mining] industry include insufficient consultation, lack of public participation, lack of education, environmental concerns and opposing expectancies of social and economic prospects."http://www.vttresearch.com/Documents/impact/Helena_Wessmann_Intl_Innovation.pdf, retrieved 2017).

Norway recently began working on a similar effort for offshore seafloor massive sulphide (sms) deposits. Little is known yet, but chances are Norway will become a leader in the trade.

Mar Mineral, Science and Riches on the Deep Seafloor

To help informing the public about seafloor mining issues we have assembled a museum exhibition, in Museu Nacional de História Natural e da Ciência (MUHNAC) in Lisbon. The exhibition, in 400 m^2, consists of panels with titles, short texts and graphics; 3D objects and specimens (all originals: there are no replicas). Ten video presentations (six of which produced originally for the exhibition) are an important part of the set. The exhibition is assembled on a grey concrete background, which emphasizes the ambiance. Dominant colours vary too (white – dark blue – brown).

The exhibition begins with a display of the diversity of industrial products (including many everyday products) that require mined resources; in a second area some achievements on the study of the deep seafloor are shown, with emphasis on mineral resources.

Exhibits include hydrothermal vent field samples, from the North Atlantic, the Arctic and the Pacific; carbonate conduits related with mud volcanoes and gas hydrates; a brief explanation concerning the deep biosphere; and exhibits of polymetallic nodules (about 250, on sediment, both from the Clarion-Clipperton Zone of the Equatorial Pacific) and ferromanganese crusts collected by EMEPC in the North Atlantic. The third main area consists of a display of technologies of access, surveying and sampling the seafloor, including an authentic

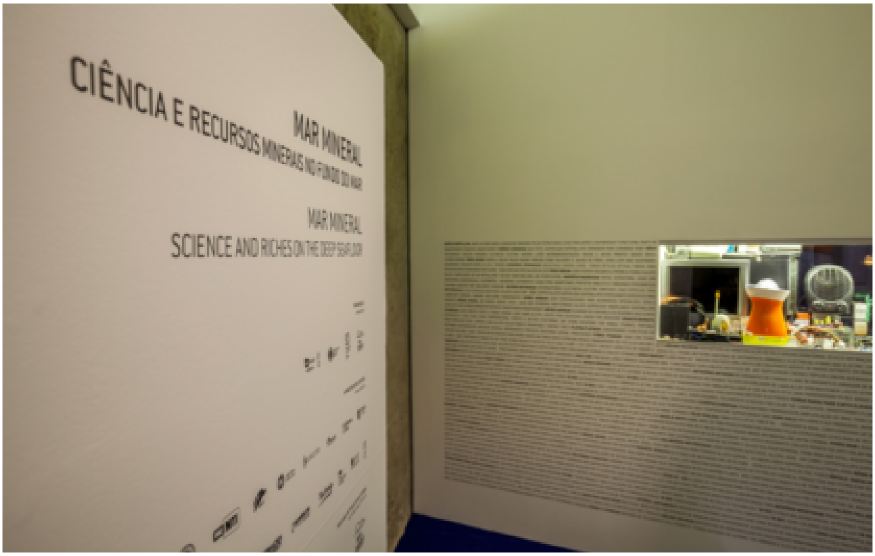

Figure 3. Mar Mineral starts by showing our extreme dependence on mineral resources. Photo Gonçalo Barriga

Figure 4. General aspect of area B, illustrating the main mineral resources already discovered on the seafloor.

AUV (Infante) made in Portugal by ISR/IST and a 3D model of the concept of seafloor mining; representations of relatively detailed exhibits on extraction solutions, vertical transport systems and ecosystem preservation; a striking presentation of the sea and seafloor under Portuguese jurisdiction, produced by EMEPC;

Figure 5. Left, the Infante AUV, made in Portugal by ISR/IST; Centre, a lightbox describes the ROV Luso (tethered), can work down to 6000 metres. Back, map with a representation of the "Portuguese Sea" and main exploration areas for mineral resources (both EMEPC).

A fourth section recalls that some types of seafloor mineral deposits, namely massive sulphide deposits, have equivalents generated hundreds of million years ago on the floors of ancient oceans, and are now exposed on land, where they can be exploited and studied, contributing to our knowledge of the modern examples. Emphasis is placed on the Iberian Pyrite Belt of South Portugal and Southwest Spain, one of the most important provinces of ancient volcanogenic massive sulphide provinces. A series of invited conferences completes the exhibition.

Acknowledgements

This article is dedicated, as is the Mar Mineral exhibition, to the memory of Mário Ruivo, a tireless defender of the Ocean, the ecosystems and the environment at large. However, Mário was also capable of agreeing with the point of view conveyed here: deep seafloor mining yes, if properly done, respecting the environment. Hence the dedication.

Figure 6. Area D of the Mar Mineral exhibition, dedicated to ancient seafloor massive sulphide deposits, with emphasis on the Iberian Pyrite Belt.

We follow closely the presentation by the author in the Underwater Mining Conference (UMC) 2017 – Berlin, and benefitted from various forms of cooperation with many colleagues and friends at MUHNAC (Liliana Póvoas and César Lopes) GeoFCUL and IDL (M. Inês Cruz, Jorge M.R.S. Relvas, Álvaro M.M. Pinto, João X. Matos, Sofia Martins, Jelena Milinovic, Ágata S.C.A. Dias, Isabel Ribeiro da Costa, Ana I. Janeiro), EMEPC (Pedro Madureira, Patrícia Conceição, Luisa Ribeiro), and Larsys/IST (António Pascoal, Luís Sebastião). They are all gratefully acknowledged.

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Environmental Challenges of Deep-sea Resource Exploitation

Nélia C. Mestre[1]

Abstract

The deep sea is the largest single ecological unit on Earth providing over 95% of global biosphere. Scientific knowledge from the deep sea greatly depends on the high-tech remotely-operated vehicles and manned submersibles that are necessary to reach and operate at these depths. As such, only less than 0.0001% of the deep sea has been target of scientific research. Nevertheless, recent technological breakthroughs have triggered the economic interest in exploiting its non-living resources. The environmental hazard posed by deep-sea mining activities needs to be evaluated using an integrated approach and should be applied to each potential mining site prior to exploitation. Still, current scientific knowledge is not enough to warrant its exploitation with a good environmental management of its resources.

Keywords: Deep-sea mining; environmental hazard assessment; ecotoxicology

Resumo

O mar profundo providencia cerca de 95% da bioesfera terrestre sendo a maior unidade ecológica da terra. O conhecimento científico sobre o mar profundo é escasso e o existente depende de veículos submarinos tripulados, de operação remota ou autónoma para recolher informação a grandes profundidades. Isto faz com que menos de 0.0001% do mar profundo tenha sido alvo de investigação científica. Contudo, os recentes avanços tecnológicos despoletaram o interesse económico nos minerais no mar profundo. É no entanto necessário avaliar o risco ambiental que a mineração no mar profundo pode vir a causar e que deve ser elaborado utilizando metodologias integradoras que deverão ser aplicadas a cada local antes da sua exploração. De qualquer forma, o conhecimento científico actual ainda não é o suficiente para garantir a exploração destes recursos que garanta a sua boa gestão ambiental.

[1] Centre for Marine and Environmental Research, University of Algarve. ncmestre@ualg.pt

Palavras-chave: Mineração do mar profundo, avaliação do perigo ambiental, ecotoxicologia

Challenge 1 – the unknown about the deep sea

From the 95% of the global biosphere that corresponds to the deep sea only less than 0.0001% has been target of deep-sea research (European Marine Board, 2013; Rogers et al. 2015). There are only a few technological means to assess and investigate depths below 200 meters and this is the main reason why it is poorly known. A diversity of habitats can be found at these depths, such as seamounts, cold-water coral gardens, sponge grounds, cold seeps or hydrothermal vents, among others. Deep-sea fauna is adapted to conditions of darkness, and temperature and pressure extremes. Temperatures below 4ºC are found in the abyssal plain, whereas the black smokers of hydrothermal vents can expel fluids exceeding 400ºC (Tyler et al. 2003). Chemosynthesis based communities resemble oasis by the abundance of organisms and have high levels of endemic species, in contrast with the abyssal plains where the abundance of organisms is low as they greatly depend from food produced in the surface waters, having slow metabolism and growth rates. However, species life cycle is mostly unknown, although this is critical to understand ecosystem functioning and to predict resilience in situations of environmental change. Still, current knowledge certifies that the entire ocean is influenced from the important ecosystem services provided by the deep ocean.

Challenge 2 – current anthropogenic pressures to the deep-sea ecosystem

In the early twentieth century the deep sea was considered species poor, tranquil and largely unaffected by human activity. However, the paradigm has since changed and several studies have already observed the effects of climate change, marine litter, fisheries and oil and gas exploitation in the deep sea (e.g. Rogers et al. 2015).

Greenhouse gases increasing in the atmosphere are interfering with temperature, dissolved oxygen, pH and availability and quality of food produced at the surface and in the water column with consequences in the seafloor. Oxygen minimum zones are expanding (Stramma et al. 2010) and it is projected an increment of about 0.01ºC per year below 3000 m depth before the end of this century (Sweetman et al. 2017), according with the already observed increase of 0.7ºC in the deep Greenland Sea since 1950 (Somavilla et al., 2013). Species living in the abyssal / bathyal are physiologically adapted to steady environmental conditions, hence cannot withstand great changes, and 1ºC increment for instance may mean that they are their tolerance limits. Most are long lived, exceeding 100 years, so they will likely not have time to evolve and adapt, being anticipated biodiversity loss, and altered ecosystem structures.

Declining fish stocks at the surface already moved 40% of fisheries grounds below 200 m depth. Deep-sea trawling is highly destructive, able to damage deep-sea habitats, such as coral gardens, with major impacts on ecosystem structures, functioning and service provisioning (Rogers et al. 2015).

Marine litter is found in all marine environment and the deep seafloor is not an exception. Plastic is the most abundant and submarine canyons are prone to accumulate more litter habitats (Pham et al. 2014). Small plastic particles sized 5 mm and below, named microplastics, result from the decay of larger plastic pieces or from proposed made small beads, and are also found in deep-sea sediments. Recent studies revealed high densities at the seafloor to the point that it is considered a *major sink for microplastics* (Woodall et al. 2014).

Oil and gas extraction industry is present in the deep sea since nearly 50 years, with maximum well depth registered at 2896 m in the Gulf of Mexico (United Nations 2016). Accidental oil spills are relatively frequent, can reach large areas and have severe impacts on deep-sea ecosystems (e.g. 45 km radius in the case Deepwater Horizon spill, Montagna et al. 2013, Cordes et al. 2016). In routine industrial activities, besides the physical damage of the seafloor area where the well, pipelines and anchors are placed, restricted to around 100 m radius, major ecological impacts due to burial or toxicity are usually within the 200 to 300 m radius, with drilling muds and produced water reaching more than 2 km (Cordes et al. 2016).

While some evidence points to potentially critical environmental impact posed by each of the above mentioned anthropogenic pressures, the lack of knowledge from the baseline status, before the effects of the stressors, is too limited to confidently assess the impacts or propose mitigation measures, if at all these are possible. Furthermore, the combined effects of these multiple stressors may pose an even greater threat to the ecosystem health of deep-sea ecosystems.

Challenge 3 – the humanity need for deep-sea mineral resource exploitation?

The world consumption of mineral raw materials is increasing and they are much needed for high-technological equipments, including those related to low carbon technologies. This increased demand for metals is more critical in economies that are highly dependent on importing these metals, often restricted to specific geographical areas (Moss et al. 2011, Kopf et al. 2012), whilst recycling is not yet at a sufficient scale to cover the needs. Some of these technologically critical elements are abundant in deep-sea mineral deposits (seafloor massive sulphides, polymetallic nodules and ferromanganese crusts) which are now seen as economically valid and technologically possible to exploit. This lead the European Union to place deep-sea mining as a potential new blue growth sector. However, it is not possible yet to properly estimate the cost-benefit of exploiting these deep-sea mineral resources. The economic cost-benefit of deep-sea resource exploitation need to accurately account for the ecosystem services that might be compromised, the scale of environmental impact and potential mitigation measures that can be implemented.

Challenge 4 – how to evaluate environmental impacts of deep-sea mining?

Deep-sea mineral resource exploitation will remove the habitat locally where the mining operations will take place and only a good spatial management might be able to minimize impacts. In addition, localized plumes created by mining collectors at the seafloor and dewatering ore slurry produced by the mining support vessel after collection may introduce complex mixtures of potentially toxic elements in the water column. Depending on the discharge point location the dewatering ore slurry may have impacts on the euphotic zone or midwater, affecting the communities living there, interrupting the vertical migration of organisms and limiting the ecosystem services they provide, such as carbon dioxide sequestration or carbon flux to the seafloor. If the discharge point is located near the seafloor the impacted area will be much larger than that affected by the mining tools, as in addition it will likely create a buoyant and warmer plume with unknown residence time near the seafloor (Hauton et al. 2017).

Based on current knowledge it is not possible to predict, in advance of deep-sea mining operations, the absolute toxicity or exposure thresholds. Many unknowns still exist in relation to deep-sea species ecotoxicological thresholds, life cycle, connectivity, ecosystem functioning and what will be the provisioning and regulating services at risk.

Species resilience to impact will be conditioned by their capacity of resistance to exposure to toxic elements (Gollner et al. 2017). It is thus important to analyse the potential toxic nature of metals likely to be released in the plumes generated from mining activities. Novel methodologies for ecotoxicological evaluation of risks of metal exposure need to be developed for deep-sea organisms, where the lack of knowledge on their physiological thresholds is critical (e.g. Auguste et al. 2016). Recently, the environmental hazard posed by a submarine mine tailings deposit was assessed using a methodology that can be applied to the deep-sea setting. The assessment is based on information provided by multiple lines of evidence (e.g. chemical composition and toxicity of the deposit/sediments, bioaccumulation and biomarkers analysis in representative local species). The lines of evidence are then integrated into a Weight Of Evidence (WOE) approach (Mestre et al. 2017). This model is at present considered as the best available option to quantify risk and should be applied to each target site, given specificities of each site including resource chemical composition or local fauna present. The WOE approach enables the identification of high-risk resources or high-risk communities within a license area during contractor exploration or environmental impact assessments

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(EIA) before any exploitation licenses can be issued. This approach was recommended to the International Seabed Authority (ISA), which regulates mining activities in the Area, to be included in future EIA and monitoring guidelines related to deep-sea mining activities.

Conclusion

The environmental hazard posed by deep-sea mining activities needs to be evaluated using an integrated approach and should be applied to each potential mining site prior to exploitation. Still, current scientific knowledge is not enough to warrant its exploitation with a good environmental management of its resources.

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Phage Solutions for Aquaculture Systems

Adelaide Almeida[1]

Abstract

Considering the increasing importance of aquaculture and the fact that several fish farming plants often suffer from heavy financial losses due to the development of infections caused by pathogenic bacteria and that the filter feeder bivalves are frequently implicated in the transmission of pathogenic bacteria to humans, more environmentally-friendly strategies to control pathogenic bacteria in aquaculture are urgently needed. Phage therapy appears to represent a useful and flexible tool for the inactivation of bacterial pathogens in aquaculture. In this study it is highlighted some of our recent works on phage therapy applied during the production of juvenile flounder fish and during cockles depuration.

Keywords: Phage therapy, pathogenic bacteria, inactivation

The use of antibiotics is yet an effective method to inactivate bacteria, but the emergence of resistant bacteria in the environment and the transference of these resistance to human pathogenic bacteria imply the development of new approaches to inactivate these microorganisms, not only in the clinic area but also in other areas, like in aquaculture, where the presence of resistant bacteria is an emergent problem.

Phage therapy is an alternative eco-friendly approach to prevent and control pathogenic bacteria. Consist in the application bacteriophages, that is, viruses that infect bacteria, to kill unwanted bacteria. Lytic phages infect a bacterial cell, producing new viral particles, which are released from the host cell through lysis. The new phage particles can infect other bacteria, lysing also them.

[1] Department of Biology and CESAM, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal. E-mail: aalmeida@ua.pt

Phage therapy present some advantages when compared with antibiotics: viral infection is specific, only the target bacteria are affected; as phages are self-replicating in the presence of their host, one dose is enough to inactivate the bacteria; phages are resistant to the variation of environmental factors; it is ease, fast and cost effective to produce a phage suspension than antibiotics. However, the specificity of phage can be also a disadvantage, but this difficulty can be overcome if phage therapy is applied to specific cases like in aquaculture, where the main fish pathogenic bacteria are well known. The development of resistant strains can also be a disadvantage, but as phages can outcompete the adaptation of the bacteria, because they present a high frequency of mutation (higher than that of the host bacteria) it is ease to produce new phages effective to these resistant bacteria. Moreover, in order to prevent the emergence of resistance, it is possible to use cocktails of phages. On the other hand, phage-resistant mutant growth is changed after phage contact and these mutants seem to be less fit than sensitive bacteria (Almeida et al., 2009; Silva et al., 2014a; Silva et al., 2014b).

With the exception of the Eastern Europe, no routine application of phage therapy is used in the clinic area. However, there are some approved applications of phage therapy in other areas, like in food industry, agriculture and veterinary, namely in the USA, but no approved approach exist for aquaculture.

In our laboratory we are working in phage therapy applied to the aquaculture area. We are testing phage therapy to inactivate fish pathogenic bacteria (such as *Aeromonas slmonicida*) and also to inactivate pathogenic bacteria transmitted to humans by bivalve consumption (*such as Escherichia coli*, *Salmonella enterica*).

Relatively to fish production, we have been involved in the evaluation of phage therapy to inactivate different fish pathogenic bacteria, such as *A. salmonicida*. *A. salmonicida* is the causative agent of furunculosis, a systemic disease, which is responsible for high mortality and morbidity of several fish species worldwide. Furunculosis in the absence of vaccine is severe. Although there is already a vaccine against furunculosis, this is expensive and often associated to undesirable side effects (Silva et al., 2016).

The results showed that AS-A phage inhibited the growth of the *A. salmonicida*, causing a decrease in bacterial abundance of ≈ 3 CFU mL^{-1} log after 6 h of treatment (Figure 1). After 72 h, the mortality of juvenile fish was higher (34%) in the fish exposed to *A. salmonicida* but not treated with phages than in the infected and treated groups (0%) (Table 1). The addition of AS-A phage to aquaculture water did not cause a detectable impact on the structure of the natural bacterial community. However, the bacteriome of the fish was significantly affected by the addition of the AS-A phage, but the differences were lower when the phage was added in the presence of the host bacteria (Silva et al., 2016).

Fish mortality					
Sample	Assay 1 (n = 30)	Assay 2 (n = 30)	Assay 3 (n = 30)	Sum of all assays (n = 90)	Average percentage of all assays (%)
Control Fish	0	2	1	3	3.3
Fish+Phage	0	0	0	0	0
Fish+*Aeromonas*	11	10	11	32	35.6
Fish+Aeromonas+Phage	0	0	1	1	1.1

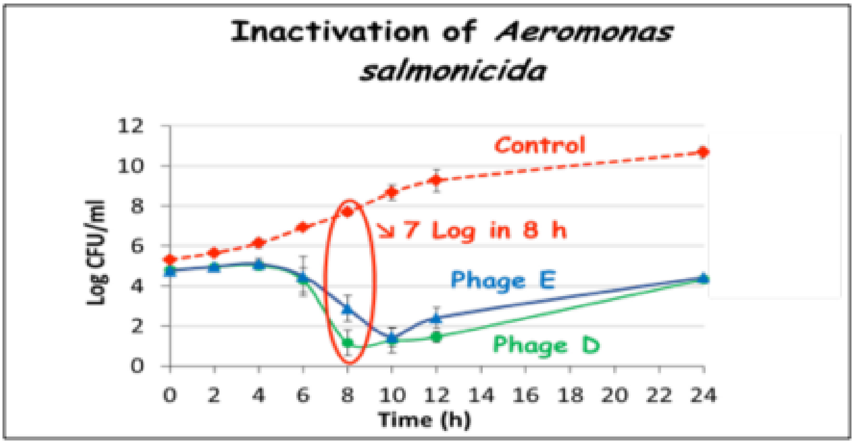

Figure 1. Inactivation of A. *salmonicida* by the AS-D and AS-E phages at MOI 100, during 24 h. Bacteria and phage were inoculated in TSB and incubated at 25 °C. Control – Bacterial control; Phage D – Bacteria plus Phage D; Phage E – Bacteria plus Phage E. Values represent the mean of three independent experiments; error bars represent the standard deviation.

Relatively to bivalves, cultured bivalves, are frequently involved in the transmission of infections to human because they are filter feeders, concentrating pathogenic bacteria, which are not efficiently removed during decontamination by depuration. Moreover, bivalves are eaten raw or barely processed.

In order to control the transmission of pathogenic microorganisms to human, production zones of bivalves are classified according the microbiological quality of meat and intravalvular liquid (*Escherichia coli* /100 g of meat and intravalvular liquid) and the decontamination of bivalves are done having into account this classification: bivalves from Zona A ≤ 230 are not depurated, Zona B > 230 e < 4600 it is necessary depuration or relaying to meet Cat A, Zona C > 4600 e < 46000 bivalves are protracted relaying to meet Cat A or relaying and depuration to meet Cat B and Zona D > 46000 bivalves are unmarketable. After depuration, the bivalves quality is evaluated using also the *E. coli* concentration and the *Salmonella* presence (FAO, 2008).

As depuration is not enough to decontaminate bivalves, more environmentally-friendly strategies to control pathogenic bacteria in aquaculture are urgently needed. Phage therapy appears to represent a useful and flexible tool for the inactivation of pathogenic bacteria during depuration.

In our study, in order to test the efficiency of phage therapy during bivalve decontamination, we start our studies using phages specific against the bacterial indicators used to classify the production areas and to evaluate the depuration process efficiency. Two *E. coli* phages (phT4A and ECA2) (Pereira et al., 2017a; Valério et al., 2017) and three phages (phSE-1, phSE-2 and phSE-5) of *Salmonella enterica* serovar Typhimurium (*Salmonella* Typhimurium) (Pereira et al., 2016a) were used during the depuration of natural and artificially contaminated cockles (*Cerastoderma edule*) in depuration systems with water recirculation (mimicking industrial depuration conditions) and without water recirculating. The results showed that, for both bacteria, approximately 2 log were inactivated in artificially contaminated cockles (Figure 2) and approximately 0.6 – 0.9 log for *E. coli* and *S. enterica* in naturally contaminated ones. It was also found that the use of phages during depuration decreased bacteria concentration faster than the use of depuration alone, as to achieve the same bacterial concentration decrease, two more hours were needed if no phage was used (Figure 3). (Pereira et al., 2016b; Pereira et al., 2017b)

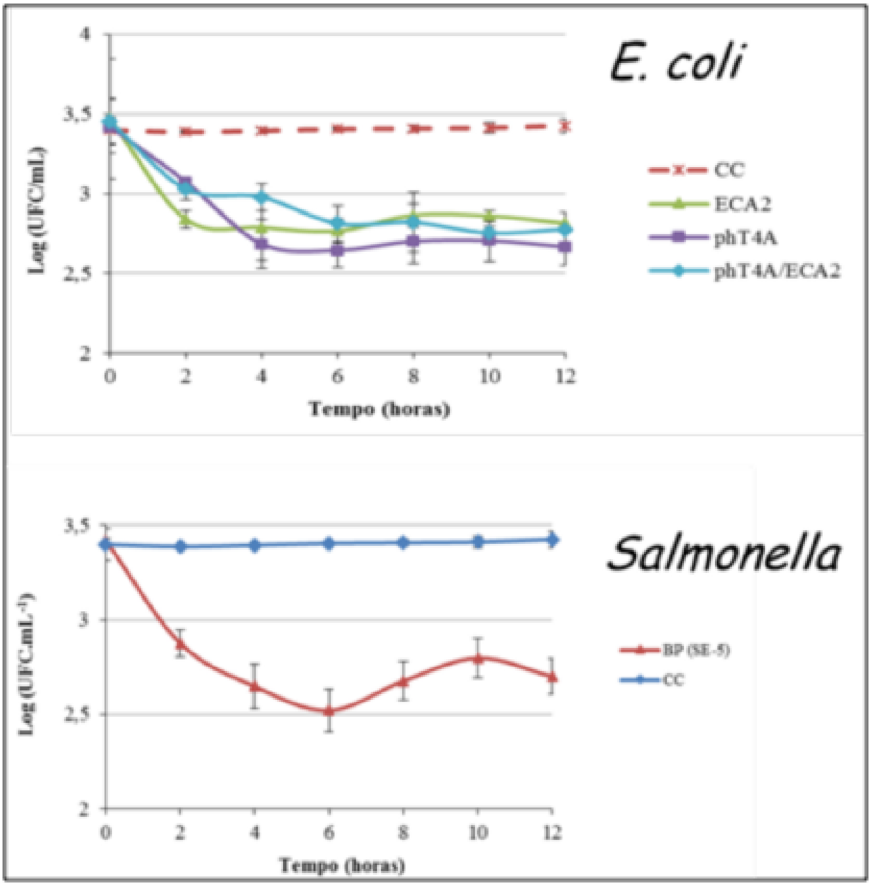

Figure 2: Inactivation of E. coli by the two phages alone (phT4A and ECA2) and phage cocktail (phT4A/ECA2) during 12 h, and of S. enterica by phage SE-5. BC — bacteria control; BP — bacteria plus phage. Values represent the mean of three experiments; error bars represent the standard deviation.

It was observed development of bacterial resistance to phages (~1 x 10^{-4} - 1 x 10^{-5}), but mutant of *E. coli* and *S. enterica* grew much slower and their colonies were small than the susceptible ones (Pereira et al., 2016a; (Pereira et al., 2017a).

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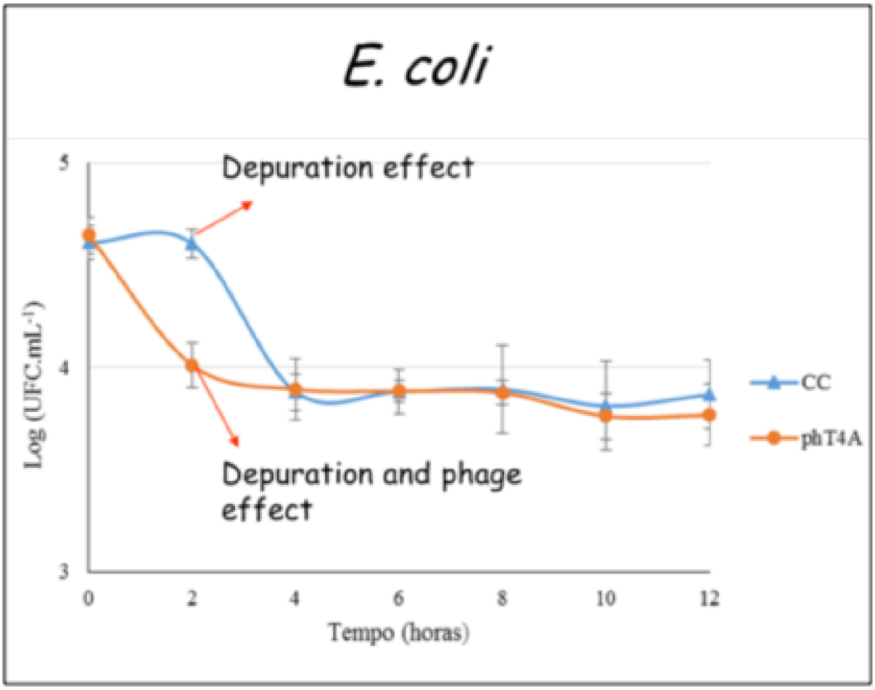

Figure 3. Inactivation of *E. coli* during depuration with recirculating water of natural contaminated cockles with and without phage suspension phT4 during 12 h. A. Bacterial concentration: CC - uninfected group (control cockles), phT4A— cockles treated with phage phT4. Values represent the mean of three experiments; error bars represent the standard deviation.

Results provide evidence that phage therapy is a feasible alternative approach against furunculosis during fish juvenile production in aquaculture systems and that combining phage therapy with depuration procedures enhance bivalve microbial safety for human consumption by improving decontamination efficiency. Moreover, this approach also displays the advantage of reducing the time required for depuration and consequently its associated costs. Furthermore, as phage-resistant bacteria growth slowly and were smaller than colonies formed by the non-phage added control, mutants should be less fit, so they can be expected to be eliminated from the environment faster than their wild-type relatives. These results suggest that the emergence of phage-resistant mutants should not be a major problem to the application of phages to control bacterial infections in aquaculture.

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SCORE - Sustainability of using Ria Formosa Currents on Renewable Energy Production

André Pacheco[1]

Abstract

On June 2016 the project SCORE - Sustainability of using Ria Formosa Currents On Renewable Energy production, initiated. The general objective of SCORE was to examine a small-scale tidal current turbine (Evopod E1, Figure 1) to be deployed in a shallow-water estuarine environment, looking at both the impacts of the turbine on its environment and the effects of the flow conditions on the turbine. The innovative aspect of E1 testing in Portugal lied with the unique morphological characteristics associated with the device deployment site at Ria Formosa, a coastal lagoon protected by a multi-inlet barrier system located in southern Portugal (Algarve Region). Ria Formosa can be used as representative of the vast majority of shallow coastal areas where TECs can be used in the future. It is therefore ideal to analyse both the energy extraction efficiency and eventual impacts that extracting energy from the flowing currents will have on the ecological communities and physical settings. Up until now almost no information exists on how cumulative effects of multiple devices will impact the near and far-field flow and sediment transport patterns from array deployments. The main expected outcome of the project is to construct an operational envelope which can be used by technology developers on design concepts of efficient tidal farms based on environmental and sustainability principles, contributing to the growth of the blue economy.

Keywords: Marine energy; tidal energy converters; blue economy

Resumo

O projeto SCORE – Sustentabilidade de Produção de Energia das Correntes de Maré da Ria Formosa (PTDC/AAG-TEC/1710/2014) propôs testar pela primeira vez um protótipo de extração de energia de marés em águas portuguesas, o protótipo à escala 1:10 da empresa inglesa Ocean

[1] CIMA, University of Algarve, ampacheco@ualg.pt

Flow Limited. O aspeto inovador do projeto SCORE encontra-se precisamente nas características únicas do local de teste: a Ria Formosa, lagoa costeira protegida por um sistema de barreira localizado no Sul de Portugal no Algarve. É um local pouco profundo e representativo da maioria das zonas costeiras mundiais de baixa profundidade onde dispositivos de extração podem ser instalados no futuro. É, portanto, ideal para analisar a eficiência de extração de energia e os eventuais impactos que a extração de energia terá sobre as comunidades ecológicas e as componentes físicas destes sistemas. O protótipo foi instalado dia 8 de Junho de 2017 e operou durante 5 meses, fornecendo dados reais e resultados concretos em relação ao local de teste, ao meio ambiente e à tecnologia de extração de energia das marés. O resultado esperado é o de construir um envelope operacional que possa ser usado pela indústria no desenvolvimento de novos protótipos de extração com base flutuante, baseados em princípios de sustentabilidade, contribuindo assim para o crescimento da economia azul.

Palavras-chave: Energia das marés; turbinas flutuantes; eficiência energética; economia azul; Ria Formosa, Portugal

Introduction

Science currently has a very poor understanding of both the hydrodynamics and the ecology implications related with the extraction of energy on coastal environments. A major part of the lack of knowledge relates to the fact that deployments of tidal energy converters (TECs) are focused on deeper areas. In few cases that devices have

Figure 1: Preparation, deployment and operation of E1 at Faro-Olhão Inlet, Ria Formosa.

been deployed closer to the coast, the data is highly commercially sensitive and thus not in the public domain to further wider understanding. Further, the measurements (when available) are often limited and do not provide the much needed information and context of the spatial and inter-annual variability inherent at such locations. The deployment of TECs has also been hindered by a lack of understanding of their environmental interactions, both in terms of the device impact on the environment (important for consenting and stakeholder bodies) and environmental impact on the device (fatigue, actual power output, etc.) which is vital to enhance investor confidence and increase financial support from the private sector.

The access to freely available, transparently collected monitoring data from real deployments is paramount both for resource assessments and for cataloguing potential impacts of any marine renewable installation. This project proposal was designed to deliver real data and concrete results in relation to the test site, the technology, the environment, and the economic benefits of tidal energy extraction. The general objective of SCORE is to examine a small-scale tidal current turbine (Evopod E1) to be deployed in a shallow-water estuarine environment, looking at both the impacts of the turbine on its environment and the effects of the flow conditions on the turbine.

The experiment

The experience with the tidal energy converter (TEC) prototype was performed at Faro-Olhão Inlet, the main inlet of Ria Formosa system, a coastal lagoon located in the South of Portugal. The objective of a real case scenario test is to validate the numerical modelling tool, to use it to analyse different extraction schemes and to predict short to long term impacts of energy extraction on shallow environments. Energy from tides was harvested before at Ria Formosa with tidal mills (XII century) and recent tidal energy assessments determined a potential extractable power of 5.7kW/m^2 (Pacheco et al., 2014). The local was chosen as a representative scenario where floatable TECs can be used to extract energy to power small communities on estuaries and coastal areas. For instance, in the United Kingdom the Severn Estuary

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has similar morphological characteristics to Ria Formosa being at the mouth of four major rivers and it is already the centre of discussions in the UK regarding renewable energy. Many other examples exist on the World, including river stream energy potential.

Prior to deploy the prototype it was need to get the authorization from the authorities, design the mooring concept, the control system and the power extraction transform solution to deploy the device. Anchoring weights were build and the mooring lines assembled. Deployment occurred on 8th June 2017, about a year after project' start. Since the project beginning SCORE team started to create a baseline marine geophysical, hydrodynamic and ecological database for the pilot site, essential to set-up and calibrate the hydro-morphodynamic platform. The team performed detailed bathymetric surveys, deployed bottom mounted Acoustic Doppler Current Profilers (ADCPs), as well as run boat-mounted ADCP surveys to fully characterised the 3D flow pattern. The marine biologists also collected ecological data from both the site of deployment and a control localization nearby, by mean of diving transects, remote operation vehicles footage and the use of bed sample collectors. Ambient noise level prior and during device operation were also obtained.

A Delft3D model of the entire Ria Formosa has been set-up and calibrated. Calibration tests were performed to match modelled and measured velocities obtained with a bottom-mounted ADCP (Nortek Signature 1000). Once the hydro-morphodynamic model is validated, the impacts of energy extraction on flow and sediment transport patterns can be simulated by enabling the sink/source momentum term to parameterize the extra loss of energy generated by a tidal energy converters (TEC) array in a subgrid-scale, following the methodology proposed by Pacheco et al (2016). To obtain drag measurements, E1 anchoring lines have load cells on their extremes.

Ongoing work

Model simulations using different hydrodynamic settings and number of units are now being performed to (1) evaluate the impacts that energy extraction will have on the temporal and spatial changes of the flow, on sediment transport patterns and, ultimately, on the habitat; (2) develop cost benefit analysis balancing supply and demand using tidal energy. These simulation tests produced so far valuable information for improvement of the prototype design and mooring structure, enabling to optimise array schemes in order to both minimise environmental impacts from operation and maximise energy extraction. Tidal array row characteristics have been defined based on Faro-Olhão channels features (i.e. geometry and water depths), results from the hydrodynamic model (i.e. occurrence of flow velocities) and TEC specifications (e.g. rotor diameter, length, etc). One main issue of this study relies on the feasibility of the tidal stream project, because it is necessary to optimise the capacity factor of the whole array avoiding turbine rows with low efficiency. For this purpose, the TEC parameterisation in the employed hydrodynamic model has to be validated, as it needs to be capable of characterising wake recovery so that the power production of turbines is estimated correctly. The next step is to evaluate impact on sediment transport patterns, which increases the complexity of the model.

Since the project relates to the sustainability of producing electric energy using the Ria Formosa currents, team members are focused on the cost benefit analysis using as case study the Culatra Island energy demands. This task aims to propose instruments, measures and guidelines that will support the future installation of TEC devices enhancing high levels of environment protection, adapted to real socio-economic scenarios, enabling to define optimum approaches to future tidal energy extraction on coastal estuaries. A techno-economic assessment will be produced offering: (1) guidelines for TEC implementation projects on similar coastal lagoons and estuarine systems worldwide analysing scenarios based on energy extraction schemes; (2) a cost benefit analysis on extracting tidal energy from Ria Formosa and adjacent waters. Energy consumptions rates were asked to EDP and different scenarios were established to evaluate project break even and investment.

Final remarks

A final report will be produced focusing on: (i) elaborating guidelines for the geophysical, hydrodynamic and ecological characterisation that can be used by TEC developers as part of an Environmental Impact Assessment in accordance with the 85/337/EEC EIA Directive (outcome: make future projects more attractive to investors and government who traditionally have seen environmental concerns as a barrier); (ii) identifying the environmental sensitivities and advice on potential impacts that could result from TEC long term and/or multiple devices operation and help developers comply with the 92/043/EEC Habitats and 79/409/EEC Wild Birds Directives (outcome: offer assurance on future projects sustainability and encourage public acceptance); (iii) determining TEC power generation capacity, energy capture area and proportion of energy flux (outcome: enable large scale implementation, easy to adapt to any other site of similar characteristics worldwide); and (iv) assessing the implications of array size, spacing and layout in conjunction with the type of technology by defining the best possible locations for the TEC device (outcome: increase confidence and encourage investment for the site development). The above information is crucial and can enable TEC developers to adapt/modify their device concepts and optimise their energy extraction schemes. The tidal energy resource and the evaluation of impacts from extraction at shallow coastal areas proposed on SCORE project can guide energy policy, and position Algarve (and Portugal) on the forefront as test sites for new and/or existing TEC energy developers (Figure 2).

So far, the project had a strong dissemination through the media with interviews to the Portuguese national TV, RTP, and two of the main national radios, TSF and ANTENA 1, this last one three times at different programmes: 90s de Ciência and an extended interview at Os Dias do Futuro. Several articles were published on national and local newspapers such as Público, Correio da Manhã, Diário de Notícias, Sul Informação, Planeta Algarve, Diário Online, Algarve Primeiro, Jornal Monchique, VozAlgarve, etc. Specialized articles were published by Ambiente Magazine and I9 Magazine. Very important was the follow up that the most important online channel TIDAL

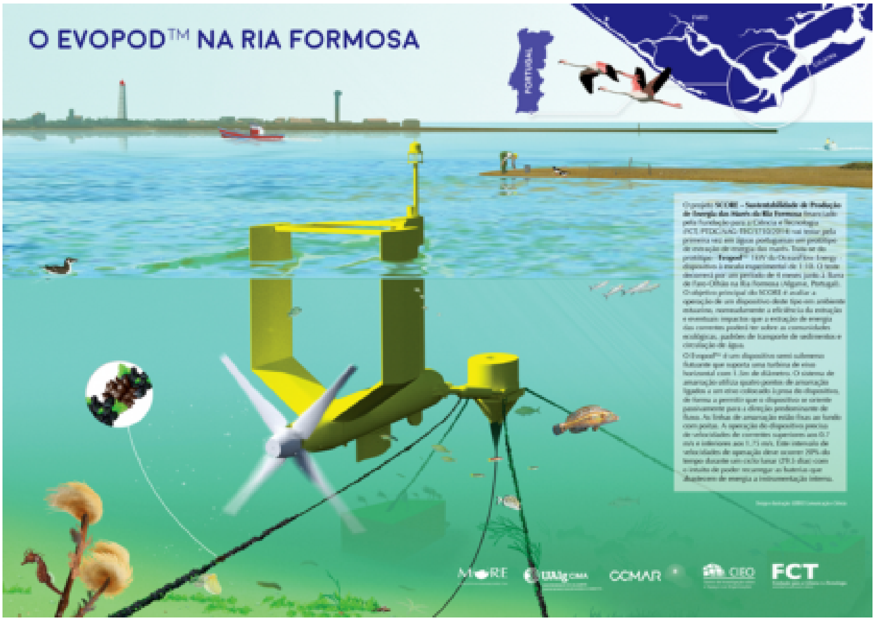

Figure 2: SCORE' Infographic for the general public.

ENERGY TODAY gave to SCORE project, with constant project updates. The team members also participated on several sea exhibitions and debates, giving lectures on local high schools and collaborating with the activities of Centro de Ciência Viva.

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Marine Biotechnology: a Challenging Path to Sustainable Food, Feed, Energy and Improved Human and Animal Health

João Varela[1] & Sara Raposo[2]

Abstract

As life began in the oceans, the past, but also the future of the human population is intrinsically linked to marine living resources. The oceans offer a bounty of biodiversity that needs to be protected, properly managed and exploited with responsibility. Recent studies on the biodiversity of marine organisms have revealed that the tree of life is actually a web of life with multiple interactions in terms of complex networks of gene transfers, endosymbiotic events and trophic relationships. The understanding of this complexity and the evolutionary history that underlies and explains the biology, biochemistry and ecology of marine life is key to its effective exploitation to benefit human beings as a whole in a responsible manner. We will discuss knowledge-based strategies that are currently being implemented in order to use the available marine living resources as novel sources of food, feed, energy and bioactive compounds, so that a more sustainable future can be provided to future generations.

Keywords: Marine resources; biorefinery, human and animal health

Resumo

A vida começou nos oceanos, e tanto o passado como o futuro da população humana estão intrinsecamente ligados aos recursos biológicos marinhos. A exploração responsável da vasta biodiversidade que os oceanos oferecem passa pela proteção destes e uma adequada gestão. Estudos recentes sobre a biodiversidade de organismos marinhos revelaram que o conceito da "árvore da vida" devia ser substituído por uma "teia da vida", a qual é constituída por interações múltiplas em termos de redes complexas de transferências de genes, eventos endossimbióticos e relações tróficas. A compreensão dessa complexidade e da sua história evolutiva

[1] Centre of Marine Sciences (CCMAR) (jvarela@ualg.pt);

[2] Centre of Marine and Environmental Research (CIMA), University of Algarve, Campus de Gambelas, 8005-139, Faro, Portugal (sraposo@ualg.pt)

fornece uma melhor compreensão da biologia, bioquímica e a ecologia da vida marinha que é fundamental para a efetiva exploração dos oceanos de modo a beneficiar os seres humanos como um todo de uma forma responsável. Neste trabalho, serão discutidas e apresentadas estratégias baseadas no conhecimento que estão atualmente a ser implementadas em que recursos vivos marinhos são usados como fontes inovadoras de alimento, energia e compostos bioativos para que haja um futuro mais sustentável que possa ser transmitido às gerações futuras.

Palavras-chave: Recursos marinhos; biorrefinaria, saúde humana e animal

1. Introduction

More than 80% of the organisms living on earth are found in the aquatic ecosystem with the marine environment containing between 250,000-270,000 different species (Reaka-Kudla, 1997; Groombridge and Jenkins, 2000). Among this enormous biodiversity, only 20% of it has been minimally characterized in terms of their genetics, biochemistry and biomedical potential (Kim et al., 2015).

Over the last few years, marine biotechnology has demonstrated that has the potential and the capacity to improve human life, where the application of biotechnological tools could develop novel and cost-effective food, feed and energy products able to improve human and animal health. Marine bioprocesses use living marine organisms as *cell factories* for the biosynthesis of these compounds. To realize the potential of marine biotechnology, it is necessary to undertake a bioprospection of biological resources with high potential to generate benefits to the economy in a sustainable way, without undermining the sustainability of the marine ecosystem.

The research groups MarBiotech of the Center for Marine Sciences (CCMAR) and Engineering and Environmental Biotechnology of the Center for Marine Environmental Research (EEB / CIMA) of the University of Algarve have joined forces to develop work in the area of microalgal biotechnology. These research groups began a bioprospection effort for studying different marine resources via isolation and cultivation of the different microalgal strains from samples collected at different locations of the Southwestern Iberian Coast under the umbrella of the ALGARED network, which is financed by the operational program EP-INTERREG VA Spain-Portugal (POCTEP). Apart from the University of Algarve, this network comprises two companies (Necton and Sea4US), one state laboratory (IPMA), two additional universities (University of Huelva and University of Cordoba), two research institutes (ICMAN, IFAPA), and Junta de Andalucia. Microalgae with interesting properties will be scaled up under different operations modes and geometries. The ultimate goal of this collaborative effort is to find different applications of microalgal bioresources that can be found in the coastal waters of the Iberia Peninsula for the production of biomass for food and feed rich in protein and high value lipids (e.g. *n*-3 polyunsaturated fatty acids), bioactive compounds, and carotenoids. The production of biofuels, such as biodiesel, bioethanol, and methane by anaerobic digestion of the residual algal fraction will also be explored (Figure 1).

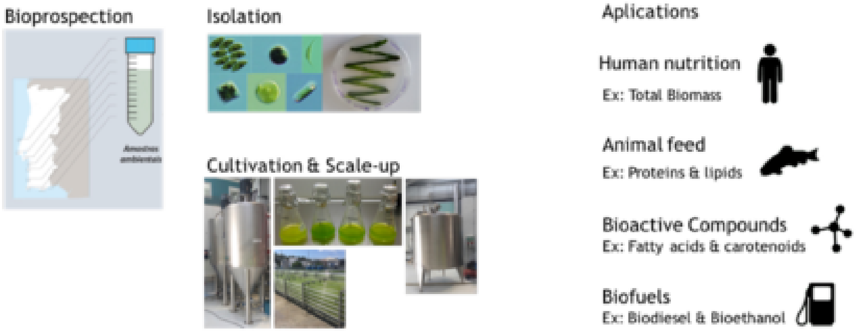

Figure 1. Different biotechnological applications from marine resources obtained by bioprospecting, isolations and cultivation of the microalgae with economical interest.

2. Marine Resources Applications

Microalgal biomass production systems includes the design and operation of the biological reactors, adapted to the different trophic modes, where the microalgae growing in an environment that favors accumulation of target products and the harvest of the microalgal biomass for distinct applications.

Microalgae can be cultured under photoautotrophy, mixotrophy, photoheterotrophy and heterotrophy. Cultivation in photoautotrophy implies the use of non-organic nutrients (e.g. nitrates and phosphates) by the microalga for the photosynthesis of organic compounds through CO_2 fixation. Conversely, growth in heterotrophy requires the supplementation of the growth medium with organic carbon substrates as C and energy sources and cell growth is independent of light energy, resulting in high productivities, yields, cell concentrations and improved growth control as compared to photoautotrophic systems. This is mainly due to the supply of ready-to-use substrates that are rich in energy and the absence of growth limitations imposed by light attenuation inside the bioreactor. However, the possible contamination of culture media for the presence of organic substrates and the increasing production costs associated with the addition of organic substrates are disadvantages of this trophic mode. Heterotrophic growth is an attractive approach for the high availability of cheap carbon sources (glucose, acetate, and glycerol) commonly used by fermentation industries and the possibility of the use of wastewaters with a substantial organic load or supplemented with other cheap nutrients, that could make production from microalgae economically acceptable (Moreno-Garcia et al., 2017). Organic substrates as diverse as monosodium glutamate wastewater, cheese whey permeate, sodium acetate, fruit peel, glucose, fructose, glycerol, etc. have been successfully used for algae growth under mixotrophic conditions (Azma et al., 2017; Daliry et al., 2017; Guldhe et al., 2017; Morales-Sánchez et al., 2017; Petrushkina et al., 2017). Mixotrophic cultivation performed in both fed-batch and semi-continuous modes is a successful strategy to be used for high biomass, lipid and co-products synthesis (Chaiprapat et al., 2017; Daliry et al., 2017; Deschênes et al., 2015; Han et al., 2016; Skorupskaite et al., 2015; Zhan et al., 2017).

Other possible modes for microalgal cultivation is under a mixotrophic model, in which cells are grown in a medium containing a carbon source, but in the presence of light. This growth modality is sometimes used for growth of specific microalgae when they are scaled up industrially if the target molecules are metabolites that require photosynthesis. Moreover, some other species require even more elaborate ways of being cultivated. For example, it has been shown that the dinoflagellate *Dinophysis acuminata* needs to steal mitochondrial-plastidial complexes from a ciliate (*Myrionecta rubra*) in order to acquire transiently the capacity of carrying out photosynthesis even though is a predator of other microorganisms. In turn, *M. rubra* steals the nucleus, mitochondria and chloroplasts from a photosynthetic cryptophyte (*Geminigera cryophila*; Wisecaver and Hackett, 2010) in order to be grown and serve as live feed for *D. acuminata*. This "photoheterotrophic" lifestyle of minute predators translates the intricate and complex trophic interdependences that are found in aquatic environments, which need to be understood if one wants to cultivate these organisms.

Concerning applications of their biomass, microalgae produce lipids, proteins and carbohydrates that can be processed into both biofuels and valuable co-products with the capacity to replace fossil fuels and to supply demand for food supplements, animal feed, colorants, enzymes, and several other valuable chemicals (Moreno-Garcia et al., 2017).

The saccharides in microalgal biomass can be used to produce bioethanol or biogas via fermentation or anaerobic digestion (Chen et al., 2013; Sanchez et al., 2017). In the case of the *Tetraselmis* CTP4 microalga, a high yield bioethanol of 0.47 g / g was produced, reaching a very close to the theoretical maximum level (0.51 g / g) (unpublished results).

Bio-hydrogen can also be produced via biodegradation of starch extracted from microalgae. The microalgal biomass is a good and inexpensive source of protein that can be used as additives for animal and fish feeds. Some microalgae species produce several valuable bioactive compounds such as polyunsaturated fatty acids, and carotenoids such as astaxanthin (Odjadjare, et al., 2017).

The involvement of groups of EEB / CIMA and MarBiotech / CCMAR in the ALGARED+ network also include other laboratories located at the University of Algarve. For example, Elsa Cabrita (AQUA group) will be crucial to develop novel methods of cryopreservation for the isolated microalgae together in collaboration with IFAPA, University of Huelva and IPMA. Other groups (Leonor Cancela's, Wolfgang Link's and Dina Simes's laboratories) will be essential for the development and implementation of novel screening platforms for bioactive and extracts obtained from microalgal biomass. The objective of this network is the implementation of a strategy that promotes research and technological development in the area of microalgal biotechnology and its use in health products, cosmetics and aquaculture (Figure 2).

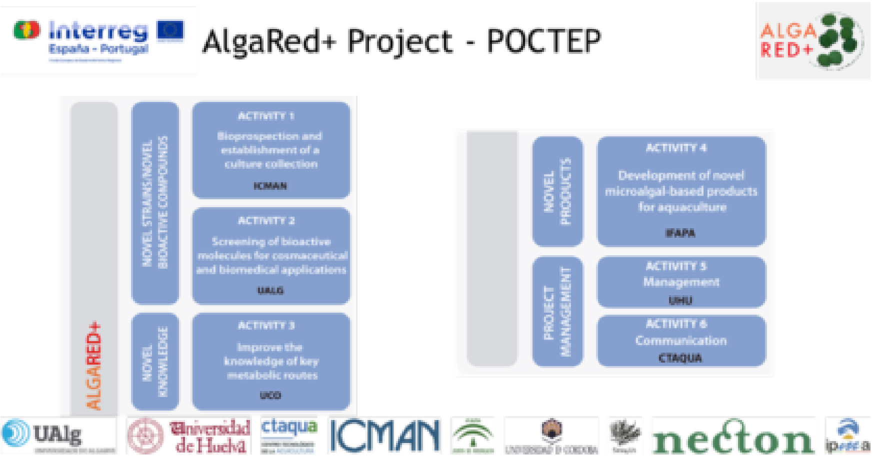

Figure 2. Algared+ Project, a network stablished between 9 institutions

This project will be carried out in the Algarve / Western Andalusia cross-border area, a region heavily influenced by the Atlantic Ocean, home to ecosystems of great richness and biodiversity that can form a framework for important economic activities of great strategic importance, such as aquaculture and phycoculture. More specifically, microalgae have a high potential for innovation and may be untapped sources of wealth in the form of metabolites of pharmacological and cosmetic interest.

The ALGARED network will implement six activities aimed at the bioprospection, isolation and valorisation of novel microalgal strains. Another goal of the network is to coordinate all these efforts across the Portuguese-Spanish border and exchange scientific personnel and students in order to push the field of microalgal biotechnology forward. This exchange will enable cross-pollination via the complementarities found among the Portuguese and Spanish partners.

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3. Microalgae Biorefinery

Today, the concept of biorefinery is a prominent issue in our society that aims at the integrated exploitation of a given biological resource. This concept can be applied to microalgal biomass, so that it is fully utilized in terms of its constituent fractions, from lipids (oils) to carbohydrates and proteins. The co-production of biofuels (biodiesel, bioethanol, biofuel and biogas), protein-rich feed and extracts containing bioactive compounds with biomedical, nutraceutical and / or pharmaceutical applications is one of the scenarios to be studied.

This system could be economically sustainable and could contribute to the use of biofuels as a by-product from biomass cultivated for higher added-value products such as carotenoids, vitamins, and algal extracts with high antioxidant content for cosmetic and food products.

In this context, biofuels will also be considered as by-products resulting from the process of treating wastewaters with a high organic load. The current research at the University of Algarve, in the area of biotechnology and blue energy, intends to make use of marine bioresources for domestic or agroindustrial effluent treatment. Wastewaters are sources rich in organic matter and nutrients that can be used in the growth of microalgae, whose biomass can be used as a source of oils for the synthesis of biofuels. This possibility of transforming the treatment of wastewaters in a potentially self-sustaining process, generating additional revenue, could lower operating costs for companies and municipalities across the Iberia Peninsula and elsewhere.

Presently, there is no biorefinery in Portugal for the production of biofuels, both bioethanol and biodiesel, to allow its incorporation into additives. If Portugal wants to fulfill its community goals, it is still dependent on the importation of (bio)fuels, which represents a significant burden on the country's economy. At present, efforts have been made to find processes that make the production of these biofuels economically viable, using an integrative approach under the concept of a biorefinery.

4. Conclusions

One of the conclusions that can be drawn right now is the urgent need for Portugal, Spain and Europe in general to support efforts related to marine biotechnology. Thus, marine biotechnology clearly stands as a key lever in the strategy of training human resources for the sustainable use of its marine resources and job creation through knowledge and innovation. The University of Algarve, through the cooperation of several national and international research groups as well as business partners, has taken important steps in this direction. The exploration of novel co-products is an important aspect of improving the economics of algal biofuels. The development of the technologies and the advances in the area of algal biofuels goes by hand in hand with the interest of the general public in the achievement of a sustainable source of clean energy and their concern over climate change and environmental remediation. The world interest in microalgae-based biorefineries is growing rapidly as shown by the increased investment from the industrial, institutional and governmental sectors, as well as by the enormous number of publications on the subject in recent years.

Acknowledgements

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Marine Bioremediation: New Tools for Ecosystems Recovery

Ana Paula Mucha[1]*, M. Fátima Carvalho[1], Sandra Ramos[1], Catarina Magalhães[1] & C. Marisa Almeida[1]

Abstract

The development of strategies to recover marine and coastal ecosystems affected by pollution events is still a challenge to the scientific community. Bioremediation is a nature-based option for the cleaning of these areas, presenting significant environmental and economic advantages compared to other alternatives such as physical and chemical technologies. Bioremediation involves the use of microorganisms to remove environmental contaminants, making use of their natural capability to degrade organic contaminants. These microorganism have the ability to use organic contaminants as a carbon source, or by co-metabolism. Several ongoing studies at CIIMAR are exploring the potential of autochthonous organisms for bioremediation of contaminants in marine and coastal areas, through the development of biotechnological tools for ecosystems recovery.

Keywords: Bioremediation, native microbial consortia, oil spills

Bioremediation of Oil Spills

Marine oil spills are catastrophic events that lead to high losses of marine life and ecosystems, with major economic and environmental damages. Recently, several oil spill disasters have occurred, with Deepwater Horizon (2010) being considered one of the largest accidental oil spill in the history of the petroleum industry. In the last 50 years, several major spills occurred in the NW Iberian Peninsula, one of the main routes of oil cargo in Europe: e.g. the oil tanker Jakob Maersk in 1975, and more recently, in 2002, the oil tanker Prestige

[1]CIMAR/CIIMAR – Centro Interdisciplinar de Investigação Marinha e Ambiental, Universidade do Porto, Terminal de Cruzeiros do Porto de Leixões, Av. General Norton de Matos s/n, 4450-208 Matosinhos, Portugal

*amucha@ciimar.up.pt

which sank at 250 km from the coast of Galicia (North of Spain) spilling more than 60.000 tons of crude oil (Bernabeu et al. 2013), polluting thousands of kilometers of coastline and causing great harm to the local fishing industry.

The occurrence of such incidents requires immediate, simple, effective and eco-friendly actions to minimize environmental damages. First-line responses typically include physical (e.g., controlled burning; absorbing) and chemical (e.g., dispersing) removal of oil. These treatments are important to rapidly control the diffusion and drift of the oil, but they are not suitable for ecological restoration. Recently, bioremediation using microorganisms to degrade the remaining spilled oil has been proposed as a cost-effective alternative to chemical additives. The use of microorganisms with a natural capacity to degrade oil is highly advantageous in that it is an environmentally friendly process and allows complete decomposition of complex oil hydrocarbons (Speight and Arjoon 2012). The efficient biodegradation of oil spills requires a jointed action of a consortium of microorganisms, i.e., a group of diverse microbial species with a complementary range of metabolic capabilities, rather than the action of individual microbial species.

The success of bioremediation, to improve oil removal and reduce clean up time and cost, relies in two major approaches: (i) addition of nutrients to stimulate the growth of microorganisms that break down oil (Biostimulation) and (ii) addition of pre-grown microbial cultures/consortia to enhance degrading microbial populations (Bioaugmentation) (Tyagi et al. 2011). This latter mitigation strategy usually involves the introduction of non-native microorganisms in the affected environment. Thus, most of the commercial solutions based on bioaugmentation strategies currently employed for bioremediation of oil spills are based in the addition of exogenous or genetically modified microbial strains. These approaches may, however, result in ecosystems disturbances through the introduction of non-native microbial strains able to be involved in the horizontal transfer of exogenous genetic material to the indigenous community. On the other hand, their use is limited in the environment because of the instability of the inserted genetic material, resulting in a low efficacy of the exogenous organisms to adapt and survive in a new habitat with highly stable cooperative communities that will outcompete with the introduced strains (Hosokawa et al. 2009, Joutey et al. 2013).

The natural cooperative partnership in microorganisms is a key element to be taken into account when we plan to develop bioaugmentation strategies to degrade highly diverse and complex compounds, such as oil and petroleum products. The efficiency of this strategy has already been demonstrated for sandy beach sediments, in microcosm (Almeida et al. 2013, Reis et al. 2014) and mesocosm (Pontes et al. 2013) laboratory experiments, by our team in a previous project (OILDEBEACH, an FP6 project) implemented in the frame of the response to the Prestige oil spill. At CIIMAR, our team, the Bioremediation and Ecosystems Functioning (EcoBioTec), aims to contribute to the advance of science from a multidisciplinary point of view, focusing its research on ecosystem function and anthropogenic impacts in marine and coastal zones and on the development of biotechnological tools for ecosystems recovery. This team has been working together in the development of biotechnological tools based on the ability of native microorganisms to remove contaminants through bioremediation processes, with the ultimate goal of promoting clean and economically reliable tools to mitigate pollution effects and promote ecosystem recovery (e.g. Almeida et al. 2013, Pontes et al. 2013, Reis et al. 2014, Teixeira et al. 2014, Oliveira et al. 2014, Ribeiro et al. 2015, Ribeiro et al. 2016, Montenegro et al. 2016, Fernandes et al. 2017).

SpilLess - First-line response to oil spills based on native microorganism cooperation

Now, in the project SpilLess, the EcoBioTec team proposes a new concept of bioaugmentation by taking advantage of the highly effectiveness of native cooperative consortia to bioremediate oil spills, and thus potentiating microbial survival and bioremediation efficiency in the affected areas, while avoiding environmental issues derived from the introduction of non-native organisms.

SpilLess (http://spilless.ciimar.up.pt/) aims to implement an innovative 'laboratory' (Blue Lab) to pilot new and viable solutions to tackle with one of the most damaging sources of maritime pollution: oil spills. These solutions are based on the production of native microbial consortia with oil bioremediation capacity, and the adaptation of unmanned autonomous vehicles for combating *in-situ* oil contamination. This novel approach can be used as first line responders to pollution incidents in a fast, efficient and low cost way.

This Blue Lab is a multidisciplinary team gathering a group of young scientists, supported by senior researchers from three institutions (CIIMAR, INESC TEC and the University of Vigo) and also by experienced business tutors from three private companies (ACSM, Biotrend and MARLO). Moreover, the R&D team is mentored by a stakeholder's platform that includes several public and private entities. SpilLess will be implemented in the region of the Atlantic Ocean, with potential for transferability to other regions facing similar challenges.

The project started by identifying the operational needs to respond to oil spill incidents in offshore platforms, ports and other industrial complexes. In the meantime, a library of microbial strains with oil bioremediation capacity and native to the target region, is being created for further development of the microbial consortia. In addition, consortia production for large scale application will be optimized. Unmanned autonomous vehicles are being adapted for application of the bacteria (bioaugmentation) and nutrients (biostimulation), thus providing air, surface and underwater oil spill combat. Finally, this innovative solution will be validated through field tests and the proof-of-concept will be demonstrated at a "quasi-real" scenario.

This solution is environmentally friendly, and can act as fast first line response, with low time to reaction and mission costs, and will set-up holistic pollution combat and provide environmental monitoring.

The project is result-oriented as it aims to develop marketable services and products, such as, microbial consortia for bioremediation, a cocktail of additives to stimulate the consortia activity, devices for application of bioremediation treatments by unmanned and autonomous vehicles, and an integrated protocol for bioremediation application. Market analyses, technology watch reports, and exploitation and business plans will be developed to exploit project's results and to bring the technologies to the market.

Acknowledgments

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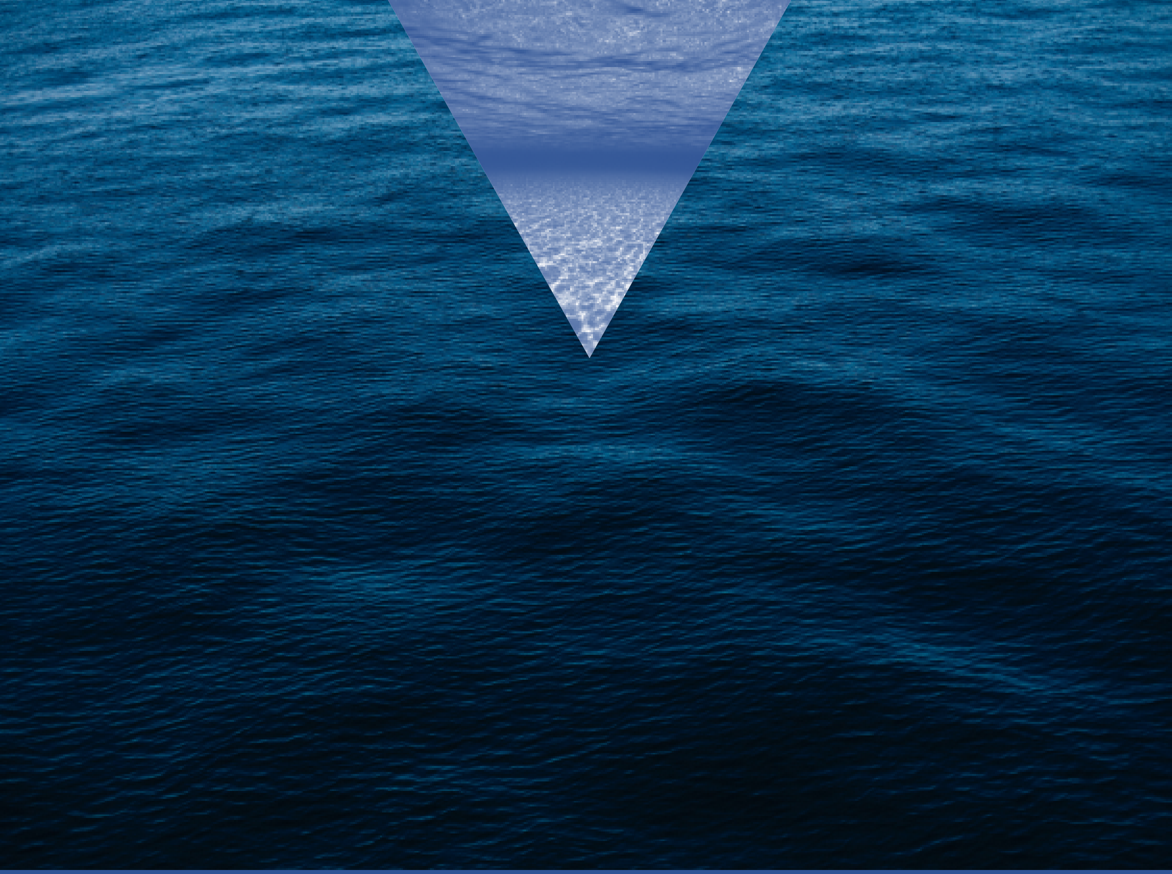

ALTERAÇÕES GLOBAIS E RISCOS

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GLOBAL CHANGES AND RISKS

In the first presentation "Desenvolvimento Sustentável dos Oceanos: Uma Utopia Útil" we listen to an introductory note by Telmo Carvalho, highlighting the three dimensions of the oceans and the need for an interdisciplinary way to approach the associated challenges. During the following presentations the three dimensions (ecology, policy and human/people dimension) were presented separately or combined under different but complementary angles and viewpoints. Firstly, there was an overview of the ecological dimension under multiple stressors and the use of modelling tools for the forecast of possible future steady states. The policy dimension was then introduced in a presentation focusing on the impacts of climate change on deep-sea ecosystems, including in the discussion the policy implications. Human dimension was then linked to policy through a presentation on adaptation to climate change and the tragedy of climate refugees. The policy of the sea was subsequently presented in the perspective of the UN sustainable development goals. In this context, special attention was given to environmental stressors of concern, e.g., metals and litter, and to the impacts on species used for human consumption. In this presentation, Maria João Bebianno also highlighted the need for a better communication. Finally, the three dimensions were again presented together having the Algarve coastal area as showcase. This presentation enclosed and overview of the climate change adaptation plan at Algarve municipalities association level. The plan was developed following the scope of the ClimaAdapt local project, which included a multidisciplinary team and the local population, i.e., the programme for climate change adaptation and mitigation was co-developed in a transdisciplinary context.

The following discussion focused on the presenters' experience regarding the human dimension, specifically stakeholders engagement, and on communication within and between the three dimension key-actors, including citizens. In this context the moderator Cristina Veiga Pires, who is also the executive director of the Algarve Ciência Viva Centre took the opportunity to challenge the community to produce an itinerant exhibition commemorating the 20 years of the United Nation Convention on the Law of the Sea 's signature by Portugal.

Ana Lillebø & Cristina Veiga Pires

Humanity and the Three Dimensions of the Ocean

Telmo Carvalho

Like Prof. Mário Ruivo used to say frequently: "The three-dimensional occupation of the Ocean is under way". An ongoing process of integrating this immense space on the Planet, until a few years ago inaccessible, in a space available from the coast to the high seas and from the surface to the seabed.

And he always related this new trend with what is considered the present geological period (designated by Paul Crutzen) as Anthropocene A period marked by the increasing capacity of the human species to interfere with natural processes, of which climate change is a paradigm, highlighting the degradation of the capacity of the Planet to host humanity.

The Ocean plays a central role in this process, though often unnoticed. Indeed, the "representation" of climate change remains in general public opinion as a fundamentally atmospheric phenomenon, masking the dynamics of the ocean as a mediating system in ongoing global warming.

But this notion (except for the experts) is still very far from the common perception, be it from the population or even from the decision-makers, the Ocean is, in a way, still regarded as a mysterious and unknown space. However, the United Nations Convention on the Law of the Sea already recognizes it (mineral resources of the seabed) as "common heritage of humanity", that is, a space serving the common good. In UNCLOS the ocean tends to be seen in a sustainable development perspective whose ultimate instrument is the management of human affairs, impressive qualitative leap when a few hundreds years ago our species wandered only along the insurmountable barrier of seas and inland waters, surviving, observing, and thinking. As Mário used to say "I like the Ocean because I care for the people".

It was with this perspective that Mário defended (in a visionary, but sometimes considered *naïf way*) that the new ocean economic activities that are rapidly occupying all dimensions of the ocean need to be clearly addressed and regulated, because we are still in a uncertain framework about the potentialities, levels of exploration, impacts and governance modalities or institutional arrangements, that because of their initiatory nature, are still not "tested enough" even in advanced democracies.

Besides some examples of activities that are impacting or may impact the ocean natural resources, he used to say, and I fully share and support his idea, that the only way to prevent harmful activities or support sustainable ones, is through solid Knowledge.

That is the reason why he defied, several times in the course of the years, the Scientific Community, to assume its role as an active social actor, as the ones more reliable (because are the ones with the best knowledge available about the ocean) to influence and sustain public policies.

In fact, back in November 2011 when we gather in this university, and I believe in this same room, for a Conference that produced the Algarve Declaration, this issue was clearly identified and agreed. The Declaration stated that the Portuguese Scientific Community call the attention to the need of "assuming Marine sciences and technologies, including its social component, as a fundamental pillar of the strategic and sustainable development."

And it's this Social component that I would like to emphasize, because I believe it's the only answer to the correct usage and appropriation of the three dimensions of the Ocean, but at the same time, in Portugal we are still not addressing this component in a systematic way.

And when I'm talking about the social component of marine sciences I'm also talking maritime and about economy, law and culture in all its historical and anthropological aspects, because as stated in the Universal Declaration on Cultural Diversity of Unesco, "cultural diversity is as important for mankind as biodiversity is for nature – and nature is everything."

In this sense:

Who is dealing with the study for the protection of coastal communities, which sooner or later will be forced to change their life paradigm because they will have to stop fishing?

Who is studying the economic and social alternatives that those populations have?

Who are the social mediators that are "teaching" those populations that there are alternative and more sustainable ways?

Who is dealing with the preparation of regulations and laws that will prevent the national ocean territory from being exploited without safeguarding the country's and populations duly rights?

Who is dealing with the fact that at the same time that we are defending free circulation of people and goods in land, we are defending the bordering of the maritime spaces, and that obliges humanity to learn a new type of relations with the ocean?

It's true that we have some specialist in some of these fields in Portugal, but the linkage, the interdisciplinary is not there yet!!! And we need it.

I believe that the Portuguese Scientific community pretty much achieved one of the steps that I believe are necessary, we have a stable scientific community that can inform on environmental sustainability, but we are not at the same level if we are talking about, public policies, economic exploitation or cultural values of the ocean, and if that knowledge does not exist it will be very difficult to achieve a balanced and equitable ocean governance of the Portuguese sea.

For me it's clear that we need social sciences and humanities in this process! We need ocean socio-economy and we need ocean culture. Even to be able to understand and go beyond the natural difficulties (because they are cultural) in changing populations established cultural and behavioural patterns.

Because at the end, as Mário would say, everything is about the people, even the ocean even the planet, and we need to find the most balanced solutions for them. For us!

Environmental Stressors from the Law of the Sea to World Ocean Assessment

Maria João Bebianno[1]

Abstract

A healthy ocean is vital for human well-being but is increasingly threatened by anthropic activities. Therefore the impact of these activities in the ocean needs to be properly managed. For that reason the United Conference on the Law of the Sea (UNCLOS), that provides the legal framework for governance of all aspects of the ocean, established in its general provisions of Part XII Protection and Preservation of the Marine Environment that states have the obligation to protect and preserve the marine environment (article 192) and have to take measures individually or jointly to prevent, reduce and control pollution to the marine environment from any source (article 194). At that time, the stressors of concern were metals, pesticides and illegal or accidental oil spills. In the meantime new substances were produced that have new implications to the health of the oceans and to human well-being.

Therefore to maintain a sustainable development, the United Nations, under The Agenda 2030 for Sustainable Development, established 17 Sustainable Development Goals in which Sustainable Goal 14 deals with conservation and sustainable use of the oceans, seas and marine resources for sustainable development. Meanwhile the United Nations established the Regular Process to assess the quality of the marine environment that produced the first World Ocean Assessment (UNWOA1), recently approved by the United Nations, that highlight concern about the impact of human activities by emerging compounds in the ocean and establishes that states must prevent and significantly reduce pollution from all kinds, including marine debris.

The lack of proper and innovative wastewater treatment and the release of stressors from point and diffuse land-based sources and from the sea constitute one of the major threats for the maintenance of a healthy ocean. Among these stressors marine debris, which 80% has origin on land-based sources, are presently one of the major global ocean stressors of

[1] CIMA, University of Algarve, mbebian@ualg.pt

concern. The impact of plastics and in particular of microplastics to the marine resources and to biodiversity will be discussed.

Keywords: Ocean; marine debris, microplastics

Resumo

Um oceano saudável é vital para o bem-estar humano, mas esta cada vez mais ameaçado por atividades antrópicas. Portanto, o impacto dessas atividades no oceano precisa ser adequadamente gerido. Por essa razão, a Conferência das Nações Unidas sobre o Direito do Mar (UNCLOS), estrutura legal para a governança de todos os aspectos do oceano, estabeleceu nas suas disposições gerais da Parte XII - Proteção e Preservação do Ambiente Marinho - que os estados têm a obrigação de proteger e preservar o ambiente marinho (artigo 192) e tomar medidas individualmente ou em conjunto para prevenir, reduzir e controlar a poluição do meio marinho a partir de qualquer fonte (artigo 194). Naquela época, os poluentes com maior preocupação eram os metais, pesticidas e derrames de petróleo ilegais ou acidentais. Entretanto, novas substâncias foram sendo produzidas com novas implicações para a saúde dos oceanos e para o bem-estar humano.

Para manter um desenvolvimento sustentável, as Nações Unidas, adoptou a Agenda 2030 para o Desenvolvimento Sustentável, que estabelece 17 Objetivos de Desenvolvimento Sustentável nos quais o Objetivo de Desenvolvimento Sustentável 14 trata da conservação e uso sustentável dos oceanos, mares e recursos marinhos para o desenvolvimento sustentável. Paralelamente, as Nações Unidas aprovaram a criação do Processo Regular para avaliar a qualidade do ambiente marinho que produziu a primeira Avaliação Mundial do Estado dos Oceanos (WOA1), documento recentemente aprovado pelas Nações Unidas, que destaca a preocupação com o impacto das atividades humanas com compostos emergentes no oceano e estabelece que os estados devem prevenir e reduzir significativamente a poluição de todos os tipos de poluição, incluindo detritos marinhos.

A falta de tratamento adequado e inovador das águas residuais urbanas e libertação para o oceano de diversos stressores a partir de fontes de contaminação terrestre pontuais e difusas e do mar constitui uma das principais ameaças para a manutenção de um oceano saudável. Entre os principais stressores do oceano a nível global, incluem-se os detritos marinhos, 80% dos quais têm origem em fontes terrestres, e são considerados atualmente os de maior preocupação. O impacto dos plásticos e, em particular, dos microplásticos para os recursos marinhos e para a biodiversidade será discutido.

Palavras-chave: Oceano; detritos marinhos, microplásticos

Introduction

I met Professor Mário Ruivo 40 years ago when I had the chance to be nominated member of the Portuguese delegation to the United Nations Conference of the Law of the Sea (UNCLOS). At that time he was the head of the Portuguese delegation. As a young scientist I had the enormous chance to begin my international carrier in the most important political arena of the world. I do clearly remember how I was amazed to see the prestige and recognition that Professor Mário Ruivo had among heads of delegations and world leaders. We worked together since then in several landmarks of the development of marine sciences in Portugal namely: in the programme for the dynamization of the marine sciences and technology, the commission for the evaluation of the State Laboratories on marine sciences, the National Council for Sustainable Development of the Ministry of Environment, the of COI – Intersec and in the preparation of several documents for the EXPO 98. In the international fora, in the General Assembly of the International Oceanographic Commission (IOC) of UNESCO where, at the time, he was Secretary Executive and later head of Portuguese delegation and in the Marine Board of the European Union. Again the recognition I saw at the United Nations some years ago continued and was reinforced at science and marine policy level. Moreover, at the national level he played a decisive role for the success of the development of the marine sciences in Portugal.

Coming back to the time I met Mário Ruivo during the negotiations of UNCLOS, I had the role, within the Portuguese delegation, to participate in the 3rd Commission on Protection and Preservation of the Marine Environment. This Commission was responsible for PART XII – Protection and Preservation of the Marine Environment of UNCLOS (UNCLOS, 1982). At that time, following several environmental accidents that resulted in the Minamata and the Itai-itai diseases due to mercury and cadmium poisoning, and took the life of several people particularly in Japan, Sweden and Iraq among others, the stressors of concern in the ocean where those that nowadays are known as traditional contaminants and included metals, organohalogenated compounds, illegal or accidental oil spills and pesticides. Dumping of wastes in the ocean, including radioactive wastes, was still allowed. Pollution from land-based sources was already a major concern along with pollution from vessels and from the atmosphere.

The Convention was signed by Portugal twenty years ago (3rd of November 1997) but was already in force since the 16th of November 1994. Provisions on Part XII of the Convention established that, *States have the obligation to protect and preserve the marine environment* (article 192) *even when they want to exploit their natural resources* (article 193) and *states have to take measures individually or jointly to prevent and control pollution of the marine environment from any source using the best practicable means at their disposal* (article 194).

Although the efforts taken, during the last 40 years, in the North Atlantic and in other parts of the world to reduce the impact of these stressors were successful, the export of less environmentally friendly technologies from the developed world to developing countries and the development of new technologies therein, increased the input of some of these traditional contaminants of concern in other parts of the ocean and, even after 40 years, the levels of these stressors in several parts of the world ocean are still increasing (UN, 2016).

In the meantime, the increase of the world population and the quality of life along with life expectancy lead to the development of thousands of new products some of which are of environmental concern. Although being produced on land they are introduced into the ocean due mainly to the lack of treatment or of innovative technologies for wastewater treatment able to reduce the input of these compounds into the ocean or from other land-based non-point sources or from atmospheric transport. Therefore new problems emerge and the presence in the ocean of pharmaceutical compounds, personal care products (PCPS), nanoparticles, compounds that induce endocrine disruption and litter including plastics are the new emerging stressors of concern (Brauch and Rand, 2011).

Because the ocean capacity is decreasing and there is an urgent need to maintain its sustainable development, the United Nations decided to adopt under the 2030 Agenda for Sustainable Development, 17 Sustainable Development Goals (SGDs). Sustainable Development Goal 14 applies to the ocean and aimed to conserve and sustainably use the ocean, seas and marine resources for sustainable development.

On Table 1 the targets and indicators for SDG 14 are listed and on Figure 1 the SDGs presented highlight the ones that will contribute to SDG 14 and the ones that will benefit from it. At the same time a Regular Process for the Global Reporting and Assessment of the State of the Marine Environment was established under the United Nations and The First Global Integrated Marine Assessment also known as Word Ocean Assessment I was produced and recently endorsed by the United Nations (UN, 2016). The scope of the first cycle was to establish a baseline of the state of the ocean while the second five-year cycle of the Regular Process, launched in 2015, will also include socioeconomic aspects and will focus on evaluating trends.

Figure 1 – Sustainable development goals that will contribute and benefit from the targets of SDG 14.

Impact of marine debris in the ocean

One of the main targets of SDG14 is to prevent and significantly reduce, by 2025, *marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution*. The amount of marine debris, 80% of which came from land-based

Table 1. Targets and indicators for Sustainable Development Goal 14 (UN, 2016).

Targets	Indicators
14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution	**14.1.1** Index of coastal eutrophication and floating plastic debris density.
14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans.	**14.2.1** Proportion of national exclusive economic zones managed using ecosystem-based approaches.
14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels.	**14.3.1** Average marine acidity (pH) measured at agreed suite of representative sampling stations
14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics.	**14.4.1** Proportion of fish stocks within biologically sustainable levels
14.5 By 2020, conserve at least 10% of coastal and marine areas, consistent with national and international law and based on the best available scientific information.	**14.5.1** Coverage of protected areas in relation to marine areas.
14.6 By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation.	**14.6.1** Progress by countries in the degree of implementation of international instruments aiming to combat illegal, unreported and unregulated fishing.
14.7 By 2030, increase the economic benefits to Small Island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism	**14.7.1** Sustainable fisheries as a GDP % in small island developing States, least developed countries and all countries.

sources, represents a threat to the health of the world ocean and a global pollution problem (Allsop et al., 2006). Marine debris are present in several areas of the ocean from densely populated to remote areas and from shallow waters to the deep ocean (Pham et al., 2014). Moreover, it is estimated that 60 to 80% of marine debris is plastics.

Plastic production started in the 40's, and due to their light weight and durability have a wide range of applications. Its production reached around 322 million tons in 2015, and is expected to grow 4% a year. Plastics have different chemical composition that includes polyethylene (PE), polyethylene terephthalate (PET), polypropylene (PP), polyvinyl chloride (PVC), and polystyrene (PS) (Plastics - the Facts, 2010). They also have different densities some of them higher than seawater. Plastics enter the ocean from land-based sources or from ships. Within the ocean, the plastic is broken down by solar radiation and wave action into small pieces that when they reach size <5 mm are known as microplastics and if they are even smaller (<100 μm) they are considered nanoplastics. Plastic found in the ocean include a wide range of materials namely: fishing nets, ropes, buoys, plastic bags, plastic packaging, plastic toys, tampon applicator and plastic resin pellets.

The density of plastic identified in the ocean vary between 13000 and 18000 pieces per square kilometre while data on plastic accumulation in the North Atlantic and Caribbean showed to be more than 200000 pieces per square kilometre (Law et al., 2010). For that reason, the World Economic Forum drew the attention to the fact that if no action is taken, by 2050 the ocean will have more plastic that fish (World Economic forum, 2016). Examples of marine mammals and turtles entangled with plastic bags or with "ghost" fishing nets, fish and birds with caps of water bottles and plastic particles in their stomach were identified and shared all over the world by the media.

Within the ocean, plastic can be accumulated by marine organisms and biomagnified. They can also adsorb persistent, bioaccumulative and toxic (PBT) compounds present in the ocean from other sources and act as carriers of these stressors to marine organisms where they can be a vehicle of biomagnification of other contaminants. On the other hand, plastic contain several potential toxic compounds known as additives that can be released to the ocean and became bioavailable to marine organisms and have toxicological effects (Litner et al., 2011). Conversely, marine organisms can act as a source of microplastic bioavailability to humans.

Effects of microplastics in the ocean

Microplastics besides being formed as a result of macroplastic broken down, are also introduced in the ocean through point sources from untreated sewage or in treated wastewater effluents. For that reason microplastics are classified as primary (particles originally manufactured to be that size) and secondary (result from the breakdown of large particle items) (Kershaw, 2015). It is estimated that around 35 000 tons of microplastics were detected floating in the ocean and that the amount in the North Pacific Gyre has doubled in the last four decades (Cozar et al., 2014). In Portugal, 62% of microplastics were identified by trawling, with a density of 580 000 particles per km^2 and detected in 61% of the water samples collected along the Portuguese coast ranging from 0.002 to 0.036 particles m^{-3} (Frias et al., 2014). Nevertheless, information about micro and nanoplastic effects in marine organisms is very scarce. For this reason several research projects were funded by the European Union under JPI Ocean Programme. One of them is the JPI Ocean project EPHEMARE whose aim is to assess the toxic effects of microplastics on marine organisms (www.jpi-oceans.eu/ephemare). Recent results reported from the EPHEMARE project identify new plastic species that were named as zooplastics that organisms by mistake identify them as good food.

Within the EPHEMARE project, the Centre of Marine and Environmental Research (CIMA) of the University of Algarve has to assess the acute toxicity and carry out laboratory experiments with different types of microplastics (polystyrene and polypropylene) with size ranging from (6-500 μm) of virgin microplastics or with several organic contaminants adsorbed (benzo[a]pyrene - BaP, benzophenone-3 – BP3, and perfluorooctane sulfonic acid – PFOS)) using the clam *Scrobicularia plana* as a bioindicator along with the collection of different marine species (shellfish, crustaceans and fish) from different areas in the South Coast of Portugal to access the microplastics levels accumulated from the field (www.jpi-oceans.eu/ephemare). Toxic data obtained with Microtox assay revealed that the EC_{50} levels are extremely high (ranging from 418-1284 mg/l) and still difficult to be reached in the oceans. Regarding chronic effects, the exposure of *S. plana* exposure to 1 mg L^{-1} of PS microplastics (20 μm) for two weeks and depurated for another week, revealed, by Diffuse Reflectance Infrared Fourier Transform Spectroscopy (DRIFT), the presence of PS microplastics in the gills and digestive gland, while using a microscope it was possible to detect the presence of individual or aggregated/agglomerated microplastics in the haemolymph. Once accumulated in *S. plana* PS microplastics induce oxidative stress, genotoxicity and oxidative damage indicating that microplastic accumulation induce a cascade of stress responses. Moreover, microplastics were not eliminated after one week of depuration and some of the biological effects still persisted. These results indicate that if the situation in the ocean does not improve in the future, this clam population can be in danger and can also represent a possible source for microplastic accumulation by humans (Ribeiro et al., 2017).

Moreover, microplastics have a large ratio of surface area to volume that can easily adsorb and concentrate other stressors including PBTs from other sources on their surface and transport them a long way. In order to assess the impact of microplastics with PBT stressors adsorbed, known concentration BaP, BP3 and PFOS were adsorbed to low density polyethylene microplastics (LPDE) to assess their effects in *S. plana*. BaP is a polycyclic aromatic hydrocarbons (PAHs) well known carcinogenic and also with endocrine disruption properties that are present in the oceans as a result of deliberated and accidental oil spills, BP3 a organic UV filter present in sunscreens and in other personal care products (PCPs) known to accumulate and biomagnify in the marine environment, and PFOS a class of perfluorinated alkylated substances, produced synthetically in an electrochemical fluorination process.

S. plana were exposed to 1 mgL^{-1} of LPDE with size range of 11-13 μm and with known concentrations (from ng/g to μg/g range) of the organic stressors. Results highlighted that the biological effects induced by the presence of microplastics with or without adsorbed organic compounds were dependent on the type of plastic and type

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of contaminants adsorbed. In some cases there were synergistic (super oxide dismutase and lipid peroxidation) and in other antagonistic effects in the clam gills due to the presence of LPDE and adsorbed contaminants (O'Donnovan, 2017) suggesting that physical ingestion or toxicity might be dependent on the type of organic contaminant adsorbed.

Conclusions

These results highlight the importance of the negative impact of microplastics to the health of the oceans and point out to the fact that exposure to PS seems to have an increased toxicity compared with that of LPDE indicating that among these two types and sizes of microplastics, PS seems to have higher toxicity for the marine environment health.

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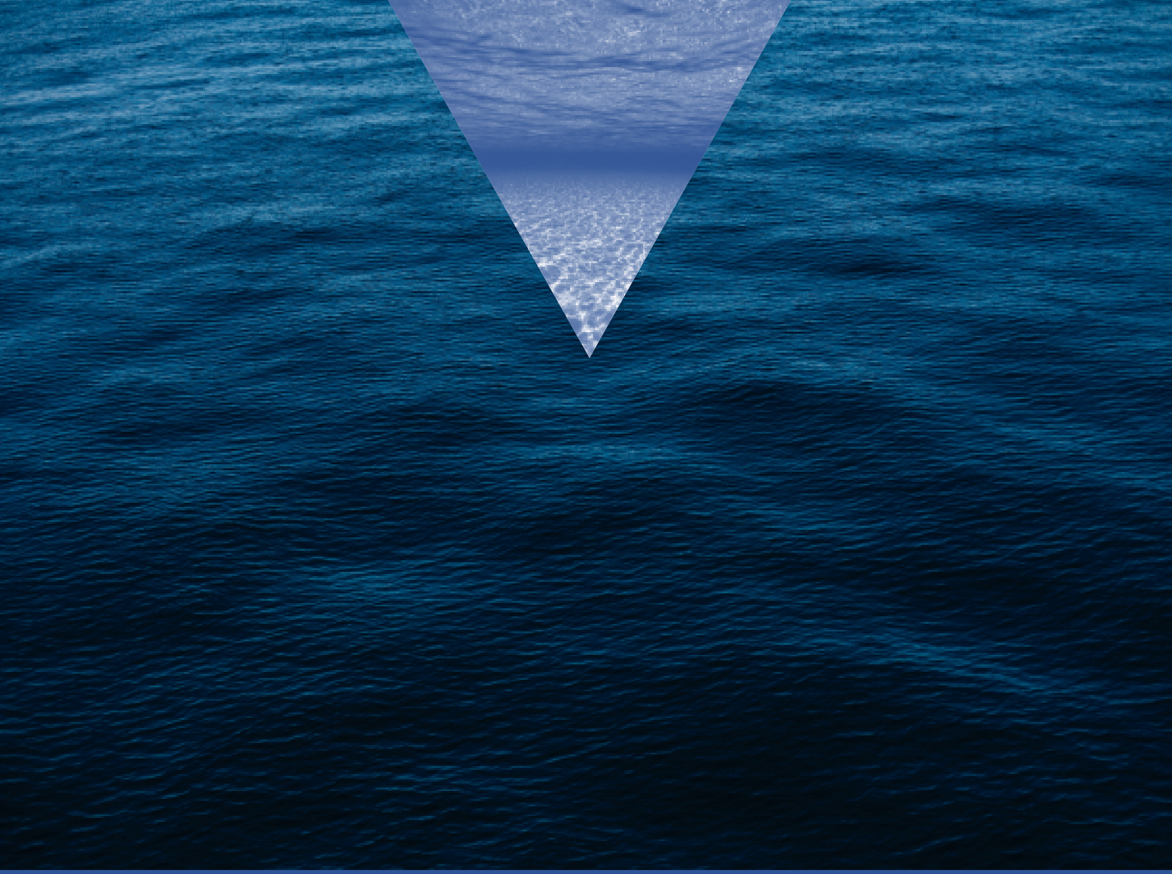

SESSÃO DE ENCERRAMENTO

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CLOSING SESSION

Mário Ruivo: uma ação persistente no desenvolvimento das ciências do mar

Luis Magalhães[1]

Agradeço o convite para intervir nesta conferência e felicito os organizadores por a dedicarem a homenagear o Professor Mário Ruivo.

Devido ao adiantado da hora e a estarmos no final de dois dias de trabalho nesta conferência a minha intervenção será curta.

O Oceano é simultaneamente uma grande **oportunidade de futuro** – também para Portugal – e uma **responsabilidade comum** de o manter em boas condições para a vida do Homem e outras espécies, remediando erros que foram feitos.

A Universidade do Algarve tem nesta área um importante campo de afirmação e uma enorme oportunidade de diferenciação, que já se tem afirmado mas ainda pode ser melhor aproveitada, precisamente no espírito desta conferência em que se olha o Oceano numa perspectiva global e multifacetada, englobando os aspectos de recursos marinhos, biotecnologia, sustentabilidade ambiental, tecnologias no e para o Oceano, e o direito do Mar – precisamente a perspectiva de Mário Ruivo.

Tive oportunidade de beneficiar do convício com Mário Ruivo a partir de 1996, quando, um ano antes de iniciar funções de 5 anos como primeiro presidente da FCT – Fundação para a Ciência e a Tecnologia, coordenei a primeira avaliação internacional de Unidades de I&D e Mário Ruivo coordenou o painel de avaliação de Ciências e Tecnologias do Mar. Depois fomos colaboradores intensos e cúmplices em várias iniciativas marcantes com efeitos que perduraram.

Desde logo, o Programa Dinamizador de Ciências e Tecnologias do Mar de 1998-2002, com vertentes de financiamento de projectos,

[1] Instituto Superior Técnico, Lisboa

bolsas e equipamentos, mas sobretudo de um esforço de coordenação que se deve muito a Mário Ruivo. Essa área foi então identificada como prioritária e requerendo uma perspectiva e acção orientadas. É de recordar que na altura a investigação em Ciências do Mar era incipiente e circunscrevia-se a um pequeno número de cientistas isolados ou em pequenos grupos – heróis e heroínas nas actividades que protagonizavam mas sem grandes oportunidades de projecção e impacto.

O Programa Dinamizador de Ciências e Tecnologias do Mar alterou em pouco tempo essa situação e criou as condições para uma rota que colocou Portugal numa posição bastante interessante no panorama internacional.

Lembro-me quando em 2008 fui visitado por um alto responsável da editora científica Elsevier na Agência para a Sociedade do Conhecimento (UMIC), a que presidi durante 6 anos e meio com início em Julho de 2005. Este responsável da Elsevier pretendia, naturalmente, aumentar as vendas para a b-on – Biblioteca Científica Online, que foi promovida, orientada e financiada pela UMIC, e também queria passar a vender serviços de valor acrescentado com base na análise de publicações científicas. Para me encher o olho trazia um estudo muito bem concebido e com uma apresentação gráfica notável sobre a área em Portugal que, de um ponto de vista de análise bibliométrica com metodologias inovadoras, tinha uma evolução que mais se destacava de outros países na altura. Surpresa das surpresas: a área era Ciências e Tecnologias do Mar.

Desde o início do Programa Dinamizador de Ciências e Tecnologias do Mar, Mário Ruivo – Coordenador do Programa – imprimiu-lhe uma orientação inovadora e vista na altura com grande desconfiança por biólogos e geólogos marinhos, que tradicionalmente estavam quase isoladamente ligados às Ciências do Mar. Defendeu que era essencial trazer para o Programa as **tecnologias de exploração e observação do Oceano** – modelação, robótica, sensores, sistemas de informação e computação avançados. Iniciou um percurso difícil, como sempre que se aproximam áreas que tinham pouco contacto, mas que foi fortemente útil e produtivo e que se vê hoje a fazer parte do nosso contexto natural, até na escolha dos temas desta conferência. Uma outra área de insistência de Mário Ruivo era a investigação sobre o **Mar Profundo**, expressão que pronunciava com uma ênfase fonética muito própria e inesquecível, como se faz para algo misterioso, reveladora da grande paixão que tinha pelo assunto.

Note-se que já em 1970 Mário Ruivo tinha tido um papel fundamental na organização na ONU da 1ª Conferência sobre Poluição do Meio Marinho e dos Seus Recursos, revelando a perspectiva ampla que já nessa altura tinha das questões marinhas.

Um outro episódio em que a nossa parceria teve um desenvolvimento interessante foi o da 1ª Comissão para o Alargamento da Plataforma Continental, que integrámos. Nesta Comissão foram criadas as bases para o processo de alargamento da plataforma continental. Na altura, a Marinha Portuguesa tinha uma perspectiva deste assunto quase exclusivamente territorial e de defesa. Com posições concertadas entre nós os dois fomos conseguindo que ficasse bem expresso que esse alargamento devia ser feito em estreita colaboração com a comunidade científica e as missões de levantamento de dados deveriam sempre incluir cientistas que se envolveriam noutras actividades, além das directamente relacionadas com os levantamentos necessários para instrução da candidatura a alargamento da plataforma continental. Foi o início de um esquema de partilha de meios e navios com a comunidade científica que, depois de um arranque vigoroso, teve altos e baixos, mas acabou por atingir uma situação de normalidade que, mesmo assim, deveria ser intensificada pois tem ampla margem para isso e apresenta um óbvio potencial de significativos benefícios.

Também não podemos esquecer o papel de Mário Ruivo para a realização da EXPO98, em particular na escolha do Oceano como tema da exposição e, muito especialmente, nas negociações e redacção da Declaração de Lisboa da Comissão Mundial Independente para os Oceanos intitulada "Para uma Governação do Oceano no séc. XXI: Democracia, Equidade e Paz no Oceano". Esta declaração sublinhava logo no início a **Unidade do Oceano** – no singular (e Mário Ruivo não se cansava de nos lembrar a contribuição única de Portugal para essa unificação, sucessivamente Atlântico-Índico, Atlântico-Pacífico e Pacífico-Índico, levando a um Oceano contínuo em todas as longitudes). Nesta declaração encontramos passagens (premonitórias) **críticas das forças de mercado globais** e o sublinhar da **importância da equidade**. Alertava que a governação eficaz do Oceano depende da concretização de melhores **ideias**, **métodos de cooperação** e **institui-**

ções. Além disso, sublinhava a importância da **participação** em parceria de governos, entidades não-governamentais e sociedade civil em geral.

É grandioso e admirável o legado de Mário Ruivo. Era sábio, sagaz, prático, persistente mesmo em face de obstáculos que pareciam intransponíveis, extremamente organizado e com uma capacidade de concretização individual que excedia a de equipas competentes – tinha a fibra do que em gíria militar se chama operações especiais.

Inspirou-nos e deu-nos um exemplo de vontade inquebrantável em todas as alturas, mesmo quando dizia “a navegação não está nada fácil, mas a jangada, entre ventos e marés, lá se vai aguentando!”

Temos todos de contribuir para que esse espírito perdure e se renove!

Biographical Notes

António Branco
PhD in Portuguese Literature, Faculty of Human and Social Sciences, University of Algarve, Portugal.
Professor at the Faculty of Human and Social Sciences, University of Algarve, Portugal.
Researcher at the Centre for Research in Arts and Communication, University of Algarve, Portugal.
Former Rector of the University of Algarve.

Rogério Bacalhau Coelho
Degree in Mathematics, Faculty of Sciences and Technology, University of Coimbra, Portugal.
Mayor of the Faro Municipality, Portugal.

Patricio A. Bernal
PhD in Oceanography, Scripps Institution of Oceanography University of California, San Diego, USA.
Professor at the Pontifical Catholic University of Chile, Santiago UC, Chile.
Former Coordinator of the High Seas Biodiversity Initiatives, IUCN.
Former Executive Secretary of the Intergovernmental Oceanographic Commission (IOC-UNESCO).

Jean-Pierre Levy
PhD in International Law, University of Strasbourg, France.
Member of the Finance Committee of the International Seabed Authority.
Former Director of the United Nations Division for Ocean Affairs and the Law of the Sea. Member of the Independent World Commission

on the Oceans (The Soares Commission). Participation as United Nations staff member to the Third United Nations Conference on the Law of the Sea.

Vladimir Ryabinin
PhD in Physical and Mathematical Sciences (Oceanography and Geophysics), Supreme Attestation Committee of the Russian Federation, Moscow, Russia.
Executive Secretary of the Intergovernmental Oceanographic Commission (IOC-UNESCO) and Assistant Director General.

New Dwyer
PhD in satellite remote sensing applications, Instituto Superior Técnico, Portugal.
Executive Director of the Eurocean Foundation

João Guerreiro
PhD in Economic Science, University of Algarve, Portugal.
Professor at University of Algarve. Former Rector of the University of Algarve.
Member of the National Council of the Environment and Sustainable Development.

Ricardo Serrão Santos
PhD in Biology and Animal Ecology by the University of Liverpool, UK and the University of the Azores, Portugal.
Member of the European Parliament.
Principal Researcher at the University of the Azores.
Former Provost for the Integration of Sea Affairs, University of Azores.

Maria Eduarda Gonçalves
PhD in International and European law, University of Nice, France.
Professor at ISCTE-Lisbon University Institute and Researcher at Dinâmia'CET-IUL, Centre for socioeconomic and territorial studies.
Member of the Delegation of Portugal to the III UN Conference on

the Law of the Sea (1975-78) and to the FAO Committee on Fisheries (1977-79).
Delegate of Portugal to the Advisory Group of Experts on the Law of the Sea (ABE-LOS) of the IOC/Unesco.

Ana Paula Vitorino
Minister of the Sea of Portugal.
Masters in Transportation, Instituto Superior Técnico, Lisbon, Portugal.
Professor at Instituto Superior Técnico and Researcher at CESUR - Urban and Regional Systems Center.
Secretary of State for Transport in the XVII Constitutional Government - 2005-2009, and Member of the Assembly of the Republic since 2009.
Director and Editor-in-Chief of Cluster Magazine since 2012, and author of several articles published in technical or scientific journals in the area of Transport, Infrastructure, Logistics and Economy of the Sea.

Maria Inês Gameiro
PhD in International Law, New University of Lisbon, Portugal.
Researcher at CIMA – Centre for Marine and Environmental Research, University of Algarve; Dinâmia'CET-IUL, Centre for socioeconomic and territorial studies and CEDIS – Research Center on Law and Society, New University of Lisbon.
Member of the World Commission on Environmental Law – IUCN.

Luís M. Pinheiro
PhD in Marine Geophysics, Imperial College, London, UK.
Professor at the University of Aveiro, Portugal. Researcher at CESAM – Centre for Environmental and Marine Studies, University of Aveiro.
Executive President of the Portuguese Committee for the Intergovernmental Oceanographic Commission IOC/UNESCO.

Vitor H. Magalhães
PhD in Geosciences. University of Aveiro, Portugal.
Researcher at IPMA - Portuguese Institute for the Ocean and Atmosphere.

Ana Hilário

PhD in Ocean and Earth Science, National Oceanography Centre, University of Southampton, UK.
Assistant Researcher at CESAM – Centre for Environmental and Marine Studies, University of Aveiro.

Maria Baker

PhD in Fertilization kinetics, University of Southampton, UK.
Senior Research Fellow within Ocean and Earth Science, National Oceanography Centre Southampton at the University of Southampton, UK.

Sérgio Alves de Carvalho

Master's degree in European Studies (Institute of Political studies of the Portuguese Catholic university); law degree (faculty of law of the university of Coimbra).
Head of unit in charge of oceans affairs and law of the sea at the directorate-General for foreign Policy, Ministry of foreign affairs.
National representative and member of the EU negotiating team in the negotiations on the new UNClOS Implementation agreement on the conservation and sustainable use of marine biodiversity in areas beyond national jurisdiction; expert responsible for supporting the work of co-facilitating the negotiations of the political declaration of the first United Nations Ocean Conference.

Ana Colaço

PhD in Ecology and Biossistematics, University of Lisbon.
Principal Researcher at IMAR - Institute of Marine Research,
Centro Okeanos-University of the Azores, Portugal.
Member of the Board of the MARE-Marine and Environmental Sciences Centre
Member of the InterRidge "Integrating Multidisciplinary Observations in Vent Environments .
Member of the ICES Deep-sea Ecology working group.

Marina Carreiro-Silva

PhD in Marine, Estuarine and Environmental Sciences, University of Maryland, USA.

Researcher at MARE-Marine and Environmental Sciences Centre and at IMAR - Institute of Marine Research, University of the Azores, Portugal.

Catarina Eira
PhD in Animal Parasitology, Pharmacy Faculty, University of Barcelona.
Researcher at CESAM - Centre for Environmental and Marine Studies, University of Aveiro.

Sílvia Monteiro
PhD in Biology, University of Minho, Portugal.
Researcher at CESAM - Centre for Environmental and Marine Studies, University of Aveiro.

Fátima M. Sousa
PhD in Oceanography, University of Lisbon.
Professor at Faculty of Sciences, University of Lisbon, Portugal.
Researcher at MARE – Marine and Environmental Sciences Centre.

Helena Frazão
Master of Marine Sciences, University of Lisbon.
Research grant of the Project TROANTE.

Pedro Raposo de Almeida
PhD in Biology, University of Lisbon.
Professor at the University of Évora. Researcher and member of the Board at MARE – Marine and Environmental Sciences **Centre**.

Bernardo Quintella
PhD in Biology, University of Lisbon.
Professor at Faculty of Sciences, University of Lisbon, Portugal.
Researcher at MARE – Marine and Environmental Sciences **Centre**.

Catarina S. Mateus
PhD in Biology, University of Évora, Portugal.
Post-doctoral Researcher at MARE – Marine and Environmental Sciences Centre

C. M. Alexandre
PhD in Biology, University of Évora, Portugal.
Post-doctoral Researcher at MARE – Marine and Environmental Sciences Centre

S. Pedro
PhD in Biology, University of Lisbon, Portugal.
Researcher at MARE – Marine and Environmental Sciences Centre.

Emanuel J. Gonçalves
PhD in Biology (Ecology and Biosystematics), University of Lisbon, Portugal.
Professor at ISPA, Instituto Universitário de Ciências Psicológicas, Sociais e da Vida, Lisbon, Portugal.
Member of the Board of Directors of the Oceano Azul Foundation.
Member of the National Council of the Environment and Sustainable Development.
Former Deputy-head of the Portuguese Task Group for Maritime Affairs under the Secretary of State of Defense and Sea Affairs.

Fernando J. A. S. Barriga
PhD in Geology, University of Western Ontario, Canada.
Professor at Faculty of Sciences, University of Lisbon, Portugal.
Former Director of the Natural History National Museum (Mineralogy and Geology).
Former Director of Creminer - Centro de Recursos Minerais, Mineralogia e Cristalografia, Faculty of Science, University of Lisbon, Portugal.

Nélia C. Mestre
PhD in Ocean and Earth Sciences, University of Southampton, United Kingdom Researcher at CIMA – Centre for Marine and Environmental Research, University of Algarve, Portugal.

Adelaide Almeida
PhD in Biology, University of Aveiro, Portugal.
Professor at University of Aveiro.

Researcher at CESAM - Centre for Environmental and Marine Studies, University of Aveiro.

André Pacheco
PhD in Physical Oceanography, Universidade do Algarve, Portugal and University of Plymouth, UK.
Researcher at CIMA – Centre for Marine and Environmental Research, University of Algarve.
CIMA Vice Director. Coordinator of the Marine Offshore Renewable Energy Team at CIMA.

João Varela
PhD in Biochemistry, Faculty of Sciences, University of Lisbon, Portugal.
Researcher at CCMAR – Centre of Marine Sciences, University of Algarve, Coordinator of the Group of Marine Biotechnology.
Professor at Sciences and Technology Faculty, University of Algarve, Portugal.

Sara Raposo
PhD in Biotechnological Sciences, University of Algarve, Portugal.
Researcher at CIMA – Centre for Marine and Environmental Research, University of Algarve, Coordinator of the Group of Engineering and Environmental Biotechnology.
Professor at Sciences and Technology Faculty, University of Algarve.

Ana Paula Mucha
PhD in Aquatic Sciences, University of Porto, Portugal.
Principal Investigator at CIIMAR – Interdisciplinary Centre of Marine and Environmental Research, University of Porto, Team Leader of the EcoBioTec Group (Bioremediation and Ecosystems Functioning).
Scientific Coordinator of the CMIA – Environmental Monitoring and Interpretation Centre of Vila do Conde, Portugal.

M. Fátima Carvalho
PhD in Biotechnology, Portuguese Catholic University, Portugal.

Researcher at CIIMAR – Interdisciplinary Centre of Marine and Environmental Research, University of Porto.

Sandra Ramos

PhD in Aquatic Sciences, Institute of Biomedical Sciences Abel Salazar, University of Porto, Portugal.
Researcher at CIIMAR – Interdisciplinary Centre of Marine and Environmental Research, University of Porto.
Professor at Instituto de Ciências Biomédicas Abel Salazar, University of Porto.

Catarina Magalhães

PhD in Marine Sciences, University of Porto, Portugal.
Researcher at CIIMAR – Interdisciplinary Centre of Marine and Environmental Research, University of Porto.
Professor at University of Porto and member of the Coordination Committee of the Portuguese Polar Program.

C. Marisa Almeida

PhD in Chemistry, Faculty of Sciences, University of Porto, Portugal.
Researcher at CIIMAR – Interdisciplinary Centre of Marine and Environmental Research, University of Porto.

Ana Lillebo

PhD in Biology, University of Coimbra, Portugal.
Principal Researcher in Marine Biotechnology & Aquaculture and Scientific coordinator of CESAM - Centre for Environmental and Marine Studies, University of Aveiro.
Director of the Master course in Marine Biology, University of Aveiro

Cristina Veiga Pires

PhD in Environmental Sciences, University of Quebec in Montreal - UQAM, Canada.
Researcher at CIMA – Centre for Marine and Environmental Research, University of Algarve, and associated researcher at GEOTOP-McGill-UQAM Research Center.

Professor at Sciences and Technology Faculty, University of Algarve, Portugal.
Executive Director of Algarve Ciência Viva Interactive Science Museum, Portugal.

Telmo Carvalho
Master's degree in Social Sciences (science policy).
Member of the Board of Directors of the Portuguese Institute for the Sea and Atmosphere (IPMA)
Advisor of the Minister of the Sea of Portugal (2015-2018), Coordinator of the Ocean Office of the Portuguese Foundation for Science and Technology (2015) and Executive Director of the European Centre for Information on Marine Sciences and Technology (EurOcean - 2009-2014).

Maria João Bebianno
PhD in Ecotoxicology, University of Reading, United Kingdom and in Oceanography, University of Algarve, Portugal.
Professor of the University of Algarve.
Coordinator of CIMA – Centre for Marine and Environmental Research, University of Algarve. Member of the group of Experts of the Regular Process for Global Reporting and Assessment of the state of the Marine Environment, including Socio-economic Aspects of the United Nations. Member of the Portuguese delegation to the III United Nations Conference on the Law of the Sea (1978-1981).
President of the Portuguese Society of Women in Science – AMONET.

Luís Magalhães
PhD in Applied Mathematics, Brown University, USA.
Professor at Instituto Superior Técnico, University of Lisbon, Portugal.
Former President of the Foundation for Science and Technology, Portugal.
Chair of the OECD Working Party on Indicators for the Information Society and Head of the Portuguese Delegation to the OECD Committee on Information, Computers and Communication Policy.
Former President of the General Council of the University of Algarve.

List of Abbreviations and Acronyms

ABE-LOS	Advisory Body of Experts on the Law of the Sea
ADCP	Acoustic Doppler Current Profilers
Agenda 21	United Nations Conference on Environment and Development
AOM	Anaerobic Methane Oxidation
BaP	Benzo[a]pyrene
BBNJ	Biodiversity in Areas Beyond National Jurisdiction
BSR	Bottom Simulating Reflectors
CCZ	Clarion-Clipperton Zone
CIMA	Centre of Marine and Environmental Research
CNADS	Conselho Nacional do Ambiente e do Desenvolvimento Sustentável
COI-MCTES	Comissão Oceanográfica Intersectorial do Ministério da Ciência, Tecnologia e Ensino Superior
CTD	Conductivity, Temperature, and Depth
DGAM	General Directorate of the Maritime Authority
DGRM	General Directorate of Marine Resources
DOSI	Deep Ocean Stewardship Initiative
DRIFT	Diffuse Reflectance Infrared Fourier Transform Spectroscopy
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EMSO	European Multidisciplinary Seafloor and water column Observatory
EOV	Essential Ocean Variable
EU	European Union
EurOcean	European Centre for Information on Marine Science and Technology
EUROGOOS	European Global Ocean Observing System
FAO	Food and Agriculture Organization of the United Nations
FCT	Fundação para a Ciência e a Tecnologia
GMES	Global Monitoring for Environment and Security
GOOS	Global Ocean Observing System
Group of 77	United Nations Intergovernmental Organization of Developing Countries
IOC	International Oceanographic Commission ofthe United Nations
IODE	International Decade of Ocean Science
ISA	International Seabed Authority
IWCO	Independent World Conference of the Oceans
LPDE	Low density polyethylene microplastics
MAC	methane-derived authigenic carbonates

MUD	Movimento Universitário Democrático
NAFO	Northwest Atlantic Fisheries Organization
PAHs	Polycyclic aromatic hydrocarbons
PB3	Benzophenone-3
PBT	Persistent, Bioaccumulative and Toxic
PDCTM	Programa Dinamizador das Ciências e Tecnologias do Mar
PE	Polyethylene
PET	Polyethylene terephthalate
PFOS	Perfluorooctane sulfonic acid
PP	Polypropylene
PS	Polystyrene
PVC	Polyvinyl chloride
Rio+20	United Nations Conference on Sustainable Development
RRE	Rare Earth Elements
SAR	Synthetic Aperture Radar
SDG14	Sustainable Development Goal 14 -Conserve and Sustainably Use Oceans, Seas and Marine Resources for Sustainable Development
SMS	Seafloor massive sulphides
TEC	Tidal Energy Converters
Ualg	University of Algarve
UAV	Unmanned Aerial Vehicle
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNCTAD	United Nations Conference on Trade and Development
UNEP	United Nations Environmental Programme
UNESCO	United Nations Educational, Scientific and Cultural organization
USEN/MNE	Unity of Overflights and Naval Scales of the Ministry of Foreign Affairs
WMO	World Meteorological Organisation
WOE	Weight of Evidence

O desaparecimento do Professor Mário Ruivo, após décadas de dedicação às problemáticas do oceano, representou uma perda para toda a comunidade científica. A dimensão do seu prestígio internacional e da sua capacidade de intervenção criou, com o seu desaparecimento, um vazio difícil de colmatar.

O Centro de Investigação Marinha e Ambiental (CIMA), da Universidade do Algarve, entendeu dinamizar uma reflexão abrangendo os temas do oceano e contribuindo, dessa forma, para honrar a memória de Mário Ruivo. Para tal, o CIMA desafiou os centros de investigação das universidades portuguesas que incidem as suas pesquisas nestas problemáticas, e que reconheciam a figura de Mário Ruivo como o grande impulsionador da investigação científica na área das ciências do mar, para se associarem a esta iniciativa.

O resultado deste desafio pode agora ser apresentado. Um conjunto de textos que refletem o "estado da arte" da investigação em ciências do mar realizada pelos centros de investigação das universidades portuguesas. A anteceder essas contribuições, recolhem-se as diversas intervenções destinadas a evidenciar a personalidade de Mário Ruivo, proferidas na primeira sessão da Conferência Internacional que recuperou um dos seus criativos pensamentos: "Desenvolvimento Sustentável do Oceano: uma Utopia Útil".

The disappearance of Professor Mário Ruivo, after decades of dedication to the problems of the ocean, represented a loss for the entire scientific community. The size of its international prestige and its capacity to intervene has created a vacuum that is difficult to overcome.

The Center for Marine and Environmental Research (CIMA), of the University of the Algarve, aimed to stimulate a reflection covering the ocean themes and thus contribute to honor the memory of Mário Ruivo. To this end, the CIMA challenged the marine research centers of the Portuguese universities that focus their research on these issues, and recognized the figure of Mário Ruivo as the great promoter of scientific research in the field of marine sciences, to be associated with this initiative.

The result of this challenge can now be presented in this e-book. A set of texts that reflect the "state of the art" of marine sciences research carried out by the research centers of the Portuguese universities. Prior to these scientific contributions, there were various interventions designed to highlight the personality of Mário Ruivo, during the first session of this International Conference, where and one of his creative thoughts has been taken up: "Sustainable Development of the Ocean: a Necessity."

Com o Alto Patrocínio de Sua Excelência
O Presidente da República