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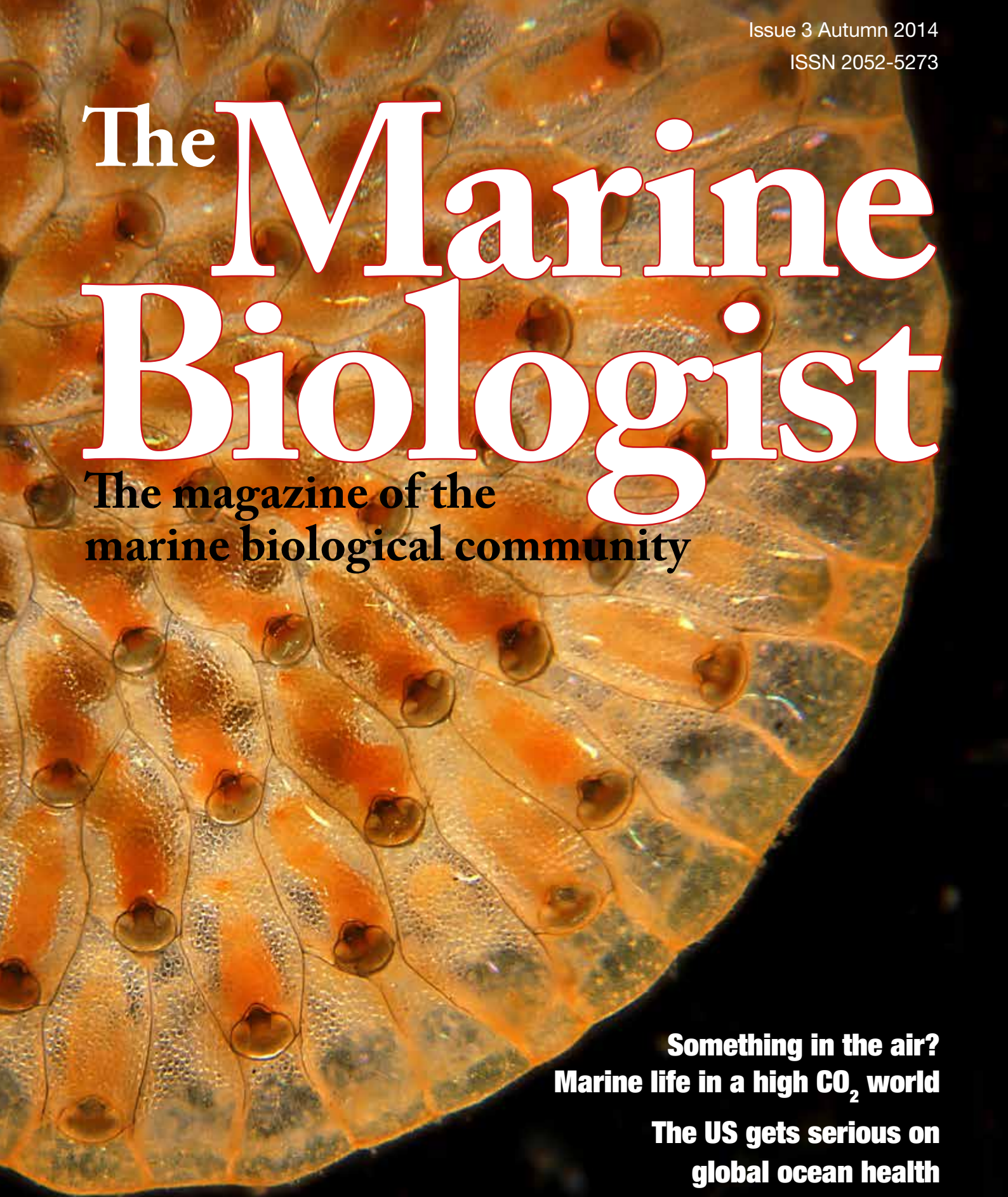
The Marine Biologist

The magazine of the marine biological community



Something in the air?
Marine life in a high CO_2 world

The US gets serious on global ocean health

THE MARINE BIOLOGICAL ASSOCIATION
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White shark populations recover | Azorean lagoons | Inside the squid giant axon

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We welcome submissions of original and relevant material, letters and responses to published articles. For guidance, please see the magazine website at **www.mba.ac.uk/marinebiologist** or contact the Editor.

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Editorial

Do we need 'ocean optimism'?

A very warm welcome to *The Marine Biologist* magazine.

Scientists tend to be a cautious lot, having much to lose from over-egging the implications of their findings. This may explain why good news is often wrapped up in caveats and qualifications, so that if things turn out worse than predicted, expectations have not been dashed. And it is a media maxim that bad news sells. Scientists want to present credible evidence, newspaper editors want to sell papers; it's hardly surprising that we are fed a diet of environmental doom and gloom.

Please bear with me while I hold off from bucking a perfectly good trend. According to recent research (summarized in our headline article on page 6), it is likely that kelp forests will disappear from southern parts of the north-east Atlantic – a shocking prediction of just one of the effects of climate warming and ocean acidification on coastal ecosystems.

But should we focus on the seemingly inexorable degradation of the biosphere or is this counterproductive? In this issue we discover that apex predators, including north-east Pacific white shark populations, are showing signs of recovery (see page 10). At the 'Our Ocean' conference (covered on page 18), some of the world's most powerful people asked scientists to share their knowledge about ocean issues, and help develop an Action Plan to address them. This year, increased protection has been declared for an area of ocean roughly the size of India (including the world's largest marine protected area, the Pacific Remote Islands Marine National Monument).

So, are there grounds for ocean optimism or are science communicators telling good news stories to stave off apathy and helplessness? I would be interested to hear reader's views on this question.

There are a host of careers under the umbrella of 'marine biology'. In this issue we offer information and advice on a career in marine biology for young people. There are around 16 UK universities that offer BSc Hons degrees in marine biology, and we begin a regular feature in which staff and students from one of these institutions tell you why you should consider studying there.

It is 75 years since Hodgkin and Huxley's Nobel Prize winning work on the squid giant axon - a classic example of research using a marine organism having far-reaching consequences for our understanding of basic biology. Page 29 features the least interesting photograph about one of the most fascinating chapters in the history of marine biological research. The picture shows the physical remnants of world-famous research, but I like it because it jars with the perception of scientists as single-minded and serious and is a reminder that those who carried out that research were ordinary people with a sense of humour.

I hope you find plenty to interest you in issue 3 and that as members you are satisfied with the way our magazine is taking shape. As always I am keen to hear feedback and suggestions for improvement.

Front cover: An image of the red ripple bryozoan (*Watersipora subatra*). This is a non-indigenous species spreading rapidly in Great Britain following its first recorded occurrence in 2008. Image: John Bishop, the scale is 4 mm across the page. **Back cover:** Juvenile grey seal (*Halichoerus grypus*) in the Scilly Isles. Image: Sue Daly www.suedalyproductions.com

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Image credits: Top: Juliet Brodie. Middle: Kevin Weng. Bottom: US State Department.

Welcome to the plastisphere: biota may be more efficient at taking up microplastics

In June a study carried out by the University of Cadiz, gathering data from the circumpolar expedition Malaspina 2010 and various other reports, confirmed a worldwide distribution of plastic in the surface of the ocean, accumulating in the five ocean gyres and in Arctic sea ice. However, estimates of the amount of plastic were much lower than expected. One hypothesis regarding the fate of the missing plastic is that—following degradation to microplastic—it has entered the food web.

Marine invertebrates are known to ingest microplastics. But recent research led by the University of Exeter, UK demonstrated that inhalation through gills and gill-like structures of marine organisms is also a significant pathway for microplastics into the food web. Inhalation leads to a residence time up to six times higher than ingestion, increasing significantly its risk of being passed up the food web.

This year has seen a real effort in scientific research regarding plastic pollution but also in policy initiatives, (e.g. in the US the ban of microbeads in Illinois, and of single-use plastic bags in California). Kara Law of the Sea Education Association and Richard Thompson of Plymouth University, two of the world's leading researchers in the field, recently called for urgent action to 'turn off the tap' and divert plastic waste away from the marine environment. Professor Thompson attended the US State Department 'Our Oceans Conference' (see page 18) where he urged society to "reduce, reuse and recycle" plastics.

Marine debris on the Hawaiian coast. Image: NOAA. Source: marinedebris.noaa.gov/marinedebris101/photos_ecosys.html

Wind farms and apex predators

A study led by Dr. Deborah Russell from the University of St. Andrews, Scotland showed that harbour seals and grey seals display grid-like movement patterns at offshore wind farm sites. This type of movement is associated with foraging effort, suggesting that animals adjust their behaviour to make use of these anthropogenic structures. "Ecological consequences of animal-structure interactions are still uncertain and further research is necessary", say Dr. Russell and her colleagues. "With the increasing development of marine renewable energies, it is likely that more and more apex predators will encounter wind farms or other anthropogenic structures."

Grey seals. Image: Guy Baker.

Deep-sea mining

Seven new exploration licences were issued in July by the UN's International Seabed Authority towards the deep-sea mining of precious minerals. The permits have been secured by, amongst others, Russia, Germany, Brazil, Singapore and the UK, and allow for the mining of various valuable mineral deposits as sources of copper, cobalt, gold and manganese. Interest in deep-sea mining is soaring to respond to the increasing demand of our current economies for minerals, particularly in the technology industry.

The seven new licences bring the total area licensed to 1.2 million km² under 26 different licences, with operations set to begin in 2016.

Warnings raised by the scientific community echo those expressed in 2011 when the first deep-sea mining licence was issued to the Canadian company Nautilus to explore a large area of the Bismarck Sea floor. Mining activities result in over 90% of waste, and risks include increased turbidity and toxicity, and irreversible damage to unique habitats. A recent review published in the journal Geosciences summarises the services and functions of deep-sea habitats, and shows how vital the deep-sea is in supporting our current way of life. Lead author of the review Andrew Thurber stated: "there's this idea that we don't know anything about the deep-sea […], we know enough to start to understand how our actions can impact the environment".

New MPAs in Scottish waters

In July, Richard Lockhead, Scottish Cabinet Secretary for Rural Affairs and the Environment, announced the creation of 30 new Marine Protected Areas (MPAs) in Scottish waters. The sites, 17 within territorial waters and 13 offshore, contribute to a network of MPAs established by the Scottish government.

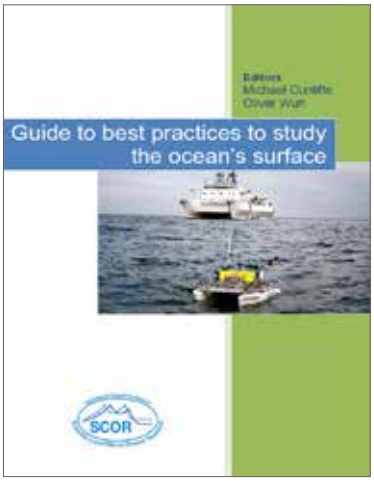
The creation of these new sites contributes to the UK's commitment under international legislation and conventions to take measures to conserve biodiversity and protect the marine environment, including the creation of an ecologically coherent network of MPAs.

They were selected collaboratively by the Joint Nature Conservation Committee (JNCC) and Scottish Natural Heritage to help protect important habitats such as seagrass beds, kelp forests and maerl beds, and deep-sea ecosystems such as coral reefs and sponge beds. The MPAs will safeguard these important ecosystems and will in Richard Lockhead's words "enhance our marine environment so that it remains a prized asset for future generations".

Sampling the ocean surface – a free guide

The sea surface microlayer (SML) is the boundary interface between the atmosphere and ocean, covering 70% of the Earth's surface. With physico-chemical and biological properties that are measurably distinct from underlying

waters, and occupying a unique position at the air-sea interface, the SML is central to a range of global biogeochemical and climate-related processes.



The SCOR (Scientific Committee on Oceanic Research) SML working group brings scientists together from several disciplines to consider chemical, biological and physical aspects of the SML, and to understand governing mechanisms in its formation and role in biogeochemical cycling and climate science.

Members of the working group have produced a guide to best practices to study the ocean's surface, which is freely available to download via the working group website (http://www.scor-int.org/Working_Groups/wg141.htm).

Cunliffe M. & Wurl O. (2014) Guide to best practices to study the ocean's surface. Occasional Publications of the Marine Biological Association of the United Kingdom, Plymouth, UK. 118 pp.

Conferences and events

Share positive stories, says Glasgow conference

the International Marine Conservation Congress (IMCC3), which was held in Glasgow, Scotland in September, is one of the most important gatherings of marine conservation professionals and students on the global conference calendar.

IMCC3 aimed to develop new and powerful tools to further marine conservation science and policy. Discussion topics ranged from genetics, modelling and human impacts to planning and management, valuing our oceans and communicating marine conservation.

A stated aim of the conference was to catalyse change and delegates left with a clear inspirational message to share positive and inspiring stories about the ocean and conservation work as a way of encouraging conservation action in wider society. See the hashtag #oceanoptimism on Twitter.

Spreading the word about ocean literacy in the US and the EU

The Marine Biological Association is part of a growing movement to help citizens become 'ocean literate'.

The National Marine Educators Association (NMEA) was formed in the US in 1976 to bring together scientists and marine educators to 'make known the world of water both fresh and salt'. In 2004 work began on the development of the 'Ocean Literacy Framework' with its seven essential principles; these are now seen as the foundation for teaching about the ocean in both formal and informal education.

The NMEA annual conference provides an opportunity for educators to network and share resources and inspiration.

Supported by the NMEA's scholarship scheme, MBA Education Team member Fiona Crouch travelled in July to Annapolis, USA for the the 2014 conference. Fiona presented on the MBA's education work and EMSEA, and attended the Global Ocean Literacy meeting prior to the main conference.

The EMSEA 2014 conference in Gothenburg, Sweden wrapped up as we go to press. More detail on the outcomes of these conferences and ocean literacy developments will appear in the next edition of *The Marine Biologist*.

Plymouth hosts the 16th Challenger conference

The Challenger Conference for Marine Science arrived in Plymouth, UK this year and welcomed scientists and students from all over the world.

Policy has only recently been included in the Challenger Conference discussions, but linking scientific research with management emerged as one of the hottest topics.

One major debate that arose during the Marine Policy session was whether or not more scientific data were needed in order to create efficient policies. Chair of the Marine Policy Session Abigail McQuatters-Gollop explained in her blog: "As we get more information we can change our management plans, but we have to act now" (see planktonpolicy.org/blog).

With this statement she echoed one of the key messages of the conference: we need to learn how to use the data that we already have in order to stop delaying actions that are critical to achieving conservation aims.

Sharks and rays are important, make no bones about it

Professor David Sims, Senior Research Fellow at the MBA, is convening the Fisheries Society of the British Isles (FSBI) symposium in Plymouth on the topic of "The Biology, Ecology and Conservation of Elasmobranchs".

The symposium will take place on 27th – 31st July 2015.

References and links for these stories can be found on *The Marine Biologist* website. Scan the QR code to view the web page.

For marine events, see the **UK Marine Science Events Calendar** at **www.mba.ac.uk**

For the latest news from the UK marine science community subscribe to the Marine Ripple Effect or follow on Twitter **@MarineRipple**

Maerl from Iceland. Image: Juliet Brodie.

Losers and winners in a high CO_2 world

Juliet Brodie, Chris Williamson and Jason Hall-Spencer assess the future of northeast Atlantic seaweeds and seagrasses

There is no doubt that seaweed and seagrass communities on shores and in shallow seas of the north-east Atlantic are changing, and that the pace of change is increasing at an alarming rate. If you take a look at the seashore along the south-west coast of England, for example, you will see rock pools stuffed full of seaweeds that, on closer inspection, are often dominated by non-native species such as the large brown seaweeds *Sargassum muticum* (wireweed) and *Undaria pinnatifida* (wakame). We know of 44 non-native seaweed species in the north-east Atlantic; whilst not all of these are invasive, species continue to arrive at an increasing rate. The region is undergoing such a rapid rate of acidification and warming that we expect this to combine with the spread of invasive species to drive radical changes in coastal ecosystems.

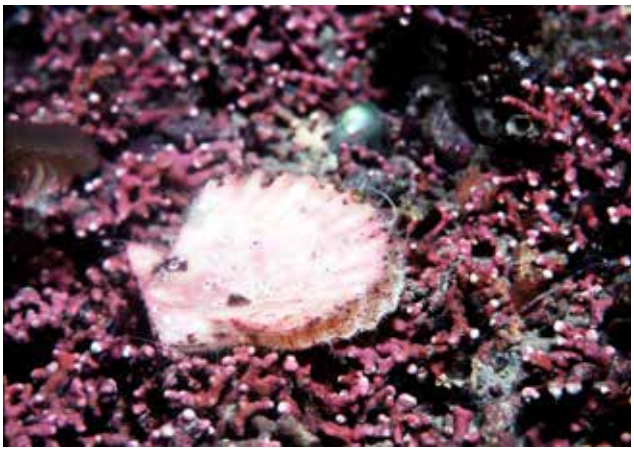
In June 2013, we brought together a group of phycologists to brainstorm these problems and deliberate on what will happen to marine plants and algae in the southern, mid and northern parts of the north-east Atlantic by 2100 if CO_2 emissions are not reduced. The outcome is that predicted changes in ecosystem structure are expected to have serious implications for ecosystem functioning and services, and for the fortunes of fisheries that are supported by these communities.

The workshop considered the fate of fleshy and calcified seaweeds, seagrasses and the microphytobenthos (MPB). The fleshy algae will be familiar to anyone who visits the shore, as these include the habitat-forming kelp (Laminariales) and the fucoids (Fucales) that cover many sea shores. Kelp forests are some of the most productive ecosystems on Earth and along with the fucoids cover approximately three times the area of woodland in the UK. The calcified seaweeds include crustose, free-living (maerl) and branched species. Maerl beds provide habitat for a rich flora and fauna forming 'hotels' for invertebrates and juvenile fish. Seagrass beds are extensive in the north-east Atlantic and play a vital role in storing carbon. Their leaves provide a habitat for a range of epiphytes, notably crustose calcified seaweeds. MPB include cyanobacteria, diatoms, dinoflagellates and life history stages of the seaweeds. They provide a food source for thousands of species of grazing and deposit-feeding organisms and stabilize coastal mud flats. Some of these algae are symbionts with other organisms and others live in shellfish and can be severely toxic to humans.

Our predictions indicate that there will be some losers and some winners over the rest of this century. Warming will likely kill off kelp forests in southern parts of the north-east Atlantic; cool water adapted kelps and fucoids have already undergone significant changes in their distribution with losses reported from several regions of the north-east Atlantic. Maerl beds are predicted to disappear from the northern parts due to falling levels of carbonate (from which their calcified skeletons are made). We know from CO_2 seeps around the world that calcified seaweeds are corroded and outcompeted in acidified seawater. Not only will fish that depend upon kelp be lost but so will shellfish from coral-

Kelp at extreme low tide, Combe Martin, Devon, southwest England. Image: Juliet Brodie.

Juvenile scallop on maerl off Falmouth, southwest England. Image: Jason Hall-Spencer.



line seaweed habitats. The calcified algae may look like inert pink paint on the rocks but they emit chemicals that trigger shellfish settlement when they metamorphose from free-swimming larval forms to adulthood.

In contrast, we predict that invasive species will thrive, exploiting both niches left vacant by the loss of native species, and space provided by the spread of artificial marine structures such as coastal defences, human-made reefs and wind turbines. Seagrasses are also predicted to be winners as they can benefit from increased carbon availability under future ocean conditions. Seagrasses will likely expand their range in all regions of the north-eastern Atlantic, provided they can withstand competition from invasive seaweeds and are protected from other human impacts such as dredging. However, their epiphytic cover of crustose calcified seaweeds is predicted to reduce or disappear, while diatoms may well proliferate in their place. Whilst less is known about them, diatoms are again predicted to increase in abundance based on evidence of these communities from CO_2 seeps. Compared to the seaweeds and seagrasses, we require a much deeper understanding of the tinier organisms in life. Crucially, the impact of high CO_2 on toxic dinoflagellates needs to be given more consideration as there is some evidence that they may become more toxic under future conditions.

Kelp forest and animals. Image: Paul Naylor www.marinephoto.co.uk

On the whole, the predictions provide a clarion call for action on two fronts. Firstly, urgent reductions in greenhouse gas emissions are needed to curb runaway warming and ocean acidification; this is a global phenomenon that is having real-time impacts on our coastal systems and requires global action to prevent future catastrophe. Secondly, careful monitoring of the changes occurring along our shores is required to allow a clear assessment of the consequences of these changes. Our future coastal marine communities will be very different to what we see today, and we need a greater understanding of what this means for the human communities that rely on these important resources.

Eelgrass at Studland on England's south coast. Image: Paul Naylor www.marinephoto.co.uk

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FURTHER READING

Brodie J., Williamson C.J., Smale D.A., Kamenos N.A., Mieszkowska N., Santos R., Cunliffe M., Steinke M., Yesson Y., Anderson K.M., Asnaghi V., Brownlee C., Burdett H.L., Burrows M., Collins S., Donohughe P., Harvey B., Foggo A., Noisette F., Nunes J., Raggazola F., Raven J.A., Schmidt D.N., Suggett D., Teichberg M. and Hall-Spencer J.M. (2014) The future of the NE Atlantic benthic flora in a high CO_2 world. *Ecology and Evolution*. Volume 4, Issue 13, pages 2787–2798, July 2014.

Invasive non-native species – terms, schemes and resources

TMB writes: Biological invasions are considered to be one of the biggest threats to the integrity of ecosystems worldwide. In the marine environment, containment and eradication of invasive non-native species (INNS) are problematic, leading to a greater emphasis on prevention and understanding of invasion biology.

In the magazine there are references to 'non-native' and 'invasive' species. Not all non-native species are considered to be invasive, but when they are, they are known as INNS. (Find out more at www.nonnativespecies.org/index.cfm?sectionid=15)

A new surveillance scheme has been launched for the brown alga *Undaria pinnatifida* (wakame). Find out more at "wakame watch" on www.facebook.com

The MBA's Bishop Group have published a new waterproof identification guide for selected marine non-native species. An electronic version can be downloaded for free from www.mba.ac.uk/bishop

Not all algae who wander are lost

Erik Sotka and Stacy Krueger-Hadfield describe an unusually successful invasion—and a novel partnership.

In his classic 1958 book *The ecology of invasions by animals and plants*, an English zoologist named Charles Elton warned of the growing scourge of invasive species, or species which humans accidentally or intentionally introduced outside their native range. The book arrived when the threat of nuclear Armageddon was constant, but Elton argued boldly and persuasively that the impacts of rodent, plant and insect pests on native ecosystems were tantamount to the effects of a nuclear bomb. The "ecological explosions" of invasive species are "not making such a loud noise and taking a longer time, but just as impressive." Unfortunately, in the intervening 65 years since Elton's book raised awareness of the issue, the rates of invasion have not just continued unabated, but accelerated.

Today, non-native species occur virtually everywhere, including within our oceans and estuaries. As an example, over 400 species of marine macroalgae, or seaweeds, have been introduced into coastal habitats worldwide. Some of these introductions were intentional, such as seaweeds grown for food, fertilizer or extractable compounds. Wakame, the brown seaweed *Undaria pinnatifida*, is consumed widely and was intentionally introduced to Europe during the 20th century. However, many seaweeds are introduced accidentally, either by hitching a ride with commercially-produced invertebrates (e.g. oysters), as insulation during 19th century shipping (e.g. fucoids) or released into local waters after being part of the aquarium trade (e.g. *Caulerpa taxifolia*, nicknamed killer algae).

Critical questions persist, the answers to which

are important to management strategies as they provide information on where and how to target our resources toward prevention, mitigation or both. Are invasive populations increasing or stabilizing in number? What are their impacts? And how did a particular species succeed when others failed?

We have been attempting to answer these questions with an non-native red seaweed called *Gracilaria vermiculophylla* (or Gverm). Gverm is originally from the north-west Pacific, but invaded most temperate estuaries of eastern and western North America and Europe within the last 30–40 years. Therefore, it is arguably one of the most geographically widespread and successful invasions in the ocean that has ever been recorded. In Atlantic estuaries of the south-eastern United States, Gverm arrived around 2003 and within 10 years, the biomass has dramatically increased to cover upwards of 100% of some high-salinity mudflats (inset image). We are currently using DNA-based tools to understand the history of this incredibly rapid expansion. Our preliminary evidence suggests that the seaweed spread to Europe and the west coast of the United States via exportation of Japanese oysters sometime after World War II. Within coastlines, the spread of Gverm was likely facilitated by commercial and recreational gear that harvests native shrimp and crabs.

Gverm has the potential to transform ecosystems into which it is introduced by outcompeting native seaweeds, adding structural complexity to mudflats and altering detrital and consumptive food webs. It is important to remember, however, that in common with many invasive species, some of the ecological impacts of Gverm are positive. In Atlantic estuaries of the south-eastern United States, the invasive Gverm has formed a novel mutualism with a native decorator worm called *Diopatra cuprea* (Figure 1). Much as a spider weaves a web, the decorator worm produces mucus-based tubes embedded in mudflats. The worm then decorates its home with Gverm, a behaviour benefiting both worm and Gverm. The non-native Gverm gains a foothold in shallow water where photosynthesis is possible. The native worm 'farms' small prey (e.g. amphipods, isopods and decapod larvae) and simultaneously seeks refuge in the 3D structure created by the seaweed.

We believe Gverm may have succeeded where other seaweeds have failed due to rapid evolutionary changes enabling particular strains of Gverm to spread. Seaweeds in the genus *Gracilaria* (ogonori) have been used as a source of agar in the Japanese mariculture industry for at least 300 years. Gverm itself was intensively cultivated for its high quality agar. Cultivation practices impose artificial selection, not unlike what occurs in terrestrial crops and ornamental plants. Algal individuals, or genotypes, are chosen based on agar yield, recovery and growth rates, and these same hardy genotypes are likely able to withstand large fluctuations in temperature, salinity and light. To confirm these suspicions, over the next three years, we will use population genetic data that reconstruct invasive history and common-garden experiments that compare phenotypes among native and non-native populations.

Over the last sixty years, we have witnessed an enormous homogenization of the Earth's biota. At face value, this is dispiriting, given the clarion call to action that Dr Elton provided. At the same time, biologists have learned an enormous amount about the ecology and demography of invasion. This ecological knowledge has been used to successfully prevent other invasions and mitigate their impacts. Ultimately, we hope that using Gverm as a case study, we can help understand to what extent microevolution should be incorporated into management decisions.

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Dr Stacy A. Krueger-Hadfield (kruegersa@cofc.edu), Post-doctoral Fellow.

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Fig. 1. A tube cap formed by *Diopatra cuprea*, to which Gverm has been added as decoration. Image: Stacy A. Krueger-Hadfield.

Growing white shark populations in US waters – a sign of ecosystem recovery?

Top marine predators appear to be making a comeback in US waters. By Chris Lowe.

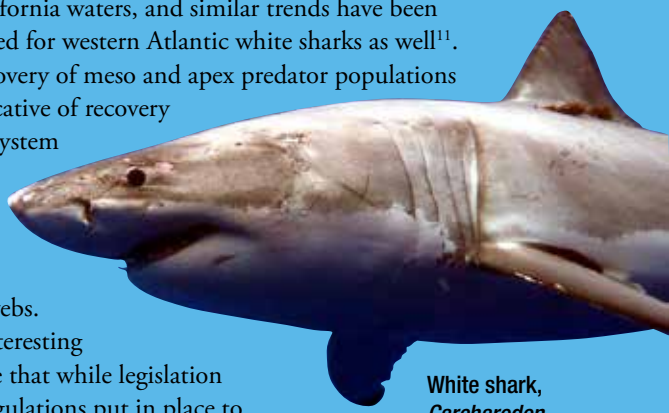
Over the last 50 years, a growing army of scientists have been busy documenting and warning of the systematic degradation of the marine environment as the result of anthropogenic influences. These effects have been well documented in areas of high human population growth and density, particularly California, where coastal populations have grown from a few hundred thousand to over 28 million people in a little more than a century. As a result of this rapid population growth and coastal development, California experienced some of the worst coastal air and water quality problems, overfishing, and coastal habitat loss observed anywhere in the US between the 1920s and 1990s. These effects prompted a wide range of landmark federal, state legislation and other regulations designed to restore marine populations and ecosystem health.

Typically, the organisms most affected by this wide array of anthropogenic influences are top predators, which occur at low abundances and are strongly dependent on lower trophic levels. Marine meso and apex predator populations (e.g. teleost fish, sharks, pinnipeds and cetaceans) experienced significant declines over the last 100 years, primarily due to direct harvesting or by-catch mortality in fisheries, and secondarily impacted by coastal habitat loss and poor water quality resulting in reduced forage fish productivity[1]. However, over the last 20 years there is growing evidence of population recovery for many meso and apex marine predators throughout California and US waters. Populations of marine meso predators (e.g. white seabass, giant black seabass, leopard sharks and tope) have been increasing since prohibition of near shore gillnets and overall reductions in commercial fishing in California introduced in the mid-1990s[2]. Many north-east Pacific marine mammals have shown remarkable population recovery over the last 40 years, some growing at rates of 6–10% annually. In 2012 NOAA concluded that the California sea lion population had reached carrying capacity with numbers of approximately 300,000, a dramatic increase from only 2,000 estimated in 1920[3].

Historic depletion of marine mammal populations since the early 1900s, reduction of fish populations due to pollution and overfishing in the 1940s–1990s, and fishing mortality of juvenile white sharks in the 1980s–1990s have probably impacted the white shark population for over 100 years[4,5]. In 2011, a research group from central California published a study attempting a population estimate for white sharks in the north-east Pacific and concluded that there may be as few as 350 adults and that the population was lower than other large marine predators[6]. However, more recent studies have concluded that population estimates for white sharks in the north-east Pacific are more likely an order of magnitude greater than that estimated in the Stanford study and that the population appears healthy and growing, despite some fisheries by-catch mortality[7,8,9,10]. Improvements in water quality and fisheries management are the most likely explanation for increasing population growth of marine predators in California waters, and similar trends have been observed for western Atlantic white sharks as well[11].

Sea lions *Zalophus californianus* and (foreground) northern elephant seal *Mirounga angustirostris*. Image: Jeff Harris.

Recovery of meso and apex predator populations is indicative of recovery of ecosystem function and coastal food webs. It is interesting to note that while legislation and regulations put in place to improve air and water quality, and to reduce overfishing and by-catch mortality were not necessarily intended to protect or restore white shark populations. These combined actions have likely been essential in driving the white shark population trends currently seen in US waters.



White shark, *Carcharodon carcharias*. Image: Kevin Weng.

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FURTHER READING

References for this article are available in full at www.mba.ac.uk/marinebiologist/issue-3-white-shark-populations-recover

Seeing in the dark: eye reduction and loss in deep-sea snails

Lauren Sumner-Rooney

Animals live in darkness all over the world. Whether they live in caves, burrows or the ocean abyss, they share many common features such as a lack of coloration and long, slender limbs and antennae. The loss of eyesight is one of the most profound and widely-reported of these. Over 150 years ago, this phenomenon was a source of frustration for Darwin, who could not understand any disadvantage to eyesight and decided the loss of eyes must be 'attributed wholly to disuse'. Since then, several authors have demonstrated that there is in fact a selective pressure for eye loss: it reduces energy wasted on growing and maintaining such a costly and redundant feature. But how exactly does an animal lose its eyes over time? Many reports of dark-living animals describe gradients of eye loss, indicating that the process is successive and constrained. There have been numerous studies specifically focusing on *Astyanax mexicanus*, a freshwater fish that has several independently blind cave-dwelling populations. These studies have shown that a change to lens development is responsible for blindness in many cases and that certain genes are implicated again and again in independent cases of eye loss. However, no one has yet objectively studied the series of morphological changes that contribute to eye loss throughout a larger group of animals to determine whether the process is in fact constrained and predictable.

In a collaborative study with the Natural History Museum, London, I am studying eye morphology in a family of marine snails called solariellids. They are found globally from the coast to the abyss and have very simple eyes, so they make an excellent model for studying depth-related changes to anatomy. After looking through 109 specimens of 29 species under the microscope, it was clear that many deep-sea species display some form of eye alteration. Several had eyes that were sunken beneath the skin and many lacked pigmented eyes altogether. We examined the eyes of nine shallow and deep water species more closely by embedding them in a plastic resin and cutting them into sections 1.5 µm thick. From the sections we reconstructed digital models of the eyes (see Figure 1) in three dimensions and compared their structure between species.

Fig 1. Tomographic model of the eye of the marine snail *Bathymophila diadema*, with nerves shown in purple and body outline in brown. Image: Lauren Sumner-Rooney.

Even amongst such closely related animals, we found a surprising amount of variation and a wide range of morphological features, many of which were invisible from the outside. Five out of nine species showed clear signs of eye reduction including loss of retinal pigmentation, reduction in size, sinking beneath the skin and degradation of the lens. Most intriguingly, these features did not appear in any particular combinations in different species, indicating that the order of reduction events can be surprisingly variable. For example in some species, the eyes were almost perfectly intact but covered over by skin, and in others they remained at the surface but lacked pigmentation and other important structures. In one case two completely different eye conditions have even evolved within a single genus. There was some evidence for limited constraint—we did not find that the optic nerve was damaged in any of the species examined, for example—but the extent of the variation shown in eye anatomy in different species clearly shows that the process of eye loss is highly plastic. By plotting the evolution of each character (e.g. loss of pigment and lens fragmentation) on a phylogenetic tree, we can conclude that eye reduction has evolved at least five times in solariellids, and that the process of eye loss often differs between these instances.

***Ilanga laevissima*, a shallow-water solariellid snail with fully-formed eyes. Image: Professor Dai Herbert.**

As eye loss has evolved several times independently, here we are essentially able to examine a naturally replicated evolutionary experiment. Other factors which shape the evolution of animal vision such as habitat, physiological constraints and evolutionary heritage, remain largely similar throughout the study group. Of course, there are almost certainly ecological differences between these species that we cannot account for, as most of these animals are highly inaccessible and few (if any) live observations have ever been made of them. However, the fact that under similar conditions several closely-related snails evolve eye loss very differently, or not at all, is very interesting indeed. The evolution of loss is an intriguing field of study which requires more attention, where modern anatomical techniques can shed much light on historical problems such as eye reduction. By studying the evolution of vision and sensory systems, we can better understand how animals interact with their environment and the evolutionary implications that such study holds.

Lauren Sumner-Rooney (lsumnerrooney01@qub.ac.uk) won 'best oral presentation' at the Postgraduate Conference in Hull. Lauren is a member of the MBA.

Protected, but still vulnerable? Lagoonal wetlands in the Azores

Brian Morton makes the case for designation of two lagoons as World Heritage Sites

Located in the North Atlantic Ocean about 1,500 km from Europe and 1,900 km from North America, the Azores is a remote archipelago (Figure 1) comprising nine islands and several islets of recent volcanic origin spread over 600 km of ocean. My most recent research on the islands, which was published in the Journal of the Marine Biological Association of the United Kingdom, involved a survey of the island's marine bivalves and showed (Morton *et al.*, 2013) that in these productivity-poor waters species were less diverse, less numerous and, on average, half the size of their mainland European conspecifics.

I first visited the Azores, however, in 1965 as a member of the Chelsea (now King's) College, University of London, Azores Expedition and published my observations on the molluscs and on the lagoon of Fajã de

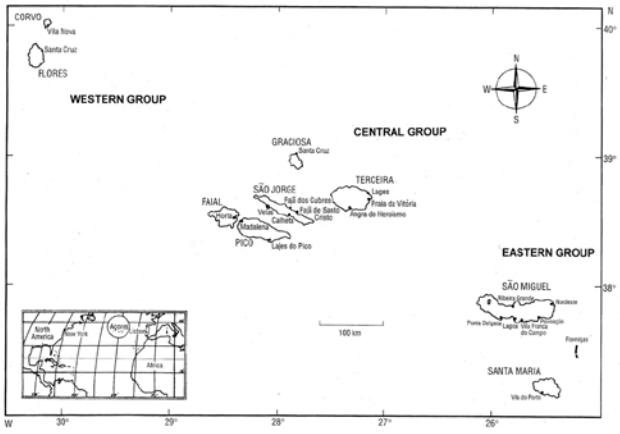

Fig. 1. Map showing the location of the Azores archipelago.

Santo Cristo, in São Jorge, subsequently (Anon, 1967). I have since returned to the archipelago many times principally in connection with the research for and writing of the book Ecologia Costeira dos Azores (Coastal Ecology of the Azores). Chapter 10 of this book dealt with marine conservation particularly with regard to the few wetland areas found in the Azores—all lagoonal.

Coastal lagoons are shallow bodies of water separated from the sea, by barriers. Lagoons are commonly divided into two categories, atoll and coastal, the former situated behind a coral reef barrier and occurring, therefore, only in the tropics, the latter worldwide. More temperate lagoons are often, but not necessarily, associated with riverine estuaries and are separated from the sea by pebbles, gravel and sand barriers—the latter in temperate environments topped by dune fields. They are also, typically, young and dynamic and may be short-lived in overall geological terms. Coastal lagoons are also defined as coupled systems, which, under the influence of the tides and freshwater runoff, are both the givers and receivers of nutrients and sediments that accumulate over time. Such exchanges are facilitated by inlets. The number and size of the inlets, rates of precipitation, evaporation and the inflows of fresh water all affect the character of a lagoon. Typically too, lagoons are fringed by mangroves in the tropics and marsh plants, Juncus, in temperate zones, and are host to unique suites of benthic organisms which interract dynamically with the lagoon floor sediments to create a rich ecosystem that is especially important, for example, for resident and migrating sea birds. The environmental conditions of lagoons are inherently variable, both spatially and temporally, and in the historical short and geological long terms. Such variations are unique to lagoons and reflect, in part, their formation, evolution and loss, latterly often through neglect and development. The inherent variability of lagoons imparts environmental stresses upon what are highly specialized ecosystems, resulting in the development of unique communities of plants and animals. Perhaps owing to their geographical isolation too, similar habitat regimes can be encountered but the communities present in them are rarely predictable, and the species present show stochastic variations in terms of recruitment, occurrence and relative significance. These specialist lagoon species are thus restricted to extremely narrow niches along narrow stretches of the coastline and, as the lagoons themselves evolve and change, so do their resident communities.

In the past, lagoonal wetlands/marshlands were not regarded as important and worldwide many have been drained, filled and developed over. In that small south-eastern quadrant of England where I now live, for example, salt marshes and their associated lagoons have been eroding rapidly for about the last 50 years, at a continuing rate of some 40 hectares per year. It is recognized today, however, that each lagoon is unique and they are receiving degrees of protection and conservation not hitherto contemplated. In 1992, the EU Habitats Directive was published, which urged member states to bring into force laws, regulations and administrative provisions necessary to comply with it within two years of the notification.

The Government of the Portuguese Autonomous Region of the Azores must comply with the EU's Direc-

tive with regard to the marine environment. Within the Directive, lagoons are classified as priority habitat types. Coastal lagoons—'Areas of shallow, coastal saline water, [either] wholly or partially separated from the sea by sandbanks, shingle, or less frequently rocks [or boulder ramparts in the Azores]'—constitute sites for which there is some national/regional obligation to establish Special Areas of Conservation (SACs). Within the framework of this definition, four intertidal areas can be recognized as definable Azorean lagoons. Of these, I consider two to be worthy of World Heritage Site status, as follows:

The Fajãs dos Cubres and Santo Cristo, São Jorge

Of all the Azorean scenery none is more magnificent than the view from the top of the near-vertical cliffs above the north shore of the island of São Jorge (Figure 2). From near the middle of the island's 27 km length, looking east, one can see two coastal platforms each containing a lagoon, or fajã. Fajã dos Cubres and Fajã de Santo Cristo were formed contemporaneously by massive landslides resulting from a violent earthquake on 9 July 1757, with its epicentre at Calheta. Forjaz & Fernandez (1975) concluded that the volume of debris dislocated from the cliffs would have been six times greater than that presently in existence. There is historical, colloquial, evidence in support of this.

In 1924, Padre da Cunha recorded that the Santo Cristo lagoon was closed to the sea and bigger than today. He recorded that then, for example, one could see the Islet of Topo, some 9 km to the east on the western tip of São Jorge from the northernmost shore of the lagoon. Not now, however. Since the 1757 earthquake, the present, shrunken, landforms of the two platforms have been shaped by a combination of marine and, to a lesser extent, freshwater erosion. Today, both fajãs enclose lagoons (lagoas), which are separated and protected from the sea by boulder ramparts. Both also receive freshwater inputs from groundwater reservoirs within the island, and the gently sloping platforms landward of the lagoons are occupied by tiny agricultural and fishing villages.

Fajã dos Cubres

The lagoon of Fãja dos Cubres is situated on the north shore of São Jorge some 2 km to the west of Fãja de Santo Cristo. The fãja comprises a shallow, 2 m deep, lagoon contained within a coastal platform and protected from the sea by a tall boulder rampart. Morton *et al*. (1985) showed that the lagoon is influenced primarily by fresh water draining from the land behind, but is also affected by seawater percolating with the rise and fall of the tides through the seaward rampart. In 1951, a small causeway was built between the land, central lagoonal islets and the seaward rampart, dividing the lagoon into eastern and western sections, which have thereby become predominantly freshwater and seawater influenced, respectively (Figures 2 & 3). The lagoon is fringed virtually along its entire perimeter by a *Juncus acutus* marsh that, in turn, is fringed internally by a widgeon grass, *Ruppia maritima*, bed. This is the only locality in the Azores where this seagrass occurs.

Fig. 2. Fajã dos Cubres, Calheta, ilha de São Jorge, Azores. Image: José Luís Ávila Silveira/Pedro Noronha e Costa.

Fajã dos Cubres is currently classified as a Site of International Importance under the Ramsar Convention relative to the List of Wetlands of International Importance, and was designated on 2 December 2005, especially with regard to protection of its habitat for aquatic birds.

Fajã de Santo Cristo

The Special Ecological Area of the Fajã de Santo Cristo also sits on the north shore of São Jorge and has a total area of only 0.86 km^2 (length, 500 m; width, 250 m) and a maximum depth of 6 m. The lagoon itself sits behind a boulder rampart through which is a channel that was (and still is) kept open by local villagers. An early text discusses Santo Cristo and records that the lagoon there was full of shrimps (probably *Palaemon* sp.), which were caught and used by fishermen as a bait to fish for grouper, possibly the solitary dusky grouper, *Epinephelus marginatus*, which is considered to be one of the non-resident juvenile visitors to the lagoon.

When I visited Santo Cristo in 1965, I made the first map of the lagoon (Figure 4) and, in addition to determining that it had a landward freshwater source, also identified an area of the inlet that was clearly, then, man-made. This was

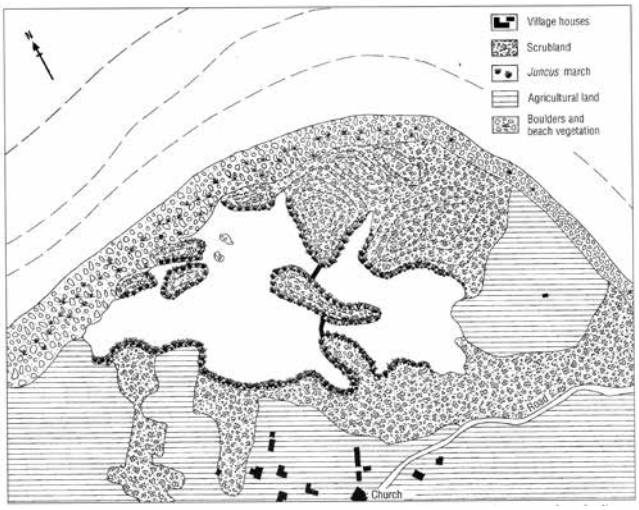

Fig. 3. Fajã dos Cubres, Calheta, ilha de São Jorge, Azores.

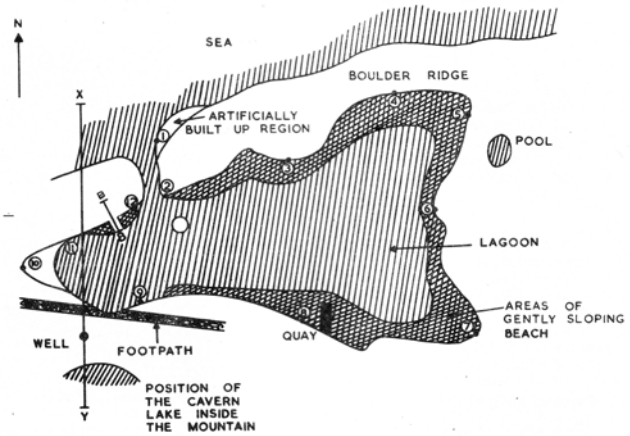

Fig. 4. Fajã Santo Cristo, ilha de São Jorge, Azores.

the first scientific illustration I ever made. Although the Fajã de Santo Cristo was first studied in 1965, subsequent, more detailed studies were not undertaken until over 20 years later. These have been, for example, of the lagoon itself (Morton & Tristão da Cunha, 1993; Fonseca *et al.*, 1995) and of the introduced clams, or amêijoas, *Venerupis decussata*, harvested from therein (Santos, 1985; Santos & Martins, 1987; Santos *et al.*, 1989; Gonçalves & Martins, 1991; Morton & Tristão da Cunha, 1993). The story of this bivalve's introduction into the lagoon is shrouded in mystery but I and Regina Tristão da Cunha (in press) have suggested that it was taken there as on-board seafood by the British merchant clipper *Spindrift* (below, in text), which, on the night of 6 December 1870, blown off course by a storm en route to Mexico via the Caribbean, smashed into the (then much bigger) Fajã de Santo Cristo and sank with the loss of all hands save for two apprentices—who, upon their return to England, told the story to the Liverpool Echo.

Occupied subsequent to the earthquake of 1757, the platform of Santo Cristo is towered over by the precipitous north face of São Jorge (Figure 5), its village comprising a church and a few houses and outbuildings. Communication with the São Jorge plateau, to avoid the arduous climbs both up and down was achieved by steel hawsers that could be wound down and up manually carrying the necessities of life and village exports, respectively. Such windlasses were still in operation in 1965.

The lagoon of Fajã de Santo Cristo was initially protected as a 'Partial Nature Reserve' (Decreto Legislativo Regional No. 4/84/A, 1984) and subsequently as a 'Special Ecological' Area (Decreto Legislativo Regional No. 6/89/A, 1989). In 2005, Fajã de Santo Cristo was also classified as a Site of International Importance under the Ramsar Convention. Morton & Tristão da Cunha (1993), however, argued for a stricter conservation designation of the lagoon. Santos *et al.* (1994) similarly identified Santo Cristo as being of conservation interest and agreed that the lagoon should be protected and conserved albeit still allowing artisanal exploitation of the resident amêijoas. In this context, this singularly unique and probably most important of all Azorean marine intertidal habitats could, owing to its historical importance, also be managed for ecotourism.

World Heritage Site designation

Coastal lagoons are—or at least used to be—common on continental margins, occurring along nearly 15% of the world's shorelines and mainland Europe was especially rich in them. Today, however over 75% of humankind

lives on the coast and the threats to delicate marine habitats, especially lagoons, are growing. Coastal lagoons usually form along gently-sloping coasts; therefore, the Azorean lagoonal wetlands are of especial importance and interest occurring, as they do, in the case of São Jorge especially, behind large boulder rampart barriers.

The processes of recruitment to lagoons are virtually unstudied and the suite of species present in any one of them is not just variable but also unique. Even given their common genesis, both Fajã dos Cubres and Fajã de Santo Cristo lagoons are intrinsically different both physically and biologically. Both lagoons were designated as Ramsar Sites in 2005, however, it is herein concluded that this level of protection is neither strong enough nor sufficiently appropriate to protect the twin sister fajãs of Cubres and Santo Cristo on São Jorge.

Although decrees by the Azorean Regional Government have been published recently which strengthen protection of Fajã de Santo Cristo and Fajã dos Cubres, I believe and recommend that the two São Jorge fajãs are so important, geologically, geomorphologically, ecologically, historically and culturally that they should be designated as a single (since they were formed at the same time) World Heritage Site.

To be included on the World Heritage List, sites must be of outstanding universal value and meet at least one out of ten selection criteria.I suggest that the following are the most important criteria with regard to the designation of the two fajãs:

- "... an outstanding example of a traditional human settlement, land-use, or sea-use, ... representative of a culture ... or human interaction with the environment especially when it has become vulnerable under the impact of irreversible change."
- Containing "superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance."
- "... outstanding examples representing major stages of Earth's history, including the record of life, ... geological processes ... or significant geomorphic or physiographic features."
- " ... outstanding examples representing ... ecological and biological processes in the evolution and development of ... ecosystems and communities of plants and animals."
- Containing "the most important and significant natural habitats for in situ conservation of biological diversity ..."

(The full list of World Heritage List selection criteria can be seen at www.mba.ac.uk/marinebiologist/issue-3-azorean-lagoons/)

Earlier this year, I laid out in greater detail the case for designation of the São Jorge fajãs as World Heritage Sites (Morton, 2014). This paper re-iterates the proposal that application be made for designation and brings these arguments to a wider international audience.

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FURTHER READING

N.B: the selected references are in English for accessibility. A full reference list is available online at www.mba.ac.uk/marinebiologist/issue-3-azorean-lagoons

Fonseca L.C., Menezes G., Gonçalves J. and Porteiro F. (1995) Environmental characterisation of 'Sto. Cristo' coastal lagoon (S. Jorge, Azores). *Boletim do Museu Municipal do Funchal*, **Supplemento 4**: 219–232.

Morton, B., Britton, J.C. and Frias Martins, A.M. (1995). Fajã dos Cubres, São Jorge: a case for coastal conservation and the first record of *Ruppia maritima* Linnaeus (Monocotyledones: Ruppiacea) from the Azores. *Azoreana* **8**: 11—30.

Morton, B., Britton, J.C. and Frias-Martins, A.M. de (1998). *Coastal Ecology of the Azores*. Sociedade Afonso Chaves, Ponta Delgada, São Miguel, Azores, Portugal. pp. i—x + 249 pp.

Morton, B. and Tristão da Cunha, R.M.P.T. (in press 2014). The history of an invasion: chance consequences of chance events. The first and last voyage of the *Spindrift* and introduction of *Venerupis decussata* (Bivalvia) into the Fajã de Santo Cristo, São Jorge, Azores. *Azoreana* (In press).

Santos, R.S., Monteiro L.R., Alves M., Isidro E.J., Martins H.R. and Hawkins S.J. (1994). *A review of marine research in relation to conservation in the Azores*. Relatórios Internos do Departmento de Oceanografia e Pescas, Universidade dos Azores, Horta, Azores 1, 58 pp + 2 plates.

Morton B. (2014) The conservation of important lagoonal, wetand, habitats in the Azores. And a proposal for World Heritage Site designation for Fajã dos Cubres and Fajã de Santo Cristo, São Jorge. *Boletim do Nucleo Cultural da Horta* **23**: 115–134.

Morton B. and Tristão da Cunha R. (1993) The Fajã de Santo Cristo, São Jorge, re-visited and a case for Azorean coastal conservation. *Azoreana* 1993: 539–553.

Fig. 5. Fajã Santo Cristo, ilha de São Jorge, Azores.

Evidence: the key to local marine conservation


Image: Caz Waddell.

The Intertidal Discovery project has completed the first ever baseline survey of intertidal habitats for conservation and public benefit along the coast of north Cornwall, England. Martin Goodall explains the background to this work.

There is a desperate need for baseline marine data, and monitoring in the marine environment is high on the UK Government's agenda to underpin local and national marine conservation strategies. This article gives an overview of a project that addresses these needs, and hopefully will stimulate thoughts about large-scale monitoring, methodologies and best methods of sharing/disseminating results.


Conducting foot surveys for the Intertidal Discovery Project. Image: Caz Waddell.

An evidence-based approach

In 2011, a national evidence-gathering exercise recommended the designation of 127 Marine Conservation Zones (MCZ) in England, under the Marine and Coastal Access Act (2009). However, in 2012 the UK Government's scientific advisors argued that only 31 sites were deemed to have a sufficient evidence-base on which to proceed.

Anyone who has spent time at the coast will know what a fascinating variety of species are present. That is all well and good, but when it comes to conservation management and legal designations it is essential to be able to turn general appreciation and anecdotal accounts into robust scientific evidence.

In southwest England the Environmental Records Centre for Cornwall and the Isles of Scilly (ERCCIS) and Cornwall Wildlife Trust (CWT), hold a wealth of information about Cornwall's marine habitats and species. This is a truly fantastic resource but it is not publically available, and is only of limited use to those making management decisions (as illustrated during the recent MCZ consultation process). To address this, and to provide much needed information about the ecological state of our coastline, a project called 'Intertidal Discovery' was set up in June 2012 by ERCCIS and CWT.

Box 1.

The Intertidal Discovery Project staff and volunteers have:

- Surveyed over 32,000,000 m^2 of intertidal habitat stretching 450 km (over 280 miles) along the entire north coast of Cornwall and accurately mapped 111 intertidal habitat types (including 32 HPI (Habitats of Principal Importance)/FOCI (Features of Conservation Interest) habitat types);
- Discovered approximately 1,200 hectares of rocky habitats—of which 6.5% is HPI habitat (from 18 HPI habitat types) and found approximately 1,850 ha of sediment habitats—of which 24% is HPI habitat (from 14 HPI habitat types);
- Produced records of the location and extent of over 200 intertidal species (including data on invasives/non-natives species).

The Intertidal Discovery Project

The project team and volunteers have surveyed the entire Cornish north coast using Intertidal Biotope Mapping. This approach has been recognized as the best method for collecting broad-scale, baseline data for intertidal areas (Wyn *et al.*, 2006), and allows the results to be utilized as widely as possible.

The team use hand-held computers in the field to produce habitat maps, assess site characteristics, take detailed target notes and geo-referenced photographs, and produce comprehensive species lists for each area of survey. This use of technology dramatically reduces the office time needed to collate the data for analysis and eventual dissemination.

It is essential to turn anecdotal accounts into robust scientific evidence

In addition to the intertidal surveys, we have undertaken trials to ground-truth inshore sub-littoral habitats using a drop-camera with lighting and cage array. The resulting high quality video footage of the seafloor is geographically referenced and we can analyse this footage to identify and map the extent of some seafloor habitats. The full method used follows the Mapping European Seabed Habitats (MESH) methodology (White *et al.*, 2007).

Underpinning this survey effort, our training programme for local volunteers and students teaches survey techniques, GIS mapping, data analysis, evidence


Drop camera image of Laminaria bed. Image: Intertidal Discovery.

Box 2.

The legacy of the Intertidal Discovery project is:

- Production of the first ever complete baseline of intertidal habitats in Cornwall;
- Production of a comprehensive, interactive mapping portal (www.intertidaldiscovery.org.uk/HabitatMap);
- The provision of robust scientific data to marine planning authorities and statutory bodies;
- Guides for technical and non-technical audiences (see the website for details on how to obtain guides);
- The ability to train staff/volunteers in undertaking field surveys using mobile GIS technology;
- Hundreds of volunteers trained in elements of marine fieldwork, surveying and data management.

dissemination and habitat/species identification. These are all long-term, transferable skills.

What do we know now?

We have only just started to analyse this amazing resource and given the detail we envisage this to be a lengthy process! However, an initial view has revealed superb examples of intertidal underboulder communities (a 2007 priority habitat) located around Cape Cornwall and St Ives, where iconic species such as stalked jellyfish (*Lucernariopsis campanulata* and *Haliclystus auricula*), light bulb sea squirts (*Clavelina lepadiformis*), and candy striped flatworms (*Prostheceraeus vittatus*) have all been found intertidally. The honeycomb worm (*Sabellaria alveolata*) has been extensively mapped around the Bude area, where only ad hoc records existed previously.

The surveys have revealed surprisingly large numbers of the strawberry anemone (*Actinia fragacea*), together with notable records for the bushy rainbow wrack (*Cystoseira tamariscifolia*) dominating rockpools, and the brown fork weed (*Bifurcaria bifurcata*) on open rock of the lower shore. This would appear to support suggestions from the previous MarClim (www.mba.ac.uk/marclim) study that these species could be among the 'winners' of climate change in the south-west (Hiscock *et al.*, 2005).

Ultimately this baseline is already proving an extremely useful resource at a local level and we are looking at how outputs from this project can be used as a tool for marine planning, environmental monitoring, and decision-making. It is our hope that this project will inspire other non-governmental organizations and public bodies to obtain much-needed baseline marine data, and to work together to collate vital evidence to underpin local and national marine conservation.

Martin Goodall (martin.goodall@cornwallwildlifetrust.org.uk) is the Data Manager for ERCCIS and Cornwall Wildlife Trust.

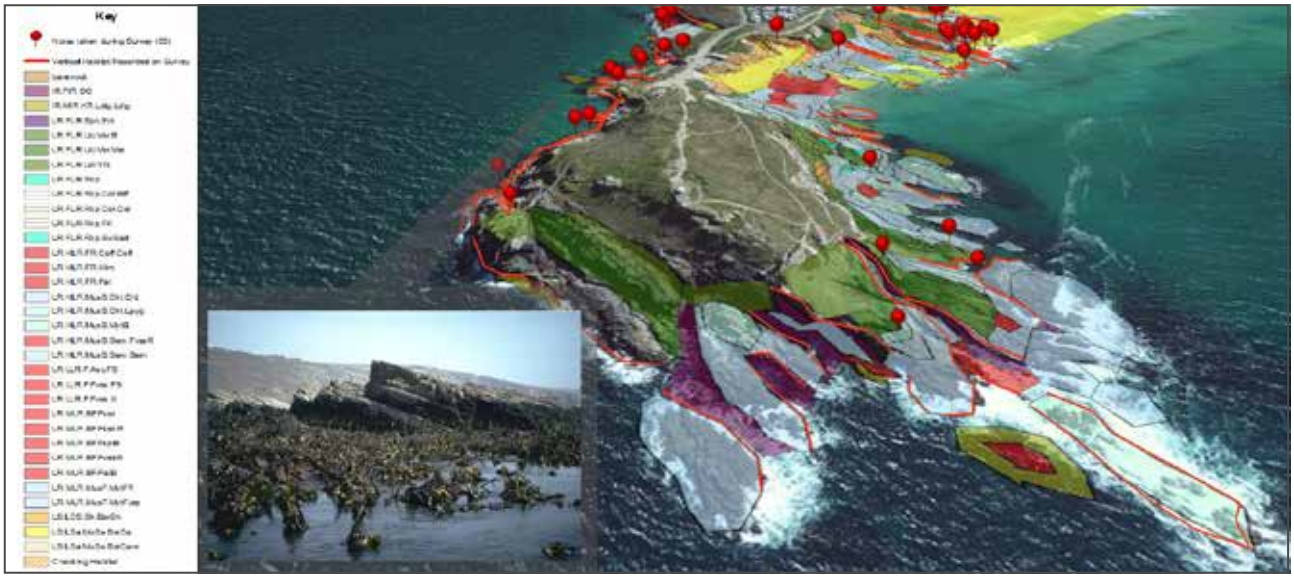
FURTHER READING

Hiscock K., Baker G., Crump A. and Jefferson R. (2005) Marine life topic note. Climate change and marine life around Britain and Ireland. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [online]. Plymouth: Marine Biological Association of the United Kingdom. Available from: http://www.marlin.ac.uk

Wyn G., Brazier P., Birch K., Bunker A., Cooke A., Jones M., Lough N., McNath M. and Roberts S. (2006) Handbook for Marine Intertidal Phase 1 Biotope Mapping Survey. Countryside Council for Wales. ISBN: 1 86169 144 0.

White J., Mitchell A., Coggan R., Southern I. and Golding N. (2007) Seafloor video mapping: collection, analysis and interpretation of seafloor video footage for the purpose of habitat classification and mapping. MESH.

Survey approach. Image: Intertidal Discovery



Towan Head habitat map in 3D effect by Intertidal Discovery.

Secretary Kerry holds discussion with Prince Albert II of Monaco at the "Our Ocean" conference in Washington, D.C. in June. Image: US State Department.

The US gets serious on global ocean health

Phil Williamson and Carol Turley report from the "Our Ocean" conference hosted by John Kerry at the U.S. Department of State in Washington, D.C. in June.

Government departments for foreign affairs might not seem the obvious protagonists for ocean science, the sustainable use of marine resources and the need to address climate change. Yet there is strong logic for their involvement: most marine ecosystem services are either delivered by the 'high seas' (shared by all nations as common assets); or else directly depend on sound management by others, within their exclusive economic zones (EEZs). Since any single country, however large, can only make limited progress in tackling marine issues on its own, regional and global policy action becomes essential; for example, to prevent fishery over-exploitation and tackling wider issues of ocean health. European and UN bodies clearly play a major role in that regard, yet there is also scope for individual countries to both lead and stimulate commitment and collaborative action.

The US Department of State (equivalent to the UK Foreign & Commonwealth Office) has recently risen to that challenge by giving high priority to ocean issues, with strong personal involvement by Secretary of State John Kerry. Originally entitled 'Oceans under threat' and scheduled for last October, the 'Our Ocean' conference was held on 16–17 June 2014 in Washington, DC—with the change in title recognizing that there is just one, interconnected global ocean, and that its stewardship is a collective responsibility for everyone, everywhere.

Kerry did not limit his attendance to the formal opening (as has been known for senior politicians with busy agendas), but dominated the conference—giving four speeches, as well as remarks at lunchtime and at an evening reception. The conviction of those speeches, exhorting the world's decision-makers not just to hear the science but to act on it, gives rise to optimism.

The conviction of [Kerry's] speeches, exhorting the world's decision-makers not just to hear the science but to act on it, gives rise to optimism

Most researchers are very familiar with science conferences and their formats; a few also go to policy-directed events, either at the national or international level. The 'Our Ocean' conference was a unique mix of both, based on scientists sharing their knowledge not only with heads of state, ministers and other government representatives from more than 80 countries, but also with around 400 others from industry, philanthropic bodies, non-governmental organizations, universities and intergovernmental organizations. Hundreds more followed a live online broadcast of the event at US embassies around the world, including London, with wider social media coverage of over 6 million[1]. Celebrity guest appearances included Ted Danson (No. 2 in US TV star ranking) and Leonardo DiCaprio. The latter was the conference highlight as far as the UK media was concerned, even in the 'quality' coverage of the issues, such as by the BBC and the Guardian[2].

Discussions at the conference focused on three of the most serious problems that threaten the global ocean: over-fishing; pollution; and acidification. From Kerry's perspective, none of these are intractable problems, yet effective remedial actions require substantive national and international political will: to improve fishery regulation and traceability; keep rubbish out of the seas; and at least make a start on changing energy policy to reduce, and eventu-

ally halt, the increase of atmospheric carbon dioxide, and its associated chemical and ecological impacts.

Three UK experts were amongst the twenty scientists invited to speak, each delivering their messages in 5 minutes of non-technical information. Richard Thompson (Plymouth University, UK) discussed the problems of marine plastic litter, whilst the authors of this article explained the chemistry, scale and unprecedented speed of ocean acidification, and the closely-related need for more ocean acidification data on a worldwide basis, to improve understanding, short-term forecasting and long-term projections: 'what you don't measure, you can't manage'. Bill Dewey (Taylor Shellfish Farms, WA) and Ove Hoegh-Guldberg (University of Queensland, Australia) also spoke in the ocean acidification session: the former described how ocean acidification impacts, with potentially serious socio-economic consequences, were already underway in the north-west USA; the latter, how it would take ocean chemistry and ecosystems more than 10,000 years to recover from the changes that are currently occurring.

The aspirational headlines from the Action Plan arising from the conference[3] were sufficiently generic so that all countries represented would (hopefully) be able to agree on them, without formal sign-up:

- End overfishing in the ocean
- Prevent illegal, unreported and unregulated (IUU) fishing
- Reduce nutrient pollution to the marine environment
- Reduce marine debris
- Stem the increase in ocean acidification
- Create worldwide capability to monitor ocean acidification
- Create more marine protected areas
- Protect coastal ecosystems that provide critical services.

Speakers at the ocean acidification session: (L to R) Phil Williamson, Yimnang Golbuu, Bill Dewey, Alexis Valauri-Orton, Ove Hoegh-Guldberg and Carol Turley. Image: Richard Thompson (Plymouth University).

The next level down of the policy response—involving specific implementation actions—is, however, of critical importance, since that will determine the extent that current trends can be slowed or reversed. Is it envisaged that there will be legally-binding targets at either the national, regional or international level? How would complementarity be achieved with other ocean health initiatives, such as the EU's Marine Strategy Framework Directive and associated national commitments to achieve good environmental status? How will conflicts of interest be resolved? Little mention was made of the UN bodies with relevant responsibilities, perhaps

> **"Energy policy is the solution to climate change"**

because the US has limited influence at the Intergovernmental Oceanographic Commission of UNESCO (having recently lost its voting rights there) and has yet to ratify the Convention on Biological Diversity.

At the conference itself, a flurry of announcements and commitments were made, mostly relating to fishery control and enhanced marine protection. Thus, in addition to DiCaprio's pledge of an extra US $7m for marine conservation projects, Barack Obama announced (by video) additional protection for the Pacific Remote Islands Marine National Monument; President Tong of Kiribati and the President Remengesau of Palau declared that commercial fishing would be phased out within most of their countries' EEZs; and Sir David King, representing the UK Government, reminded the conference of the establishment in 2010 of the Chagos Archipelago (British Indian Ocean Territory) marine protected area, whilst also announcing that protected status around the Pitcairn Islands was now under consideration. In total, increased protection was declared for more than 3 million km^2 of ocean—an area roughly the size of India.

Coldwater corals off NW Scotland, a habitat threatened by ocean acidification. Image: UKOA/Changing Oceans expedition, Heriot-Watt University

All these conservation initiatives are, of course, highly desirable, and are to be warmly welcomed. But what about the more difficult challenge of ocean acidification, closely related to climate change? Policy 'solutions' to that problem can be considered on several levels[4], including the need for better scientific understanding and improved monitoring. Yet there is fundamentally only one way to reduce future ocean acidification, and that is by reducing future carbon dioxide emissions. Here is what Kerry had to say on such issues at the conference:

'What's interesting about the challenges we face, I might add—and it is not just about the ocean—but so many of the challenges that are confounding the world today actually have pretty obvious solutions that

Leonardo DiCaprio delivers remarks at the 2014 "Our Ocean" Conference at the U.S. Department of State in Washington, D.C. on June 17, 2014. Image: US State Department.

are staring us in the face. It's not as if we're sitting around scratching our heads saying, "How do we solve the problem?" It's really a question of "How do we find the political will?" "How do we get people to move—to sometimes move back very vested, powerful interests that like the status quo because change means reinvesting or changing the way you do business, even though in the long run it will save everybody a lot of money and a lot of grief?" It is pretty obvious where we are. The solution to climate change, which is a serious problem with respect to the oceans, as we have all seen, is very simple actually. It's called energy policy. Energy policy is the solution to climate change'.

The implications of such an approach will, no doubt, take a lot more time and effort to be fully realized. Nevertheless, those views would seem of crucial importance as an indication of US policy intent[5]—with particular regard to negotiations under the UN Framework Convention on Climate Change (UNFCCC) that the US has ratified and within which it plays a pivotal role. In just over a year's time, all countries will meet in Paris for the 21st UNFCCC Conference of Parties, to negotiate reductions in their greenhouse gas emissions, to come into effect by 2020. As a short-term verdict on the 'Our Ocean' conference, we concur with Ambassador David Balton (US Deputy Assistant Secretary for Oceans and Fisheries) that the event 'exceeded even our greatest expectations'. But the long-term test will be around 2020, when—it is to be hoped—it could be seen as a turning point not just for US ocean policy, but in rescuing the future.

Phil Williamson (Natural Environment Research Council and University of East Anglia) and Carol Turley (Plymouth Marine Laboratory)—Phil and Carol are the Science and Knowledge Exchange Coordinators of the UK Ocean Acidification (UKOA) research programme, co-funded by NERC, Defra and DECC.

FURTHER READING

1. https://www.thunderclap.it/projects/12223-help-protect-our-ocean

2. http://www.theguardian.com/environment/2014/jun/17/obama-oceans-marine-reserves-leonardo-dicaprio

3. 'Our Ocean 2014', 16–17 June: Conference outcomes (Our Ocean Action Plan and Our Ocean Initiatives). http://www.state.gov/e/oes/ocns/opa/2014conf/index.htm

4. Herr D., Isensee K., Harrould-Kolieb E. andTurley C. (2014) Ocean Acidification: International Policy and Governance Options. International Union for Conservation of Nature, Gland, Switzerland; www.iucn.org/about/work/programmes/marine/?16064/ocean-acidification-policy-guidance

5. US policy implications were further discussed at a round-table meeting in mid-August, involving the US Department of State, the Foreign Service Institute, the Bureau of Oceans and International Environmental and Scientific Affairs and the National Oceanic and Atmospheric Administration (also with UK science representation).

England's MPAs – towards a well-managed network

By Jen Ashworth and Leanne Stockdale.

In recent years the marine biological community has focused a lot of attention and effort on identifying and establishing new marine protected areas (MPAs). In England the government designated 27 new Marine Conservation Zones in 2013 bringing the number of MPAs around England (out to 200 nm) to 114 with more to come. Together with MPAs designated by other UK authorities the MPA network covers 16 .2% of UK waters. Creating new MPAs is only the first step. The UK is committed to a network that is also well-managed so that habitats and species can thrive and contribute to healthier seas across the UK. No-one wants paper parks!

Well-managed MPAs in England require many organizations to work well together. In other countries there is often a single body responsible for managing MPAs such as the Great Barrier Reef Marine Park Authority. In the UK we have different authorities to manage different activities happening at sea including the 10 regional Inshore Fisheries and Conservation Authorities (IFCAs), the Marine Management Organization (MMO) and local authorities. However, far from being a weakness, this framework can be a strength allowing regional and local decision making. The key issue is to ensure that regulators, national, regional or sectoral, are clear why a site has been designated and what effect the actions they manage can have on those sites.

These managers use advice from the nature conservation agencies, Natural England and the Joint Nature Conservation Committee (JNCC), on the importance and objectives of protected habitats and species. This gives rise to many questions. What does a healthy rocky reef look like? What habitats and species should it contain? How big should it be? What ecological processes are important to the reef and what pressures (and activities that cause these) might damage the reef? Natural England also undertakes monitoring to check the health of the habitats and species against the objectives, often in partnership with management bodies.

Immediately from designation, and as good practice even before designation, management bodies have legal duties to protect MPAs. Those proposing new activities such as dredge disposal or development of marine infrastructure must apply for a licence (usually a marine licence from the MMO) and licences will not be granted unless consideration of their effect on the site has been assessed. The licencing body can refuse or modify consents to avoid or mitigate environmental impacts.

In the last year Defra, the MMO, IFCAs, Natural England and JNCC have been working together to improve the management of fisheries within MPAs following a change to how these activities could be managed. The MMO and IFCAs have put in place 17 by-laws which protect features such as *Sabellaria* reef and seagrass beds in MPAs from high-risk fishing activities. This was a big step towards achieving a well-managed network and in 2016 other fishing activities will be assessed and, if required, new management measures agreed.

The English coast is a busy place and some of our coastal MPAs are highly complex with many management bodies and activities occurring. The managers of some of these sites have come together to produce a management scheme. This local partnership working has led to new codes of conduct, joint research projects and raising awareness with communities about MPAs and the importance of our marine wildlife.

We are actively working towards all MPAs being well-managed and with this mixture of legal duties to protect MPAs, licencing, identifying management measures for existing activities and local partnership working it is clear that England's MPAs are not paper parks.

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Leanne Stockdale (Leanne.Stockdale@marinemanagement.org.uk) is Senior IFCA Byelaws and Liaison Officer at the Marine Management Organization, UK.

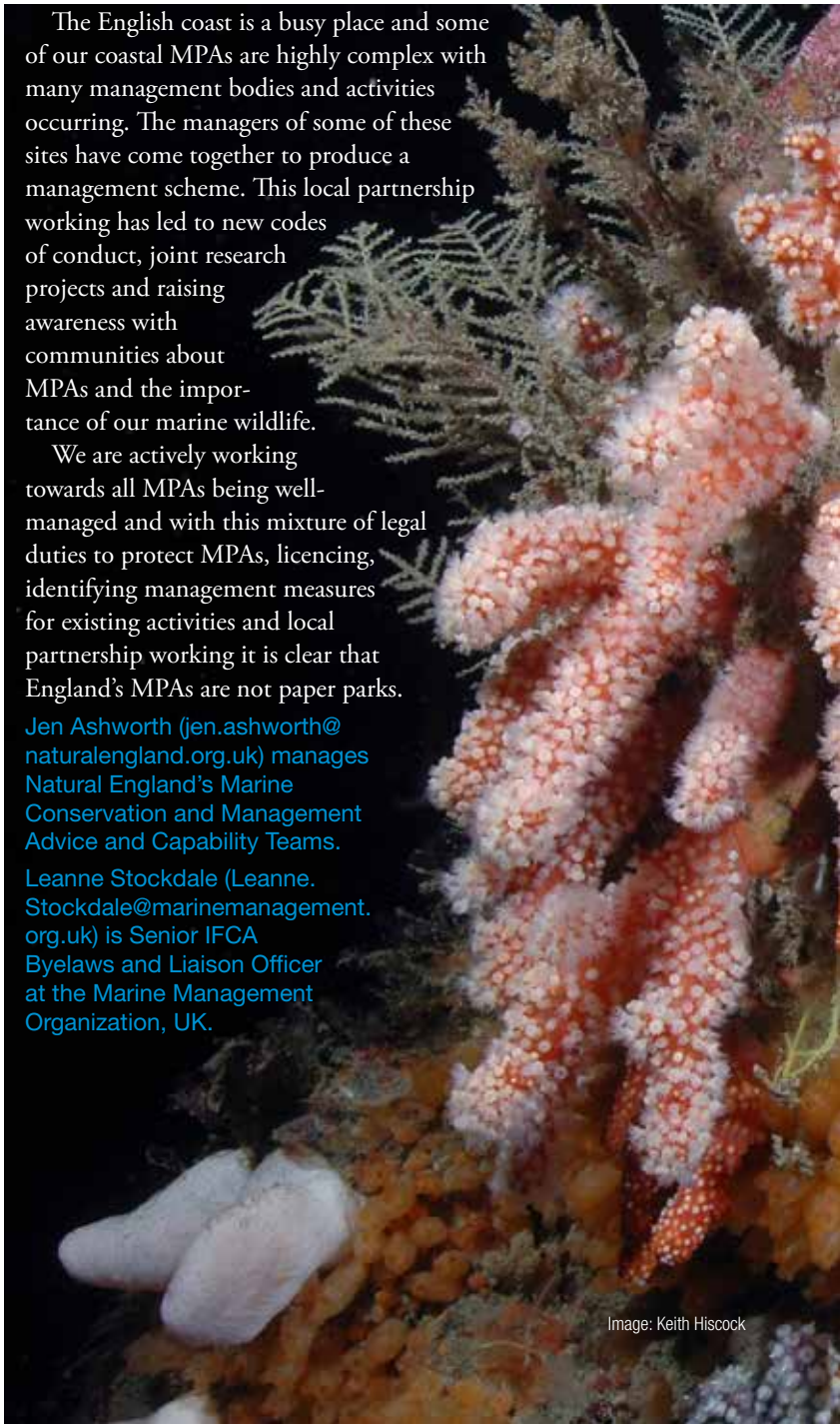


Image: Keith Hiscock

Marinexus

Our shared sea

Mechanisms of ecosystem change in the Western Channel

The Marinexus project brought together scientists and outreach experts from Plymouth, southwest England and Roscoff, France in an effort to improve our understanding of ecosystem functioning in the western Channel and to raise awareness of these ecosystems, particularly among schoolchildren and the public.

Both the English and the French partners of this project have long traditions of ecosystem monitoring in the western Channel. The Marine Biological Association's long-term monitoring programme dates back to the 19th century, and the Station Biologique de Roscoff also has a long history in this domain. Marinexus provided a long-overdue opportunity to integrate monitoring activities on the two sides of the Channel, and to trial innovative new observation methods, such as the installation of a 'ferry box' on the Brittany Ferries ship *Armorique* (see map on P23). The project also provided a forum for the exchange and comparative analysis of monitoring data. In addition to monitoring physical and chemical parameters, the project also implemented several approaches aimed at evaluating changes in biological diversity both in the open Channel and in different coastal environments.

A major aim of the Marinexus project was to investigate effects of modifications to the marine environment on Channel ecosystems, through, for example, identification and monitoring of invasive species on both sides of the Channel (see the section on non-indigenous species below).

The project also looked at how indigenous species are equipped to deal with changes to their environment. For example, seaweeds are an important component of coastal ecosystems but many have complex life cycles and it is not clear to what extent the complexity of their life cycles influences their susceptibility to changes in the environment. One of the aims of the project was to better understand how these complex life cycles function in order to address this question. Planktonic microalgae of Channel open water environments also fell under the scrutiny of this part of the project. Ocean acidification represents a significant challenge for several of these species because it affects their capacity to fabricate their protective calcium-based exoskeletons.

Culturing algae. Image: © R. Lamoureux (photothèque CNRS).

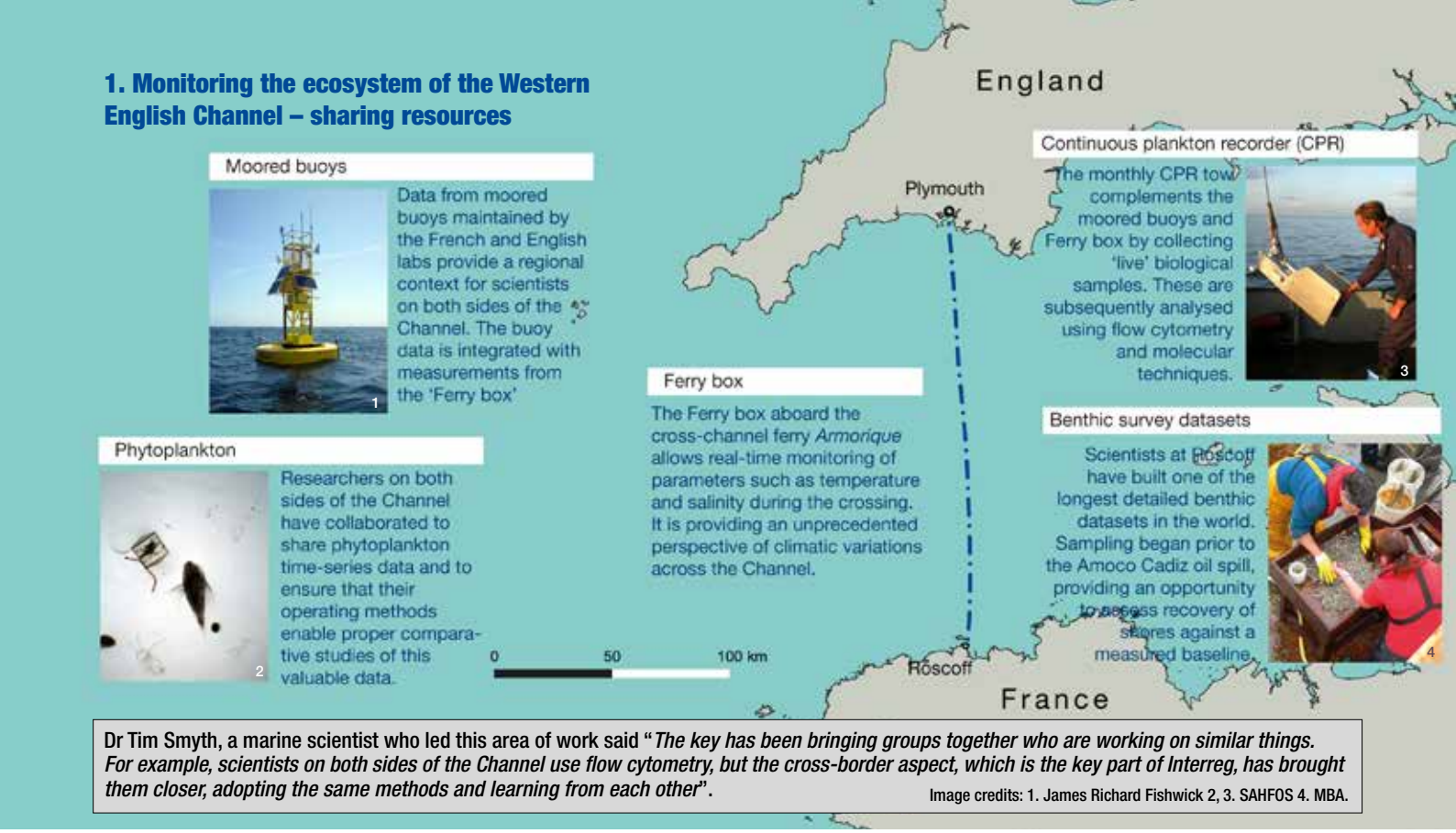
The outreach activities of the project used the results of these various research projects as raw material to construct attractive communication tools aimed at increasing knowledge about marine ecosystems and promoting citizen involvement in their protection and sustainable use. Activities aimed at schoolchildren and the public included workshops on Brittany Ferries ships during the crossings between Plymouth and Roscoff, and visits to schools on both sides of the Channel. On the French side, these and other activities were carried out using the 'Marinexus Bus', a dedicated outreach vehicle equipped with laboratory and demonstration apparatus. In Plymouth, a number of activities were organized, such as the 'Marine biologist for a day' programme and Bioblitzes, which involved the public and schoolchildren in describing biodiversity at seashore sites. As with the research projects, the outreach activities involved multiple interactions between the English and French partners, sharing of ideas and joint participation in several of the initiatives.

The Marinexus bus in action at a Bioblitz event.

In addition to increasing general awareness about marine ecosystems in the Channel, Marinexus ran several activities aimed specifically at stakeholders. For example, a day dedicated to several round tables with themes such as 'Citizen science as a means to involve the public in environmental issues' and 'The added value of international cooperation' attracted participants from several sectors including local government and environmental protection agencies. This type of action proved to be a very effective means of transmitting key messages to local decision-makers.

Just over 100 scientists, outreach and technical staff worked on a range of projects under Marinexus. More information is available on the website but let us look at just two areas of research in a little more detail.

1. Monitoring the ecosystem of the Western English Channel – sharing resources



Dr Tim Smyth, a marine scientist who led this area of work said "*The key has been bringing groups together who are working on similar things. For example, scientists on both sides of the Channel use flow cytometry, but the cross-border aspect, which is the key part of Interreg, has brought them closer, adopting the same methods and learning from each other*".

Image credits: 1. James Richard Fishwick 2, 3. SAHFOS 4. MBA.

2. Non-indigenous species on the Channel coast

During the lifetime of the Marinexus project, substantial changes were documented in the marine non-indigenous fauna of the western English Channel.

Species deposited beyond their natural geographical range by human activities, either accidentally or deliberately, can modify ecosystems and pose major threats to both economic interests and native biodiversity. The Marinexus project included appraisal of these non-indigenous species (NIS) in the fouling communities of harbours and marinas—artificial environments in which NIS are particularly prominent and which can act as stepping-stones for spread around the coast and thence into natural habitats. Marine biologists from the laboratories in Plymouth and Roscoff adopted joint protocols and undertook collaborative work to enable direct comparisons of localities on the two sides of the Channel, in north-west Brittany and south-west England (Devon and Cornwall).

Methods included deployment of settlement panels in marinas, standardized timed searches of a series of sites (Rapid Assessment Surveys—RAS), both of these activities being repeated to monitor changes during the project, and the recording of species growing on yacht hulls and on the hull and in the ballast tanks of a cross-Channel ferry.

The lists of NIS on the two sides of the Channel were remarkably similar, the great majority of species being present on both sides. Nevertheless, the animal communities developing on panels during one year's immersion in 13 marinas, scored in terms of the space occupied by each species, showed a consistently greater prominence of many of the NIS in Brittany (Figure 1).

RAS of 10 English and seven French marinas were undertaken in 2010 and repeated in 2013. In 2010 the marinas studied in Brittany had almost complete site occupancy by many of the sessile animal NIS present in the region—most

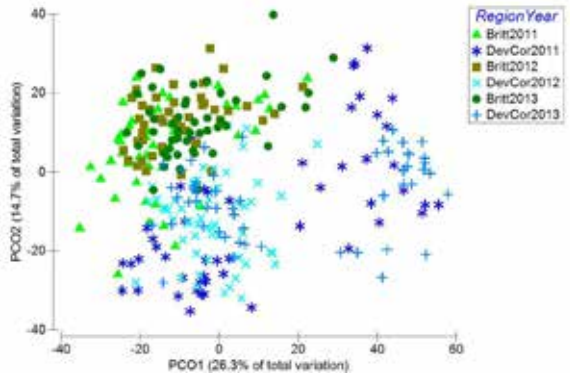


Fig. 1. Plot of faunal composition on settlement panels in marinas during three successive annual deployments, showing a consistent distinction between panels in Brittany (green symbols) and Devon & Cornwall (blue symbols).

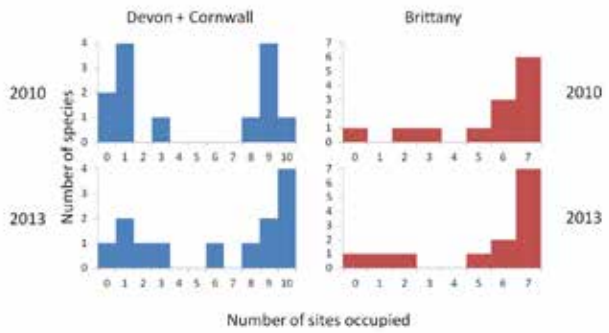


Fig. 2. Frequency distribution of 13 non-indigenous species (NIS) based on the number of marina sites occupied by each species in surveys in Devon and Cornwall, and Brittany.

NIS were present in most marinas—and the picture remained the same in 2013 (Figure 2). In Devon and Cornwall, occupancy was substantially lower in 2010 but had increased by 2013 largely because two species spread to several new marinas in Devon and Cornwall between the surveys: the compass sea squirt (*Asterocarpa humilis*) and red ripple bryozoan (*Watersipora subtorquata*). In Brittany, both these species were already present in 2010 at all of the marinas surveyed.

Parallel DNA-based population genetic studies suggested a common origin of the populations of NIS on the two sides of the Channel, i.e. a shared history of introduction with efficient spread across the Channel following initial establishment on one or other side. Based on the greater occupancy of habitat patches (marinas) and higher abundances seen in France, a general pattern over the past 3–4 decades of spread of marine NIS from France to England is inferred. The Marinexus studies and earlier records document a cluster of discoveries of new sessile animal NIS around the turn of the millennium. At least three of these are native to the north-west Pacific and are candidates for introduction to France via commercial movements of Pacific oyster (*Crassostrea gigas*).

We also inspected the hulls of over 120 yachts, documenting an average of four species of animal NIS per vessel in both Devon and Brittany, with similar lists of species on both sides of the Channel.

A picture therefore emerges of England and France sharing a common history of introductions of NIS on their Channel coasts, with a recent burst of new arrivals spreading across the Channel predominantly northwards, often after only a brief delay. Probable vectors of spread include leisure craft and cross-Channel commercial vessels, with initial introduction to north-west Europe often originating from aquaculture-related shipments of commercial species.

Confusingly similar species: DNA to the rescue

DNA-based identification (molecular 'barcoding') has been vital for resolving a group of polymorphic species that can closely resemble each other.

Colonial sea squirts of the genus *Botrylloides* (relatives of the better-known 'star sea squirt', *Botryllus schlosseri*) include at least two non-indigenous species in the Marinexus study region: orange cloak sea squirt (*B. violaceus*); and San Diego sea squirt (*B. diegensis*). Both occur in a variety of colour forms, and these species can resemble each other closely and are also difficult to distinguish from the putatively native species *B. leachii*. Molecular barcoding enabled colonies to be classified so that distributions could be clarified and subtle morphological distinctions looked for in well-chosen comparisons of specimens. A fourth group of DNA sequences brought to light an overlooked species within the samples, and distinguishing morphological characteristics in the corresponding specimens were then recognized.

Three species of *Botrylloides*, with the probable undescribed fourth species bottom-right. Images: John Bishop.

Conclusion

Over its four and a half year duration, the Marinexus project has significantly strengthened links between marine research institutions in Plymouth and Roscoff and many of the collaborative initiatives will be continued and expanded in the future. The strong outreach component of this project has also been very enriching for partners on both sides of the Channel, creating partnerships between academic and outreach organizations and allowing new skills to be developed by both types of partner. Discussions are currently underway to follow up on the success of this project with a similar collaborative initiative in the future.

www.marinexus.org

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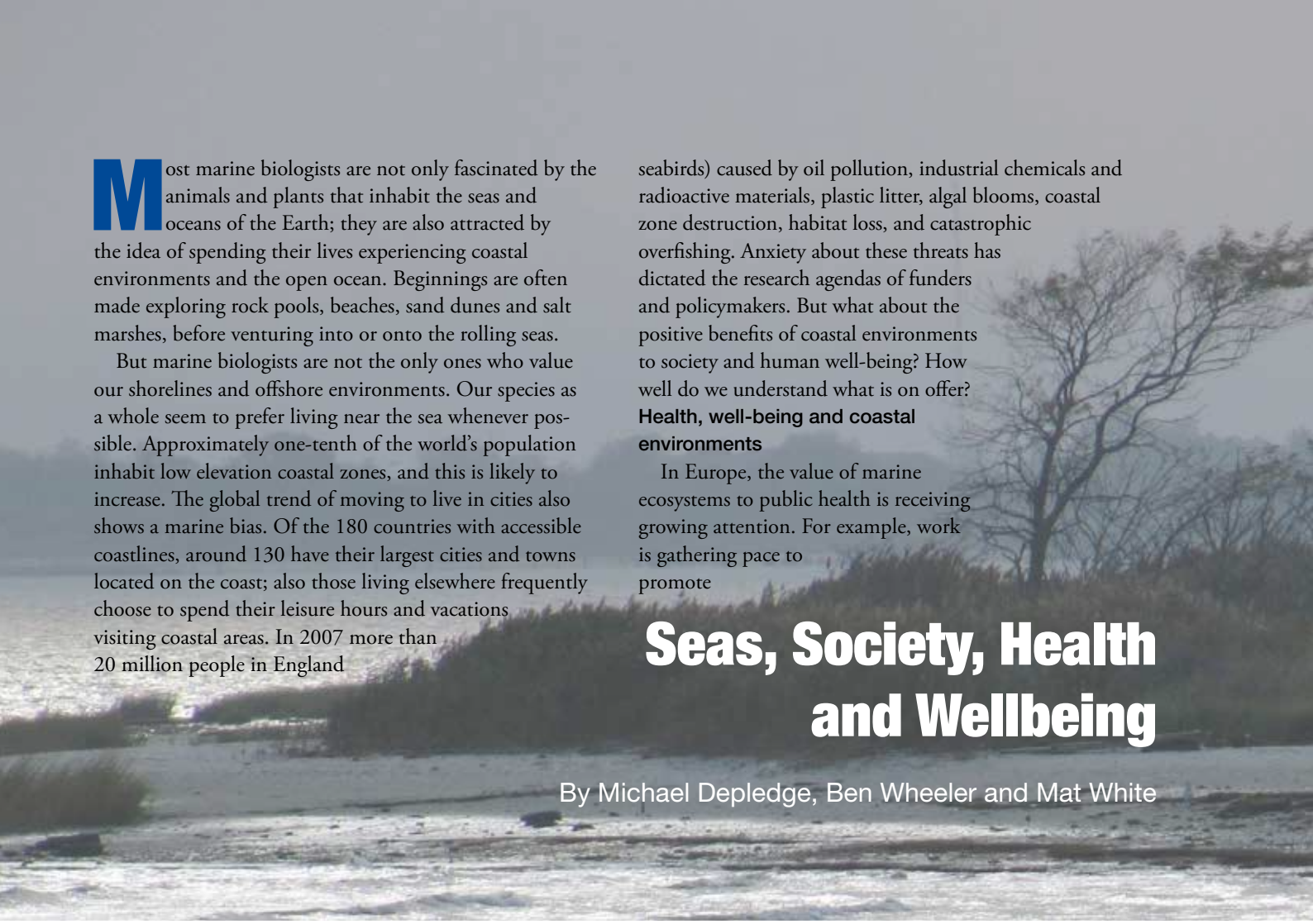
Marinexus partners:

1. Station Biologique de Roscoff (Centre national de la recherche scientifique/Université Pierre et Marie Curie)
2. Plymouth Marine Laboratory
3. Marine Biological Association

Sir Alister Hardy Foundation for Ocean Science
National Marine Aquarium
Centre de Découverte des Algues (Algae Discovery Centre), Roscoff
Brittany Ferries
Subcontractor: Association les Petits Débrouillards Bretagne (Young Investigators)

Marinexus was funded by the European Union Interreg program.



Seas, Society, Health and Wellbeing

By Michael Depledge, Ben Wheeler and Mat White

Most marine biologists are not only fascinated by the animals and plants that inhabit the seas and oceans of the Earth; they are also attracted by the idea of spending their lives experiencing coastal environments and the open ocean. Beginnings are often made exploring rock pools, beaches, sand dunes and salt marshes, before venturing into or onto the rolling seas.

But marine biologists are not the only ones who value our shorelines and offshore environments. Our species as a whole seem to prefer living near the sea whenever possible. Approximately one-tenth of the world's population inhabit low elevation coastal zones, and this is likely to increase. The global trend of moving to live in cities also shows a marine bias. Of the 180 countries with accessible coastlines, around 130 have their largest cities and towns located on the coast; also those living elsewhere frequently choose to spend their leisure hours and vacations visiting coastal areas. In 2007 more than 20 million people in England went to the seaside. Once there, they willingly paid extra for a view of the sea from their guest houses and hotels.

Taking a broader view illuminates the variation across the world in how people interact with marine ecosystems. Some areas, such as the North Sea, are heavily exploited while others, such as parts of the Indian Ocean, are far less influenced by human activity. The US coastline is ca.153, 650 km long; that of Europe only ca. 89,000 km. In the USA, ca. 90 million people are regarded as living by or near the coast, whereas in Europe, there are at least 200 million coastal inhabitants. Particular attention should be paid to areas of high intensity human activity, as our predilection for living by the sea and for extraction of natural resources has sadly led to adverse consequences for marine ecosystems. For instance, more than 50% of the Mediterranean coast has been modified by coastal defences, promenades, marinas, etc., while elsewhere in Europe approximately two-thirds of coastal wetlands have been lost since the beginning of the 1900s to development (farming, housing, etc.). Many other examples can be cited, including those remote areas experiencing burgeoning tourism (e.g. the Maldives) as well as the alarming new prospect of extensive submarine hydraulic fracturing to obtain gas and oil. But proximity and contact also foster a fascination with marine life. Indeed, when asked, most people express concern about damage to charismatic marine animals (mainly whales, seals, dolphins, turtles and seabirds) caused by oil pollution, industrial chemicals and radioactive materials, plastic litter, algal blooms, coastal zone destruction, habitat loss, and catastrophic overfishing. Anxiety about these threats has dictated the research agendas of funders and policymakers. But what about the positive benefits of coastal environments to society and human well-being? How well do we understand what is on offer?

Health, well-being and coastal environments

In Europe, the value of marine ecosystems to public health is receiving growing attention. For example, work is gathering pace to promote more active, outdoor lifestyles to help combat the epidemics of obesity, depression and other physiological and psychological disorders. One programme, the 'Blue Gym' promotes participation in coastal activities, such as swimming, sailing, surfing and kayaking, but also coastal walks and rock pool rambles. It is imperative that we gather evidence that ultimately leads to reduced incidences of disease and improved well-being. The programme also explores the cues and clues that we pick up from the seashore environment. In shaping future actions, we need to know how our brains actively respond to different natural settings. Other work is addressing why marine environments are viewed so positively, compared with other natural or urban settings. Recent evidence from the UK suggests that those living near the coast tend to be healthier than those living inland, after accounting for differences in economic status and age. Of relevance to policymakers, the greatest positive effects on health from coastal living were seen for the most socio-economically deprived communities.

Well-being may also be boosted by time spent near or on the sea. To some this seems obvious, but deeper consideration suggests that a more complicated situation exists, often determined by social and cultural factors. Attitudes differ greatly around the world, with fear of the sea predominating in some island communities and in locations that have experienced natural disasters.

Population well-being has emerged as an important issue for government policymakers as it becomes clear that healthier physical and mental states amongst the population can reduce healthcare costs. It is notable that in the UK the National Health Service, primarily focused on treating rather than preventing disease, costs the taxpayer ca. £110 billion pounds per year. Fostering access to marine environments that promote well-being could contribute significantly to reducing these costs. Although a start has been made, there are issues to resolve regarding how to measure well-being and its economic value. Here we enter into a domain of intense debate, with a plethora of indices and measures already in circulation.

Many definitions of well-being rely on the identification of circumstances that can be objectively measured, delivering quantifications of well-being. However, others posit that an individual's sense of well-being can only be determined by themselves; it is what they perceive it to be. Perhaps the only way to find out is to ask each person, 'How do you feel?'. Of course, numerous factors contribute to creating a particular level of well-being including physical health, the state of personal relationships, past experiences, hopes for the future, levels of satisfaction with home and work circumstances, financial and physical security, personality and aspirations, strong and inclusive communities but also, critically, the type and quality of environments in which individuals live. These factors change over time, sometimes rapidly. Whilst accepting that it is very difficult to determine the relative importance of elements of this mosaic, it does appear that for many, time spent on seashores and in coastal areas can provide a considerable boost to overall well-being, however defined. It is this observation that might help guide our future actions.

Implications for policymakers

The Marine Strategy Framework Directive (Directive, 2008/56/EC of the European Parliament, 2008) provides the main framework for marine environmental policy. The aim is to deliver 'Good Environmental Status' (GES) by 2020 using 'qualitative descriptors' as measures of progress (for the list of descriptors, see www.mba.ac.uk/marinebiologist/issue-3-blue-mind).

Notably, none of these descriptors directly addresses the health and well-being of coastal communities, or the population more generally (although threats from contaminated seafood are mentioned). Benefits to health and well-being that might accrue from spending time in coastal areas are ignored.

Until we fully acknowledge that coastal ecosystems can provide 'ecosystem services' that maintain or improve health and well-being, we will fail to reap the wealth of benefits that policy interventions can contribute to improving public health. Better coastal access, motivating physical activity through marine pursuits, sensitive development of coastal cities and towns, are all areas where policymakers can make a difference. These measures will also deliver economic dividends by reducing healthcare costs, reducing days lost from work, reducing dependency on social support services, and if done appropriately, increasing resilience to climate change.

Promoting a strong dialogue among researchers, managers and policymakers across sectors such as Environment, Health, Social Services, Economics, Law, Planning and Construction continues to pose challenges. Policymakers in health departments are more likely to focus on provision of good services in hospitals than on the latest research indicating that living by the sea, or spending time in coastal areas, reduces the risk of succumbing to diseases and has positive effects on well-being.

Happily, as a result of rising interest across Europe and elsewhere, hopeful signs are emerging. For example, recently published proposals in the European Marine Board White Paper (2014) bring to light the prospect of re-energizing efforts in Europe to explore the interconnections between the oceans and human health through research and training. This prospect is now tantalizingly close.

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FURTHER READING

Oceans and Human Health: Implications for Society and Wellbeing (2014). Edited by R.E. Bowen, M.H. Depledge, C.P. Carlarne and L.E. Fleming. Oxford, UK: Wiley Blackwell.

Linking Oceans and Human Health: A Strategic Research Priority for Europe. European Marine Board. Available at: www.marineboard.eu/

Image: Mike Depledge.

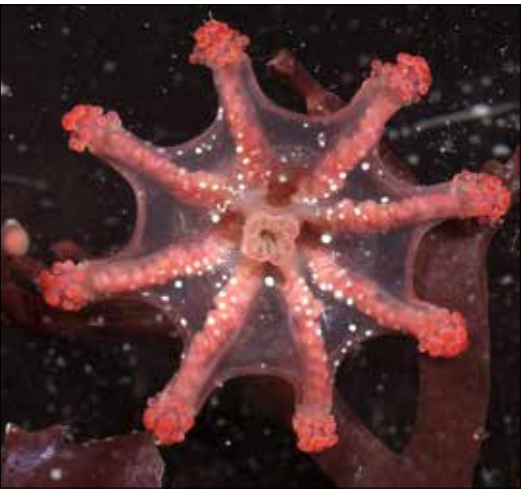
Recording in the marine environment; building a community for the future

Becky Seeley writes about the value of volunteer records and citizen science

Marine life recording has always been a fun and social activity. Here we look at the benefits and uses of volunteer records, and at developments in the systems that help the records flow to end-users.

The Chinese mitten crab recording page (mittencrabs.org.uk) has been successful in stimulating new records of this and other non-native crustaceans from anglers and other water users. Images from smartphones wing their way to the Non-Native Species Secretariat (NNSS) who pass them on to the Marine Biological Association for verification.

The streamlined reporting process put in place by initiatives such as the NNSS means that in the event of a new arrival, or of an invasive marine species being recorded in a new area, the right agencies are briefed and information can quickly be passed on to monitoring teams and recorders across the UK. With identification information to hand, Agency staff and volunteer recording networks are alerted to keep their eye out for unwelcome invaders and to conduct intensive surveys of the areas where they have been spotted.



Volunteer recorders have been instrumental in improving our understanding of the distributions of protected species such as the stalked jellyfish *Lucernariopsis campanulata*. Image: David Fenwick.

This illustrates why volunteer recorders are important. Information supplied by volunteers (either *ad hoc* data or data collected as part of a marine life recording scheme) is critical in expanding our knowledge about the distributions of marine species, in marking phenological change, and in reporting the occurrence of ephemeral events such as mass strandings. The long-term nature of some schemes means this information can be used to investigate aspects of species distribution, for example, a paper published in the JMBA (Journal of the Marine Biological Association of the United Kingdom; the paper can be accessed online via 10.1017/S0025315414000137) in June this year used data from a public jellyfish sightings scheme (www.mcsuk.org/sightings/jellyfish.php) managed by the Marine Conservation Society.

Although not to be considered a substitute for professional monitoring and structured survey work, and not a solution for all taxonomic groups, the value of volunteer records and citizen science is increasingly recognized. Natural history recording schemes from the terrestrial, freshwater and marine environment are co-operating, with a common aspiration of ensuring improved flow of verified public records. A key aspect of this is a verification process by experts who 'quality assure' each record.

The advent of social media and the ease of submitting digital photographs have allowed the proliferation of communities of recorders with Facebook groups for regions and taxonomic groups, as well as websites such as iSpot, where images of species can be posted that allow experts to support new recorders with identifications. Although social media and mobile phone applications are not for everyone, they are likely to prove essential in engaging the next generation of biologists and amateur naturalists.

Organizations supporting marine life recorders continue to work towards making recording easier for both the recorder and verifier, ultimately to facilitate better marine environmental decision-making. Means to automatically port information to national and international databases such as the National Biodiversity Network (data.nbn.org.uk) are currently being explored. Making records available as quickly as possible and providing important data through initiatives such as the European Marine Observation and Data Network (EMODNET) underpins work taking place under the Marine Strategy Framework Directive.

Recording marine life is fun. Image: Becky Seeley/MBA.

This work is more than just an exercise in data collection; marine life recording is a great way to engage and empower people and it really does help demonstrate what an amazing and varied place our marine environment is.

Sealife Signpost (www.marinesightingsnetwork.org) leads to known marine recording schemes in the UK, and we have recently added an 'Identification help' section. If you would like your scheme or group added, please contact recording@mba.ac.uk

Becky Seeley is Recording Officer at the Marine Biological Association.

The first international conference on communicating marine science

Over 100 science communicators, scientists and journalists gathered at the first International Marine Science Communication Conference in Porto, Portugal in September.

Anyone believing that communicating marine science is a waste of time would have had their conviction swiftly despatched during a keynote address by Nancy Baron (author of *Escape from the Ivory Tower: A Guide to Making Your Science Matter*) who told scientists that "being a communicator is not a trade-off, it makes you a better scientist".

Speaker after speaker told delegates that they need clarity on what they are saying, why they are saying it and, crucially, who are they saying it to. If we are to realise the beneficial outcomes of effective communication then we must identify and understand our audiences. For marine scientists and communicators whose business is making the invisible visible, and with so much at stake in our seas, clarity and focus in communication is of paramount importance.

One of the conference workshops focused on Web 2.0, which "describes Web sites that use technology beyond the static pages of earlier Web sites" (Wikipedia). Blogging, tweeting, LinkedIn, Google hangouts ... it can be bewildering. Use of social media is optional, but if scientists wish to communicate directly with people who read their work, or participate in real-time conversations, then they can choose their platform and enter the fray. Reassuringly, David Braun (senior digital editor at National Geographic) urged us to focus more and publish less. This workshop showed that the web exists not just to transmit information but to interact with many people and to listen to what they are saying about the marine environment.

As well as in-depth analysis and case studies, practical tips for communication came thick and fast, for example: always use images in your blog to increase traffic (For David's blogging top tips, see www.mba.ac.uk/marinebiologist/issue-3-iccms); use any opportunity to get your science message across - hoax images or sensational stories are a good excuse to explain a phenomenon; and word choice matters, for instance 'uncertainty' is interpreted by the public as 'ignorance'. Messages about climate warming or ocean acidification could be better received if the word 'range' was used instead.

Also at the conference, POGO (Partnership for Observation of the Global Oceans) launched 'Ocean Communicators United', an informal forum for oceanographic research organisations to share information and expertise on marine science communications matters.

So the message for scientists is that communication must be central to your enterprise. As Nancy Baron put it: know thy audience, know thyself, and know thy stuff!

Guy Baker

Delegates at the first IMSCC in Porto, Portugal, jointly organized by the CIIMAR (Interdisciplinary Centre of Marine and Environmental Research of the University of Porto), Ciência Viva (National Agency for Scientific and Technological Culture) and the European Marine Board Communications Panel (EMBCP).

Inside the squid giant axon

This summer marks the 75th anniversary of a ground-breaking experiment undertaken at the Laboratory of the Marine Biological Association by Alan Hodgkin and Andrew Huxley that helped launch a golden era of neurobiology.

In July 1939 the pair travelled from Cambridge University to Plymouth to work on the giant nerve fibre of the squid *Loligo*. The way had been prepared for their landmark achievement by the Oxford zoologist J.Z. Young (MBA President 1976–1986) who, in 1929, unexpectedly found the giant nerve fibres of *Loligo* while looking for an epistellar body (a vestigial photoreceptive organ), such as he had already discovered in the octopus *Eledone*. Instead, Young found a group of nerve cell bodies. Working at the MBA, Young noticed that from each cell projected a fine process, and that some 300 to 1500 of these processes were fused, forming the giant axons—crucially having 'large' diameters up to 1.0 mm that were suitable for insertion of a fine electrode. Young had confirmed experimentally that the structures were nerve fibres. However, it was left to Hodgkin and Huxley to probe the axon's inner workings.

Their first experiment in the summer vacation of 1939 investigated the nature of the nerve fibre contents. Finding it to be a solid gel and not a viscous liquid, Hodgkin had the insight to realize a fine saline-filled glass tube containing a chlorided silver wire could be pushed down the giant fibre to act as a non-polarizable electrode. With this set-up they were able to record

the potential difference between the interior and exterior of the fibre using equipment Hodgkin had built and found the internal 'overshoot' of 40–50 mV above the external potential, the hallmark of the action potential. After checking their results several times into late August 1939, and with the Second World War imminent, they left Plymouth and published their findings in a now famous letter to Nature (Action potentials recorded from inside a nerve fibre. *Nature* **144**, 710–711; 1939). Follow-up work for Hodgkin and Huxley became impossible for another eight years with the pair engaged in war work, during which time the MBA Laboratory was badly damaged by bombing and all the electrophysiology equipment destroyed.

Starting again at the MBA in mid-June 1947, and continuing through the 1948 and 1949 squid 'seasons' using the new voltage-clamp technique, they managed to record propagating nerve impulses culminating in their quantitative theory of nervous conduction published in a seminal series of papers in 1952. A share of the Nobel Prize for Physiology or Medicine in 1963 followed.

Squid giant axons (normally preserved beneath perspex) on a laboratory ceiling at the Marine Biological Association. Image: Fotonow.

Research using squid giant axons as a model system greatly expanded in Plymouth over the four decades following the first announcement in Nature, and involved such scientific luminaries as Bernard Katz and Richard Darwin Keynes. Obtaining recordings was technically very difficult and presumably it was the relief of finishing a fibre that started the tradition among the squid scientists of throwing them upwards over the shoulder with such speed that the sticky fibres became stuck fast to the ceiling! Some are still preserved *in situ* at the MBA (pictured) to commemorate the hugely important work done there, and to celebrate its ushering in of modern electrophysiology and the myriad of important discoveries in neuroscience that have followed.

Professor David Sims (dws@mba.ac.uk) MBA Senior Research Fellow.

Careers in marine biology

***TMB* writes**: As a leading learned society, an important part of the mission of the Marine Biological Association is to help ensure that a new generation has the opportunity to increase our knowledge of the seas. *The Marine Biologist* will publish articles that look at the broad range of careers available under the umbrella of 'marine biology', and that offer advice on how young people can maximize their chances of getting a foot in the door of their chosen career. We begin this section with an article from Dr Paul Greer, a careers advisor with over 30 years experience.

We also invite establishments that offer training in marine biology to tell you why you should consider studying with them. This will be a regular feature, and in this edition Liverpool University—the first UK university to offer a degree in marine biology—takes up the pen.

A career in marine biology

What do marine biologists do? How can school students plan for a career in this desirable field? Paul Greer explains.

Marine biology is the study of all aspects of life in the sea and the environment on which it depends. The main aims are to improve our understanding of the marine world and to understand and predict changes in ecosystems affected by human and natural disturbances.

Marine biologists share a fascination for marine animals and plants and a desire to spend a large proportion of their lives close to the coast or on the open ocean. Many are motivated by a desire to ensure that future generations enjoy healthy and productive seas. The popular image is of wetsuit-clad figures swimming past tropical fish to examine coral reefs. This is a narrow view. In fact, marine biologists work in many areas including policy, industry, communications and media, research, education, conservation and recreation (e.g. ecotourism).

Research scientists study ocean systems at scales from molecules to ecosystems, and their relationships to people and changing environmental conditions. They also study basic biology (often using marine organisms as 'models' —see pages 11 and 28) and develop ways to solve problems. Areas of concern right now are climate change, ocean acidification, overfishing, degradation of habitats and invasive non-native species.

A typical project may last between 6 months and 3 years, and focus on specific processes related to how organisms function and interact with each other and the environment.

Operational stages will probably include gathering samples, examining these to acquire relevant data and using specialist equipment or computer models for analysis.

Once established, findings will be disseminated through papers in scientific journals, reports or articles in the mass media, and presentations to academics, government, industry and environmental pressure groups.

Many marine biologists work exclusively in laboratories and offices for a research organization, consultancy, government agency or university, analysing observations or data and developing ideas for further investigations. At universities, they may have teaching responsibilities, perhaps instructing newcomers to the subject, or (with experience) supervising graduate research students. They also inform and learn from other professionals and scientists, such as geologists, physicists and biochemists.

Not all marine biologist work in the field – but some do! Image: MBA.

The capacity for fine and accurate observation, and care in gathering and presenting data, are important. So are patience in unfavourable conditions or when progress seems slow, physical fitness for collecting samples, and a disposition sociable enough to work and live with others (sometimes for quite long periods) on, for instance, a ship or remote research base. A high level of IT and communication skills are needed, too.

Good GCSE passes in English and maths, plus high grades in sciences (notably biology and chemistry), provide a sound base. Geography, too, is useful, though rarely compulsory. A-level choices should include biology and (preferably) chemistry. Applicants to university with other qualifications (such as BTEC) should consult institutions first, as competition for places is strong. Open days are good sources of information, too.

First (undergraduate) 3–4 year degree courses in marine biology are offered at about 16 British universities, all by (or very near) the sea (see www.mba.ac.uk/marinebiologist/issue-3-career-in-marine-biology for a list, and the article below about studying marine biology). Alternatively, a relevant but broader subject (e.g. biological science) may be followed by a second, higher degree such as MSc (Master's) or Phd (Doctorate). The second route allows anyone hesitant about committing to marine biology as a career more time to decide, as well as providing the level of qualification typically required for research posts.

A first degree is sufficient for many non-research jobs, and GCSE/A-levels may be enough for technician posts. Though often hard to obtain, work experience in marine biology is important, and 'ways in' might be found through university departments, marine laboratories, research institutes and government bodies.

If you would be interested in finding out more about careers in marine biology at an MBA event, please contact Jack Sewell jase@mba.ac.uk

Dr Paul Greer (paulgreer1@aol.com)

One hundred and thirty-five years of marine biology at the University of Liverpool

By Bryony Caswell

The University of Liverpool was the first UK university to offer a degree in marine biology (in 1973), and its marine activities can be traced back to the appointment of William Herdman (later 'Sir') in 1881 as a Professor of Natural History. Herdman developed and drove forward a major programme of marine biology and fisheries research. In 1890 the university's first marine education programme began with courses to instruct fishermen 'on biological matters with bearing on the fishing industry' which ran for 14 years. The university's marine biology degree can claim many esteemed alumni including Professor Nicholas Owens (Director, Sir Alistair Hardy Foundation for Ocean Science and previously Director of the British Antarctic Survey), Professor Steven Hawkins (Dean, University of Southampton and previously Director of the MBA), Professor Martin Attrill (Director of the Marine Science Institute, University of Plymouth), Professor Michael Burrows (Scottish Association of Marine Science) and Professor John Orr (former head of marine monitoring at the Environment Agency).

From 1973 until 2006 the marine biology degree at Liverpool was delivered partially from the Port Erin Marine Laboratory on the Isle of Man giving the programme a unique immersive aspect. However, the changing nature of the science and student body led the university to review its marine biology provision. This resulted in the programme being relocated to the main campus with £6 million investment in marine biology staff and infrastructure. Christopher Frid was appointed Chair of Marine Biology and worked with the new team to redesign the degree to reflect the challenges to marine biologists in the 21st century. The university offers three or four year IMAREST accredited degree programmes in marine biology and marine biology with oceanography that are delivered by a dedicated teaching team with diverse research interests. We also offer a range of MSc and MRes courses.

As a research-led university Liverpool's curriculum is continually evolving to improve the quality and reflect advances in the core science. Over the last three years we have been revising the programme so that it has now had a complete overhaul. The syllabus is fresh and innovative and tackles many contemporary themes. The teaching is strongly informed by our research that aims to improve our understanding of how ecosystems are structured, how they function and how we can best manage them in the face of today's societal challenges.

The Liverpool degree places a strong emphasis on field and laboratory training and our students embark on a one week-long residential field trip in each year of study to various UK localities. The students also undertake an independent overseas trip at the end of year 2. With a subsidy from the university the students spread across the globe to research what is 'hot' in marine biology at research institutes, universities, aquaria, non-governmental organizations and eco-education providers. Our students have spread far and wide visiting every continent except Antarctica[1]. For students interested in travel we also offer a semester abroad to various international destinations.

The Marisa moored in the Albert Dock outside of Tate Liverpool.

1 For links to a map of student's destinations and projects visit: www.mba.ac.uk/marinebiologist/issue-3-university-of-liverpool

In addition to our longer residential field courses we also undertake local field excursions. These sites include seven marine Special Sites of Scientific Interest, two Special Areas of Conservation, three Ramsar sites (wetlands of international importance) and four Special Protection Areas for birds. Within reach are a diversity of different habitats including the Sefton sand dune ecosystem (a national nature reserve), extensive mud flats, sand flats, rocky shores, salt-marsh, saline lagoons, marshland, heathland and man-made habitats such as Antony Gormley's seaside art installation on Crosby beach[2]. The Irish Sea remains a key area for research with excellent facilities for linking marine biology to oceanographic processes and the need for scientific evidence to support management of contemporary challenges such as fisheries overexploitation, offshore wind and tidal power schemes and the designation of marine conservation areas.

Liverpool's world heritage site: the three graces, as viewed from on-board the Marisa.

Having the oldest fully enclosed dock system in the world Liverpool's historic industries centred on international trade and the marine sector, and the city played major roles in the slave trade and industrial revolution. At the start of the 19th century 40% of the world's trade passed through Liverpool. Although port trade is now of lesser magnitude it remains the sixth largest UK port. The dock system is home to our research vessel the Marisa[3]. The Mersey's long history of human use led to it being described, in 1980, as the most polluted river in Europe. Since then the estuary has undergone extensive regeneration and being located at the interface between industry and the sea, Liverpool presents exciting opportunities to explore the impacts that we humans have had, and continue to have, on marine ecosystems.

Liverpool University recognizes that 21st century marine biologists need to be proximal to and focus on contemporary challenges, and their solutions. Our graduates are trained to be independent marine scientists with up to date

2 For a link to an article by a former student and staff on which organisms inhabit Gormley's inner thigh, visit: www.mba.ac.uk/marinebiologist/issue-3-university-of-liverpool

3 For links to a video of our students on Marisa, visit: www.mba.ac.uk/marinebiologist/issue-3-university-of-liverpool

knowledge and the skills to tackle the challenges presented by the rapidly changing marine global agenda. Recent marine biology graduates are employed within private consultancies, government organizations, renewable energy companies, universities, the fishing and water treatment

industries, the banking, health and biomedical industries, research laboratories, schools, zoos, international education providers, charities and non-governmental conservation organizations; others go on to further study.

One thing Liverpool has in addition to a diversity of marine habitats is loads of character. The city is intriguing for its history, architecture and culture. Scores of musicians, artists, writers and thespians originated here and continue to do so. With more galleries and museums than any UK city, except London, Liverpool has a multitude of extra-curricular offerings.

A student's perspective on marine biology at the University of Liverpool. By Paul Scott.

Unlike most students I started my degree at Liverpool at age 49 and last month I graduated with a first class MMarBiol degree. I am one of the first students to graduate with this new degree from Liverpool. My marine biology journey started aged 9 on a deserted rocky shore on the west coast of Ireland. My rock pool interests spread to fishing and one day I watched amazed as a basking shark passed within 50 yards of me. In the years that followed I retained an active interest in the UK coast, its marine life and conservation, chastising myself for never having studied it academically.

Searching for a silver lining from within the dark cloud that was 2007, I decided to follow my dream and study marine biology. So, 30 years after I had decided to study marine biology I finally got there. Oh, and if you are beyond the first spring of youth, don't let that put you off, not only do the staff give you a warm welcome, so do the other students, age makes no difference (other than a reduced capacity for alcohol).

At Liverpool marine biologists are able to follow a range of options beyond the core modules. For example, if you are interested in organism physiology, that is catered for as is advanced maths and statistics, chemistry and ecology, and this for me was one of the highlights of the degree. No degree would be complete without the field trips that provided fun, and a great grounding in practical skills. Liverpool has its own research vessel which is used for teaching and provides an extra skill layer. Also, you can laugh as your friends throw up.

A major part of the third year is spent on the honours project. The

Second year students on their residential field trip.

really exciting word here is '**your**'. My project was my idea and my supervisor provided backup, encouragement and made sure that the necessary science was included. The guidance and support that I received resulted in my dissertation being of sufficient quality for publication. The end result really felt like I had added something to science. I have recently been filming for a programme with the BBC, based on my research project, to be released later this summer. Overall, I'm delighted I chose Liverpool and that I now have a highly respected degree in marine biology from a university that has been engaged in marine research since the 1880s. Liverpool. It's never too late!

Dr Bryony Caswell (B.A.Caswell@liverpool.ac.uk)
Department of Earth, Ocean and Ecological Sciences at Liverpool University.

Paul Scott is a recent graduate of the new 4 year programme at Liverpool.

Reviews

Pocket Cornwall: Wild Looe

Author: Derek Spooner
ISBN 13 978-0-906720-94-3
Alison Hodge Publishers

Looe is a small fishing town built around the estuary of the Looe river in south-east Cornwall, surrounded by a large variety of habitats terrestrial and aquatic. The marine conservation zone, nature reserves and national trust woodlands provide

diversity within a relatively small (less than 70 square mile) area.

Dr Spooner takes the reader on a journey around the natural world surrounding Looe; from Seaton to Polperro along the South coast of Cornwall, and as far inland as Duloe and Hessenford. He describes with affection the various ecosystems and the organisms inhabiting them, without losing the sort of attention to detail that tends to lead books such as this to seem sterile and detached. He has an intimate knowledge of the times and places to see some of the more elusive species, describing features and characteristic behaviours in order to allow even the least experienced ecologist to find something new, rare and special.

The book is well organised, and divided into a chapter for each

ecosystem. The text is well supported by the colour photographs of stunning landscapes and the more interesting species discussed. It is easy to follow for those with prior knowledge of the region, using the map on page 9 as a simple point of reference. For new visitors however, I would recommend the purchase of a map of the local area to benefit fully from this book.

It is my hope (and it would appear that of the author) that this book may breathe life into the ecotourism of the area and secure the future and conservation of its natural wonders.

Thomas A. Baker

Whale-watching: Sustainable Tourism and Ecological Management

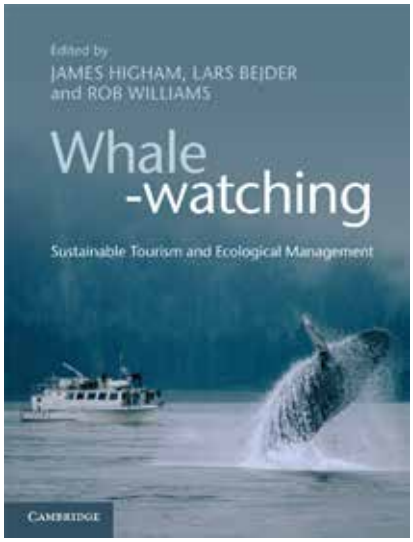
Edited by James Higham, Lars Bejderand and Rob Williams

ISBN 978-0-521-19597-3

Cambridge University Press

A few days ago, while sailing home from France, I was visited by a small pod of bottlenose dolphins (*Tursiops truncatus*). Travelling on an intercepting course, they 'stayed & played' with the boat for 15 minutes before resuming their voyage. A timely reminder of the powerful emotional impact generated by contact with cetaceans. My smile for the rest of the day was just that bit bigger.

A diverse range of nearly 50 contributors make this book on commercial whale watching a wide ranging review of the topic. A central theme in the first half of the book is to compare and contrast whale watching ('visual consumption') with the more extractive industry of whale hunting. The writers demonstrate that whale watching is not necessarily the benign pastime it is sometimes thought to be. A more nuanced approach is required to replace the simple dichotomy of past debate.



At its heart, this book deals with a powerful and controversial issue: how to observe wildlife yet conserve the environment. One of the main determinants of tourist satisfaction is the closeness of contact with cetaceans they experience and this closeness inevitably causes adverse ecological changes.

And yet such activity has become emblematic of marine conservation. Those taking part in this form of tourism feel they are doing their bit for saving the planet yet there is little evidence of behaviour change attributable to the experience.

Whale watching also impacts on near shore human communities. Some communities are harmed and exploited but there are examples quoted of more positive outcomes

This book is not exclusively for marine biologists; it is of equal interest to sociologists, social geographers and those organising or regulating ecological tourism and improving sustainability. And ultimately, it is an optimistic book with the final section detailing case studies of sustainable solutions.

Kit Harling

Sharks: Conservation, Governance and Management

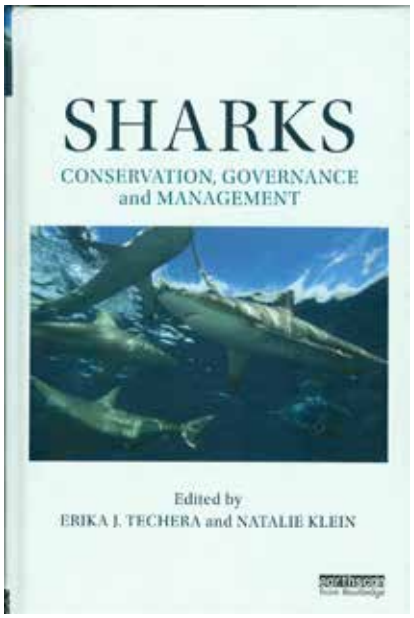
Edited by Erika J. Techera and Natalie Klien

ISBN 978-0-415-84476-5

Published by Earthscan from Routledge

In January 2014 the IUCN Shark Specialist Group released a report (Dulvy *et al*. 2014) which made for alarming reading, confirming that shark, skate, ray and chimaera species are among the world's most threatened animals.

Never has there been a more pertinent time for the spotlight to shine on Chondrichthyians



and the urgent requirement for effective and enforceable conservation management.

Sharks: Conservation, governance and management is a comprehensive publication drawing on the expertise of a wide range of individuals who present their, or their affiliated organisations, perspective on a wide range of relevant issues, all underpinned by the knowledge that sharks are an essential element of a diverse and healthy marine environment.

The delivery of effective conservation is far from simple, and this book provides insight into the complex interaction of stakeholders, governments, NGOs working to secure management for often highly mobile species across multiple national boundaries.

Reflecting at times the collaborations and allegiances of the authors' own organisations, the book is not without its politics, but these would be lost on the vast majority of readers and do not detract from the book as a whole.

Perhaps more disappointingly the book overlooks the skates and rays, the 'flat sharks', which, as highlighted by Dulvy, represent five of the seven most threatened families.

The shark conservation landscape is changing rapidly, it's a challenge to keep up and this book certainly provides some food for thought – I can't wait to have the time to read it in detail.

Ali Hood

***TMB* writes**: The Marine Biological Association welcomes responses from readers of *The Marine Biologist*. In the article below, MBA member Professor Ray Williams responds to an article in issue 2 on a traditional oyster fishery in the Fal estuary in Cornwall, southwest England.

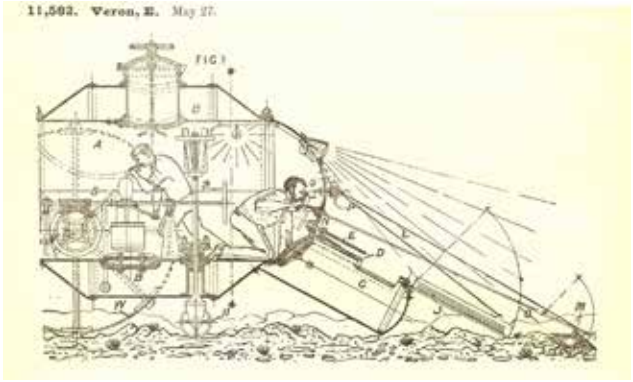
Oyster harvesting was not always as traditional as now

R. B. Williams

Millions of words must have been written about the present parlous state of the world's fisheries and the reasons for their decline. Perhaps the major blame for depleted fish stocks falls on the ever-increasing sophistication of trawls, seines and long-lines, their efficiencies further enhanced by electronic tracking of shoal movements.

However, although native oyster populations in the UK have suffered severe reductions since the mid-nineteenth century, increases in efficiency of harvesting methods have tended to lag behind those for fin-fish. Despite that, increased use of the traditional dredge was alone culpable for the reduction of natural stocks in the longer term. Nevertheless, a recent article (Baker, G., 2014, A traditional fishery enters 'a new era', *The Marine Biologist*, 2: 32) related how retention of "traditional methods" has in recent times helped to maintain the sustainability of some commercial beds in the UK. The survival of the oyster fishery in the Fal estuary in Cornwall was succinctly described, thus: "The fishery is self-sustaining and regulating in terms of fishing effort – a kind of conservation by inefficiency".

And what is this essential inherent inefficiency, but the continuation of the use of traditional dredges operated from sailing or rowing boats? The caption of one photograph noting that "Oysters have been extracted in this way for well over 200 years" triggered in my memory the invention of a very much more intensive harvesting method for oysters in the late nineteenth century, no doubt a misguided response to the dramatic fall in commercial yields. An hour's rummaging through some old journals produced what I had remembered—E. Veron's illustration of his 1896 patent specification (see Figure). Although current British native oyster production is but a very small fraction of what it was during the mid-nineteenth century, if Veron's monstrous machine had been widely used, commercially exploitable native oyster populations might now not exist at all.



Dredging apparatus for oysters. Reproduced from Patents for Inventions – Abridgements of Specifications – Class 48, Fish and Fishing, Period A.D. 1893–96 (Patent Office, 1899, p. 27).

Professor Laurence David Mee, 1951 - 2014

Professor Laurence Mee, the director of the Scottish Association for Marine Science (SAMS), died suddenly and unexpectedly on August 13, 2014 in Inverness where he had been on business. He had suffered a severe stroke.

Laurence joined SAMS as director in 2008 continuing an illustrious career including positions at the Marine Environmental Studies Laboratory in Monaco (1987-93), as founding coordinator of the Global Environment Facility Black Sea Environment Programme in Istanbul (1993-98) and at the University of Plymouth (1998-2008) as the UK's first Professor of Marine and Coastal Policy and then Director of the Marine Institute. In 1998 Laurence also became a Pew Fellow in Marine Conservation. Laurence had a long-standing relationship with the MBA through his service on the Council of Trustees (2005-08) and as a member and collaborating researcher.

Describing his work as "'big picture' science through a 'macroscope'", Laurence specialised in coupled marine social-ecological systems. He studied the relationship between people and the ever-changing marine environment, and worked with politicians, community leaders, educationalists and business leaders to devise ways to use our seas more sustainably.

Laurence was 63 years old, but seemed so much younger. He was a positive, energised, energetic, fun loving intellectual. He was a proud father of four children, a passionate sailor, diver, kayaker and swimmer. He excelled at telling anecdotes and his views on current affairs and history were highly informed, independent and insightful. He was a man of the ocean; a cosmopolitan who kept travelling the world.

He is survived by his four children, Daniel (35), David (31), Anastasia (15) and Flora (2).

There is an online memorial site http://laurence-mee.tumblr.com/ for his many friends, colleagues and family members to share their sadness and happy memories, celebrating Laurence's outstanding life and memorable personality.

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