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Royal Charter edition

The Marine Biologist

The magazine of the marine biological community

Exploring and valuing planet Earth's blue heart

with Sylvia Earle

THE MARINE BIOLOGICAL ASSOCIATION
Est. 1884
Incorporated by Royal Charter

South Atlantic | Exploring mesophotic reefs | Marine conservation in Wales

The Marine Biologist
The magazine of the marine biological community

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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

A warm welcome to *The Marine Biologist*. We are presenting the second issue as the Royal Charter edition in celebration of a real achievement for the Marine Biological Association. On page 6 the MBA's Deputy Director Matt Frost expands on what the Royal Charter means for the Association, for MBA members, and for how we aspire to promote the discipline of marine biology. We hope that this special issue answers questions you may have about the Charter and stimulates discussion about the future of our Association at this exciting time.

I am delighted to present the keystone article for this edition by MBA Honorary Fellow Sylvia Earle (see page 8), arguably the world's leading ocean advocate, in which the case for exploration, sharing knowledge and improving the public perception of "planet Earth's blue heart" is passionately and eloquently made. We see how technology is being used not just for physical exploration of the sea but to reach a global audience and deepen our understanding of ocean issues.

Our second article takes us on a lively examination of the origin of marine laboratories, and a very timely glimpse into their role in the future.

The importance of habitats at depth as refugia and repositories of biodiversity is increasingly recognized and we venture—thanks to advanced scuba technology—into the mesophotic reefs of the Philippines. Closer to home but deeper still researchers from Heriot-Watt University and the National Oceanography Centre present a project to map deep sea coral reefs which draws upon remote sensing, unmanned vehicles and ground-truthing by survey vessels. This level of resource and expertise can only be brought to bear through collaborations between institutions.

We learn about a new South Atlantic research institute for which collaboration is key to better understanding and protecting the natural resources of a vast but relatively poorly understood area of ocean. We also hear contrasting views from highly experienced people in industry and conservation on how we should go about protecting marine resources. I hope this will stimulate correspondence and debate which can be continued between editions of the magazine (see below).

Returning to the theme of marine laboratories, and skipping across the Atlantic, we hear from the world-renowned Marine Biological Laboratory at Woods Hole, Massachusetts, and how a new partnership will build on some extraordinary achievements and open up new ventures for the future.

References, links and more can be found on *The Marine Biologist* website. Also online our new members-only LinkedIn page offers access to the latest news stories and information chosen by the MBA as being relevant to the marine biological community. See page 5 for more information. I hope you enjoy the new reviews section—I would like to see reviews provided by you, the members, so please contact me if you would like to submit a review of a book, special publication, film, website, DVD or TV series.

The original brief for the magazine was for an authoritative, credible publication representative across the field of marine biology, consistent with the MBA's ethos of inclusivity and accessibility. How are we doing so far? Does *The Marine Biologist* meet your expectations of a member's magazine? Please write or call me to influence the way your magazine evolves.

Guy Baker

Front cover: Sylvia Earle at Aquarius, the undersea research laboratory in the Florida Keys. Image: Kip Evans. **Back cover**: The long snouted seahorse *Hippocampus guttulatus*. Image: Neil Garrick-Maidment/Seahorse Trust www.theseahorsetrust.org

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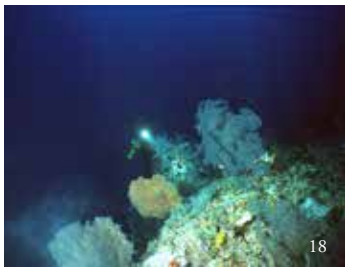


A new centre for earth and marine science and technology

The British Geological Survey (BGS) and Heriot-Watt University are joining forces to create the Sir Charles Lyell Centre which will promote innovative research at the core of geoscience, marine ecology, computing, mathematics and engineering.

The new fusion of pure and applied expertise between Heriot-Watt and BGS will enable the use of innovative methods to create real-world solutions in areas including: global change and ecosystems; seafloor-mapping using advanced robotic vehicles; earthquake and volcanic risk and monitoring, and energy security.

BGS is relocating its Edinburgh office to the £17m, purpose-built complex which is scheduled to open by 2015 at Heriot-Watt University's Edinburgh campus. There will be incubator space for spin-out and spin-in companies looking to work with Heriot-Watt and BGS staff.

David Willetts, Minister for Universities and Science said "The creation of the Sir Charles Lyell Centre assembles world-leading expertise from the British Geological Survey and Heriot-Watt University in a common enterprise bringing together investment and skills from the UK Research Council and University sectors to support future UK innovation and growth".

Fukushima - impacts on the marine environment

Professor James Smith of the University of Portsmouth told TMB: more than three years on from the Fukushima nuclear disaster, many questions remain about the impacts of radioactive releases on the marine environment. Early fears of large amounts of radiocaesium—the most significant long-term contaminant—making its way across the Pacific have proved unfounded. Massive dilution in the ocean meant that radioactivity concentrations rapidly declined to very low levels, and radiocaesium levels in tuna migrating across the Pacific to the US are tiny (Madigan *et al*. 2012). But fishing bans remain in place over a large area along the Fukushima coast, partly because the Japanese government adopted an ultra-safe consumption limit of 100 Bq/kg of radiocaesium: this is about 10 times lower than is allowed in most other countries. Radioactivity concentrations in fish are declining and most don't exceed the 100 Bq/kg level (Iwata *et al*. 2013). Nevertheless, some fish in the near zone to Fukushima can exceed this limit many times.

Radiation hotspot in Kashiwa. Image: Abasaa.

Radiocaesium concentrations in water are now low even near Fukushima, but sediments are a sink for radioactivity and bottom-feeding fish tend to have the highest levels of contamination. These species also show the slowest rates of decrease. Though the fishing bans are having a big economic impact, radiation is unlikely to damage the marine ecosystem. A recent UN report on Fukushima (UNSCEAR, 2014) found that dose rates to marine species were not high enough to damage populations of fish and other aquatic organisms, though seaweeds and bottom dwelling fish may have been affected close to the release pipeline. The positive long-term outlook for marine organisms accords with studies at Chernobyl. The cooling water reservoir at Chernobyl has a thriving fish population and our studies of lakes around Chernobyl showed invertebrate populations to be unaffected by the contamination (Murphy *et al*. 2011). But the science is less clear on more subtle genetic and reproductive effects and, as at Chernobyl, controversy over such effects is likely to continue.

Welcome to the plastisphere: microplastics modify the bioavailability of co-contaminants

Research carried out by Vicky Sleight at Plymouth University showed that PVC microparticles reduced the bioavailability of phenanthrene in zebra fish larvae.

The findings highlight a lack of knowledge about how microplastics mediate uptake of contaminants into marine food webs.

The research was presented at the second annual Posters in Parliament event. See *The Marine Biologist* website for links.

The 11th MBA Postgraduate conference takes place in Hull

The MBA's Postgraduate Conference took place this spring in the Centre for Environmental and Marine Science at Hull University (Scarborough, UK). Growing strong in its 11th year, the Conference brings together a group of early career scientists that are in the midst of their masters and PhDs at top institutions across Europe.


Delegates at the 11th MBA Postgraduate conference which took place in Hull, UK. Image: Conference Organising Committee.

The conference's growing name is also reflected by the range and expertise of keynote speakers holding esteemed positions within research institutions and NGOs across the UK. These keynote speakers not only present their research but also provide words of wisdom on how to build a career within the marine field.

MBA Ambassador and previous bursary winner Rebecca Shellock said "it's my second year attending the conference and I know I will keep coming back. The conference not only enables students to network with other like-minded individuals but provides them with an early opportunity to present their research to a large but friendly audience. This has prepared me greatly for other conferences and networking events that I attend within my role as a Marine Policy Research

Assistant at Plymouth University."

For its 12th year, the MBA Post-graduate Conference will return to Queens University Belfast (Northern Ireland).

Marinexus

People on both sides of the English Channel learned more about local marine ecosystems and their ability to cope with the effects of human activity, thanks to Marinexus, a 4-year €5 million EU Interreg project which brought together marine science and outreach in Devon and Brittany.

Marinexus funding underpinned research within three themes: long-term observation programs, the impacts of non-native species and ocean acidification and the ability of native species to adapt to changes in the environment. Support for some of the longest, broad-based ecosystem time series in the world has helped unravel how communities respond to natural and human influenced change.

In addition to scientific advances, collaboration under Marinexus has brought knowledge and learning to the public and stakeholders on both sides of the Channel. The continuity of common scientific heritage with regard to shared ecosystems is vital for sustainable use of natural resources and for innovation in the broader sense. Under Marinexus, the sharing of resources, ideas and approaches worked exceptionally well, and part of the final meeting was a discussion of themes for a possible Marinexus 2 project.

Examining the ability of macroalgae to adapt to changes in the environment of the western English Channel as part of the Marinexus project. Image: R. Lamoureaux (photothèque CNRS).

Mark Cock, Marinexus program coordinator said "The Marinexus project has considerably strengthened scientific interactions between the French and English partners and has been at the origin of some very innovative projects, such as a joint project that installed a 'ferry box' on the cross-channel ferry to monitor changes in sea temperature and salinity. The outreach activities have also been extremely enriching for all the partners of the project and the feedback from schoolchildren and the general public has been very positive".

An article on the achievements and learning gained through Marinexus will appear in the Autumn edition of the magazine.

Connect and engage with marine biologists via social media

For established (or aspiring) social media users, a new online hub for MBA members is on LinkedIn. Members receive 'digests' of the latest relevant news—a valuable benefit in an age of information overload—and can post discussions, share content, view job vacancies and connect with other members around the world.

The MBA will use the group to actively engage with the global membership and encourage sharing of knowledge and expertise.

Your LinkedIn account will also give you access to the new searchable expert database, where members can look for other members with expertise in specific areas willing to be consulted on their field of knowledge.

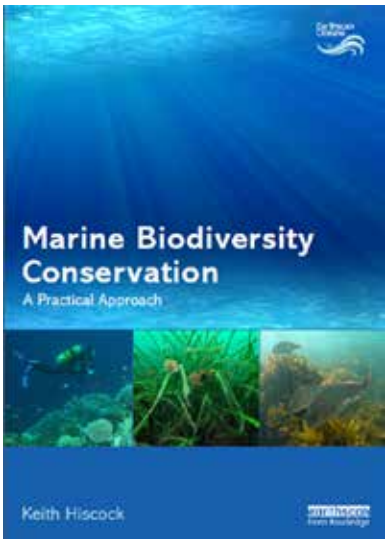
Links to the experts database of the Society of Biology are in the pipeline, further expanding the professional network and pool of knowledge available.

To access the group, members can search for "Marine Biological Association Members" in LinkedIn.

For more information, contact the Membership Secretary, Alex Street.

Being practical about marine conservation

Effective marine biodiversity conservation is dependent upon a clear scientific rationale for practical interventions. This is the premise that underpins a new book by MBA Associate Fellow Keith Hiscock. This book is intended to provide knowledge and tools for marine conservation practitioners and to identify issues and mechanisms for



upper-level undergraduate and Masters students. It also provides sound guidance for marine biology field work.

The book is a practical guide based on a clear exposition of the principles of marine ecology and species biology (the main focus is on benthic species) to demonstrate how marine conservation issues and mechanisms have been tackled worldwide and the criteria, structures and decision trees that practitioners and managers will find useful. Well illustrated with conceptual diagrams and flow charts, the book includes case study examples from both temperate and tropical marine environments. Marine Biodiversity Conservation will be published by Earthscan from Routledge on the 20th August 2014. Quote code DC361 for a 20% discount from www.routledge.com/books

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**

"The oceans deserve our respect and care, but you have to know something before you can care about it." – ***Sylvia Earle***

Onwards and upwards for Marine Biology

MBA Deputy Director Matt Frost on what the award of the Royal Charter means for the Association

Most people would know the names of Crick and Watson if asked about the discovery in 1953 that the DNA molecule exists in the form of a three-dimensional double helix. Nine years later in 1962 Francis Crick and James Watson, along with Maurice Wilkins were awarded the Nobel Prize in Physiology or Medicine. But consider another fundamental discovery in the biological sciences with an almost identical timeline. In 1952, Alan Hodgin and Andrew Huxley published their work on nerve cell excitability, with their findings recognised as being "a central pillar of modern neuroscience research"[1] and fundamental to all modern physiological research[2]. The work was only made possible by the discovery by J. Z. Young working at Plymouth, Woods Hole and Naples in the 1930s, of the giant axon in squid that made these cephalopods the ideal model organism[3]. Hodgkin and Huxley's work, undertaken largely at the MBA laboratory in Plymouth, led to the award of the Nobel Prize in Physiology or Medicine in 1963 (shared with John Eccles) but, as far as the wider public is concerned has received far less attention. The same comparisons can be drawn when looking at ocean exploration. For example, the publication of a biography of one of the great ocean pioneers William Beebe in 2004, prompted one online reviewer to ask why Neil Armstrong was a household name yet the first person to explore the depths of the ocean remains relatively unknown.

It is this feeling that the discipline of marine biology, although of enormous importance scientifically and from a conservation and socio-economic point of view, does not always merit the attention it deserves that prompted the MBA to consider an application for a Royal Charter. The MBA has an international membership and has been promoting marine biology and interest in the marine environment since its establishment as a learned society in 1884. The Royal Charter however provides formal recognition for the MBA's role and, in 2013, the Charter was granted in 'recognition of the MBA's long and eminent history and its status within the field of marine biology'. The MBA is therefore the world's only learned society dedicated purely to the study and promotion of marine biology to receive a Royal Charter.

Looking forward, the Association has invested a select group of individuals as Honorary Fellows (see opposite) who will help us to continue to raise the profile of oceans and we look forward to working with them more closely in the future.

Applications are also invited for the new MBA Fellows programme (email for details to membership@mba.ac.uk)—part of our commitment to promote and maintain excellence in marine biology as a discipline. We also want to recognise those outside of academia but who nevertheless play a vital role within the field of marine biology. To help ensure that a new generation has the opportunity to contribute to marine biology the Association is developing a new 'Young Marine Biologist' category. See page 36 for the latest information on this.

It is also important to us that we provide a forum for marine biological discussion and represent the community's views, a key element of which is the launch of *The Marine Biologist* magazine. This edition of *The Marine Biologist* celebrates this pivotal event in the history of the Association by looking at the development of marine biology both past and future with a focus on marine laboratories and the visionary individuals who established them.

If you have any questions about the Royal Charter, please contact me or refer to www.mba.ac.uk/membership/faq

Matt Frost (matfr@mba.ac.uk)

1 Catterall W. A., Raman I. M., Robinson H. P. C., Sejnowski T. J. and Paulsen O. (2012). *The Journal of Neuroscience*. October 10, 2012 32 (41):14064 –14073.

2 Vandenberg J. I. & Waxman S. G. (2012). Hodgkin and Huxley and the basis for electrical signalling: a remarkable legacy still going strong. *The Journal of Physiology*. 590.11 (2012) pp 2569–2570.

3 Schwiening C. J. (2012). A brief historical perspective: Hodgkin and Huxley. *The Journal of Physiology*. 590.11 (2012) pp 2571–2575.

New Honorary Fellows of the Marine Biological Association. From left to right: HRH The Duke of Edinburgh, His Serene Highness Prince Albert of Monaco, Dr Sylvia Earle, Professor James Lovelock and Sir Tim Hunt.

An event celebrating the granting of the Royal Charter, where the first ever Honorary Fellows of the Association were announced, was held in March 2014. His Royal Highness The Duke of Edinburgh (Patron of the Marine Biological Association) attended the event at the Fishmongers' Hall in London, and accepted an Honorary Fellowship along with His Serene Highness Prince Albert of Monaco, Dr Sylvia Earle, Professor James Lovelock and Sir Tim Hunt (see above).

It is significant that the event was held at the Worshipful Company of Fishmongers' Hall in London; they have been long-standing supporters and are one of the founding organisations instrumental in the establishment of the MBA as a learned society in 1884.

The following images show MBA members and invited guests, who included MPs and leading figures in UK marine biology, enjoying the reception.

1. Left to right: Dr Matt Frost, Sir Geoffrey Holland, HRH The Duke of Edinburgh and Professor Colin Brownlee with the Royal Charter.
2. Professor Sir John Beddington, President of the MBA.
3. Professor James Lovelock accepts his MBA Honorary Fellowship.
4. MBA student members.
5. MBA member Dr Mangaiyarkarasi Ravirajan from Tamil Nadu, India was visiting London and had the opportunity to attend the event and meet HRH The Duke of Edinburgh.
6. Left to right: Jane and Keith Lawrey, and Giulio Relini speaking to HRH The Duke of Edinburgh.
7. Left to right: Jen Ashworth, Manager of Marine Conservation and Management Advice at Natural England, Sam Fanshawe, Chief Executive of the Marine Conservation Society and Samantha Burgess, Chief Scientific Advisor at the Marine Management Organisation. Images 1-7: Alex Farquhar Photography.

Big, blue and beautiful

Why exploring and valuing planet Earth's blue heart is the key to future wealth, health and happiness

By Sylvia Earle and Dan Laffoley

Image: Tim Taylor

Water covers nearly 71 per cent of Earth and over 97% of the habitable 'living space' on our planet, yet we know more about distant stars and deep dark space than we do about the deep blue ocean. We understand why it is important to reach for the stars, to look at ourselves in perspective of the universe, ask big questions such as where did we come from, how is it that we are here in this blue speck in space, and where are we going? And we have devoted a great amount of time and resources to moving forward, but meanwhile we have neglected understanding how this part of the solar system—our home—the heart of our life support system—how this really functions.

Ocean exploration and the need to better connect people to the ocean's plight are critical to better understanding, better valuing, and better protecting the planetary systems that support us. Knowing is the fundamental basis for doing, and the need is as never before to dive below the surface of the sea to see, to realise, and to understand the significance of our actions, or to be more precise, the significant scale of current inactions and the consequences they hold for all of us. It is like trying to understand your own body—is it good enough to only look at the skin? Do we not have to delve in and understand how the heart works or the lungs or circulatory system, or do we just take that for granted?

It is incredible to think that whilst we humans have the ability sometimes to act in wise and wonderful ways, we are really still under the impression that the ocean is so big, so vast and so resilient that humans do not have the capacity to harm it—and if we do, that it does not matter. We look at the scale and how unchanging the ocean seems to be and assume it can all take care of itself, and that it is really not something we should worry about—it might be an issue for future generations but not for us! What has become increasingly clear, though, is our ability to really undermine the way the ocean works by what we take out and by what we put in. This is not something for tomorrow, it is what is happening today and that is being measured, studied and catalogued by marine scientists throughout the world.

People ask—what is the biggest threat to the ocean? Overfishing, pollution, climate change or ocean acidification are all usually mentioned. But by far and away the biggest threat to the ocean is ignorance—our ignorance of what is happening, and why and how this matters. It is a lack of understanding that what we put in and take out matters—not just to the ocean, but matters to all of us. The ocean cannot be regarded as the planet's ultimate dumpster or the ultimate place to get free food. It is our life support system, and not being aware of the importance of the ocean to every breath we take, every drop of water we drink, to a benign envelope of conditions that make the planet work—that is the biggest

threat. Not knowing that it matters.

By exploring the ocean we now understand better than ever before the consequences of what is happening. In a sense we now realise that we are sleep-walking ourselves into a nightmare. This is because changes are so slow but progressive, and at some point occur to a level when we finally do sit up and take notice. Often it is at a point that is too late given progressive changes, and is inherently linked to how much we spend on knowing what is happening. The ocean is difficult to study, much more so than dry land, but really there are no short cuts to gaining knowledge. The advent of SCUBA diving in the 1950s set up the current generation with new tools to explore the shallowest margins of our watery world, and an explosion of knowledge followed. But what of the deep ocean? Our temptation is to turn to machines as we have done in most aspects of our daily lives. But are machines good enough to take our place? James Cameron—one of only two people alive today who has travelled to the deepest part of the ocean—believes (as do the authors), that a human heart lies at the centre of ocean science. It is therefore much more than unfortunate that just as we reach an era when we have the analytical powers to start to make sense of how our planet works we see a draw back in funding on manned exploration of the ocean. Recent actions have saved the US National Oceanic and Atmospheric Administration's Aquarius underwater laboratory, located off Key Largo, Florida, so at least we have somewhere where we can live for a while immersed in the ocean, but the number of countries with submarine research capabilities continues to shrink. With the vast majority of the ocean yet to be discovered this is a mistake, and the hopes are that private donors will step forward to balance out the loss of government funding for underwater exploration because it is mission critical to somehow keep it going.

Scuba diving in Curacao. Image: Stephen Frink.

Sylvia Earle in the Deep Rover submersible, 1,000 meter record dive 1986. Image: Courtesy of Sylvia A. Earle.

What we do now know with the information we have managed to gather to date is that the blue heart of the planet is in danger of malfunctioning because of actions we have taken in recent years. It is partly because there are now over seven billion of us. The value of seeing beneath the ocean surface is immense. We are now impacting every part of the blue planet, from polar areas to the deep sea, and we are exploiting the deep sea even before we have explored it. We do not even know the names of the creatures that are now being dragged from the ocean to provide animal food and food for us, too. What we do know is very worrying to an increasing number of people—not perhaps because they care for a particular ecosystem or species, but because we are beginning to realise how linked our wellbeing is to the wellbeing of the ocean. We now know that about half of the world's coral reefs are either gone or in a serious state of decline, as compared to where they were in the middle of the 20th century. Ninety per cent of many of the big fish that we consume are gone—tunas, swordfish, sharks, halibut, groupers, snappers, down to about ten per cent of what they were 50 years ago. And we are changing the very chemistry of the blue part of our world that sets us apart from any other place we have so far discovered in the universe. Excessive carbon dioxide emissions from our activities are not just changing the climate,

far and away the biggest threat to the ocean is ignorance

they are driving the balance of the ocean waters towards more acidic conditions with as yet unclear but likely significant consequences for some marine life.

The impacts of these and many other effects will be felt by communities around the world—not just those in coastal-dependent communities but, with our superfast and super-efficient supply systems, people inland who are very remote from the ocean. It matters because we blindly rely on the ocean providing and yet we are degrading the blue heart of the planet that keeps our world habitable. Even the smallest items play a role, though most people would never give them a passing thought. Plankton drive the oxygen cycle, and we are all the beneficiaries of what those little green and blue-green creatures in the ocean do. About 70 per cent of the oxygen in the atmosphere comes from these photosynthetic organisms in the sea. Mangroves, saltmarshes, seagrass meadows, kelp forests—they are all being depleted at a shocking rate and yet until recently have been overlooked as carbon rich habitats, their importance finally being recognised alongside similar values we have long attached to forests and peatlands.

We forget in the hustle and bustle of our daily lives that we are eating resources that have 'grown in history'. Life in the deep ocean goes slower and species can live for much longer than we can easily relate to. Orange roughy, for example, is a deep sea fish that is taken from 2,000 feet and more beneath the surface. Most people do not have any idea what an orange roughy looks like because by the time it gets to the market, all you see is a little fillet. That little fillet may be two centuries old.

Elkhorn coral. Image: Kip Evans.

Technology allows people to venture into the deep ocean. Sylvia Earle in the Jim suit at 380 metres off Oahu, Hawaii. Image: Courtesy of Sylvia A. Earle.

What we are doing to the ocean is like stripping the land of all the lions and tigers and leopards and bears and wolves and eagles and owls, because most of what we take from the sea is from the top of the food chain. Not the grazers and not the producers, or the plants. Would you eat songbirds? Would you consume eagles, owls, snow leopards, elephants, tigers, lions? That is the equivalent of what we find in our supermarkets and on our menus from the ocean. It is wildlife. And for the most part, they are not grazers; they are high on the food chain. They are carnivores. What we raise on farms, on the land, they are all grazers. They are all plant eaters. And the conversion of sunlight through plants to protein is a very short route. And they are young—in our 'terrestrial' lives we are used to taking everything to market as quickly as possible, within a year. We do not raise ten year old cows or 30 year old chicken or 100 year old sheep. And yet, we will eat 100 year old deep sea fish without blinking an eye, mostly because we do not know that they are 100 years old.

We need to reset how we connect people to the ocean to have a population better informed of what is at stake and what we can do. We can encourage ocean issues to be taught at school and encourage more people to get interested in the ocean. But those will always be limited routes, so connecting all of us in our modern-day lives to ocean issues has never been more important. Our work to create a new digital ocean on Google Earth has now benefited over a seventh of the planet's population with a new perspective on the seas. With new steps we are taking this will reach dramatically more people once ocean issues and how we are already protecting it through Marine Protected Areas appear routinely on Google Maps. The concept of 'hope spots'—places in the ocean that have yet to be protected—shows not just the scale of inaction but also hope for how we might move forwards quickly.

Mobilising—literally—how people can interact with ocean issues is driving new forms of technology based around apps for mobile phones and tablets. Soon the vision

Sylvia Earle with Wisdom. At 63, this Laysan albatross is the world's oldest known bird in the wild. Image: Susan Middleton.

of the public being able to contribute observations from their mobile devices straight to experts living elsewhere on the planet will become a reality. Imagine being able to not only marvel with your children at the discovery of say a seahorse on the seashore, but then to contribute that observation to help map and determine the status of species. Such 'crowd sourcing' should help revolutionise and accelerate our understanding of the health and well-being of marine species around the world.

Through these and other communication and education routes we can start to make headway on resetting the story and dispelling myths. When we think of how we use the ocean, for example, raising carnivores such as salmon simply does not make sense. It takes a lot of wild fish to feed salmon. And in the process, all the things that the small fish have been eating get concentrated up the food chain when they are fed to salmon. Your doctor says eat fish, but think about it. For omega 3s, we should be cultivating and consuming plankton. Fish do not manufacture omega 3s, they acquire it from the plankton.

So we must redouble efforts. Onward and downward. Let us make it our mission to go deeper, stay longer, and explore more of the ocean. The world needs to be re-sensitised, just as in the 1950s and 1960s, to explore and go do it. Now we understand that life exists from the surface to the greatest depths. And now we know that our lives

We need to reset how we connect people to the ocean

depend on the ocean, and the creatures that live there. It is our life support system. It is a shocking truth but for every pound that goes to land conservation, birds, freshwater, whatever it is, the terrestrial parts of the planet, a penny goes for ocean protection. And that is a reflection of the attitudes people have. They understand that the forests and the rivers and the lakes are in trouble—and they are—so we should not take a penny away from protecting the land. We need much more devotion to both land and sea. We need to realise this is not a luxury. This is not an option. This is critical to our health and to our survival. We need to take seriously the importance of caring for the natural systems that take care of us.

Sylvia Earle is an oceanographer, explorer, author, and lecturer. She is also the founder of Deep Ocean Exploration and Research, Inc., founder of Mission Blue and SEAlliance, and chair of the Advisory Councils of the Harte Research Institute and the Ocean in Google Earth. In March 2014, Dr Earle became an Honorary Fellow of the Marine Biological Association.

Support **mission-blue.org**

@SylviaEarle

Dan Laffoley is a leading global expert on ocean conservation. At IUCN he is Principal Advisor, Marine Science and Conservation for the Global Marine and Polar Programme, and has the global honorary role as Marine Vice Chair for the World Commission on Protected Areas.

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'The wheel comes full circle' Marine laboratories past, present and future

Mike Thorndyke and Fiona McGowan take a look at the role of marine labs into the future.

There has always been a healthy competition amongst the marine research laboratory community to lay claim to being the first marine station founded.

Most now agree that Pierre-Joseph van Beneden established the first marine station in Ostend, Belgium in 1843. Interestingly even then, this involved collaboration with industry and attention to the undoubted socio-economic benefits of marine research as well as the increasing habit of 'taking the waters' at the coast so beloved in Victorian England. van Beneden located this first laboratory ('The Dune Laboratory') at the Valcke-Deknuyt oyster farm and adjacent to the now famous leisure beaches of Ostend which even at that time were becoming popularized, not least by the Belgian royal family, as a place to relax and enjoy the health promoting effects of the coast. Van Beneden had almost certainly been inspired to set up this laboratory by a colony of Swedish and other naturalists that gathered each summer on the Swedish west coast to carry out marine research. At the time they would hire seaside huts and boathouses from local fishermen; these fishermen would also bring them marine specimens. This research would later lead to the formation of the Kristineberg Marine Station (1877), which joined an illustrious family of stations in what was in many respects a (first) Golden Age of marine stations and included Concarneau (1859), Naples and Roscoff (both 1872), and the Marine Biological Association, Plymouth (1884).

There are fascinating parallels from this period that have resonance with the modern day marine biologist. Many of these early marine biologists had been trained in medicine and

quickly recognized the potential of marine organisms for providing answers to important questions in biology. This thread has remained with the last 50 or more years seeing many Nobel laureates emerge from the ranks of marine biologists[1].

Since their inauguration in the latter half of the 19th century there has been a long-standing tradition of sharing facilities and access in marine laboratories. Currently we are seeing a reawakening of this spirit of cooperation with the advent of the 'omic' sciences, climate change, and the importance of 'ocean observation' accompanied by the critical need to share and integrate data. This, the new frontier for the marine sciences, is exemplified by the creation of consortia of marine laboratories, best known in Europe from programmes such as the European Marine Biological Resource Centre (EMBRC). One of the objectives of EMBRC is to promote the application of genomics and systems biology to biomedical sciences, marine biology and ecology. This will bring about the long-awaited 'marriage' between large scale global considerations and biological systems (environment and human impact on it, human health and sustainable exploitation). Marine model organisms have a historical and future role in basic cutting edge biological research (see Nobel laureates mentioned earlier) and in the future models should be selected which have an ecological significance as well as a medical "value". This dynamic is the front where the main future development of marine biology will be.

To facilitate this, Europe is leading a global initiative to coordinate activities between the European Network of Marine Research Institutes and Stations (MARS) and other international

groupings such as the National Association of Marine Laboratories in the USA (NAML) under the banner of the World Association of Marine Laboratories (WAMS). One of the driving issues for WAMS will be to develop its action plan with a focus on capacity building in less well-developed regions, which are often those most impacted by climate change together with anthropogenic exploitation. The WAMS action plan therefore highlights (Box 1) those issues crucial for the protection and sustainability of our seas and oceans.

Station Biologique de Roscoff (top). Image: W. Thomas / Station Biologique de Roscoff (CNRS/UPMC). The Marine Biological Association, Plymouth (right). Image: Keith Hiscock. Kristineberg Marine Station (left).

1 Eccles, Hodgkin, Huxley (squid axon); Hartwell, Hunt, Nurse (urchin eggs), Tsien, and Chalfie, Shimomura (jellyfish and Green Fluorescent Protein): www.nobelprize.org/nobel_prizes/medicine/laureates

Box 1. Objectives of the World Association of Marine Stations

- Identifying interest and major gaps from participating countries, for example from Africa, South America and Asia.
- Making contact with potential new members from these and other areas.
- Determine how best to contribute to IOC activities in research, education and training.
- Promote and participate in workshops to develop project ideas that fulfil global needs, specifically in relation to climate change impacts on marine ecosystems and ecosystem services.
- Encourage 'bottom-up' science-based discussions.
- Identify common training needs and opportunities for all staff, both scientists and technical and administrative support personnel.
- To cooperate with on-going IOC programmes such as OBIS.
- To explore further scientific partnerships.
- To support the 20 points of Rio+20.

This exciting prospect has the support of the Intergovernmental Oceanographic Commission of UNESCO and should herald a second Golden Age for marine research stations.

Since those early days, marine research stations have been established all around the world and serve a vital role in science and in the wider community (see Box 2). In this respect, marine laboratories should be considered 'windows on the ocean' and ideal places for the study of marine life as well wonderful places for the public to see research taking place. The role of marine laboratories is also to provide opportunities for the public to enhance their 'ocean literacy', an issue of increasing importance in these days where climate change and its impacts on our seas and oceans is becoming a daily discussion point in the media.

Many people will associate a marine station with being somewhere which features on a David Attenborough TV programme and is a nice place to visit with an attractive coastal location. While this is, of course, true, it is important for us all to recognize the enormous socio-economic benefits to be obtained by a greater and deeper knowledge about marine organisms and ecosystems. First, the sea provides amazing biological diversity (of 34 fundamental phyla, 17 occur on land, whereas 32 occur in the sea and 13 are exclusively marine). This diversity and the relatively large number of exclusively marine species are the reasons why the sea is an important new source of biotechnology materials, chemicals and processes. Second, marine organisms often possess unique structures, metabolic pathways, reproductive systems and sensory and defence mechanisms because they have adapted to extreme environments ranging from the sub-zero polar seas to the great pressures of the ocean floor.

The exploitation of marine organisms for food and industrial processes has an impact on one of the other main uses we make of the marine environment—leisure and recreation. Scaling up these processes will have a direct and tangible impact on marine ecosystems and will certainly change the way we perceive this environment. One major objective for coastal marine stations in the future will be to develop a dialogue with industry and stakeholders through research to arrive at a consensus on how to use, and not to abuse, this resource.

As noted earlier, the wider public represents an important stakeholder group for marine stations and what we do. Until now, 'knowledge exchange' and 'knowledge transfer' have mostly focused on the undoubted and apparently insatiable interest in marine life and the natural history of our coasts that exists in wider society.

Recent years have witnessed the emergence of the 'blue gym' concept. This has been a natural development from the 'green gym' whereby positive experiences in the environment bring measurable benefits to human health and well-being. This represents a totally new way of thinking for marine laboratories and the way they might engage with the public.

Fortunately, our colleagues in the social sciences, particularly medical sociology and public health, have a wealth of experience in this area. There is a substantial literature and research concerning the impact of environment on human health and well-being. For example, there has been increasing recognition that individual health is shaped and determined by many factors; political, economic, social, cultural, behavioural, biological and environmental factors can all favour health or be harmful to it. One of the key principles of health promotion set out by the World Health Organization (WHO) is that of 'creating supportive

Box 2. Role of marine laboratories in the modern world

- Provide access to marine ecosystems including valuable (historical) time-series data.
- Provide access to marine models for biomedicine, ecotoxicology, biodiversity and gene discovery.
- Provide logistics and modern equipment for *ex situ* experiments, in biology, long-term culture and experimental climate control.
- Ideal for long-term ecological research, real time data collection and detecting change.
- Inexpensive test-beds for new ocean instrumentation.
- Base stations for ocean observing systems, buoys, cabled arrays and submersibles.
- Support bases for research vessels and research entailing diving.
- Places to integrate social science and natural science research and education.

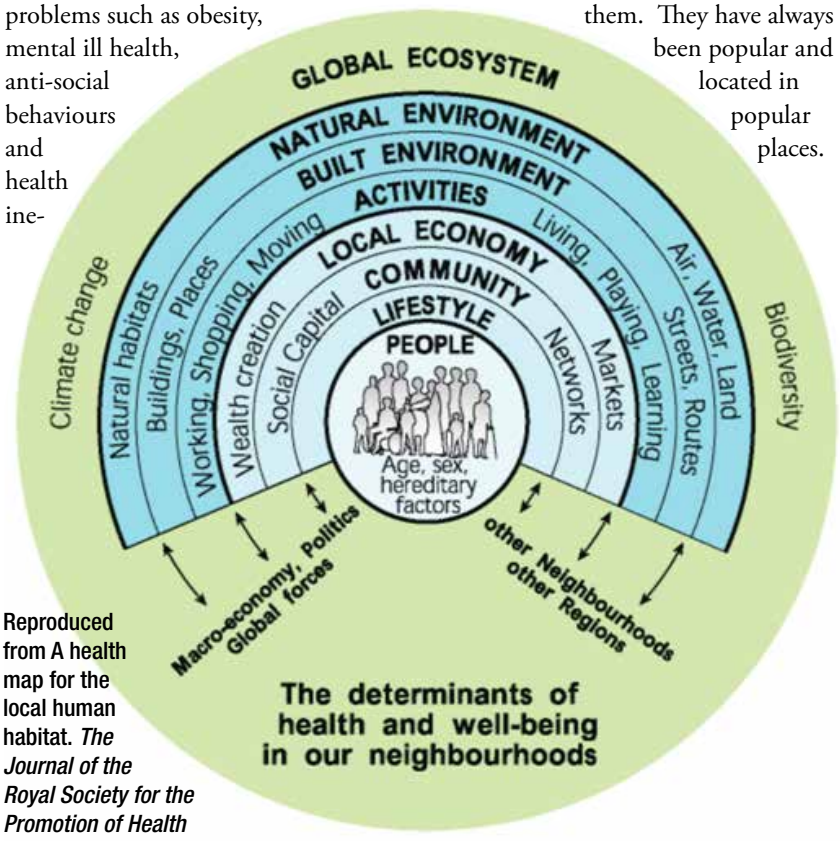
environments' recognizing that 'the inextricable link between people and their environment constitutes the basis for a socio-ecological approach to health' (Ottawa Charter for Health Promotion, WHO, 1986).

Increasingly, health outcomes can be linked directly to environment—be that physical, social, working, living or leisure—those 'places' where everyday lives are enacted and those which ultimately impact life chances. Place and space have become central considerations in health promotion—terms which refer to far more than simply geographical location, rather the spatial context in which lives are lived. Included here is the way in which human experience interacts with the natural environment and how environmental or structural factors determine human behaviour. The 2010 UK Faculty of Public Health report (The Great Outdoors: How our Natural Health Service uses Green Space to improve wellbeing) emphasized how 'access to nature can significantly contribute to our mental capital and wellbeing' and cited evidence demonstrating how green space is an important beneficial factor in tackling health and social problems such as obesity, mental ill health, anti-social behaviours and health inequality.

In May 2013 the European Environment Agency published a report which recognized the limitations of environmental quality indicators in assessments of human health and drew further attention to the ways in which health, environment and social aspects are interconnected. It stated: 'Health inequalities are pervasive in EU member states, similarly, environmental and socio-economic conditions, which determine the risk of people getting ill, their ability to prevent sickness and get access to treatment, are unequally distributed within societies'.

'access to nature can significantly contribute to our mental capital and wellbeing'

We can see then, that the role of marine stations is one of continual development and evolution, reflecting societal needs, perhaps even shaping them. They have always been popular and located in popular places. Indeed, one of the earliest stations, Stazione Zoologica 'Anton Dohrn' founded in Naples in 1872 was built with an adjoining public aquarium to provide the public with a 'window on the sea', while at the same time generating income that supported research in the laboratories next door. That same year in Brittany, the marine station at Roscoff was opened in an area famous for thalassotherapy—a treatment that employs the use of seawater, sea products and shore climate for the benefit of human health, and perhaps dates back to ancient Greek or Roman times. So, nothing is new but one thing is certain, marine stations have always been in the vanguard of social change and sensitive to the needs of society. Perhaps in the future we shall see forward thinking directors of marine laboratories working together with public health agencies to promote the marine environment as one which confers significant health and wellbeing advantages for the whole population.



Reproduced from A health map for the local human habitat. *The Journal of the Royal Society for the Promotion of Health* 2006 126: 252-253

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FURTHER READING

Please see www.mba.ac.uk/marinebiologist for references and links for this article.

Power from the sea: stepping stones for non-native species?

Marine energy extraction and the introduction and spread of non-native species by Chris Nall.

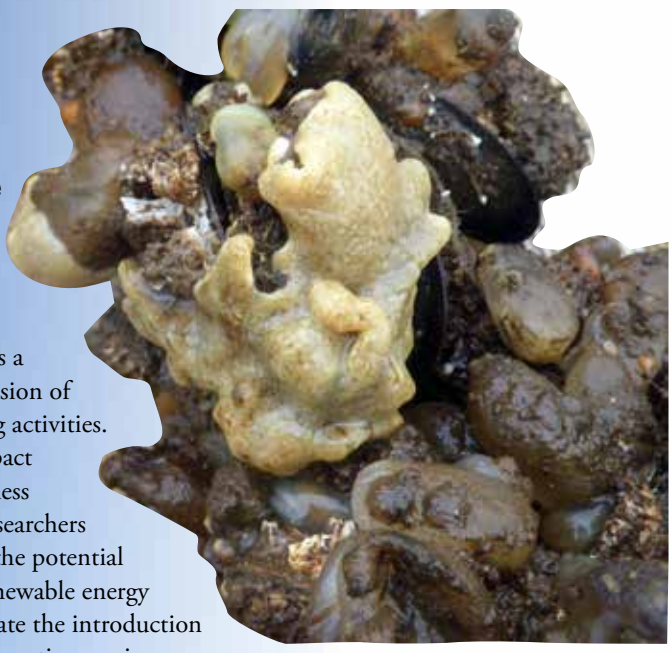

Fig. 1. *Didemnum vexillum* smothering mussels. Image: Chris Nall (ERI).

Renewable energy is a growing industry whose viability is increasing as the unsustainability and environmental pressures of conventional energy generation become more apparent. In the UK a large proportion of the future renewable energy production is planned to be generated in the marine environment from offshore wind, wave and tidal stream energy farms. At present there are a number of offshore wind farms already operational and some experimental wave and tidal stream devices are being tested; currently over 90 marine energy farms are planned or already installed. Each farm will contain an array of energy extraction devices (wind / tidal turbines or wave energy converters) amounting to 400 devices at some large sites. This represents a huge amount of offshore and coastal development and the installation of a large amount of artificial structure, not only of the device arrays but also from the installation of support technologies (e.g. cables, foundations and substations) and the expansion of harbours in order to service this industry.

There are a number of potential environmental impacts associated with the marine renewable energy industry. Some of these include: collision hazards of energy devices causing fatality or displacement to marine animals, noise from operation and installation interfering with the behaviour of acoustically sensitive species, and an increase in biodiversity to the local area as a result of the exclusion of destructive fishing activities. One negative impact that has received less attention from researchers and regulators is the potential for the marine renewable energy industry to facilitate the introduction and spread of non-native species.

Non-native species are considered to be one of the greatest threats to marine biodiversity and they can cause severe ecological and economic damage if they become invasive. For example, the invasive carpet sea squirt, *Didemnum vexillum* (Figure 1), overgrows organisms and has been shown to smother fish spawning grounds and reduce production in shellfish aquaculture. Any activity which may promote the invasion of this and similar species needs be investigated and potentially mitigated against. However, while there is legislation in place (e.g. Wildlife And Natural Environment (Scotland) Act 2011), and national strategies that attempt to reduce the introduction and impact of non-native species, the issue is not considered one of the major potential impacts of the marine renewable industry and therefore very little research has been done.

Our scientific knowledge of invasion pathways and the known association of hard substratum non-native species with artificial structure indicates a number of potential ways the marine renewable industry may facilitate the introduction and spread of non-native species.

Increased vessel activity during the installation and maintenance phases of development could cause non-native species introductions. Vessels are well known vectors of non-native species through hull fouling and ballast water exchange. Some of the highly specialised vessels used in the installation will be well travelled and therefore have a greater potential to bring in exotic organisms. If wet-towed, the devices themselves may also act as vectors of non-native species introduction through hull fouling. Floating wave devices or floating wind and tidal turbines may be towed from construction or maintenance locations where they have been left quayside for sufficient time for hard

The marine renewable industry may facilitate the introduction and spread of non-native species

Fig. 2. Biofouling on a navigation buoy (analogous structure to an offshore energy device). Image: Adrian Macleod (SAMS).

substratum communities to form.

Marine renewable devices and support technologies provide hard substratum space for fouling non-native species to colonise (Figure 2). Non-native species are often found in high abundance on submerged artificial structures. These novel habitats are widely thought to convey a competitive advantage to non-native species over indigenous species. In the case of soft sediment areas, where many energy farms are planned to be developed, installation of artificial structure will provide habitat for fouling non-native species in areas they are currently unable to settle. Provided they are capable of establishing populations in these exposed high energy environments, offshore artificial structures could aid secondary dispersal of non-native species. Populations of non-native species living on devices could source propagules to nearby natural habitat and networks of devices could link otherwise unconnected hard substratum habitats by providing a dispersal corridor for non-native species. The installation of a large number of renewable devices around the UK will also allow non-native species tolerant of offshore environments to expand their population size considerably, increasing propagule supply and strengthening their competitive advantage over native species. This will amplify the impacts of these non-natives on native biodiversity and the local economy.

In addition many of the areas with planned energy farms are located in parts of the UK where there is relatively low vector activity and a small number of non-native species, for example, northern Scotland. This therefore increases the likelihood that non-native species new to an area will be introduced by activities of the renewable industry and if they become established it increases the severity of the ecological and economic damage.

Surveys of biofouling communities growing on offshore wind turbines in the southern North Sea and navigation buoys in Scottish waters have been carried out to assess the presence and abundance of non-native species. A number of non-native species were found to be thriving on these offshore structures. Species with particularly high abundances include the invasive amphipod, *Caprella mutica* (Figure 3) and the marine midge, *Telmatogeton japonicus*. This confirms that some non-native species are capable of recruiting to hard substrata in exposed offshore environments and that they are likely to establish populations on marine renewable devices.

Researchers at the Environmental Research Institute and the Scottish Association for Marine Science are currently investigating ways in which to monitor and reduce the impact the renewable industry will have on facilitating the invasion of non-native species. So far this work has included the completion of a baseline survey for the presence and distribution of fouling non-native species within the Pentland Firth and Orkney marine energy park and the assessment of the detection abilities of different monitoring methods. Future work will investigate the potential introduction pathway of wet towed floating devices and also will assess how device material, habitat orientation and season affect non-native species composition. The results of this research will inform best practices for future monitoring programmes and suggest control measures which aim to reduce the introduction and spread of non-native species.

It is necessary to mention that although some non-natives are known to be damaging to the marine environment, the impacts of many of them (including those known to colonise renewable devices) are still unknown. Establishment of hard substratum fouling species, whether indigenous or not, on marine renewable energy devices may in fact provide benefits, such as increased productivity and additional food sources for fish species. With the potential for increased population size and increased spread of non-natives as a result of the marine renewable industry, regulators and statutory consultants need to fully understand both the positive and negative environmental impacts in order to give the best advice for focused management procedures.

Fig. 3. The Japanese skeleton shrimp, *Caprella mutica* residing on an offshore navigation buoy. Image: Adrian Macleod (SAMS).

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Refugia in the 'twilight zone': discoveries from the Philippines

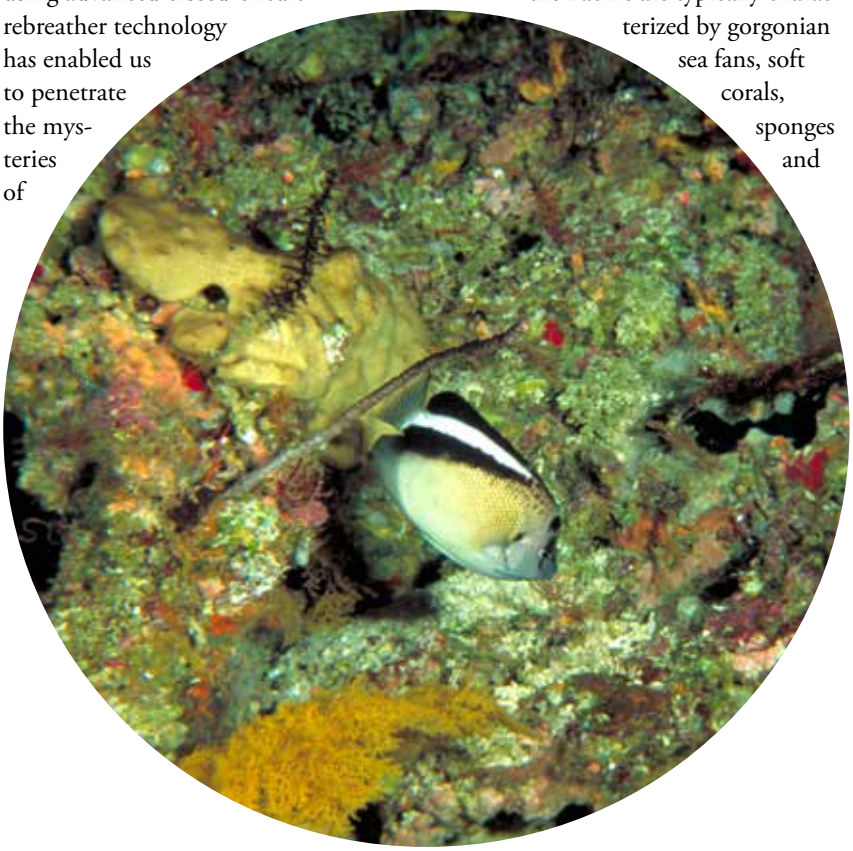
By Sonia J. Rowley

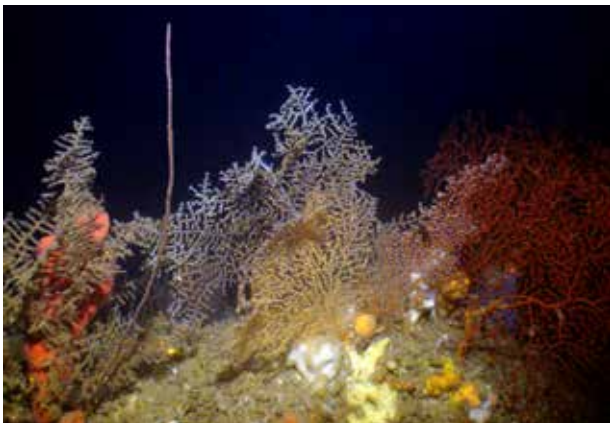
Over the millennia, perpetual geological sea level changes have continuously shaped coral reef environments. Coral reef biodiversity, considered at its peak within the Coral Triangle, is most notable throughout the Philippine archipelago largely due to it having among the highest number of islands (more than 7,100) per geographical area. The origin of such diversity remains the subject of much controversy and investigation generating hypotheses of speciation and migration from within or outside the region. Nevertheless, central to determining reef biodiversity and biogeographical distributions are species responses to environmental change, particularly as human impacts accelerate and/or exacerbate natural processes.

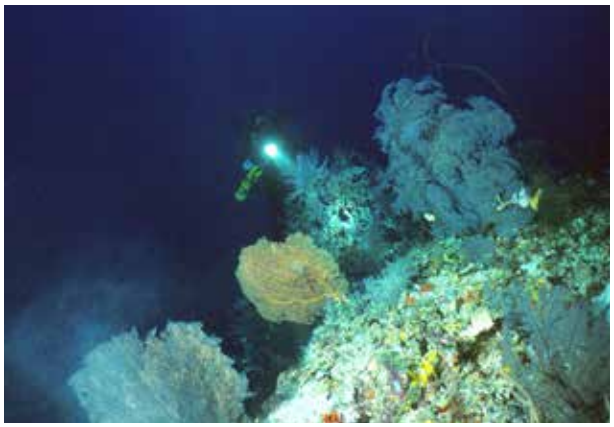
Coral reefs in the 'twilight zone' between 40 and 200 m are termed 'mesophotic coral ecosystems' (MCEs). MCEs are classified as conservation priority ecosystems (e.g. IUCN) and posited to act as refugia against environmental disturbances. Until recent technological advances, such mesophotic reefs were largely inaccessible or overlooked, being too precarious for conventional SCUBA and too shallow to justify the cost of a deep-sea submersible. However, exploration using advanced closed-circuit rebreather technology has enabled us to penetrate the mysteries of these little-studied reefs. Here, as part of a collaborative research team supported by the Seaver Institute, our mission as the Bishop Museum rebreather team was twofold: to test-pilot the Poseidon next generation rebreather; and to discover, document and characterize mesophotic reefs within the Batangas region of the Philippines.

Descending to depths unexplored, away from the bustle of the shallows, is not without risks. As inquisitive explorers we are caught in peace and exhilaration between the enticing attenuation of the deep slope and the mesophotic reef before us. To me these reefs are akin to being transported back in time. Not only do MCEs harbour a myriad of new species, behaviours and interactions just waiting to be discovered, they also hold the keys to questions of persistence, polyphyly, and the evolution of structure–function relationships over geological time. What fauna and even flora are present, how do they survive, how are they beneficially connected to the surrounding habitats if at all, and are such patterns duplicated in other areas?

With the exception of reefs within Hawai'i which are often dominated by members of the zooxanthellate genus *Leptoseris*, low-light habitats throughout the Pacific are typically characterized by gorgonian sea fans, soft corals, sponges and







Images: Opposite: A typical mesophotic assemblage from the Solomon Islands with the deep-reef Griffis' Angelfish *Apolemichthys griffisi.* Carlson & Taylor 1981. This page, from top left: *Chromis* n. sp.. *Plectranthias* n.sp.. Dr. Luiz Rocha with the pinecone fish *Monocentris* sp.. Mesophotic reefs of gorgonians in the Philippines. Mesophotic reefs of gorgonians in Fiji. Dr. Brian Bowen. The PI team: Brian Greene, David Pence, Dr. Richard Pyle, Joshua Copus, Dr. Sonia Rowley, Robert Whitton, with Poseidon prototypes and Inspiration Rebreathers.

black corals, the majority of which are unknown to science. The Philippines are no exception; on this trip alone we have discovered at least seven new fish and 20 new gorgonian species at depth, the latter providing substrate for fish to lay their eggs. Our diving experience tells us that it is at around 80 m depth that the temperature drops, a shelf emerges, and where such characteristic 'twilight' assemblages begin to be found. Dynamic sea-level changes produce extreme variations in shallow water habitats of up to 80–100 m, with these deeper reefs remaining relatively unchanged, and less than 50% species overlap with shallow taxa. Therefore, gorgonian corals and reef fish are key taxonomic groups within deep-reefs with some taxa spanning considerable depths (e.g. 5–2,000 m).

At depths greater than 100 m we work against time, determined by the ratio between the saturation of our mortal tissue with dissolved gas and the safety gas that we carry. Yet no part of what we encounter is lost; all digital imagery is synchronized with the rebreathers' advanced electronics, capturing time, depth and specimen information. I continue to collect gorgonians as we ascend—intrigued by their dynamic patterns of diversity with depth. The swim bladders of sampled fish are vented with needles as we ascend (the notorious 'Pyle' stop). At the surface, specimens are catalogued and preserved, whilst digital imagery is systematically documented for immediate dissemination in the web-based archive Explorers Log. The discovery of the twilight zone is not exclusive—everyone can immediately enjoy!

Are shallow reefs being seeded by deep reefs? Are certain taxa habitat specialists or bathymetric migrators? These questions remain to be elucidated, but when they are, key evolutionary mechanisms facilitating survival over geological time will undoubtedly be unveiled. So even though as humans we are challenged to save habitats from their ongoing destruction, 'twilight' reefs of refugia may likely replenish many of their inhabitants.

Dr. Sonia Rowley (soniajrowley@gmail.com) is an invertebrate zoologist at the Bernice Pauahi Bishop Museum, and the University of Hawai'i, USA.

Funding and collaborations: Bernice Pauahi Bishop Museum, Hawai'i, USA; Hawai'i Institute of Marine Biology, Hawai'i, USA California Academy of Sciences, California, USA; Seaver Institute, California, USA

Mapping the treasures of the deep sea

Heriot-Watt University and the National Oceanography Centre join forces to map cold-water coral habitats. By Laurence De Clippele, Veerle Huvenne and Murray Roberts.

The oceans cover more than 70 per cent of the world's surface, yet the deep-sea remains largely unexplored. Cold-water corals are one of the deep sea's treasures. These corals may grow as single polyps, as individual tree-like colonies or form complex reefs providing a range of habitats for many other species. Cold-water coral habitats are recognized by the United Nations as 'Vulnerable Marine Ecosystems', and many have been declared 'Ecologically and Biologically Significant Areas' under the Convention on Biological Diversity, indicating their importance and need for protection. Mapping marine habitats and species distributions is essential in conservation and resource management. The generation of such maps, however, is particularly challenging within poorly-sampled deep-sea ecosystems.

In 2013 Heriot-Watt University and the National Oceanography Centre (NOC) began a new study to map and characterize cold-water coral sites in the North Atlantic Ocean. This three-year project will integrate a series of datasets including one of the largest archives of high definition video data, acquired by remotely operated vehicles (ROVs) from the Logachev cold-water coral carbonate mound province and other sites on Rockall Bank. See Figure 1.

It was the pioneering work of 19th century biologists that provided the only information on cold-water coral distribution in British waters until the 1970s when distributional data were first collated and manned submersibles were first used in seafloor surveys. Cold-water coral reefs are hard to find as they grow in waters too deep to allow the use of satellite-based remote sensing techniques. In addition, the areas of the continental shelf edge and slope suitable for reef development are too large for extensive visual survey using submersibles or towed cameras. Luckily our ability to chart the seafloor has improved dramatically following the development of multibeam echosounders. These can be used not only to measure water depth, but also to generate a backscatter record giving information about the physical attributes of the seabed. The depth and texture of the seabed can indicate the occurrence of cold-water corals and, alongside ground-truthing with visual surveys and sampling, can be used to build up wide area habitat maps. In deep-sea surveys, sampling and species identification remain vital components of habitat mapping.

Few recent studies have focused on the associated fauna of deep-water coral habitats but cold-water corals, and especially scleractinians such as *Lophelia pertusa*, are today known to provide biodiversity hotspots thanks to their ecosystem engineering capacities. Their generally tree-like architecture provides biomass, structural complexity, modifies the seascape and produces a great diversity of microhabitats. The Norwegian *L. pertusa* reefs, for example, are known to support four major types of habitat: the surface of living coral; the surface of dead corals; cavities within the coral skeleton; and spaces between the branches. The corals provide shelter, food sources and spawning habitats to deep-sea fish and shark communities and to a wide range of other organisms, ranging from micro- to megafauna. A recent study recorded more than 1300 species associated with the stony coral *L. pertusa* on the European continental slope or shelf. Filter feeding organisms like crinoids tend to use the corals as feeding platforms to position themselves higher up in the currents increasing their ability to capture food. Furthermore, as the skeleton of the coral can remain long after the corals' extensive lifespan, cold-water corals are very likely to maintain benthic communities in different succession states at the same time.

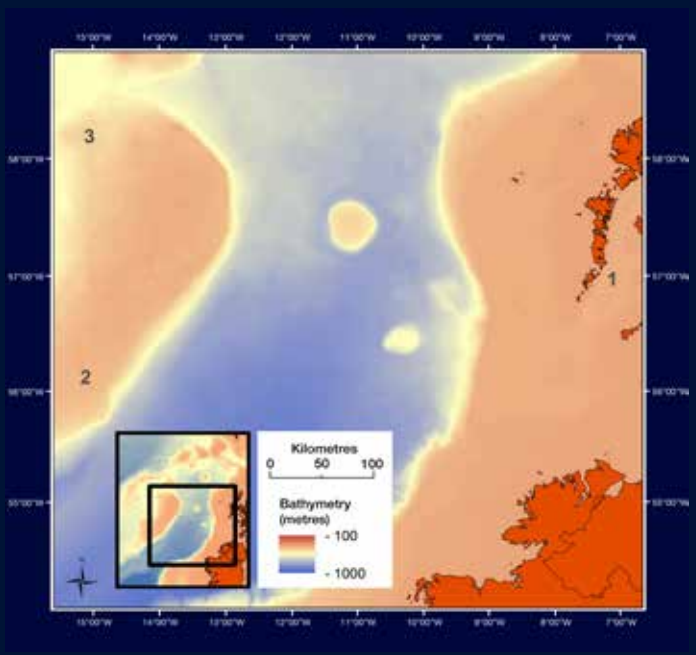


Fig. 1. High definition video and still imagery of the seabed were taken using the ROV *Holland-1* during the Changing Oceans Expedition, RRS *James Cook* cruise 073 which took place in May-June 2012. (1) Mingulay Reef Complex, (2) Logachev Mound Province, (3) Pisces 9 dive site.

Unfortunately, the significant loss of live coral, owing to climate change and other anthropogenic disturbances, can cause severe losses to reef-inhabiting macroinvertebrates, especially mobile taxa, including crustaceans and crinoids that rely on the reefs as refuges from predation. A large number of video observations have not only documented the rich biodiversity of

deep-sea ecosystems such as cold-water coral reefs, but also gathered evidence that many of these biological communities had been impacted or destroyed by human activities, especially by bottom trawl fishing. The reef-framework forming scleractinian corals build their skeletons from aragonite, the more soluble mineral form of calcium carbonate. Because of this, ocean acidification could cause these complex structures to collapse, resulting in the loss of macroinvertebrate habitat. Ocean acidification can also directly affect the physiology, reproduction, behaviour, neuronal functions and survival of many groups of marine organisms.

Global declines in biodiversity have ignited responses from local to international scales, aiming to establish management methods for the effective protection of species and ecosystems, and the limitation of human impact on the environment.

To date, decisions on area closures for the protection of 'listed' deep-sea habitats have been based on maps of recorded presence of species that are taken as being indicative of that habitat. However, large parts of the (deep) ocean have never been sampled or investigated, leaving large blank areas on the management maps. Conservationists, researchers, resource managers, and governmental bodies are increasingly turning to predictive species distribution models to identify the potential presence of species in areas that have not been sampled. Predictive habitat modelling may provide a useful method, but can only give an indication of the probability that a certain habitat will occur. Given the coarse resolution of the models, percentages should be taken as maximal figures, with habitat occurrence likely to be less prevalent in reality. Despite improvements in model algorithms, environmental data and species presences, there are still limitations to the reliability of these techniques, especially in poorly studied areas such as the deep sea.

The Coral Ecosystems Research Group at Heriot-Watt University (Edinburgh, Scotland) takes an integrated, interdisciplinary approach to understanding the biology and ecology of cold-water corals. This approach will be used in our new project to map the habitats associated with cold-water coral reefs and mounds at a series of north-east Atlantic sites, in collaboration with the Seafloor and Habitat Mapping Team of the NOC. Combining ecological, geophysical and hydrographical survey data, our study aims to achieve a more detailed quantification of the roles of the environmental factors that control the biodiversity patterns of macrofaunal species in the North-Atlantic. Data from ROV transects recorded during the 2012 Changing Oceans Expedition (RRS *James Cook* cruise 073) will be used in combination with data from acoustic sources gathered by Heriot-Watt University and NOC. A large spatial extent was covered, as this is a central requirement for the correct estimation of general patterns of species distribution.

ocean acidification could cause these complex structures to collapse

Research on cold-water corals and their associated fauna is necessary to assess their ecological importance, while efforts to map and date these long-lived habitats are vital to develop sound scientific advice on sustainable habitat and fisheries management of deep-water.

This page, left: Finding shark eggs in cold-water coral habitats demonstrates how a key ecosystem function of coral reefs (habitat provision) co-benefits both sharks and humans. **Centre:** Cold-water corals are known as ecosystem engineers because, like trees, they change the environment by their own physical structure. Crabs (*Gastroptychus sp.*) using the black coral *Leiopathes* to position themselves higher up in the currents to optimize access to food. **Right:** *Munida sarsi* can benefit from the protection of gorgonians, scleractinians but also from piles of coral rubble. They use them as a home base that provides shelter against predators.

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2. National Oceanography Center
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Further reading:

Vierod A.D.T., **Guinotte J.M.** and **Davies A.J.** (2013) Predicting the distribution of vulnerable marine ecosystems in the deep sea using presence–background models. *Deep-Sea Research II*, http://dx.doi.org/10.1016/j.dsr2.2013.06.010.

Henry L.A., **Navas J.M.**, **Hennige S.J.**, **Wicks L.C.**, **Vad J.** and **Roberts J.M.** (2013) Cold-water coral reef habitats benefit recreationally valuable sharks. *Biological Conservation* 161, 67–70.

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The full reading list for this article is available at www.mba.ac.uk/marinebiologist

From equator to ice; environmental science in the south Atlantic

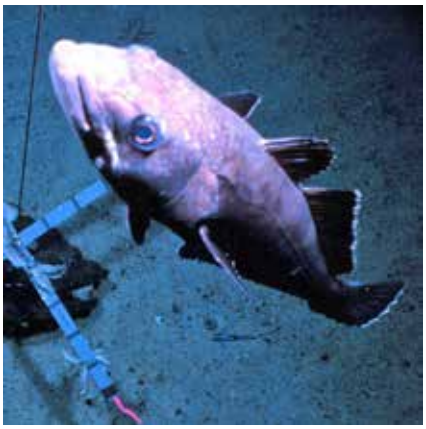
Drs Deborah Davidson and Paul Brickle describe a new research institute that oversees marine biodiversity and environmental management.

The South Atlantic Environmental Research Institute (SAERI) was created by the Falkland Islands Government (FIG) in 2012 when the need for an umbrella organization to produce environmental science within the Falkland Islands and the South Atlantic became evident. The aim was to enhance and encourage existing local research activities and to increase the volume of scientific research conducted within the Falklands and the other South Atlantic Overseas Territories (SA OTs), both locally and internationally, with a focus on localizing research and work that is currently being conducted elsewhere by other researchers and institutes. The scope of the research centre encompasses environmental research in geology, climate change, oceanography, inshore marine environment, fisheries, agriculture, biodiversity and renewable energy, extending geographically across all the UK SA OTs, from the equator down to the ice in Antarctica. One goal was also to produce a GIS Centre, based in the Falkland Islands, which would provide GIS knowledge and expertise throughout the SA OTs. However, the purpose of the Institute is not only to conduct local and international research into the natural and physical sciences, but also to teach students and build further capacity between the SA OTs and other international research institutes.

In September 2013, a GIS specialist was recruited thus forming the foundation of the GIS Centre. Work in this area and capacity building across the SA OTs has begun and is progressing rapidly. The GIS officer is crucial in furthering many of the projects undertaken by SAERI both within the Falkland Islands and in the other SA OTs, but also provides training and expert help to the other FIG departments and sectors.

Thus far, however, the main focus of the work undertaken by SAERI has been on the marine environment and fisheries-related research. The marine and terrestrial environments of the South Atlantic and South Atlantic OTs are relatively poorly understood compared to other world regions. Several short-term projects have been undertaken since its establishment, including creating a baseline database of marine biodiversity using data collected in the 1920s to 1930s by the Discovery Investigation cruises, in a joint project led by the Marine Biological Association. In a similar vein, in conjunction with Aberystwyth University an MSc project looked at data collected on the benthic fauna of Adventure Sound on the east island of the Falklands, to determine the species richness and communities of the species and link these to environmental variables within the area. The Institute also has three established PhD students, joint with the University of Aberdeen. One PhD student is investigating the uncertainties inherent within the South Georgia mackerel icefish (*Champsocephalus gunnari*) surveys. Another project aims to address the gaps in knowledge about the algal biodiversity of the Falkland Islands, with particular focus on identifying the numerous red algae found in these waters. The project will also compare the algae species and species distribution between the Falkland Islands and South Georgia. The third PhD began in January 2014 and is modelling the life history and reproductive biology of the Patagonian toothfish (*Dissostichus eleginoides*) in South Georgia. SAERI has also found the funding for a PhD to examine coastal benthic ecology in temporal and spatial scales for a Falkland Island graduate starting in April 2014.

This year is proving to be an exciting year for SAERI and will see a further increase in the faculty numbers, with four new projects commencing by



Top: Patagonian toothfish *Dissostichus eleginoides*. Image: Dr Martin Collins University of Aberdeen. Bottom: Tree kelp *Lessonia vadosa*. Opposite: Giant kelp, *Macrocystis pyrifera*. Algae images: Shallow Marine Surveys Group (SMSG).

Clockwise from top left: Patagonian scallop *Zygochlamys patagonica*, painted shrimp *Campylonotus vagans*, naked urchin *Arbacia dufresnii*, Patagonian red octopus *Enteroctopus megalocyathus*, giant mussel *Choromytilus chorus* and ribbed mussel *Aulacomya ater*. Images: Shallow Marine Surveys Group (SMSG).

April. One such, funded by the FIG, is exploring the poorly understood inshore marine resources of the Falkland Islands. Today, there are still areas where the biodiversity of the shallow marine environment is not properly known and the life history, and therefore suitability for sustainable exploitation, of many of the species found in these waters is not understood. Except for a small crab fishery in the south-east of the Islands, little artisanal fishing occurs within the coastal waters; however, it is believed that there are several inshore species which may lend themselves to sustainable exploitation. The project therefore aims to determine both the life history of several candidate shallow marine invertebrate species and their potential as a fished resource. The FIG sees the importance of understanding the near shore systems before fisheries take off, something that is not evident in many other regions where sadly, science and assessment have to play catch up against the backdrop of boom and bust scenarios.

With the burgeoning oil industry due to take off within the next few years, understanding the marine environment with respect to the habitats and species present, both inshore and offshore, becomes even more crucial. Some works have been conducted throughout the past century, but there are still many areas where there is little to no knowledge about the marine environment, and even the data that do exist as yet remain separate and un-collated. Marine predators, in particular seabirds such as penguin and albatross and pinnipeds, are potentially at risk from oil-related activities, but comparatively little is known about their behaviour, making it difficult to determine potential impacts on these top marine predators. With the onset of oil production forthcoming it was decided that this gap in the knowledge base should be addressed. Therefore, the Falkland Islands Offshore Hydrocarbons Environmental Forum (FIOHEF), comprising FIG, the Falkland Islands Petroleum License-holders Association (FIPLA) and other members of the private sector, created two projects which would identify (and in the longer term, address) these knowledge gaps within the marine environment. Both projects will collect, collate and analyse extant data, with respect to benthic ecology, oceanography and seabird and pinniped behaviour and life history, respectively. The marine predators' position will also involve tagging of pinnipeds and seabirds in order to understand more of their foraging behaviour.

Another up-coming project will address the lack of a strategic approach to marine spatial planning within the Falkland Islands. Awarded Darwin Plus funding, the Marine Spatial Planning project aims to provide the framework for future legislation and practice with regards to marine protection. The project will entail collation and analysis of marine habitat and species data (benthic and pelagic flora and fauna), in order to determine biodiversity and conservation 'hot spots' which may prove to be candidate sites for future protection. The project will feed directly into other research projects and into the oil activities within the Falklands.

Since its establishment SAERI has worked closely with

Diversity and abundance at Ascension Island. Image: Shallow Marine Surveys Group (SMSG).

the British Antarctic Survey (BAS). A Shallow Marine Surveys Group (SMSG) and SAERI member of staff was the coastal marine biologist on-board the RRS *James Clark Ross* during a survey of the waters around both South Georgia and Tristan da Cunha. SAERI and BAS also share two of the aforementioned PhD students, and the aim is for the two Institutes to work closely together in the future. Further collaborative research surveys will be conducted on-board the BAS research vessels, and a collaborative project is being undertaken later this year involving autonomous underwater vehicles (AUVs or 'gliders') to help to gain a better understanding of the Falkland Islands' large and mesoscale oceanography.

SAERI's goal of creating work and capacity within the other SA OTs has already begun: Darwin funding was approved (2013) for a project, in conjunction with the Ascension Island Government, aiming to substantially increase the currently poor marine biodiversity knowledge and fisheries science capacity within Ascension Island. Much of the existing knowledge about shallow marine biodiversity was established by a SAERI partner organization, SMSG, a group of volunteer divers and marine scientists based in the Falkland Islands, who conducted dive surveys at several sites around Ascension Island during 2012 and 2013. However, their funding, time and capacity was rather limited. Therefore, this project will provide three marine/fisheries scientists in order to build the understanding of the marine environment and biodiversity and also to provide the science base needed for sustainably managed inshore and offshore fisheries. Partner organisations in this project include SMSG, BAS, and RSPB.

Within the Falkland Islands, SAERI have hosted several parties of visiting scientists studying geological indicators of climate change, and a PhD project will begin this year in a consortium with the Natural History Museum, Nottingham University and Imperial College. Peatlands provide a detailed record of climate and how it has changed over time and the project will investigate peatlands as records of island ecosystem sensitivity to environmental change in the South Atlantic. The intention is to study the large amount of peat found in the Falkland Islands to better understand the processes associated with the formation and transformation of peat and soil and the response of these sensitive ecosystems to climate change.

SAERI will shortly become an incorporated charitable institute and therefore other sources of funding must be found to support the many projects that are happening currently, and in the future. Obviously, grant opportunities are both limited and highly competitive therefore SAERI is involved in several consultancy opportunities, mostly focused on environmental surveys and will soon be delivering fisheries consultancy work for various international fisheries.

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FURTHER READING

For more information on South Atlantic marine and environmental science please visit www.south-atlantic-research.org

Wandering albatross *Diomedea exulans*, king penguins *Aptenodytes patagonica*, elephant seal *Mirounga leonine*. Images: Dr Judith Brown.

Has marine conservation in Wales lost its way?

Blaise Bullimore has been involved in monitoring the Skomer Marine Nature Reserve since 1977. He charts the progress of marine nature conservation in Wales.

The first shoots of marine nature conservation in Wales sprang from the Field Studies Council's Pembrokeshire Dale Fort Field Centre (DFFC) in the late 1960s. Increasing numbers of professional marine scientists visiting the Centre, its developing focus on subtidal biology, the rapid development of recreational diving and the collection of shellfish and curios by divers becoming conspicuous, and a point of conflict with local fishermen, all coincided to foster a growing awareness that environmental stewardship might be just as necessary in the sea as on land.

Although Skomer Island had become a National Nature Reserve for its nesting sea birds in 1959, the conservation value of the surrounding sea went largely unrecognised despite its importance as the birds' food resource. Nevertheless, DFFC staff began a dialogue with the Nature Conservancy and Skomer Island's managers that eventually led to declaration of the near-shore area surrounding Skomer and the adjacent Marloes Peninsula as a voluntary marine reserve in 1976.

Surveys carried out by recreational divers during

Routine diver-monitoring sampling is non-destructive whenever possible, using either photography, video or in-situ recording, to ensure it has minimal or no effect on the species and communities under observation. Image: Rohan Holt.

Underwater Conservation Year in 1977 paved the way for three projects that are now a cornerstone of the 'citizen science' contribution to the Marine Nature Reserve's (MNR) monitoring programme. That same year, Dr Robin Crump—then the voluntary reserve's scientific secretary—and I discussed the need for long-term monitoring.

Eventually, in 1981 I established a permanent photo-monitoring site on Skomer's 'North Wall' to document change in some of the species whose growth rates and lifespans we knew little about, and how communities changed seasonally and over longer time scales. Additional sites were soon added to broaden the habitats and species included. Early findings confirmed that some species grew extremely slowly, but there were also surprises such as the rapid growth of some sponges and the extent to which others regressed when conditions got tough—for instance in unusually low winter sea temperatures or particularly high levels of suspended sediment—and recovered later. The importance of such factors as temperature and water quality in influencing species condition quickly became obvious and this knowledge played a major role in the way the MNR monitoring programme later developed.

After provisions for statutory MNRs were introduced and four years of negotiation, Skomer MNR was designated in July 1990, becoming the UK's second MNR. Since MNR legislation was recognised as weak, the emphasis for its management was public engagement, high profile deterrence presence and monitoring. Over two decades later the on-water public engagement and patrolling and onshore outreach and education have won hearts and minds and secured the support of most users.

Designation of the statutory MNR brought with it staff and resources to expand and improve the targeting of monitoring. Focus shifted from trying to establish what was 'normal' to determining the condition of habitats, species and communities. Particular attention was paid to what were understood to be vulnerable species and habitats, in part moving toward what has since become known as risk-based monitoring.

It was clear that simply assessing condition and detecting change, particularly adverse change, was not going to be enough on its own to inform management requirements. As we needed to be able to explain changes and identify whether their cause was natural or anthropogenic, complementary surveillance of both human activities in and near the MNR and hydrographic and other influential processes was also begun.

Since 1992 the MNR's annual monitoring programme has been a mix of in-house projects, contracts and, since 1997, a four-year cycle of citizen science projects which require modest taxonomic expertise but a lot of diver-power. Intertidal community and grey seal monitoring are essential parts of the annual programme but most effort

is expended on sublittoral species and communities, ranging from anemones to *Zostera* (eel-grass), via sea-slugs, soft-corals, sponges, starfish and sediment communities.

Every year a dedicated group of volunteer divers book early to join that year's labour-intensive resurvey of either the MNR's eel-grass bed, sea-urchin and starfish, scallop or territorial fish populations, collecting invaluable information over two weekends with MNR staff support and guidance.

An experimental investigation of scallop dredging's impacts undertaken in 1985 resulted in the local Sea Fisheries Committee introducing a bye-law prohibiting dredging, beam trawling and collecting scallops by any method. Scallop surveys by volunteer divers have helped show that the consequential conservation benefits are still accumulating, recording an encouraging and dramatic population recovery since collection was prohibited in 1988. Mean density has increased by more than 25 times, though recovery at some sites slowed after 2006 and recovery at one or two sites has been much weaker than at others.

Volunteer diver data have also enabled compilation of a time-series of detailed maps of eel-grass (*Zostera marina*) extent and density (see Box 1) and demonstrated consistently higher densities of territorial wrasse at Skomer Island sites (no angling) compared with Marloes Peninsula sites (shore angling).

The volunteer projects together with other Reserve monitoring have recorded real conservation gains. Since dredging was prohibited, benthic sediment infaunal communities in formerly scallop-dredged areas have gradually developed into some of the most diverse in Wales. The MNR also makes a major contribution to Wales' European Marine Site (EMS) monitoring programme.

Volunteer diver scallop surveys by have revealed a dramatic population recovery since collection by dredging and diving was prohibited. Image: Blaise Bullimore.

The noise in many datasets makes determination of change or stasis difficult to determine for many species. Small species such as cup-corals, anemones and small sponges may be obscured by sediment deposited in calm weather or luxuriant algal growth. Sessile marine species change their appearance and volume from one sampling event to the next depending on a host of environmental factors. Many years of consistent observations are essential to enable any judgement as to these species' condition.

Despite the noise in the data and the protection afforded by the MNR, numbers of soft corals *Eunicella verrucosa* (pink seafan) and *Alcyonium glomeratum* (red sea-fingers) have shown a gradual decrease and the size distribution of Ross coral (*Pentapora foliacea*) colonies appear skewed toward smaller sizes. The species that appear to be doing best are those that have management in place to protect them.

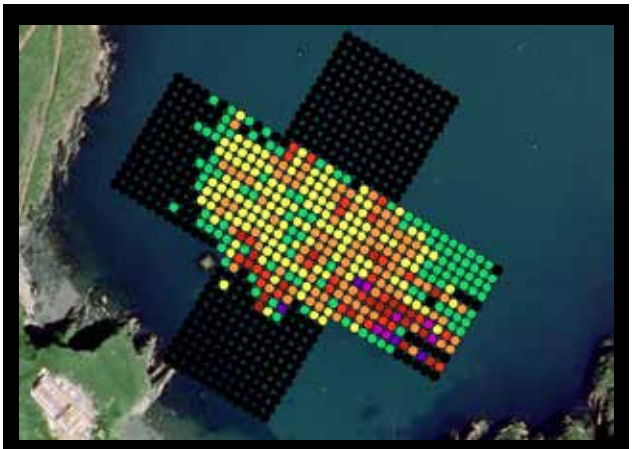
Over time it became clear that 'low-impact' shellfish potting was not quite so benign as had been popularly assumed (see photographs below) especially as fishing intensity increased—doubling between 2000 and 2005. Designation of the MNR as a 'no take zone' was proposed in 2005 but, despite two years of careful negotiations, the proposal, which would have enabled fishermen then using the MNR to phase out their effort over ten years and for angling to continue in the most popular area, was rejected by the Sea Fisheries Committee; potting effort then almost doubled again in the following three years.

Ropes connecting shellfish pots are a direct threat to fragile erect species such as the seafan *Euncicella verrucosa* (l), and Ross coral *Pentapora folicea* (r). Image: NRW/SMNR.

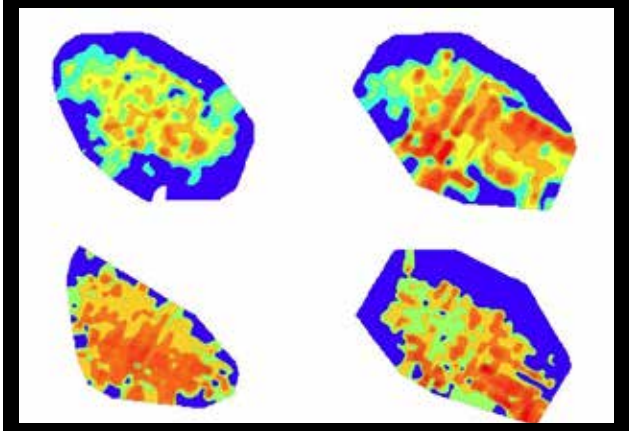
Just five wholly Welsh European Habitats Directive EMSs and two cross-border estuary sites cover over 70% of the coastline and 36% of territorial sea area. So, when the 2009 Marine and Coastal Access Act introduced provisions for Marine Conservation Zones (MCZs), rather than increase the area of designated sites, the Welsh Government announced its intention to use the new powers to create highly protected MCZs (HPMCZs) within which no extraction, deposition or damaging activities would be allowed.

By the time a prolonged, complicated and secretive site selection process was completed the rationale for the HPMCZ approach had been forgotten. The consultation

Box 1. Volunteer divers survey seagrass (*Zostera marina*) beds in Skomer Marine Nature Reserve



Zostera marina shoot density map 2010 compiled using volunteer survey data from a 5 metre grid.



Zostera marina density contour maps compiled using volunteer survey data from a 5 metre grid for 1997 (upper L) 2002 (upper R), 2007 (lower L), 2010 (lower R). The bed has increased in area, expanding to the south and east, but after increasing between 1997 and 2002, shoot density has decreased in the middle and west of the bed.

Phil Newman, Skomer MNR manager, marvels at the enthusiasm of volunteer eel-grass surveyors: "It's unbelievable that so many people keep coming back to spend hours diving in poor visibility to count blades of grass!"

which followed was badly mishandled and generated very vocal and politically active objection to the HPMCZ proposals. A Task and Finish Group was appointed by the environment minister to 'reflect on' the almost 7,000 responses to the consultation—81% of which actually supported HPMCZs—and, advised by a Stakeholder Focus Group, to advise on the way ahead with MCZs.

In July 2013 the Minister announced that all proposals were scrapped and that we are back to the drawing board, stating that more needs to be understood about the wide range of marine habitats and species that are already protected before designating more sites and tying the future of MCZs in Wales to the government's 'blue growth agenda'.

Ministers and civil servants rightly stress the need for evidence to support decision-making. So why was there no acknowledgement of the 140+ relevant survey and monitoring reports listed in the MCZ consultation document, nor of the MNR's plethora of monitoring outputs and growing list of research publications from academics at universities from Swansea to Poland to Wellington, New Zealand? Of course we always want more information but it appears that no matter how much ecological information is collected, it is deemed insufficient or not good enough. Yet, the same standards of evidence are not demanded from challengers to MPAs, whose assertions of potential economic losses seem accepted without question.

Marine conservation in Wales is struggling. The success and value of the single MNR has been underappreciated almost since the day it was designated and EMS implementation has been, at best, disappointing. At present the MCZ process seems to have set progress back, not moved it forward.

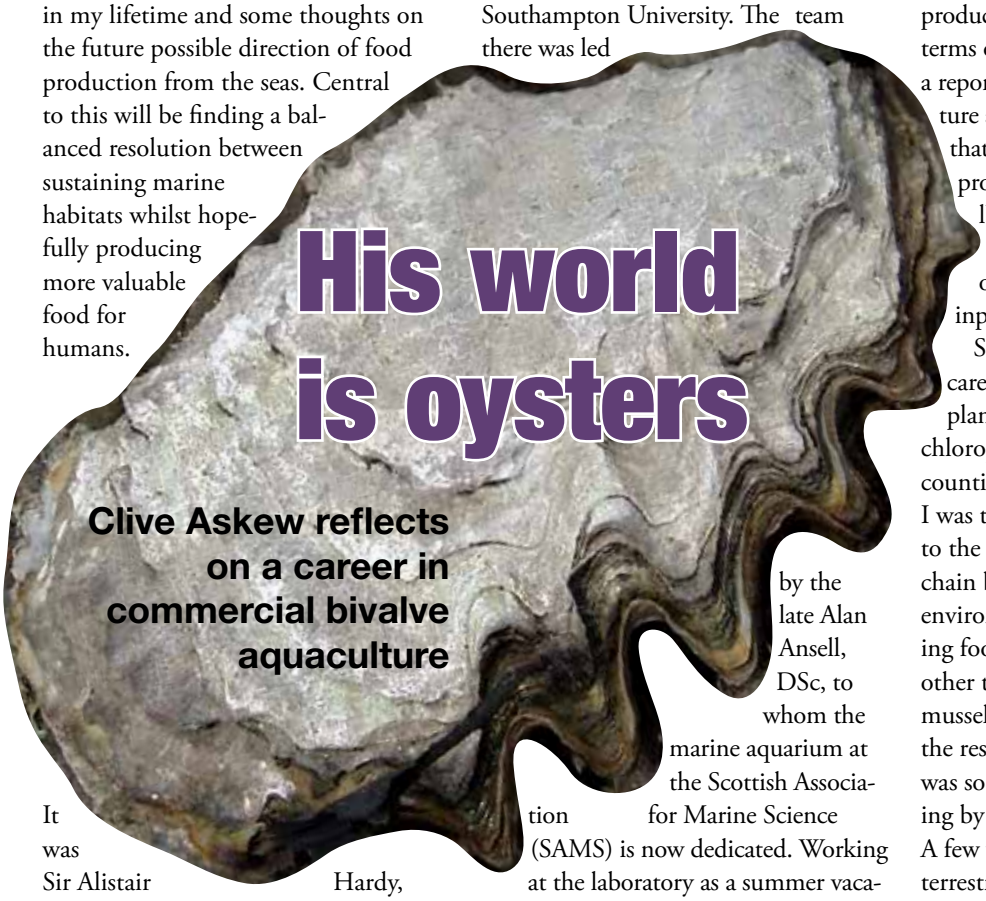
Where does this leave Skomer MNR? Twenty metres below the surface on Skomer Island's North Wall is a big seafan which I first photographed in 1982. I have been back almost every year since and it is now an old friend but hardly any bigger. It is not as cute as seal pups, clown-faced puffins or charismatic dolphins. Alone, it has negligible economic value and does not provide much in the way of ecosystem services. But its continued presence and health are still important.

It is difficult not to feel a bond with wildlife we have known personally for decades. I hope this fan will still be here next year. It is vulnerable to so many threats, suspended sediments, plastic debris and the fins of passing divers to name a few, but a direct hit from a rope on a string of pots is possibly the greatest risk. Since it is tucked into a cleft on a vertical cliff, perhaps it is safe. I hope so, and I also hope the MNR team will still be there with the resources to go back next year to check.

Blaise Bullimore first became involved with marine nature conservation in his twenties. He's just turned sixty and observes that over three decades have flown by and Wales still doesn't have a single square metre of seabed completely protected from damaging and exploitative activities. He began sublittoral monitoring on Skomer in 1982, carried out the support work for the Skomer MNR consultation and was its first manager. He is now an Honorary Warden and still helps with the annual monitoring work.

FURTHER INFORMATION

Skomer MNR's annual project status reports include details and data summaries of all the individual projects; they are available on line here: www.wwmc.org.uk/skomer-mnr-allies/science-monitoring/



His world is oysters

Clive Askew reflects on a career in commercial bivalve aquaculture

Writing as a marine biologist nearing the end of a 50-year career, mainly spent in commercial bivalve aquaculture, I feel I should be well placed to give an overview of changes I have seen in my lifetime and some thoughts on the future possible direction of food production from the seas. Central to this will be finding a balanced resolution between sustaining marine habitats whilst hopefully producing more valuable food for humans.

It was Sir Alistair Hardy, no less, who first proposed the idea that humans have an aquatic ancestry. The implications of this for human nutrition, most notably a relatively large requirement for long-chain omega-3 fatty acids, a major component of the brain and nervous system, has been highlighted by proponents such as Professor Michael Crawford, who has pointed out that the only other species on the planet with such large brains, dolphins, are fish eaters. Our ability to synthesise long-chain fatty acids (notably EPA and DHA) from the short chain ones found in terrestrial plants and hence throughout the terrestrial food-chain is very limited. The only ready-made source of long-chain fatty acids is algae and the aquatic food chain sustained by them. In terms of the global human population this means the marine food chain.

When I first entered marine biology, I was fortunate that my home town of Poole was the centre of not only a small oyster industry but also had a laboratory at the power station, run jointly with Southampton University. The team there was led by the late Alan Ansell, DSc, to whom the marine aquarium at the Scottish Association for Marine Science (SAMS) is now dedicated. Working at the laboratory as a summer vacation. student, it may come as a surprise to many to hear that we were culturing phytoplankton in large scale outdoor tanks, with the aeration enriched with CO_2 from the power station flue gas. This was in 1962, long before global warming had been thought about. The phytoplankton was then fed to American hard clams (*Mercenaria mercenaria*) a non-native species which had been found in Southampton Water and the Solent and which had become an important 'bonus' fishery in the area.

When I studied biological oceanography at Southampton, much emphasis was placed on measurement of marine productivity, the topic of Professor John Raymont's magnum opus *Plankton and Productivity in the Oceans* (1963). He had led a project during the Second World War to fertilise a Scottish sea loch with a view to increasing the harvest from inshore waters. Leading marine biologists, including F.S. Russell and C. M. Yonge in their classic book *The Seas* (1928), had pointed out that farming the sea for bivalves was the most productive way of producing food in terms of unit surface area. They quoted a report by the old Ministry of Agriculture and Fisheries (MAFF) showing that an acre of good mussel bed can produce much more food (10,000 lbs of mussel meat p.a.) than any system of terrestrial farming of animals. This is without any input of feedstock or chemicals.

So from an early stage in my career I was able to culture phytoplankton, measure it in the sea by chlorophyll analysis, filtration and by counting using an inverted microscope. I was taught that harvesting from close to the bottom of the marine food chain by filter feeders was the most environmentally benign way of producing food, because there were no inputs other than the seed bivalves, oysters, mussels or clams, and that the size of the resource at such a low trophic level was so great that the impact of harvesting by humans would be negligible. A few years later, eutrophication from terrestrial inputs became a hot issue and we were able to show that, by removing biomass from the system we were effectively improving water quality in very inshore waters. Indeed mussels have since been used for precisely that purpose in Swedish waters.

Marine conservation was very much in its infancy. For my doctorate study I monitored growth of hatchery-reared native oysters at a number of sites in Hampshire and Sussex. One of these was Pagham Harbour in West Sussex, which even in those days was a highly protected reserve. Nevertheless, I was given permission to include an experimental tray of native oysters there, though use of a boat was not permitted and the trial had to be accessed from the shore, a minor inconvenience. All the agencies I dealt with were highly supportive (Sea Fisheries Committees,

MAFF and the old White Fish Authority (WFA)—now Seafish). In 1965 the first Pacific oysters (*Crassostrea gigas*) from Canada were brought into quarantine by MAFF at Conwy and semi-commercial quantities began to be provided by the WFA, which had set up a hatchery on the same site. So I was able to compare growth and mortality rates of both native and Pacific oysters. It became clear that it was the high natural mortality rate of the native oyster, rather than its slower growth rate, that was the key factor preventing its successful large scale cultivation. Since then, Pacific oysters have come to be regarded by many as an unwanted alien, even though they have greatly reduced fishing pressure on native oysters and in areas like the Thames estuary they frequently act as 'cultch' for juvenile native oysters, so aiding their recovery. A new book, *Where Do Camels Belong?* by Ken Thompson (Profile Books, 2014) considers the arbitrary nature of such decisions and should be read by all involved in this debate, as it is so central to the issue.

An offer of work managing a hatchery for native oysters in Galicia, northern Spain took me into the world of fully commercial shellfish farming. It was here that I first witnessed large-scale shellfish farming, in

Mussel aquaculture in the Spanish Rías Baixas developed locally using home-grown expertise, but was supported by marine science led by personalities such as Miguel Torre at the Instituto Oceanográfico in La Coruña, looking at the upwelling off the north-west coast coast, and Antonio Figueras Snr, who originally worked in a hut built on an inter-tidal rock at Vilanova de Arousa, now the site of the CIMA laboratory. Growth was impressive though the 1970s and 1980s, with the introduction of mechanisation in grading, thinning and re-encording the mussels on to vertical growing ropes. At its peak, with about 3,500 large (up to 20 m × 27 m) rafts in the four rias, concerns grew that this intensity of aquaculture was resulting in excessive deposition of sediment below the rafts with consequential reduction in biodiversity in the immediate area. Controls included strict limits on the number of rafts permitted and a limit on the length of the vertical 'dropper' ropes to 12 m, (some operators had started to use ropes up to 27 m deep). The industry has stabilised and is now rigorously controlled, especially for algal toxins, which are frequent in the very productive upwelling water. Old (top) and new (bottom) 'bateas' (rafts) from which mussel growing ropes are suspended. Images: Alejandro Guerra / CIMA.

Morecambe Bay Oysters. We should celebrate the fact that a modern and environmentally benign form of oyster farming, from hatchery, through nursery stage and then to final on-growing to market size can still exist in Britain, given that it is an industry which all but disappeared fifty years ago. Images: Kelsey Thompson of Morecambe Bay Oysters.

the form of large mussel rafts in the Rías Baixas, of the Atlantic coast. That experience, though brief, was life changing. The fact that seafood was so much an everyday part of the diet of most Galicians and so important in the local economy was very different from all my previous experience.

Clearly any form of food production in the sea, either fishing wild stocks or growing fish or shellfish in aquaculture farms, will have environmental consequences of some degree. The aim should be to understand them and to manage them. That requires good marine experimental and observational science. A good example of such an approach is the long standing experimental closure of selected scallop beds around the Isle of Man.

The benign bureaucracy that existed previously has now become so complex that I would not feel capable of starting an aquaculture business today, however small. Indeed, the costs of having to deal with bureaucracy and the legal costs it could impose if any, even entirely innocent, error were made, would make it difficult to sleep peacefully at night, even if the business reached profitability. I have the greatest admiration for those few people who have succeeded in this (see above).

An area in which I have a particular interest is that of seagrass (*Zostera*) management, particularly because getting this wrong can have a very serious impact on shellfishing. Looking at the history of its decline from a fungal 'wasting disease' in the 1920s and 1930s, it is clear that inshore *Zostera* beds had survived over 50 years of extremely intensive oyster dredging during the massive boom in oyster fishery from about 1860 till the outbreak of the First World War. The decline of *Zostera* beds happened when oyster dredging was at a very low point. So the question arises whether *Zostera* beds in sedimentary estuaries may actually benefit from some disturbance. In a recent TV programme on Africa, Sir David Attenborough showed a seagrass bed being maintained precisely because it is cropped by sea turtles. On land we manage even highly protected grasslands by cropping. I do not believe we have sufficient evidence or experience of the best way of managing seagrass beds and some good experimental marine science is needed here.

The marine environment is dynamic and should be viewed as a mosaic in space and time. This means that marine conservation zones should be fluid, requiring constant monitoring and be susceptible to change or even to being rescinded as evidence of that changing mosaic emerges, not just immutable boundaries laid down for all time. The 'iterative' approach to their identification and nomination, as currently employed by the government, serves as a progressive approach towards the moving target of appropriate conservation zones, but it cannot simply cease with their designation. The sea will carry on changing.

Clive Askew (clive@bellhammer.myzen.co.uk) is a bivalve aquaculture consultant and former (retired) Fisheries Consultant to the Fishmongers' Company.

A traditional fishery enters 'a new era'

Native oysters *Ostrea edulis* are fished in the Fal estuary in Cornwall, south west England using only traditional sailing and rowing vessels. In December I accompanied Richard Clapham on board the Falmouth working boat *Holly-Anne* to see this fishery first-hand.

Dredges are dragged across the seabed by sail or by hand-operated winches from rowing boats. The repeated 'tilling' of the estuary bed pulls the oyster shells and other hard substratum out of the sediment and onto the surface. 'Cultch' in the form of shell debris is repeatedly laid, raising the substratum above the silt so that oyster spat have a clean surface to settle on.

One of the selling points for Fal oysters is their metallic taste—The

Richard Clapham hauls in the dredge. Oysters have been extracted in this way for well over 200 years.

Shellfish Association of Great Britain characterise this as "a lingering light tin and copper finish". The Carrick Roads are impacted by past mining activities, which continue to influence the system through mine water discharges and remobilisation of contaminated sediment. Oysters have a particular capacity for accumulating copper and zinc, and Fal oysters can assume a green colour through accumulation of copper.

Oysters must also compete for food and space with invasive non-native species such as slipper limpets (*Crepidula fornicata*) and the non-native red seaweed *Solieria chordalis*. The latter has proliferated in recent years, smothering an oyster bed in the north east Carrick Roads; fishermen have only recently returned to the area after the winter storms shifted the seaweed off the banks.

New rules for protecting site features in Special Areas of Conservation (SACs) mean that from October 2014, oyster and mussel dredging in the Fal can only continue under a new Regulating Order. Simon Cadnam of the Cornwall IFCA said "A new era of shellfisheries management is about to begin in the Fal. Under [the new Order] we will work closely with fishermen to make decisions which effectively manage and improve the exploitation of natural shellfisheries resources".

Paul Ferris is the Fal Oyster Bailiff. In his view the main issues are more rules and restrictions, invasive species and water quality. He told me "On the plus side we now have a Protected Designation of Origin for our oysters which may help with marketing and better prices, and the IFCA may be able to put more into improving the fishery."

Adding that the continued existence of the fishery is proof that the current management works, Paul said "The fishery is self-sustaining and regulating in terms of fishing effort—a kind of conservation by inefficiency".

How will the relationship between the fishermen and the relatively new IFCA develop? Will the present 'light touch' management continue or are there changes over the horizon that the fishermen will find unwelcome?

Like many of the oyster fishermen, Richard Clapham has a summer job to make ends meet in the closed season. The fishery is artisanal and typical of the region, but it is also a livelihood for local people in a region where unemployment is high. Are the demands of making a living and sustainability

A native oyster *Ostrea edulis*. The assemblage of flora and fauna appearing in the dredges is a result of human management —a marine parallel to a heathland or flower meadow.

in conflict? As in any fishing community there are different ideas of what constitutes sustainability and whilst various combinations of wind and tide tend to distribute fishing effort naturally around the estuary, some fishermen work the beds with more concern for sustainability than others.

After 4 hours on the water we have 7 kg of oysters. The dealer will pay £20, and each oyster may fetch £4 in a restaurant. Not a great day's fishing and I wonder uneasily how much Richard would have landed had he been alone. The wind has died completely as we return to the moorings and I reflect on how the working boats, the marine life of the estuary and a local way of life have evolved together and continue to coexist while so much around them has changed.

Guy Baker (editor@mba.ac.uk)

With thanks to Richard Clapham.
Images: MBA.

A new chapter in a remarkable history

The Marine Biological Laboratory is celebrating 125 years and a new partnership with the University of Chicago. By **Pamela Clapp Hinkle**

The Lillie building at the Marine Biological Laboratory, Woods Hole, Massachusetts.

The Marine Biological Laboratory (MBL) has been a leading force in biological discovery and research training since its founding in 1888. During the summer of 2013 the laboratory celebrated its 125th anniversary and began writing a new chapter in its remarkable history with the announcement of an exciting affiliation with the internationally renowned University of Chicago.

Located in the south-western corner of Cape Cod in the seaside village of Woods Hole, Massachusetts, the MBL is the oldest private marine laboratory in the Americas. From the beginning, the MBL has been driving fundamental advances in the biological sciences and catalysing scientific careers by providing an intellectual home for leading biologists and promising students who gather from around the world to collaborate across disciplines.

The MBL was founded in 1888 by the Women's Education Association of Boston and the Boston Society of Natural History. Its roots and mantra 'study nature not books', can be traced to the great laboratories of Europe—the Stazione Zoologica Anton Dohrn, Roscoff, Villefrance-sur-mer—and the more modest Anderson School of Natural History, founded by Harvard's Louis Agassiz (who coined the mantra) on the desolate island of Penikese, located just south of Woods Hole.

There a group of young teachers and biologists—among them the MBL's first director and later University of Chicago professor Charles Otis Whitman—gathered for two summers in the mid-19th century. Many would eventually help shape the early history of the MBL and its impact on 20th century biology more generally.

Under the early leadership of Whitman and others from universities around the country, the MBL built its reputation as, in the words of essayist Lewis Thomas, America's 'National Biological Laboratory'. A summer institution for its first eight decades, the MBL's educational and research programmes attracted the world's top biologists and their families, who relished the opportunity to gather, collaborate and exchange ideas in a beautiful location.

'The history of the [MBL] is more than the history of a distinguished institution. It is also the history of biology itself during the past 100 years', wrote science historian Garland Allen in 1988 during the MBL's Centennial.

The MBL's impact on the biological sciences has been significant, especially for an institution of its size. Since its founding, more than 50 Nobel Laureates have been associated with the MBL, either as students, faculty or researchers. Entire fields of scientific endeavour—developmental biology, neurobiology and ecosystems science, for example—have been nurtured here.

While the MBL's name would suggest that its science is largely marine-focused, its mission has always been to conduct creative, basic research and provide discovery-based training in biology. Of course, the MBL's Woods Hole location, which is a day's cruise from the cold waters of the Labrador Current and the warm waters of the Gulf Stream just offshore, means that scientists have easy access to a wide variety of marine species to use as models for their studies.

Basic research using these locally abundant organisms has resulted in a greater understanding of biological processes common to all living things, including humans. By studying the giant axon of squid, for example, MBL scientists discovered how nerve cells generate electrical impulses, how organelles and proteins are transported within them, and how ion channels facilitate the exchange of electrical current across the cell membrane.

Studies using the horseshoe crab uncovered the basic mechanisms of photoreceptor function. And studies of its blood revealed its special ability

Eggs from sea urchins are important tools for research on cell division.

to clot when exposed to bacterial endotoxins, resulting in the development of an assay now used worldwide to test for contaminants in drugs and other pharmaceutical products.

The MBL's contributions to cell

Research-based education programmes are a hallmark of the MBL. Students regularly report that their experiences in MBL courses are 'transformative' and 'career-changing'. Image: Tom Kleindinst.

biology, developmental biology and reproductive biology are also significant. Work using eggs of surf clams and sea urchins provided fundamental information about how certain proteins regulate cell division. The MBL's role in the development of new technologies in microscopy and imaging are also legendary, and the availability of the latest instrumentation in the MBL's renowned summer courses puts its international faculty and students at the forefront of experimentation.

The MBL's research-based summer education programmes are a hallmark of the institution. The Physiology and Embryology courses are almost as old as the institution itself, but the MBL's commitment to regularly refreshing course leadership and focus keeps these and all the MBL's educational programmes at the leading edge of their fields. In turn, the outstanding faculty—recruited from universities worldwide—remark that the fresh perspectives, creativity and enthusiasm of these bright students inspire them to do some of their own best work.

The MBL evolved from a summer institution to a year-round enterprise in the latter part of the 20th century. Nobel Laureate Albert Szent-Györgyi was one of the first to set up a year-round laboratory at the MBL in the late 1940s, and celebrated light microscopist and cell biologist Shinya Inoué followed in the 1970s.

The MBL's first fully-formed resident research programme—the Ecosystems Center—was established in 1975. With an early focus on studying the global carbon cycle, the Ecosystems Center has long been a leader in basic ecological research. The Center is among the world's best, and its scientists serve on the world stage, co-authoring key environmental documents such as the latest Intergovernmental Policy on Climate Change report, and providing research-based information to legislators and policy makers.

MBL scientists serve on the world stage, co-authoring key environmental documents

Today the MBL employs more than 270 scientists and support staff year-round working in the biological and environmental sciences. Research primarily focuses on ecosystems processes and climate change; microbial ecology, genomics and molecular evolution; regenerative biology and tissue engineering; imaging and cell biology; and sensory biology and behaviour.

The staff is joined each year by more than 300 visiting scientists, summer staff, and research associates from hundreds of institutions world-wide. Like generations of scientists before them, many consider the MBL their intellectual home, and return year after year to take advantage of the MBL's unique collaborative environment.

In addition, more than 1,200 students and faculty from more than 500 institutions and 45 countries participate each year in the MBL's 25 advanced laboratory-based research

A view of the MBL from Eel Pond. Image: Tom Kleindinst.

training programmes offered in fields such as cellular physiology, embryology, neurobiology, molecular evolution and microbiology. In 2003 the MBL expanded its educational opportunities by partnering with nearby Brown University to establish a graduate programme in biological and environmental sciences.

In spite of its notable history and extraordinary contributions to 20th century biology, the MBL has never been financially robust. Fiercely independent and governed for much of its history by scientists for scientists, fundraising was seldom a high priority. Today, with an annual budget of $41M and an endowment hovering around $70M, the MBL is severely under-capitalized.

Despite its recent successful $125M fundraising campaign—only the second major effort in the history of the institution—the MBL still found itself in a precarious financial situation. The economic downturn and challenging funding climate that affected all independent research institutions has not spared the MBL. In late 2012 the MBL's Board of Trustees, with the leadership of Board Chair John W. (Jack) Rowe and new President and Director Joan V. Ruderman, began to explore strengthening the institution's position through a university partnership.

On 1 July 2013, the MBL became an affiliate of one of the leading research universities in the world: the University of Chicago. It seemed an interesting choice to some, who wondered why the MBL had not selected a more local partner. But the University of Chicago's outstanding international reputation as a research institution, its experience with its other distinguished affiliates Argonne National Laboratory and Fermilab, and, most importantly, its shared values and early history with the MBL made for an ideal partner.

The MBL retains its status as a separate research institution, as well as its independent Board of Trustees. The University is working with the MBL to expand access to federal and foundation grants, enhance philanthropy and build new educational programmes. The MBL also expects to benefit substantially from several kinds of savings and synergies that flow from being an affiliate of the University. Both operational and scientific strategic planning activities are now underway. Early plans are already taking shape to take advantage of MBL's facilities during the academic year by developing a variety of training programmes that will benefit students at the University of Chicago and elsewhere. Another plus is the creation of the Frank R. Lillie Research Innovation Awards, named in honour of the MBL's second Director and Chair of the University of Chicago's Department of Zoology. These awards will provide funding for scientists to develop novel, collaborative projects based at the MBL.

'National and international collaborations are increasingly essential in biological research as we pursue fundamental problems that require many perspectives and specialties', said University of Chicago President Robert J. Zimmer upon the announcement of the affiliation. 'I am delighted that the University of Chicago is partnering with the MBL to develop new possibilities for discovery and for training the next generation of science leaders. The MBL has an extraordinarily valuable role as a source of innovation and creative collaboration in modern biology'.

'Our new partnership with the University of Chicago allows us to build on the MBL's extraordinary strengths in biological, biomedical and environmental sciences, as well as develop new and exciting ventures going forward', said MBL's President and Director Joan V. Ruderman.

Pamela Clapp Hinkle (phinkle@mbl.edu) is the MBL's Director of Development & External Relations.

Students on the graduate programme in biological and environmental science. Image: Tom Kleindinst.

So you want to be a marine biologist?

Jack Sewell introduces a new MBA membership category for young people

Most of us who work in the marine biological sciences can remember a pivotal moment when our passion for life beneath the waves or on the shore was ignited. For many it will have been an image or video, for others an encounter with a creature in the wild or a person with an infectious enthusiasm for the subject.

The Marine Biological Association has always recognised the importance of experiences such as these for young people in helping to encourage an interest in marine biological science. That is why ever since the incorporation of a public aquarium in the newly built Citadel Hill Laboratory in 1888, the Association has endeavoured to provide such experiences and supporting resources. In the 21st Century, outreach, training and education remain active parts of the Association's role.

For the first time in its 130 year history, the MBA is inviting school-students of all ages to join the marine biological community and engage with the subject in a more in-depth and meaningful way than ever before. The Young Marine Biologist membership category will be officially launched and open to members in the autumn of 2014 with the release of a new, biannual YMB magazine and a series of additional benefits, events and resources to excite and enthuse all budding marine biologists. This is a great opportunity to actively engage young people in marine biology at a time when they are deciding on the academic and professional pathways that they will follow for the rest of their lives. It is hoped that the stimulation provided by membership of the Association from such a young age will support and encourage the next generation of marine scientists.

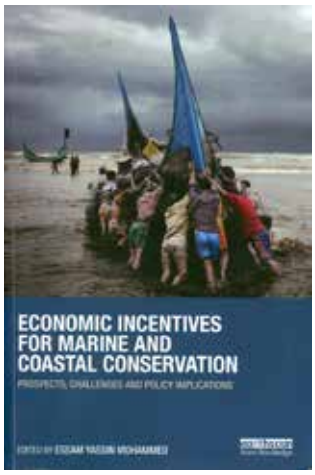
If you would like more information about the new membership category please contact me.

Jack Sewell (jase@mba.ac.uk) is Education Officer at the Marine Biological Association.
Images: MBA.

Reviews
and new titles

Economic incentives for marine and coastal conservation: prospects, challenges and policy implications

Edited by Essam Yassin Mohammed
ISBN 978-0-415-85598-3
Published by Routledge



Ecologists and what might be called 'fair-minded people' would like to see a good stewardship ethos across all that we do with the natural environment. But, the reality is that sustainable use and protection of natural resources may only happen if we can prove that all of those resources are worth something (usually in monetary terms). The authors of most of the chapters in this book have, at the centre of their case studies, the concept of Payment for Ecosystem Services (PES): financial incentives and compensation for good behavior. Furthermore, the chapters are predominantly about fisheries although mangroves and coral reefs do get a look-in together with recreational values especially of marine protected areas.

In exploring how economic incentives can change behaviour, the authors draw attention to successes and analyze failures of some of those incentives. They also include mention of such approaches as allocating fishing rights and encouraging product enhancement for customers, such as using organic methods in aquaculture to make their outputs more attractive to sensitive consumers. For many of the measures advocated, there seemed resistance from industry —perhaps that will change if consumers work harder to demand products only from well-managed fisheries and aquaculture.

The final chapter is about 'perverse subsidies', using an example from Mexico, that only served to increase the pressure on fish stocks resulting in decline in those stocks. Perhaps an example from Europe would have been appropriate!

What is clear is that every country will have different cultural and economic characteristics to take account of in determining what measures can be taken to protect ecosystems and ecosystem services. So, the book is not a manual but does give some ideas of some of the possibilities and problems that can be used to inform new economic measures in support of marine and coastal conservation.

Keith Hiscock

Blackfish (2013, Cert 15)

Director: Gabriela Cowperthwaite

When it comes to documentary films on the environment, I always find myself approaching them with that slight sinking feeling. I expect them to be worthy, educational perhaps but ultimately, well, a bit dull. When it comes to documentaries with a marine environmental theme it is even worse as I feel as I 'ought' to watch a film on 'my subject'. I definitely don't expect to be gripped or hugely entertained.

Blackfish however is a documentary that has gripped, entertained and inspired audiences since its premier at the Sundance Film Festival in 2013. The film focuses on the supposed inhumane treatment of one particular orca named Tilikum who it is alleged has been responsible for the deaths of three trainers over 30 years. The film links this behaviour to the appalling treatment of Tilikum (and killer whales in general) whilst in captivity. Alleged abuses include breaking up groups of orca in the wild in order to supply the marine park industry and separating calves born in captivity from their mothers. The case against SeaWorld and associated parks is built up over the course of the film giving it more of a mystery and suspense feel rather than just a straightforward explanation of the issues.

If there is a difficulty with the film it is that most of the accusations come from former SeaWorld employees making it hard to ascertain how impartial the film makers are being in their use of facts. SeaWorld claim the film is 'deliberately misleading and scientifically inaccurate' and their refusal to participate in the film definitely makes the documentary more of a polemic than a balanced debate. Whatever your opinion, there is no doubting the power of the film. It has resulted in a backlash against marine parks with various celebrities rushing to criticise the idea of orcas being held in captivity and bands cancelling gigs at SeaWorld affiliated venues. As a result, SeaWorld are now seeking to tell their side of the story.

So if you want to join the debate on the educational and scientific value of marine parks versus animal welfare and commercial exploitation, or just want to enjoy a film that is both unsettling and riveting, Blackfish will do the trick.

Matt Frost

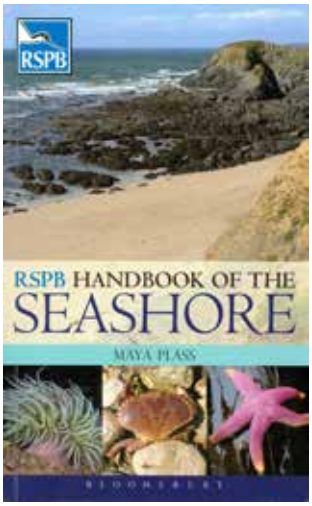
RSPB Handbook of the Seashore

Author: Maya Plass
ISBN 978-1-4081-7836-2
Published by Bloomsbury

This small book of 240 pages covers most things that one is

likely to find on the seashore—except birds! These are of course covered in another RSPB book.

There are introductory chapters on the tidal cycle, how to read tide tables, where to look, The Seashore Code, keeping a nature journal, what to do if you find something unusual, the value of the coast and sea, and conservation and climate change. Then each group of organisms is dealt with in turn. In the introduction to each group there is an account of the main features and in some cases these are illustrated with line drawings and diagrams of the life cycles. The 208 species most commonly found are described and illustrated with good colour photographs. For each species an indication is given of size, where it occurs on the shore and other similar species with which it may be confused. Finally there is a chapter on things found on the strandline. A glossary is followed by further reading, useful websites and an index. This is certainly a handy little book for those wishing to identify most of the life found on the seashore. It is a convenient size to carry onto the beach and the cover and pages should be to some extent water resistant.



Gerald T. Boalch

MBA Postgraduate Conference

The first MBA Postgraduate workshop was held in April 2002 at the MBA's Citadel Hill Laboratory in Plymouth and was attended by students and post-docs from as far afield as Dublin, Belfast and France. Before this time, there were no UK marine biological meetings where postgraduates and post-docs could meet, discuss their work and exchange ideas. As a result of the success of the meeting it was agreed that the profit made would be used towards organising the next workshop and the Annual MBA Postgraduate conference was born.

The conferences are organised by the post-graduates with support from the Association including the award of bursaries to attendees. Ben Harvey (Aberystwyth University) and Fadilah Ali each received a bursary to attend the latest workshop (held at Hull, UK). Fadilah reports on her experience below.

Experience at the 11th Marine Biological Association Postgraduate Conference 2014, University of Hull, UK, Scarborough Campus

By being awarded one of the Marine Biological Association's Student Bursaries, I was not only able to present on my research, but also experience some exciting and informative presentations from the other delegates as well as the keynote speakers. My research on the lionfish invasion in the Caribbean was unique and well received as many people were intrigued about the indestructible nature of lionfish and their ability to devastate the native populations. At this conference there was also a diverse array of research presented, including topics such as deep sea species, coastal protection, marine protected areas, ocean acidification and invertebrate ecology to name a few.

The conference and its social activities represented a fantastic networking opportunity to get to know other current postgraduate studies as well as the representatives from the University of Hull. This was especially important since these individuals who are postgraduate students now, may very well end up continuing to be my peers in the future, or hold reputable positions at the academic, government or industry level. Thus this conference could quite possibly be an invaluable investment for the future.

The fieldtrip to Flamborough Head and Bempton Cliffs was especially enjoyable even with the sometimes inclement weather. Being an international student it was great to experience the beauty and wonder of the British environment, which ranged from breathtaking chalk cliffs and caves to diverse intertidal rocky shores, to great expanses of rolling hills. The session at Bempton Cliffs was quite informative and gratifying as we were able to learn to identify a variety of species and had the chance to see puffins and a peregrine falcon!

I would like to commend the organising committee at the University of Hull for the superb session and also thank the MBA for granting me the opportunity to attend this conference.

Fadilah Ali, PhD Student, University of Southampton

Images: Organising Committee of the 11th MBA PG Conference
Lionfish: Albert Kok

Royal Charter

Royal Charters are granted by the sovereign on the advice of the Privy Council to organisations that can demonstrate pre-eminence, stability and permanence in their particular field. A Royal Charter comes into force legally once it has passed under the Great Seal of the Realm. The MBA Charter, printed on vellum and with the accompanying Great Seal (scarlet red), is shown below.

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