Issue 9 October 2017
ISSN 2052-5273

The Marine Biologist

The magazine of the marine biological community

Secretive sharks of the open ocean

Antarctic gigantism
Apps track tiny algae
Detecting biodiversity with eDNA

THE MARINE BIOLOGICAL ASSOCIATION
Est. 1884
Incorporated by Royal Charter

Tackling a lionfish invasion | Aristotle's observations | Hong Kong marine biodiversity

The Marine Biologist
The magazine of the marine biological community

The Marine Biological Association
The Laboratory, Citadel Hill,
Plymouth, PL1 2PB, UK

Editor Guy Baker
editor@mba.ac.uk
+44 (0)1752 426239

Executive editor Matt Frost
matfr@mba.ac.uk
+44 (0)1752 426343

Editorial Board Guy Baker, Kelvin Boot, Matt Frost, Paul Rose, Mike Thorndyke.

Membership Alex Street
alexa@mba.ac.uk
+44 (0)1752 426347
www.mba.ac.uk/membership

ISSN: 2052-5273

We welcome submissions of original and relevant material, letters and responses to published articles. For guidance, please see the magazine website or contact the Editor.

www.mba.ac.uk/marine-biologist

The Marine Biologist is published by the Marine Biological Association, Registered Charity No. 1155893

THE MARINE BIOLOGICAL ASSOCIATION
Est. 1884
Incorporated by Royal Charter

www.mba.ac.uk
@thembauk

Editorial

Whether this finds you in an austral spring, a boreal autumn, or a tropical monsoon, we wish you a warm welcome to *The Marine Biologist* magazine.

There really is something for everyone in this edition. We track sharks in the North Atlantic, head south to ponder questions of gigantism in Antarctica and hear about projects to remove unwanted species and restore desirable ones. Furthermore, we are delighted to present an article from Mote Marine Lab in Florida, where a new citizen science project is using mobile phone technology to generate information about harmful algal blooms affecting Gulf Coast beaches.

At 'the Ocean Conference' in New York in June, the United Nations' 193 member states met to discuss the implementation of Sustainable Development Goal 14 (SDG14), to 'conserve and sustainably use the oceans, seas and marine resources'. This really was a milestone for the seas: the Millenium Development Goals didn't even mention the ocean but since then, ocean issues have risen up the international agenda and for the ocean to have its own SDG is remarkable. As well as calls for action and voluntary commitments, some of the planned outcomes will be delivered through existing mechanisms: the Paris agreement for climate change and ocean acidification, and World Trade Organization talks for agreements to reduce fisheries subsidies. However, as pointed out in the Earth Negotiations Bulletin[1], one of the main achievements of the Ocean Conference might have been to raise awareness of the vital importance of the ocean amongst world leaders.

1 Earth Negotiations Bulletin (ENB) Volume 32 Number 33 http://enb.iisd.org/vol32/enb3233e.html

International meetings on ocean policy can seem remote but they influence how stakeholders from governments to individuals will approach marine issues. Taking marine plastic pollution, the Ocean Conference called for improved systems for manufacturing and recycling of single-use plastics, and for the need to see plastic waste as a resource. This led to a pledge from Adidas and Parley for the Oceans to significantly increase production of running shoes made from recycled ocean plastic. At the societal level, the tide of public opinion appears to have turned as shown by, for example, strong support for calls for plastic-free aisles in supermarkets.

There are serious and pressing problems facing the ocean but it is important to be like a proton (always positive) and spread some ocean optimism. This year, new species of sunfish, whale and worm came to light, showing that there is still so much to discover, learn and enjoy.

The Young Marine Biologists are growing in number (see page 31) and I would encourage all members, but our younger readers in particular, to send in your inspiring experiences, stories, book reviews and pictures.

Awareness of the state of the oceans and of the need for co-ordinated action is spreading: 2017 may be remembered as the year that the world sat up and noticed marine issues.

We welcome your articles, letters and reviews, and we can advertise events. Please contact us for details or see the magazine website at www.mba.ac.uk/marine-biologist

Front cover: A beautiful blue shark, *Prionace glauca*, in its element. © Paul Naylor (paul@marinephoto.co.uk)
Back cover: Marine biology is not all about charismatic megafauna and spectacular views… but it is sometimes. Weddell seal *Leptonychotes weddellii* and Adélie penguin *Pygoscelis adeliae* against the backdrop of the Horton and Hurley Glaciers in Ryder Bay, Antarctica. © J. I. Spicer.

Contents

Issue 9 October 2017

02 **Editorial**

04 **In brief**

Research digests

06 **Secretive sharks of the open ocean** David Sims

10 **There might be giants, but why?** John Spicer

13 **Can a new project remove lionfish from the Mediterranean?** Demetris Kletou, Periklis Kleitou and Jason Hall-Spencer

14 **Saving the Solent, one oyster at a time** Luke Helmer, Joanne Preston, Simon Harding and Morven Robertson.

Policy

16 **The MBA takes on the MARS challenge** Matt Frost

Features

17 **Apps track tiny algae with huge impacts** Hayley Rutger

19 **On Aristotle's observations of fish reproduction** Kostas Ganias and Eleni Voultsiadou.

21 **Hong Kong reveals underwater riches** Terence Ng and Gray Williams.

23 **Symbiosis on the shore** Michael Cunliffe

24 **eDNA: a 'forensic' approach for detecting biodiversity and unravelling ocean complexity** Kelvin Boot

Sharing marine science

26 **Could studying marine biology at Hull be a gateway to your future?** Sue Hull

28 **The National Marine Biological Library** Emily Miles and Barbara Bultmann

29 **The MBA 2017 Postgraduate Conference**

31 **Marine biology for all! Young Marine Biologist update** Eliane Bastos

33 **Reviews**

Top: © MBA
Middle: © J. I. Spicer
Bottom: © Conor Goulding/Mote Marine Laboratory

Deep sediment community in Loch Duich, Scotland with the fireworks anemone *Pachycerianthus multiplicatus* and tall sea pens *Funiculina quadrangularis*. Scale in foreground ca. 50 cm. © Keith Hiscock.

Celebrating Britain's Hidden World

'What do you think is out there?' is a question that I often ask bystanders as I get ready to go diving in Plymouth Sound. Usually, their answer is, 'It's just mud, isn't it?' Show them pictures of forests of sea fans or walls of jewel anemones and ask, 'Where do you think these pictures were taken?' and they might venture, 'Red Sea?' or 'Caribbean?' but not, 'Out there.'

The shallow seabed around the coast of Great Britain has a remarkable variety of habitats and associated communities of species. Those habitats have been sampled and described for over 200 years, with much pioneering work carried out by Marine Biological Association (MBA) researchers from the end of the 19th century onwards. I have been part of the drive, over the past 50 years, to better understand what is where and why it's there. A fortuitous combination of interests in marine biology, diving and photography, together with a lot of luck in the jobs that I have had, has enabled me to see at least a part of the 'big picture' and my images enliven many lectures and publications. Time to pull it all together!

Exploring Britain's Hidden World: the Natural History of Seabed Habitats will be published in spring 2018. The book is dominated by images from the fabulously colourful to, well, estuarine mud. A series of coloured line drawings illustrate some of the habitats hidden within the sediment and their associated communities (biotopes). The book reviews the early days of exploration and discovery, continues through the past 50 or so years by looking at gathering knowledge and creating information, then illustrates the communities and species that occur in different major habitat types in the shallow seas around our coasts. The chapter on 'Shaping the seabed environment' describes especially the physical and biological factors that determine what will be where. Finally, the book describes the information resources we have now but that would have been unbelievable a couple of decades ago, and looks at how new technology is likely to increase that knowledge.

MBA members can purchase the book at a discounted price and will be notified through the Members' Bulletin. For more information, see:
www.wildnaturepress.com

Keith Hiscock, MBA Associate Fellow

Marine contamination fears as mercury is remobilized

Recent research has raised concerns that despite drastically reduced emissions, human exposure to mercury from marine food could rise as a result of global warming.

Mercury has been widely used for hundreds of years, it is highly mobile in the environment and has been distributed globally via precipitation. As methylmercury it is highly toxic and readily taken up by biota, and has a propensity to bioaccumulate.

Mercury locked in ice is likely to be released from permafrost regions. A team led by Qianggong Zhang of the Institute of Tibetan Plateau Research, China, measured mercury levels in soils and rivers in the Himalayas and found it is being released as glaciers melt[1].

Another recent study highlighted the potential threats posed by mercury to marine biota and humans as the climate changes[2]. Erik Bjorn and his team at Umea University, Sweden, used mesocosm experiments to examine how increases in humic-rich runoff from land sources will affect mercury uptake in coastal ecosystems.

Under a scenario of 20 to 30% increase in runoff, Bjorn's team measured carbon fixation in mesocosm ecosystems which were treated with inorganic nutrient and enhanced natural organic matter (NOM). In the reduced light conditions of the NOM treatment, the balance of productivity had shifted away from autotrophs (phytoplankton) in favour of heterotrophs (microbes). Bacterial food webs are more complex than those based on phytoplankton and the authors found mercury bioaccumulation was three to six times higher in zooplankton in the NOM treatment that favoured bacteria, and that food web length was measurably greater at the zooplankton trophic level compared to phytoplankton-driven food webs in the mesocosm treated with inorganic nutrients. Given that mercury levels increase around 10-fold at each trophic step, the potential exists for concentrations of mercury to exceed safe levels in marine top predators.

1. https://goo.gl/uj3iFd
2. https://goo.gl/AWaagX

A model of science-to-policy reporting is 10 years old

A major assessment of climate change impacts on the UK marine environment over the past decade was released in August.

The 2017 Marine Climate Change Impact Partnership (MCCIP) report card examined what was reported in 2006 and how this has changed for key topic areas over the past 10 years. The Partnership brings together scientists, government, its agencies and NGOs to provide co-ordinated advice on climate change impacts and adaptation around our coast and in our seas.

Its importance was recognized by Sir David Attenborough who said, 'Concern about the state of our seas has caused them to be studied more intensively—and extensively—than ever before. Here is a summary of the findings. They have never been more important.'

The 2017 report card has also provided lessons for science to policy reporting. The MBA's Dr Matt Frost, chair of the MCCIP working group that delivered this report, praised 'the development and evolution of a robust mechanism for communicating science to policy-makers that has now been taken up as a model for use in other countries and for other elements of science to policy reporting'.

The fact that MCCIP has been running for over 10 years and involved hundreds of scientists adds significant weight to the evidence being presented—perhaps the reason that the media has taken particular interest in this story: as well as appearing on UK national TV News (ITN), the story was published in the *Guardian* and reproduced across the web.

The Asian shore crabs, *Hemigrapsus sanguineus* (left) and *H. takanoi* (right).

Invasive crabs; a sanguine tale?

The non-native Asian crabs *Hemigrapsus takanoi* and *H. sanguineus* arrived in Europe in 1994 and 2002 respectively. They spread steadily and in 2014, as anticipated, both species were recorded for the first time on mainland Britain.

Evidence has recently been published of established populations of *H. takanoi* in the south-east of England, including the discovery of a record dating back to 2011, previously misidentified and recorded through a citizen science initiative.

Despite two geographically well-separated records and apparently favourable conditions, no records have been published of *H. sanguineus* since 2014.

More information is needed to track invasive crabs and we are keen to receive records of these species through our new, free Crab Watch app (IOS and Android). Get involved and help us answer questions about these mysterious invaders!

Jack Sewell

Marine science camps for young people

The MBA has recently been working with the Field Studies Council (a leading UK environmental education charity) to deliver a series of residential Marine Science Camps around the UK.

The camps, for 16 to 24 year olds, aim to inspire young people about the marine environment and to allow them to share the experience with others with similar interests. They are an ideal way to gain skills in marine biology, conservation, and species identification. Activities are led by experienced FSC field tutors and MBA marine biologists, with contributions from working marine scientists and current marine biology undergraduates.

They are hosted at FSC Field Centres, with full board and accommodation and fully equipped laboratories provided. Attendance can also qualify participants for their Duke of Edinburgh Gold Residential. The camps have already run successfully for three years at Dale Fort Field Centre in Pembrokeshire, Wales.

From 2018 there will be camps at Millport Field Centre on the Isle of Cumbrae in Scotland and at Slapton Ley Field Centre in South Devon, England, with day visits from the latter to the MBA's Citadel Hill laboratory and the National Marine Aquarium included. Also included is one year's membership of the MBA. See the FSC and MBA websites for details.

The great fish migration

Records of 'strange' catches from fishermen in sub-tropical and temperate regions around the globe have been collated by Ben Goldfarb in an article in *Yale Environment 360* as evidence that warming seas are displacing tropical fish into cooler, higher latitude waters.

The Gulf of Maine on the US east coast shows how our oceans might look in the future. Due to the combined effects of climate change and a natural cyclical fluctuation known as the Atlantic Multidecadal Oscillation, sea surface temperatures here rose 2°C between 2004 and 2013; faster than almost anywhere else on earth. Tropical fish have invaded areas of the Cape Cod Canal: sailfish, cobia and torpedo rays can be found with increasing regularity.

Temperate species are feeling the heat too. In northern Europe, herring, haddock and cod are moving north and being replaced by sardines, sea bass and red mullet. This migration is not viable for all species; bottom-feeders like sole are prevented from moving north by the limits of the continental shelf.

The picture is not always clear. Some species are seen to shift away from the poles, reflecting local oceanographic conditions, and the replacement of herring with sardines (and vice versa) has been seen before, having been recorded in detail in the long-term records collected in the Western English Channel by MBA research vessels over the past century.

Shifts in commercial stocks have significant implications for fishers who may have to change the type of fish they catch or move with the fish—much easier for larger operations with the resources to absorb change than for inshore boats. This is particularly bad news where fish migrate away from the relative safety of zones set up to protect them to areas with fewer or no restrictions on fishing. From a management perspective, the ideal scenario is that zones will move dynamically to follow the fish stocks they protect. Fishers must either follow the fish or stay and adapt to catch the new influx of warm-water fish.

Lauren Shipston

The descent of plastic

Field studies have found significantly less microplastic in the open ocean than expected, and attention has turned to the biota for an explanation.

Research led by Kakani Katija and C. Anela Choy at the Monterey Bay Aquarium Research Institute looked at the role of giant larvaceans—a class of free-swimming tunicate that secretes a large mucus sac or 'house' which is thought to have a protective function and through which water is drawn to concentrate food particles.

The scientists squirted tiny plastic particles at larvaceans between 200 and 400 m depth and observed that particles were ingested but that they also adhered to the houses. Larvaceans regularly shed their houses and secrete new ones, meaning that plastic particles can sink either in a faecal pellet or attached to the house.

The authors propose that larvaceans and other abundant pelagic filter feeders make up a mechanism for packaging and delivering plastics to the seabed. The uncertainties inherent in such a study are acknowledged: the distribution of microplastics in relation to pelagic filter feeders is largely unknown, as is the extent to which larvaceans are able to selectively reject microplastics in their diet.

A complicating factor is that the buoyancy of faecal pellets may be affected by plastic particles, slowing their descent and increasing the chance of them being ingested by other animals, thus dispersing plastics more effectively through the food chain. Additionally, increased particulate matter in the water column has possible knock-on effects for wider marine ecological processes. (see Lindeque, P., 2017, Plastics, Plankton and pollution, *TMB*, 7: 16).

Secretive sharks of the open ocean

Open ocean sharks face an uncertain future, but new research gives hope, says **David Sims**.

Blue shark. © Jeremy Stafford-Deitsch.

Blue stretched down as far as could be seen, illuminated by shifting shafts of down-welling light. Gazing down through this drop in the ocean I'd expected to see something, but nothing moved across the void, nor had it for hours. A container ship, like a skyscraper on its side, churned past us a few miles away. Then from the deep a shape glanced across the corner of my eye, there and not there at the same time. Coming back into view, a sleek, torpedo shape with a sinuous movement, well camouflaged against the inky backdrop: it was a large blue shark.

a sleek, torpedo shape with a sinuous movement

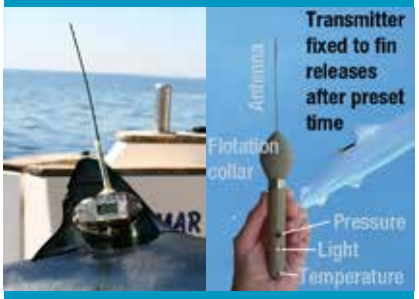
Now our boat was a hive of activity as we made sure lines were secure, tagging equipment was set and the satellite transmitter tags turned on. Within a few minutes we were guiding a blue shark alongside and fixing the tag onto the triangular dorsal fin so that the little antenna reached above the fin's tip. The tag would signal the shark's geographic position each time it cruised at the surface (Box 1). After taking the shark's length and sex, we released this 2 m long female and watched her disappear into the depths, knowing we'd be tracking her movements for many months to come.

That was over 10 years ago and since then our project has provided insights into the secret lives of oceanic sharks (see Box 2). Based at the Marine Biological Association (MBA), we commenced the Save Our Seas Foundation funded project on blue and shortfin mako sharks in 2006 to satellite track their ocean travels. Very little was known about them in deep waters of their oceanic habitats, such as where juvenile and adult oceanic sharks spend time, how and when they move between preferred areas, and the timing and location of migratory routes. The project started out very much as a basic science study. However, it quickly became evident to me and my then research student, Nuno Queiroz (now a PhD with his own shark research group at the University of Porto) that finding sufficient oceanic sharks to tag would be one of our major challenges.

Absent sharks

The longer we spent at sea in the western English Channel off Plymouth, our first tagging site, the more we

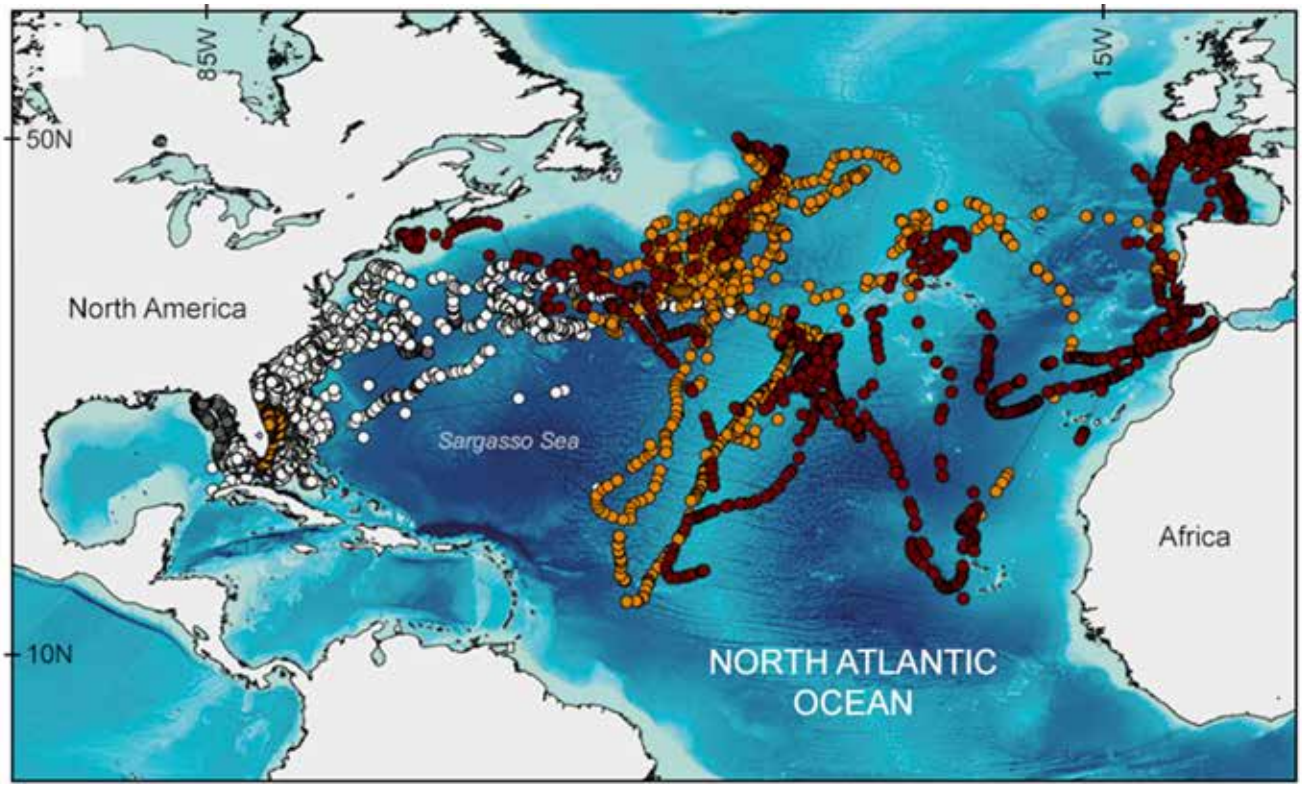
Box 1. Satellite tracking



We use two types of electronic tag to track long-distance movements of sharks. The first is an Argos transmitter that emits ultra-high frequency radio signals when the tag's antenna breaks the sea surface. Polar-orbiting satellites relay data to ground stations. Geographic positions of the tag are computed in near-real time and available to researchers via a web portal.

The second is a pop-off satellite-linked archival transmitter (PSAT) that is attached to the shark's fin and records depth, water temperature and light intensity, before releasing from the shark at a pre-programmed time, floating to the surface and relaying data to overpassing Argos receivers. Data are then processed by researchers to estimate movement paths and activities.

Tags are small, (ca. 120g) and can be attached rapidly. Tagging procedures require institutional and, in the U.K., governmental training and approval to reduce the potential of injury to sharks.



Oceanic sharks aggregate in preferred space use 'hotspots' strongly associated with productive thermal fronts. Satellite tracks of ~100 large sharks totalling 8,000 track days (2006 to 2012) shown: red colour dots, blue shark track locations; orange, shortfin mako; white, tiger shark; grey, hammerhead sharks. A collaboration between MBA and the universities of Porto and Miami.

realized that our catch rates were much lower than previously recorded there. In the 1970s John Stevens, also working from the MBA, had studied blue shark ecology. His pioneering work on their diet, reproduction and long-range movements informed from mark-recapture tagging provided valuable new data on this species. In the summers of 2006 and 2007 we repeated his surveys, but our catch rates were about 75% lower than Stevens'. Were the numbers of blue sharks visiting the Channel simply lower in more recent years, perhaps altered by different sea temperatures or prey movements? Or had fishing taken its toll on populations in the intervening three decades?

Overfishing was certainly possible. Blue and mako sharks together make up about 90% of all sharks caught by open ocean pelagic fisheries (see Box 3). Catches are high too, having increased greatly in recent years as eastern markets for valuable fins expanded. However, there was and continues to be poor monitoring and data reporting of oceanic shark catches, making it difficult for stocks to be assessed accurately. Today, catches of blue and mako sharks remain largely unregulated globally, particularly in international waters where no management is in place to help sustain populations for the future.

To shed light on potential overfishing in the blue ocean we decided from 2007 not only to track shark movements by satellite, but also to track vessels from the Global Positioning System (GPS) transmitters many carry (see Box 3). By doing this we could explore how ranges of sharks overlapped with ocean-wide fishing grounds—were oceanic sharks at risk year-round or only in certain seasons? Also, we needed to tag sharks in the heart of their distribution—the central Atlantic, where the bottom can lie some 5,000 or 6,000 m below.

Box 2. Oceanic sharks

Sharks that spend most of their lives in deep waters of the open ocean away from continental landmasses are termed oceanic sharks. The blue shark is one of the widest ranging sharks, found globally in all temperate and tropical oceans. They can grow to 3.8 m in length with females giving birth to between four and 135 pups per year. As the most fished oceanic shark they are IUCN Red Listed as Near Threatened.

The shortfin mako is warm-bodied, maintaining body temperature some 6-8°C above ambient and thought to be the fastest swimming shark, clocking burst speeds above 30 mph. It can grow to 4 m long. This species is at particular risk from overfishing because growth to sexual maturity is long (18 yrs in females) with few pups produced per female (four to 18 every three years); it is IUCN Red listed as globally Vulnerable.

Shark secrets glimpsed

The project has managed to tag and track over 140 blue and mako sharks and the insights have been fascinating. In the first years we found that blue sharks visiting UK waters during summer months migrated primarily from further south off the Azores, Iberia and north-west Africa, moving north as sea temperatures warmed in spring to spend the summer foraging on mackerel and herring schools in northern shelf seas. Tracking more

Box 3. Fishing

Pelagic longline fishing vessels are large ships that deploy a monofilament line extending up to 100 km long. From this surface line over 1,200 baited hooks hang down to depths of between 50 – 300 m. For many years swordfish and tuna were target catches with sharks being low value by-catch, however, as target stocks declined and markets for sharks fins developed, oceanic sharks have become targeted by-catch.

Hundreds of longliners operate in Atlantic, which is the most heavily fished open ocean in the world. Atlantic longline fishing is up to eight times higher than in the Pacific. Global catches of blue and mako sharks are estimated to be many millions, however on the high seas catches remain largely unregulated.

than 180 longline fishing vessels it was clear that to reach the UK, migrating blue sharks had to pass through a dense 'curtain' of hooks stretching along the shelf-edge off south-west England. We speculated that increasing fishing pressure from growing longline fishing fleets along the shelf-edge could be one reason why we observed fewer blue sharks in the Channel than 30 years before.

Within a couple of years of tagging smaller sharks in shelf seas we ventured into the centre of the North Atlantic. Focusing on three tagging sites hundreds of kilometres apart, we found that blue and shortfin mako sharks there were much larger in body size compared to most sharks found near North Atlantic landmasses. Several years of tracking indicated that we had stumbled across areas where adult males and females of both species aggregated, including pregnant sharks. Like the smaller shelf-edge sharks, these large individuals moved north and west as summer came, and moved back south as waters cooled in autumn. Movements were extensive: makos could cross the North Atlantic in a matter of weeks, while adult, possibly pregnant, female blue and mako sharks migrated south to tropical waters, perhaps to give birth in productive areas off Africa and South America.

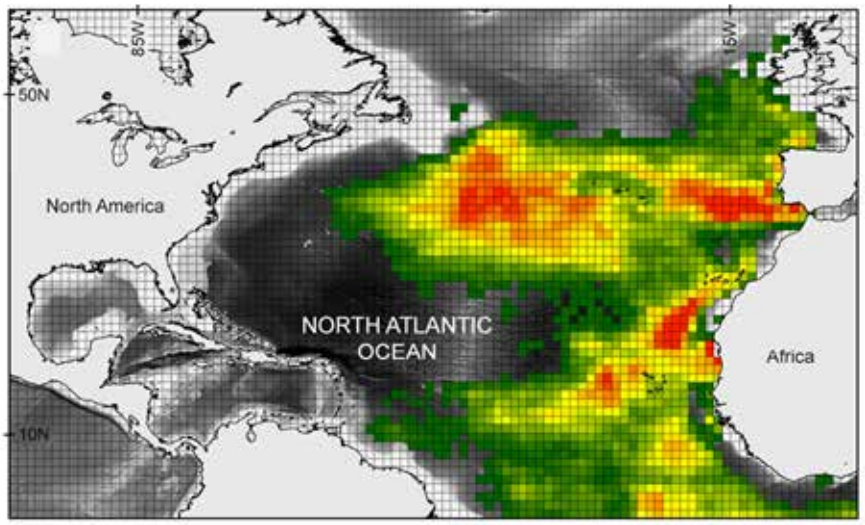
Oceanic shark hotspots

The emerging picture of multi-species aggregation areas led us in 2014 to collaborate with colleagues in the United States who were tracking blues and makos in the western North Atlantic—together our shark tracks spanned the entire ocean. Slowly, our view of oceanic sharks became a little less mystified. Spatial analysis of shark tracks in relation to satellite remote-sensing maps of temperature and productivity for example, identified multi-species shark 'hotspots' in open ocean regions far from land and existing management measures. These hotspots were where oceanic sharks spent extensive periods of time each year—for instance, ten makos were tracked for six months and remained within an area about 800 km in diameter, which sounds enormous but actually is very localized in the context of how far the individuals move during an annual cycle.

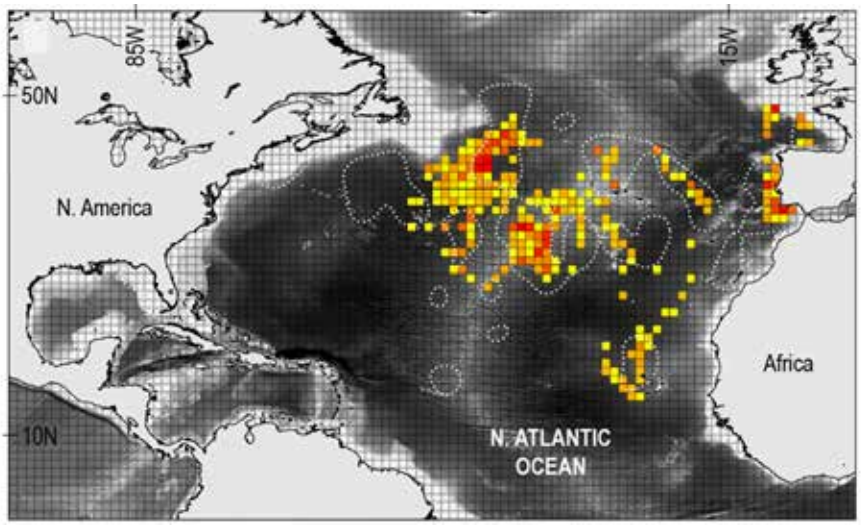
blue sharks had to pass through a dense 'curtain' of hooks

A key question was: what determined where a hotspot was found? Several months of analysis provided a clue to the common factor. It appeared that hotspots were strongly associated with ocean thermal fronts, boundaries between different temperature water masses with high plankton biomass. It seemed oceanic sharks were preferring to spend extended periods of time in productive areas.

Another discovery related to what the sharks were doing in the hotspots. Both blue and mako sharks undertook very deep dives down to more than 1,700 m, sometimes on a daily basis. What was the function of deep dives into the midnight zone where no surface light reaches? Examining sharks caught by commercial longliners in the region gave an answer: stomach contents comprised many different species of



Distribution of individual longline deployment from 186 Spanish and Portuguese fishing vessels, 2003-2011. Fishing locations occurred predictably in shark space-use hotspots, overlapping their tracked range almost entirely. Redder colour in grid cell denotes more longline deployments.



Map of the major locations where large sharks co-occur with longliners. Shark space-use hotspots denoted by dotted lines. Redder colour denotes more shark/fishing vessel spatial interactions.

deep-sea cephalopods, including the enigmatic vampire squid, *Vampyroteuthis*. So shark hotspots seemed to be areas not only with high surface production and prey biomass but also huge abundances of squids and octopuses way below the sunlit surface waters.

Tracking sharks to their death

As our study progressed, the number of tagged sharks caught by commercial longliners grew too. Tags were returned to us from many different countries, such as Spain, Japan and the United States. Importantly, from satellite tracking we could detect a shark mortality in a fishery-independent manner—from the different movements of tags when aboard a vessel compared to when attached to a free-living shark we could tell when a shark was caught. And capture rates seemed high, at around 20%, at least several times higher than fishing mortality estimates used in blue and mako fishery stock assessments. The data were pointing towards much higher fishing pressure for oceanic sharks than previously realised. But it was our next analysis that emphasized oceanic shark vulnerability to fishing.

Overlaying simultaneous GPS trackings of the entire Spanish and Portuguese longline-vessel fishing fleets with oceanic shark hotspots showed an 80% overlap with fished areas. Regions of high overlap between oceanic tagged sharks and longliners included the North Atlantic Current/Labrador Current convergence zone east of Newfoundland and the Mid-Atlantic Ridge southwest of the Azores. Strikingly in these main regions, and subareas within them, shark/vessel co-occurrence was spatially and temporally persistent between years, which highlighted how broadly the fishing exploitation efficiently 'tracked' oceanic sharks within their hotspots year-round. The shark/vessel interaction maps enabled us to calculate that an individual shark may be at risk of capture for up to 20 days per month, highlighting that blue and mako shark hotspots were at risk of overfishing (see Further reading).

Conserving shark hotspots

In light of this, something worth considering in addition to much-needed catch limits for oceanic sharks, and for mako sharks in particular, is the role that high seas Marine Protected Areas (MPAs) could play in helping to conserve oceanic sharks.

No-take marine reserves currently cover only a few per cent of the ocean's surface. However, in the last few years, some very extensive no-take MPAs have been designated around oceanic islands, for example in the British Overseas Territory of Pitcairn Island in the Pacific Ocean. MPAs of this size are those most likely to encompass a significant proportion of the space used by oceanic sharks, effectively protecting them for the period they remain within the MPA. Key to appropriate designation of MPAs will be knowing where oceanic shark hotspots are located and the timings and duration of movements to and from the area.

Our research has identified two shark hotspots in the North Atlantic called Mako Metropolis and Blue Shark Central, both of which have recently been designated as Hope Spots (see Box 4). As part of our ongoing work we are launching the Shark Hotspots Ocean Challenge (SHOC), to double the number of oceanic shark hotspots found in the Atlantic within three years. It is hoped that by understanding more about the odysseys of oceanic sharks there will be a greater chance of sustaining their populations. After all, managing populations effectively will be difficult if we don't know where they are and how and when they move between exploited areas.

Prof David Sims (dws@mba.ac.uk)
MBA Director of Research, MBA Senior Research Fellow, and Professor of Marine Ecology at the University of Southampton.

Further reading

N. Queiroz *et al*. (2016) Ocean-wide tracking of pelagic sharks reveals extent of overlap with fishing vessel hotspots. *Proc. Natl. Acad. Sci. USA* 113: 1582-1587.

Box 4. Shark Hotspots Ocean Challenge (SHOC)

Working with Mission Blue's Hope Spots programme, we are launching the SHOC project to discover new oceanic hotspots in the Atlantic Ocean (www.mission-blue.org/hope-spots/).

We are raising funds to purchase new satellite tags that we'll deploy on sharks in areas with strong ocean thermal fronts. To learn more visit www.mba.ac.uk/simslab

There might be giants, but why?

John Spicer investigates this much-debated question.

Giants are fascinating. Whether it's an imaginary giant spider like Shelob in Tolkein's *Lord of the Rings*, the mythical Nephilim of the Old Testament, or the very real giant squid, these oversize creatures grab our attention. The fact that they are not always imaginary or mythical may terrify, but it also makes them interesting.

Gigantism turns up in many groups of organisms but the interesting question is, why? As Oscar Wilde famously wrote, 'the truth is rarely pure and never simple', and it is unlikely that there is a one-size-fits-all explanation when it comes to answering this question.

'the truth is rarely pure and never simple'

Some of the first Antarctic explorers commented on how many of the marine animals they encountered seemed able to achieve such large body sizes. They brought back stories and specimens of giant aquatic woodlice and giant sea spiders. Numerous explanations of 'polar gigantism' were put forward but two have long pervaded popular and scientific thought. The first is that because the continent had been isolated from the rest of the world for so long, an estimated 34 million years, much of the marine life—around 50% of the species—is endemic; that is, distinctive and restricted to that region, and had followed its own undisturbed evolutionary course. The second explanation has to do with the fact that Antarctic waters are very cold and so litre for litre are able to hold more dissolved oxygen than temperate or tropical waters, and that high oxygen availability and low temperatures were somehow linked to gigantism. The neat thing about both ideas is that it is possible to construct scientific hypotheses to test them, and in the case of the latter, hypotheses that can be tested experimentally.

In 1999 Guy Chapelle and Lloyd Peck published a fascinating study in one of the top science journals, *Nature*, which related the maximum body size of amphipod crustaceans—'little' shrimp-like creatures related to the beach hoppers commonly found in and around strandlines at the top of the shore—to the oxygen content of the water the particular species inhabit. In this study Chapelle and Peck put forward the 'oxygen hypothesis', which stated that the 'maximum potential size [of aquatic animals] is limited by oxygen availability'. If correct, this would explain why there is, at least the possibility of more giants in Antarctic waters compared with temperate and tropical regions. Since then the oxygen hypothesis has received a lot of attention, and considerable support from subsequent work on the amphipods in particular. But its beauty (yes, I think you can have a beautiful hypothesis—although its beauty doesn't make it any more right!) lies in the fact that there are experimentally testable predictions that arise from the hypothesis. For instance, if oxygen is limiting then larger individuals or species should perform less well under conditions of reduced oxygen (hypoxia) than smaller individuals/species.

And this prediction has been tested. About 10 years ago Lloyd Peck and colleagues from the British Antarctic Survey (BAS) found that large Antarctic clams weren't as good at burying themselves as smaller clams

Two of the Antarctic amphipod species we studied showing the difference in body sizes typical of this region. © J. I. Spicer.

Collecting amphipods in the intertidal zone. © S.D. Morley.

if the environmental oxygen was low, upholding the prediction and thus providing support for the oxygen hypothesis. However, around the same time Art Woods and colleagues found that the ability of sea spiders of different body sizes to right themselves if they were turned over onto their backs was overall poorer under conditions of reduced oxygen but there was no consistent difference between large and small species. This finding did not provide support for the oxygen hypothesis although Art, being the careful experimental biologist he is, did explore and discuss some reasons why he was not totally convinced that their experiments could be used to unequivocally reject the hypothesis. What *is* clear is that the overall picture is still not clear. There is still a need for empirical tests of the oxygen hypothesis, in particular on groups like the amphipods, which are extremely common in the Antarctic, show comparatively little body diversity, and have contributed so much to establishing the pattern of large body size being related to the oxygen content of the water.

And it was with the intention of testing the oxygen hypothesis that I spent two months of the austral summer, early in 2017, working in the Antarctic. The British Antarctic Survey (BAS) run three research stations on the continent, the largest of which is Rothera, the centre of BAS field and air operations in Antarctica. The station, which houses around 20 people over the dark winter period when temperatures can plummet to minus 30°C, and over 100 in the austral summer when air temperature can get up to 5°C, is situated on Adelaide Island, part of the western Antarctic Peninsula. Rothera is 869 nautical miles, or about four to five hours' flying time, from Punta Arenas in Chile, a small city near the southernmost tip of South America. The station is nestled in, and dwarfed by, an area of outstanding but austere beauty. The surrounding sea is littered with icebergs of every shape and size, peppered with penguins and seals, all against a backdrop of serious mountains sporting massive glaciers in abundance. That first sight of the Antarctic Peninsula from the plane and the descent into Rothera was crystal clear, and overwhelming.

I had come to work with Dr Simon Morley, a biologist with BAS. We share a common interest in investigating how marine animals 'work where they live' and how those workings will be affected by local and global environmental change. When I arrived I found him mopping the floor in one of the accommodation buildings on base—everyone mucks in here, no matter who you are.

Before engaging in any research, there is a thorough training programme obligatory for all new arrivals, ranging from how to use communications on and off base, through to observing safety measures and practical ways of preventing pollution and reducing energy use. You are issued with appropriate outdoor and working clothes (that you tried on back in Cambridge, UK, during the Antarctic Predeployment Training and First Aid course), allocated a bunk in a shared accommodation block (appropriately named 'Giants'!), given a detailed tour of the station, and

Simon and the dive team set off to collect amphipods from the sea bottom in Ryder Bay, adjacent to Rothera Station. © J. I. Spicer.

The British Antarctic Base at Rothera as seen from a research vessel in Ryder Bay. © J. I. Spicer.

expected to undertake any specialized training you may require. Only then are you ready to start work.

As mentioned above, one of the main aims Simon and I shared was to test the oxygen hypothesis. Within the small tidal range and in just 6 m of water very close to the Station it was possible to collect amphipod species whose adult length varied from up to 10 cm right down to just a few millimetres. We predicted that if oxygen was a major factor determining maximum body size then the larger species would not perform as well compared with smaller species as we reduced the oxygen in their environment. So that's what we set about doing, testing the ability of about five species of different body sizes to maintain their rate of oxygen consumption, as a measure of their metabolism, as the external oxygen decreased. Working at around 0°C this was no trivial or quick task.

A 'typical' work day for Simon and me consisted of breakfast at 7.30 am, meeting the boat and dive team, and at 8.30 am, weather permitting, going into the field to collect specimens. Alternatively, we would head to the lab to carry out experiments. We would take an hour for lunch, then return to the lab. Another hour for an evening meal and once more to the lab. We would try and fit in a walk (about 40 minutes) round the peninsula on which Rothera is situated, for exercise but also to take in the incredible beauty of the thick ice and snow cover disappearing sometimes perceptibly, sometimes imperceptibly, day by day. The sun—which didn't set until about 6 weeks after we arrived—cast shadows and spread its amazingly diverse light on the surrounding mountains, glaciers and islands. Out to sea were shifting scenes of seemingly sculpted icebergs wandering and toppling, and different seal species swimming nearby or resting on ice floes.

The excitement of formulating and then testing ideas and theories when you do research belies the sheer hard work, perseverance and time required to test those ideas. It's not all zooming around in ribs, watching humpback whales feed, and experiencing nature at its most amazing and pristine … but it is sometimes. While I do believe in eureka moments in science, much of the time you are busy collecting data, and for good and legitimate reasons, rarely find out what you've discovered until sometime afterwards—particularly if you are working somewhere as remote and difficult to get to as Antarctica, and want to make the most of your trip. So what did we find? All I'll promise is that you'll know when I know… watch this space.

Professor John Spicer
(J.I.Spicer@plymouth.ac.uk)

This work was funded by a Natural Environmental Research Council CASS award.

Can a new project remove LIONFISH from the Mediterranean?

By Demetris Kletou, Periklis Kleitou and Jason Hall-Spencer.

Adult lionfish *Pterois miles* photographed at Cape Greco, Cyprus at 10 m depth. © MER Lab.

Biological pollution is one of the major threats to global biodiversity and it can profoundly disrupt ecosystem function. Marine invasive species are particularly difficult to control due to a lack of barriers to their spread. One of the most ecologically harmful marine invasions to date is the rapidly expanding population of non-native lionfish (*Pterois* sp.) in the western Atlantic. These fish have had marked ecological impacts throughout the Caribbean and in some areas lionfish increases have coincided with significant regional declines in the biomass of native fish species.

Lionfish are highly fecund; they mature within a year and then spawn every four days, year-round. They can produce two million buoyant eggs per year and these develop into pelagic larvae that disperse widely on currents. The adults have anti-predatory venomous defences and an ability to prey upon a wide range of fish and invertebrates, a combination that makes lionfish rapacious invaders. The lionfish problem got out of control off Florida and in the Caribbean due to a slow management response in developing and implementing an eradication plan.

A lionfish invasion is now underway in Europe

A lionfish invasion is now underway in Europe. Two decades after their first appearance in the Mediterranean, a specimen was caught off Lebanon in 2012 and in just four years, lionfish became established around Cyprus, Greece, Lebanon and Turkey.

Only two specimens were caught in Cyprus in 2013, by trammel-net fishermen. In 2014 and 2015, there were many more verified reports and now lionfish are commonly seen by fishermen and divers around Cyprus. In 2016, eleven lionfish were seen on a single dive at Cavo Greco, an EU Natura 2000 Marine Protected Area. Our research team collected two juveniles (around 2 – 3 cm) from this area; the first confirmed evidence that lionfish are reproducing in the Mediterranean. The lionfish population around Cyprus forms the largest known reproductive population in the Mediterranean and poses a serious ecological threat that has raised public calls for immediate action.

Clearly, current environmental conditions are now suitable for lionfish reproduction off Cyprus. Continued warming of the Mediterranean basin increases the risk of a speedy invasion; single adult fish seen off Italy and Tunisia in 2017 confirm they are spreading westwards. To stand any chance of controlling this invasion the competent authorities and relevant stakeholders must work together to combat the problem at this early stage. Although it may already be impossible to eradicate the lionfish from the Mediterranean, it is feasible that its impact on priority habitats and biodiversity hotspots can be minimized.

However, no concrete actions are yet in place to deal with the lionfish invasion. Some view it as an attraction that will boost dive tourism and many spearfishers avoid lionfish as they do not know how to safely handle this venomous fish. Yet there is hope. An EU LIFE Nature and Biodiversity project, RELIONMED aiming to REmove LIONfish from the MEDiterranean, started in September 2017. The project includes the University of Cyprus and the University of Plymouth, as well as the private sector (Marine & Environmental Research Lab Ltd), a local NGO (Enalia Physis) and the Department of Fisheries and

Juvenile lionfish photographed at Cape Greco, Cyprus, and right: the same individual for scale. © MER Lab.

Marine Research of Cyprus. RELIONMED aims to set up a line of defence against the lionfish invasion by demonstrating early detection, rapid response and effective management of marine coastal habitats off Cyprus.

The four-year project plans to enlist citizen scientist and stakeholder participation in surveys that increase awareness, and motivate, train and equip divers and fishermen to participate in removals. We will assemble and equip teams to demonstrate how to remove lionfish from Marine Protected Areas and from areas where they aggregate and breed. We will also explore the market potential of lionfish products to help sustain removal efforts. The project will also develop tools and guides for managers in neighbouring countries also affected by the lionfish invasion.

As we will be learning on the job, we will need help to design and promote effective ways in which to mitigate the impacts of this lionfish invasion. Only by working together is there a chance of protecting diverse Mediterranean coastal systems, and the fisheries they support, from this invasive predator.

Demetris Kletou[1,2] (dkletou@merresearch.com), Periklis Kleitou[1] (pkleitou@merresearch.com) and Jason Hall-Spencer[2,3] (jason.hall-spencer@plymouth.ac.uk)

1. Marine & Environmental Research Lab Ltd, Cyprus
2. University of Plymouth, UK
3. University of Tsukuba, Japan

Preventing a lionfish invasion in the Mediterranean through early response and targeted removal (LIFE16 NAT/CY/000832). With the contribution of the LIFE financial instrument of the European Union / www.ec.europa.eu/life

Further reading

Ballew N. G., Bacheler N. M., Kellison G. T., and Schueller A. M. (2016). Invasive lionfish reduce native fish abundance on a regional scale. *Scientific Reports*, 6.

Hixon M. A., Green S. J., Albins M. A., Akins J. L., and Morris Jr J.A. (2016). Lionfish: a major marine invasion. *Marine Ecology Progress Series*, 558: 161-165.

Kletou D., Hall-Spencer J.M., Kleitou P. (2016). A lionfish (*Pterois miles*) invasion has begun in the Mediterranean Sea. *Marine Biodiversity Records* 9:46.

Saving the Solent, one oyster at a time

By **Luke Helmer** with **Joanne Preston**, **Simon Harding** and **Morven Robertson**.

Coastal and estuarine environments have been subject to anthropogenic pressures for thousands of years. However, since the industrialization of fishing in the late 19th century, many of the habitats and species present in these exploited environments are at a very real risk of collapse. Considered alongside other detrimental impacts such as poor water quality from sources including sewage treatment plants and agricultural runoff, the outlook can appear bleak.

Finding solutions

Restoration of native oyster populations and habitats is one of the potential solutions being explored not only to improve water quality and enhance biodiversity, but also to provide jobs and income for local communities in the long term. Already well established in the US, native oyster restoration is gaining momentum in other parts of the world due to the similarity in the problems experienced by many species of oyster.

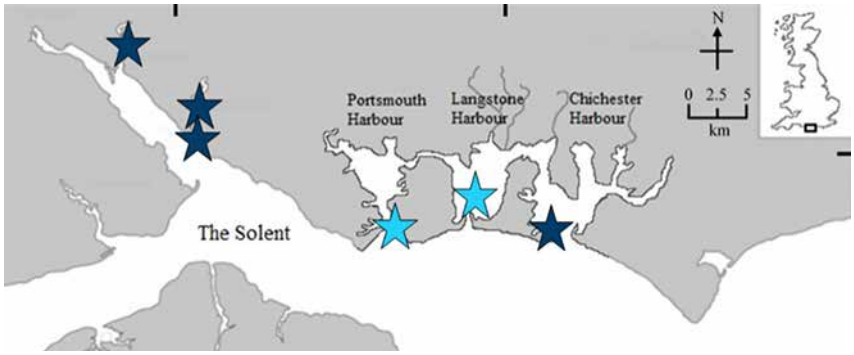


Figure 1. Solent experiment locations for the pilot study (light blue) and expanded study (light blue + dark blue). © Luke Helmer.

The Solent Oyster Restoration Project—one of many restoration efforts that have sprung up across Europe—began in 2014 with the intention of restoring the European flat oyster (*Ostrea edulis*) populations in the area that separates the Isle of Wight from mainland England (see Fig 1).

Once supporting the largest oyster fishery in Europe, the Solent's oyster population is currently in a very poor state. A chronic reduction in the population, followed by an acute decline in landings from 200 to 20 tonnes over a five-year period (2007 to 2012), led the Southern Inshore Fisheries and Conservation Authority (Southern IFCA) to close the fishery in 2013. The IFCA approached the Blue Marine Foundation (BLUE), a UK-based marine conservation charity, to help address the issues surrounding the collapsing fishery. BLUE conducted a feasibility study and developed a management plan, whilst also setting up a stakeholder working

group which included researchers from the University of Portsmouth (UoP), in association with the Southern IFCA, BLUE, Land Rover Ben Ainslie Racing (BAR) and MDL Marinas. My involvement in the project began when I conducted an initial pilot study for the stakeholder working group in 2015/16 as part of my Masters research.

The pilot study was to test the viability and efficacy of suspended broodstock cages to increase larval supply to the remaining natural oyster populations. Cages containing mature broodstock oysters were suspended from an existing pontoon and from UoP's research raft. The results obtained confirmed that successful reproduction and larval release from caged oysters could occur within the surface waters. However, the results also indicated that issues such as nutrient-driven phytoplankton blooms may be having detrimental effects on oyster survival and health within Langstone Harbour.

Project expansion

The success of the pilot study led to my PhD studentship, joint-funded by the UoP and BLUE, to further develop the research around broodstock cages. The cage system was improved and put into four additional MDL marinas across the Solent, between Southampton Water and Chichester Harbour (Fig 1). The new cage system incorporates sets of 'micro-reefs' (Fig 2), designed by Tony Legg of Jersey Seafarms, that allows the stacking of oysters within cages that are then suspended below pontoons. Not only does this system allow for easy access to the cages but it also drastically reduces monitoring costs associated with boat use and diving work. The exciting thing about this design is that it can be easily adapted and trialled for any bivalve species. *Ostrea edulis* are surviving and thriving with the total monthly survival remaining at 95% for the first four months!

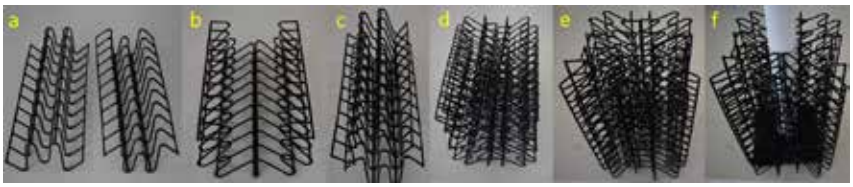


Figure 2. Micro-reef assembly with (a) individual units hog-ringed together to enclose one side (b) and then to allow one side to be opened slightly (c). Four of these combined units are then hog-ringed together (d) and (e), leaving a central section which can be placed onto PVC tubing as additional support (f) as these are then stacked three high. © Luke Helmer.

Assessing the state of Solent oyster populations

As part of my PhD studies, I am compiling baseline information regarding the current state of the exploited oyster populations within Portsmouth, Chichester and Langstone Harbours. This includes the size class distributions, and molecular analysis of oysters to determine infection prevalence of *Bonamia ostreae*, an intrahaemocytic protozoan parasite that can cause mass mortality in *O. edulis* populations. Low prevalence of *B. ostreae* was recorded for both Chichester and Langstone Harbour sample populations, whilst the parasite was absent from the Portsmouth sample population.

Surveys to determine the current densities of *O. edulis* and the invasive American slipper limpet *Crepidula fornicata* within these harbours are also underway. Preliminary results show that oyster densities are extremely low within Langstone Harbour and that the area is dominated by *C. fornicata*.

Using celebrities to our advantage

This larger scale cage system expansion gained the attention of UoP alumnus, TV broadcaster and conservationist Ben Fogle (Fig 3), who offered his services during a press launch for the project's cage system. The media attention achieved from the launch has proven extremely beneficial in raising awareness with the wider public and sponsors, some of whom own vessels in the marinas and have become very interested in the work being conducted. In the future the project aims to expand the cage system to new audiences including the residents around the Solent who would adopt and look after their own populations of oysters to further increase larval supply.

Figure 3. Ben Fogle at Port Hamble marina alongside the University of Portsmouth's Marine Biology course leader Dr Joanne Preston (Black buoyancy aid, far right), Solent Oyster Restoration Project PhD student Luke Helmer (Black buoyancy aid, centre), supervised by Dr Preston, and UoP student volunteers (Blue and red buoyancy aids). Image: MDL Marinas. © Luke Helmer.

Multiple problems, multiple solutions

The cage system is the first of many techniques being trialled in this restoration effort, with the University of Southampton also conducting studies on the seabed. The importance of having enough suitable habitat for juvenile oysters to settle upon was realised when representatives of the Solent project joined an international study tour of restoration sites in the US. The success of this work owes much to the use of protected areas where either old oyster shells or spat (juvenile oysters) on shell, from hatchery production, are placed. Given the precarious state of natural stocks of the European flat oyster, the development of successful hatcheries across Europe is likely to be an important step towards large-scale, meaningful restoration.

Luke Helmer[1] (luke.helmer@port.ac.uk) Postgraduate Research Student

Dr Joanne Preston[1] (joanne.preston@port.ac.uk) Principle Lecturer and Course Leader, Marine Biology BSc

Dr Simon Harding[2], (simon@bluemarinefoundation.com) Head of Conservation

Morven Robertson[2] (morven@bluemarinefoundation.com) UK Projects Officer

1. The University of Portsmouth's Institute of Marine Sciences.

2. The Blue Marine Foundation

The MBA takes on the MARS Challenge

In 1992 the United Nations Conference on Environment and Development, Rio de Janeiro, Brazil, put biodiversity firmly on the political agenda, a move welcomed by the scientific community who saw biodiversity research as an urgent priority. The marine science community in particular understood that the interconnected nature of the marine environment required a coordinated approach to biodiversity research. This need for better collaboration was a key driver for the establishment in 1996 of the European Network of Marine Research Institutes and Stations (MARS).

The idea of marine biologists working together as a community was not new; Anton Dohrn, founder and first director of the Stazione Zoologica in Naples in 1872, coined the term marine 'stations' as analogous to train stations in the sense that he saw marine stations existing as part of a connected network, not just 'ploughing their own furrow' in splendid isolation. MARS was therefore mainly a mechanism to formalise this arrangement in Europe, and for over 20 years it has allowed directors of marine stations to come together to discuss everything from the European research funding landscape and collaboration on biodiversity monitoring to forging international links and supporting the movement of students between institutes.

When approached about taking over as President of MARS, I immediately felt this was something that fitted well with the broader ethos of the MBA in working collaboratively with marine biologists everywhere; the MBA has a history of involvement in pan-national collaborative projects such as the EMBRC, and our members are spread across the world. As one of the older marine research institutions the MBA understands the truly key role marine stations play in giving voice to ocean issues, and the marine community needs to work together if we are going to prevent them falling victim to an uncertain economic climate (see the article by Mike Thorndyke and Fiona McGowan in the Spring 2014 issue of *The Marine Biologist*).

I am therefore excited and honoured to be leading MARS into its next chapter. The focus will be on developing the international element of MARS in concert with IOC-UNESCO on moving forward with the World Association of Marine Stations (WAMS). Links with UNESCO and other governance and policy bodies will be strengthened to ensure the marine community maintains a strong policy relevance. MARS will also continue to do what is has done for over two decades by providing a forum for marine science leaders to come together to identify and address key challenges for the marine biological community.

If you would like further details on how to become part of MARS then please contact Dr Matt Frost or Pim Van Avesaath at the MARS secretariat: secretariat@marinestations.org

Matt Frost (matfr@mba.ac.uk)

www.marinestations.org

Apps track tiny algae with huge impacts

Red tides caused by *Karenia brevis* algae naturally and periodically occur along the Gulf of Mexico coastline. They can kill fish and cause respiratory irritation among people on shore, as shown in this picture from a Florida Gulf Coast beach. © Conor Goulding/Mote Marine Laboratory.

Scientists at Mote Marine Laboratory in Florida are enlisting citizen scientists with the goal of real-time reporting and forecasting of harmful algal blooms on the Florida coast. By **Hayley Rutger**.

Virtually anyone with a smartphone can give scientists and society a helping hand—whether you're logging birds in your backyard, traffic on your commute, ocean debris or invasive species.

Now the smartphone application (app) spotlight has even turned to phytoplankton—tiny plant-like organisms that produce oxygen, support the ocean's food web and, in some species, produce toxins and other harmful impacts that range from annoying to dangerous. For example, the Secchi app encourages seafaring users to make and use a simple water-clarity measuring device, the Secchi disk, and report their findings and notes to scientists at the UK's Plymouth University, who are trying to create better estimates of phytoplankton abundance at sea.

smartphone apps have been developed to boost monitoring and forecasting of a microscopic menace

More recently, smartphone apps have been developed to boost monitoring and forecasting of a microscopic menace—*Karenia brevis*. This red tide-causing phytoplankton produces neurotoxins and, in elevated concentrations, can cause fish kills, close shellfish beds, make human beachgoers cough and sneeze, lead to millions of dollars in economic losses and send people with chronic respiratory diseases to emergency rooms along the Gulf of Mexico coast.

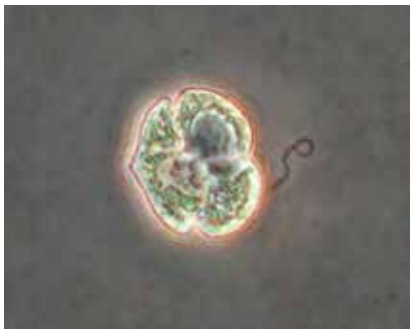
Over the past decade, scientists and resource managers have significantly advanced *K. brevis* data collection and forecasting. Florida's Fish and Wildlife Conservation Commission's Research Institute (FWRI) provides twice-weekly reports on red tide, based on cell counts from water samples which take days to complete. Trained volunteers in Mote Marine Laboratory's Beach Conditions Reporting System provide daily, qualitative information about beach conditions, but the system does not cover every Gulf Coast beach. Texas Red Tide Rangers are volunteers who gather and test water samples during red tide blooms, but they do not cover the entire Texas coast. The National Oceanic and Atmospheric Administration's (NOAA) Harmful Algal Bloom Operational Forecast System (HAB-OFS) issues red tide advisories, covering county-wide areas, but they aren't detailed enough to provide information on impacts on specific beaches.

Now scientists are looking toward smartphone apps to help fill the gaps.

Got red tide? Get CSIC

In early summer 2017, Mote Marine Laboratory—an independent, nonprofit marine science institution based in Sarasota, Florida—released a new app for the public to self-report impacts of Florida red tide algae: the Citizen Science Information Collaboration (CSIC). This free app allows users to report when and where they experience respiratory irritation or see discoloured water or dead fish—all potential indications of Florida red tide. (Search for CSIC in the App Store or on Google Play.)

Users with iOS and Android phones report water discoloration by choosing among several sample pictures, and they follow brief captions to consistently report dead fish and respiratory irritation—or lack thereof. Reports



The single-celled, microscopic algae species *Karenia brevis* causes harmful impacts when it forms elevated concentrations, or blooms, in the Gulf of Mexico. © Mote Marine Laboratory.

display for eight hours on CSIC's map. Over time, Mote scientists hope to enhance the app with a system to validate the data and reward reliable users.

'We're doing this to obtain new data streams while empowering the public by putting the reporting in their hands,' said Dr Tracy Fanara, manager of Mote's Environmental Health Program, who worked with Dr Vincent Lovko, manager of Mote's Phytoplankton Ecology Program, and web development contractors at Function on Phones to create the app.

The concept for the app was informed by a project completed by a former Mote intern and through discussion with collaborators from the Harmful Algal Bloom (HAB) group at the FWRI.

Smartphone meets microscope

During fall 2016 into winter 2017, red tide bloomed along the south-west Florida Gulf coast. While locals and visitors checked reports in order to find beaches that were clear of dead fish and

Aerial view showing a bloom of *Karenia brevis* algae along south-west Florida's Gulf of Mexico coast in the U.S. © Manatee Research Program/Mote Marine Laboratory.

respiratory irritation, scientists began working to improve public health and safety information. NOAA scientist Dr Richard Stumpf has been leading a team of researchers developing an app that will fine-tune Florida red tide models and forecasts, thanks to a three-year, $1.1 million grant from NASA.

'Our forecast abilities have come a long way since the early 2000s,' said Stumpf, Oceanographer with the NOAA National Centers for Coastal Ocean Science. 'When we initially created our forecast models, our goal was to help aquaculture officials know when to close shellfish harvesting areas to protect the public from neurotoxic shellfish poisoning, which is caused by eating seafood containing red tide toxins. But later research showed that the airborne toxins are not only a nuisance, but also a human health risk. So we knew we needed to protect the public from that risk as well. Today, our forecasts provide information about where red tides are and where they're going on a county level. But red tide blooms are patchy and the effects can vary greatly from beach to beach—even when the beaches are right next door to each other. By bringing in new technology, this project will get us much closer to the goal of a forecast for every beach, every day.'

The new system, called HABscope, is being developed by NOAA and the Gulf of Mexico Coastal Ocean Observing System (GCOOS). HABscope combines a new smartphone app with a low-cost microscope adapted to work with a smartphone. The app, being developed by Robert Currier, GCOOS Research Specialist and Product Developer, is designed to allow trained beach observers with specially adapted smartphone microscopes to collect videos of water samples that can be uploaded to a cloud-based server for automated evaluation. The server will use TensorFlow, Google's open-source deep-learning library, to identify *K. brevis* red tide algae in water samples taken right on the beach. This system will then provide a real-time response on the presence or absence of *K. brevis*,

A new system called HABscope, involving a microscope, smartphone app and special software to detect the harmful algae *Karenia brevis*, is being developed through a multi-partner project led by the U.S. National Oceanic and Atmospheric Administration to provide better public information about harmful algal blooms, or red tides, along the Gulf of Mexico coastline. © Conor Goulding/Mote Marine Laboratory.

estimated cell counts and information about whether its quantities warrant a health concern. Results and improved forecasts will be available to government and research institutions focused on public health and natural resources, with the ultimate goal of enhancing public information through NOAA's HAB-OFS and Mote's Beach Conditions Reporting System.

'With this new app, we can improve red tide forecasting from an 18-to-30-mile coverage area down to the beach level,' said GCOOS Executive Director, Dr Barbara Kirkpatrick, who developed the Beach Conditions Reporting System when she was Manager of Mote's Environmental Health Program. 'The new app-based forecasts will also rely on cell counts rather than subjective observations, and be provided in real-time, instead of the hours-to-days-long approach some

of our forecasts are limited by now.'

NOAA and Mote have been field testing the smartphone-microscope-app system since November 2016 with help from four Mote volunteers who were trained to collect small water samples, place them onto a microscope slide, take videos with a smartphone attached to the microscope, and upload those videos to GCOOS to be automatically assessed for red tide algae cells. They reported about 500 times, giving project partners useful data for fine-tuning the software.

'It was beneficial to train our volunteers and have them sample water during the red tide bloom, because we were working with concentrations of *Karenia brevis* that scientists encounter during our regular monitoring efforts, and the public was encountering in real time,' said Fanara. She and her staff are responsible for training volunteers. 'We went through the process of training volunteers and learning how to optimize our training system by finding the most effective ways to help people learn how to homogenize a sample, place the sample on the slide and focus the microscope just right to get an acceptable video the algorithm could use. The volunteer network is one key to dependable data collection.'

Project partners plan to increase volunteer training this year and expand the program to Texas, where Master Naturalist/Red Tide Rangers currently monitor some beaches for red tide.

Volunteer-gathered data will be uploaded to the GCOOS data portal, which provides real-time and near-real-time information on a variety of Gulf environmental conditions. 'More data, over longer periods, means that we will be gaining a more precise picture of how red tides move in the Gulf of Mexico,' Stumpf said. 'In addition to providing better forecasts right now, we can also improve the accuracy of our forecast models.'

Hayley Rutger (hrutger@mote.org)
Content Development Manager Mote Marine Laboratory and Aquarium
https://mote.org

On Aristotle's observations of fish reproduction

By Kostas Ganias and Eleni Voultsiadou.

The year is 348 BC. Aristotle is teaching the young Alexander about the fascinating world of fishes. He leans down to pass on some incredible science facts:

"There is a fish called rhinobatos [the guitarfish] which has the tail of rhine [the angelshark] and the head of batos [the ray] which originates from the interbreeding of these two fishes."

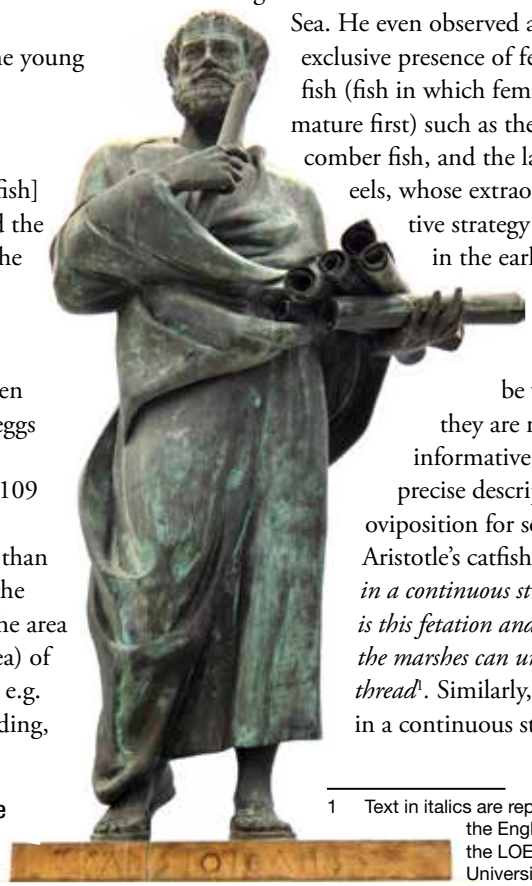
"Did you know that the eel comes from the guts of the Earth?"

"Another strange fish called the pipefish, when spawning time comes, bursts asunder and the eggs emerge."

In his biological corpus, Aristotle identified 109 individual species of fish, and examined and described the reproductive life history of more than 40 species. Most of these descriptions refer to the timing (duration, seasonality, frequency) and the area (habitat type, bathymetric zone, geographic area) of breeding as well as to their reproductive mode, e.g. oviparity vs. viviparity, benthic vs. pelagic breeding, and so forth. Even if these descriptions are mostly brief and general, Aristotle's survey is impressively comparative showing his profound knowledge of fish life history.

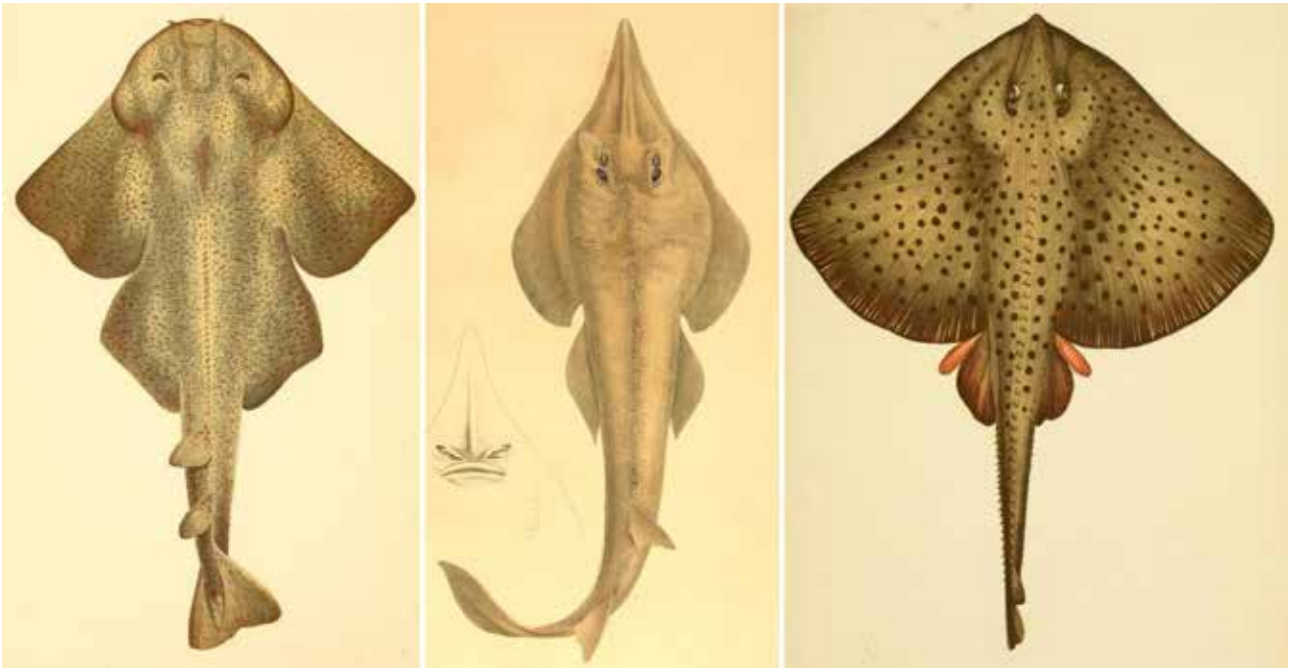
For certain fishes with exceptional breeding patterns, Aristotle proceeded to more detailed descriptions such as the courtship and the parental care of the pipefish, the mating behaviour of stingrays and other rays and the reproductive migrations of scombrids from the Aegean to the Black Sea. He even observed and tried to explain the exclusive presence of females in protogynous fish (fish in which female reproductive organs mature first) such as the red-pandora and the comber fish, and the lack of sexually mature eels, whose extraordinary reproductive strategy was only understood in the early 20th century.

Aristotle's descriptions of fish reproduction might sometimes be vague but for some species they are rather accurate and informative. For instance, he gives a precise description of the process of oviposition for some freshwater fish like Aristotle's catfish which: *deposits its spawn in a continuous string, as frogs do; so twisted is this fetation and so even that fishermen in the marshes can unwind it off the reeds like thread*[1]. Similarly, the perch deposits its eggs in a continuous string and: *spawns at*



Bronze statue of Aristotle by the modern artist George Tsaras, located at the campus of the Aristotle University in Thessaloniki, Greece. © Eleni Voultsiadou.

1 Text in italics are representative excerpts from the English translation of Aristotle by the LOEB classical Library, Harvard University.



Aristotle describes the rhinobatos (the guitarfish; middle) as having the tail of a rhine (angelshark; left) and the head of a batos (the ray; right). He suggested that rhinobatos originated from the interbreeding of these two fishes. Pictures from *A history of the fishes of the British Islands* By Jonathan Couch, Groombridge and Sons, 1862.

stagnant pads left behind by river floods and near the reedy parts of marshes. But even more astounding are descriptions for marine pelagic spawners like the bonito which spawn at the Black Sea. Their eggs are called *afxides* (from *afxanō* meaning to grow) because they grow in just a few days; their young leave the Black Sea and enter the Aegean together with *thynnides* (the young tunnies) and swim back again in spring, when they are fully grown bonitos. For some fishes his descriptions must have been based on direct observation, for example the sand smelt whose: *reproduction takes place close to the land and spawns by rubbing its belly against the sand*.

It appears that Aristotle was particularly fascinated by the reproduction of cartilaginous fish, calling them *selachia* in his works. Aristotle distinguishes the selachians from the other fish because they are *zootoka* (viviparous), they have cartilaginous skeletons and uncovered gills. He knew that fish with scales (*Lepidotoi*, Actinopterygii) are oviparous, producing more offspring than the selachians, and that there is a natural decrease in the number of offspring in favour of their size. In all the selachians, the female is larger than the male, while the same is true for most other fishes. His most detailed descriptions are of the hypotremata (*platei*), whom he describes as *wide-bodied fish that have their gills on the ventral surface*. For the skates and rays he says that they *copulate not only lying side by side but also by the mounting of the male upon the female, underside to rear side*. The angel shark, however, *and other such fishes which have a large tail copulate only by rubbing together their under-sides*. Aristotle describes the mermaid's purse—the casing that surrounds the fertilized eggs of many sharks and skates—*as a shell-like object, in which an egg-like fluid appears whose shape is similar to the tongues of an 'aulos'*[2] *and which has hair-like passages attached to its edges*. When the ray has laid the egg and the shell has broken open, then the young emerges.

Aristotle was a highly intuitive person with a strong passion for observing and explaining anything related to the living world. However, scientific understanding was much less developed in his day and this is why one finds several misinterpretations about fish in his zoological works. Some of these trivial facts, such as the spontaneous generation of eels, recounted above, would have fascinated not only children but everyone for many centuries before being refuted by scientific facts. No, selachians do not have breasts but they do have nidamental (shell) glands which are involved in the secretion of their compact and protective egg capsule. And no, the young of the spiny dogfish do not return to the belly of their mother. Yes, Aristotle's descriptions are often vague, non-specific and maybe naïve to the eyes of smug scientists. Nonetheless, 2,400 years ago this intellectual giant made an immense contribution to the human understanding of nature, and his zoological corpus—in which the fishes feature significantly—offers an invaluable insight into the roots of modern biological knowledge.

Kostas Ganias (kganias@bio.auth.gr) and Eleni Voultsiadou (elvoults@bio.auth.gr) Department of Zoology, School of Biology, Aristotle University, 54124 Thessaloniki, Greece

Further reading

Ganias, K., Mezarli, C. and Voultsiadou, E. (in press) Aristotle as an ichthyologist: Exploring Aegean fish diversity 2,400 years ago. *Fish and Fisheries.*

2 an ancient Greek wind instrument.

Hong Kong reveals underwater riches

Figure 1. A few of the nearly 6,000 species in the marine waters of Hong Kong. Image © HKU/SWIMS.

Marine scientists are racing against time to study and catalogue the region's marine biodiversity so that it can be protected. By **Terence P. T. Ng** and **Gray A. Williams**.

An extensive review covering more than 650 literature sources has shown that Hong Kong is not just an urban paradise for tourists but also for marine life. A recent study published in *Biodiversity and Conservation* highlights Hong Kong's location within the fringes of the world's marine biodiversity hotspot—the Western Indo-Pacific. This small but heavily populated city, with only 1,651 km^2 of marine waters, has a record of 5,943 marine species, which is equivalent to around 26% of the total marine species recorded in China, and is comparable to the Baltic Sea (Fig 2). Hong Kong also hosts more hard corals than the whole Caribbean Sea, and has more mangrove tree species than the whole of East Africa.

Hong Kong hosts more hard corals than the whole Caribbean Sea

Hong Kong lies at the edge of the tropics, and the mixing of three ocean currents (the Taiwan, Kuroshio and Hainan currents) and the influence of the seasonal monsoons favour the survival of both tropical and temperate marine species. These geographic and climatic features, together with other factors such as the influence of its complex geology, proximity to the Pearl River (China's second largest river system by volume), relatively long coastline (around 1,189 km) and diverse marine ecological habitats (Fig 3), all contribute to shape the remarkably diverse marine life in Hong Kong.

Threats and conservation

Hong Kong is one of the world's busiest harbours, and its marine environment has been historically degraded by anthropogenic activities such as coastal reclamation, dredging, dumping, overfishing and pollution. The natural terrain of Hong Kong is incredibly hilly with a scarcity of buildable land, and hence over 35% of its developed land area has been reclaimed from the sea, and more is anticipated to cope with Hong Kong's growing population. Meanwhile, southern China is also undergoing rapid development so that the threats to Hong Kong's marine life are both local and regional; and global impacts such as climate change and ocean acidification add to these problems. It is unknown to what extent all these threats have already reduced the overall species richness of Hong Kong, but this recent survey suggests there is still a wealth of biodiversity worthy of protection.

On the other hand, the present wealth of marine life in Hong Kong has yet to receive an appropriate level of conservation as, currently, only around 2% of Hong Kong's marine area is protected as marine parks or reserves. Encouragingly, the Hong Kong SAR Government implemented a territory-wide trawl ban in Hong Kong waters

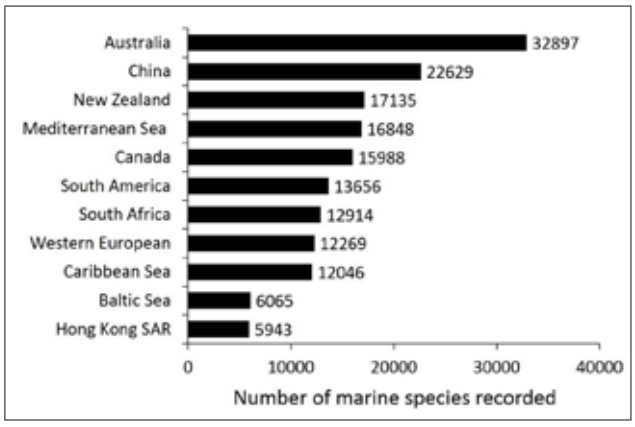


Figure 2. A comparison of the number of marine species between Hong Kong and other regions (Archambault *et al.* 2010; Butler *et al.* 2010; Coll *et al.* 2010; Gordon *et al.* 2010; Griffiths *et al.* 2010; Miloslavich *et al.* 2010; Narayanaswamy *et al.* 2010; Ojaveer *et al.* 2010; Miloslavich *et al.* 2011; Liu 2013).

Figure 3. Examples of the diverse ecological habitats in Hong Kong. © Prof Gray A. Williams, Dr Calton Law, Dr Cynthia Yau.

in December 2012 to help protect its marine resources and ecosystem. The Government has also committed to designate more marine parks in the coming years under the framework of the city's Biodiversity Strategy Action Plan established to achieve the goals of the Convention on Biological Diversity. Given the historic and current impacts on Hong Kong's marine environment, the city can be considered a 'crystal ball' of what many of the world's coastal cities will become. As such, it is likely that the lessons we learn in Hong Kong can be used as an example to illustrate how Government, NGOs and marine scientists can help predict, mitigate and manage the health of coastal marine ecosystems in a sustainable manner.

Keeping track of marine biodiversity

Hong Kong is a 'world city' but, unlike Singapore and many western countries, it lacks a central repository for its catalogue of marine species, such as a natural history museum that collates, manages, analyses and makes accessible data of local species. It is, therefore, difficult to confirm the validity of past records or keep track of the status of Hong Kong's marine resources. To better inventory the marine species recorded in Hong Kong, a regional node of the global marine biodiversity database, the World Register of Marine Species (WoRMS), has been launched (see Hong Kong Register of Marine Species: www.marinespecies.org/hkrms/) and an editorial team consisting of local experts has been established to curate and maintain the database.

The next step is to develop a marine biodiversity centre, which can act as a central repository for storing specimens and host a marine geographical information system (GIS) for long-term tracking of changes in marine biodiversity and abundance, and this is a central goal of The University of Hong Kong's Swire Institute of Marine Science (SWIMS), in its ongoing three-year expansion. Recently SWIMS has won several large-scale projects to investigate marine biodiversity in different ecological habitats or areas in Hong Kong; it is anticipated that these studies will generate up-to-date information to help assess the status and long-term patterns of Hong Kong's marine biodiversity.

SWIMS also aims to contribute towards the conservation of marine biodiversity in Southeast Asia, a region that hosts the world's most diverse marine life and habitats but which is also being rapidly impacted by human activities. Together with its regional collaborators in Southeast Asia, SWIMS plans to play a major role in trying to measure and conserve the important marine resources in the region. A recent opinion piece from the international conference BECoME 2015, hosted in Hong Kong, warned that this is a race against time and this new evidence of the rich biodiversity found in Hong Kong highlights the importance of acting quickly to conserve the riches we still have.

Terence Ng (puntung.ng@gmail.com)

Further reading

Ng, Terence P. T. *et al.* (2017) Hong Kong's rich marine biodiversity: the unseen wealth of South China's megalopolis. *Biodiversity and Conservation* 26(1), 23–36.

The research team (from left: Dr Terence Ng, Prof Gray Williams and Martin Cheng) displaying some Hong Kong marine species in front of SWIMS. © HKU.

Symbiosis on the seashore

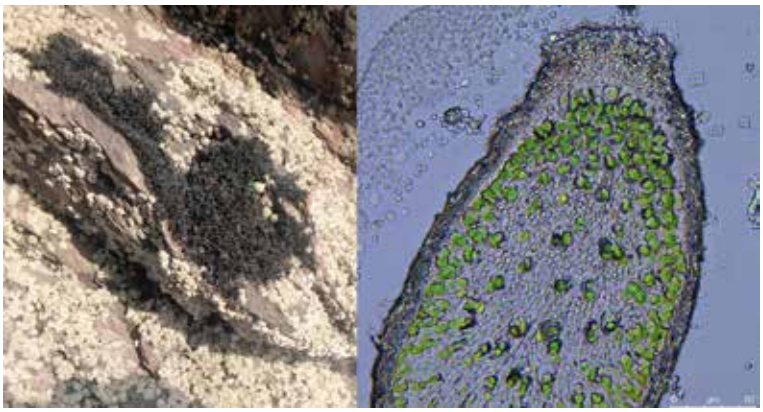
A very brief history of research at the Marine Biological Association on the marine lichen *Lichina pygmaea*. By **Michael Cunliffe.**

It all started with a conversation sometime in the 1920s between Gladys L. Naylor (a botanist who worked at University College London) and J. H. Orton who worked at the MBA between 1910 and 1929, later becoming the Derby Chair of Zoology at the University of Liverpool. Orton had observed the marine lichen *Lichina pygmaea* (see Figure) on the North Cornwall coast in South West England and suggested to Naylor that it might be interesting to determine their distribution around Plymouth. The inspired Naylor subsequently surveyed the distribution of *L. pygmaea* and the closely related *L. confinis* from the River Yealm, across Plymouth Sound and to Whitsand Bay. Based on the distribution patterns, Naylor made preliminary ecological inferences about why *L. pygmaea* was present at some locations and not in others, highlighting that the lichen was most abundant on steeply inclined rock faces in exposed positions.

Shortly after Naylor's survey, John S. Colman was also working at the MBA as a student-probationer (he later became the Director of the Port Erin Marine Station on the Isle of Man). At the MBA, Colman focused his attention on the distribution of multiple flora and fauna, including *L. pygmaea*, across four transects on Church Reef at Wembury. The surveys showed that different species occur at specific positions on the shore, with *L. pygmaea* abundant just below the high water level on exposed rock with barnacles. Conversely, the kelp *Laminaria digitata* is found in the lower intertidal and sublittoral fringe. Gerald Boalch and colleagues repeated Colman's survey at Wembury in the early 1970s, showing that the distribution of some species had changed since the 1930s, suggesting that increased visitor numbers at the site could be impacting the ecology of the reef.

Alan J. Southward worked at the MBA for more than 50 years, with many achievements including pioneering the use of marine ecosystem time-series and being a world-leading expert in barnacles. Using his own distribution data, including on *L. pygmaea*, and data collected by Naylor, Colman and others, Southward determined a mechanistic understanding of the ecological factors, such as tide height and wave exposure, controlling the zonation of organisms on rocky shores, which are now established 'text-book' paradigms.

The study of *L. pygmaea* is ongoing at the MBA. Its distribution around the UK continues to be mapped by the MBA MarClim® project, which is the most spatio-temporally extensive time-series for rocky intertidal organisms globally.



***Lichina pygmaea* co-occurring with barnacles on the wave exposed rocky shore at Wembury near Plymouth, and cross-section of *Lichina pygmaea* thallus showing green endosymbiont cyanobacteria. © Michael Cunliffe / MBA.**

We are also applying molecular ecology tools to characterize and understand the diversity and distribution of the microbial components of the *L. pygmaea* symbiosis (see Box on Lichen Symbiosis). The lichen appears to be a promising novel marine model for future microbial ecology studies.

Michael Cunliffe (micnli@mba.ac.uk) Marine Biological Association & School of Biological and Marine Sciences, Plymouth University

Lichen Symbiosis

Lichens are a close and long-term biological interaction between different organisms. The fungus host produces the physical structure of the lichen (thallus), providing an enclosed environment for photosynthetic microalgae (cyanobacteria or microbial eukaryotes) (Figure). The microalgae produce organic compounds using sunlight energy that sustain the fungus. Non-photosynthetic bacteria also form part of the lichen symbiosis and have important ecological roles that include provision of nitrogen-containing compounds and host defence.

Further reading

Naylor, G. (1930) Note on the Distribution of *Lichina confinis* and L. pygmaea in the Plymouth District. *Journal of the Marine Biological Association of the United Kingdom*, 16 (3), 909-918.

Colman, J. (1933) The Nature of the Intertidal Zonation of Plants and Animals. *Journal of the Marine Biological Association of the United Kingdom*, 18(2), 435-476.

Southward, A. J. (1958) The Zonation of Plants and Animals on Rocky Sea Shores. *Biological Reviews*, 33 (2), 137-177.

Boalch, G., Holme, N., Jephson, N. and Sidwell, J. (1974) A Resurvey of Colman's Intertidal Traverses at Wembury, South Devon. *Journal of the Marine Biological Association of the United Kingdom*, 54(3), 551-553.

Mieszkowska, N., Sugden, H., Firth, L. B. and Hawkins, S. J. (2014) The role of sustained observations in tracking impacts of environmental change on marine biodiversity and ecosystems. *Philosophical Transactions of the Royal Society A*, 372: 20130339.

Hollingsworth, A. L. (2016) The microbiome of the marine lichen *Lichina pygmaea*. Masters Research (MRes) Marine Biology Thesis, University of Plymouth/Marine Biological Association.

eDNA: a 'forensic' approach for detecting biodiversity and unravelling ocean complexity

eDNA promises to provide cheaper, more accurate assessments of biodiversity. **Kelvin Boot** looks at two projects that explore the potential of this powerful tool in the marine environment.

As we continue to encroach upon the remaining 'wild' areas of our planet, evidence of the presence of rare and endangered species is a prerequisite for the implementation of conservation measures and management actions designed to ensure their survival in the future. But what about those creatures that are seldom seen and provide little or no evidence of population numbers or even whether they exist in an area at all; and what about those organisms we do not even know of yet? Trekking through the wilds in search of clues or setting camera traps works for some animals and plants but it's the evolving technique of analysing environmental DNA (eDNA) which may provide insights into what is, or at least has recently been, present in an area. The implementation of this powerful tool owes much to the great strides that have taken place in molecular biology which enable the smallest of samples to be collected, filtered and sequenced to provide evidence of an organism's presence within an environment; in a forensic sense, the 'fingerprints' left behind.

Traces of organisms can be extracted from samples of seawater and the DNA analysed to identify the species present. Left and bottom: © Kelvin Boot, top: © Martin Genner.

This DNA technology has been applied on land from sampled animal droppings, which has helped identify species thought to be extinct, has given clues to population diversity, and has found new species. The technique of analysing eDNA is not restricted to samples from animal waste, however. In one analysis eDNA from the guts of blow flies showed the presence of 11 mammal species in a Malaysian forest. In the aquatic environment the presence of a rare, cave-dwelling salamander has been detected in Slovenian and Croatian caves without it being seen. The technique is now established in freshwater systems for determining fish and invertebrate species' presence, but something of a 'Holy Grail' has been applying it in seawater.

Two Natural Environment Research Council (NERC)-funded projects are working in parallel to develop eDNA techniques to bring about a step change in the way we sample and monitor our marine environment.

Fishing for eDNA

Martin Genner of Bristol University is leading 'SeaDNA', which is concentrating on fish: 'The big question is, how can we accurately survey for the presence or absence of fish species and get an idea of the abundance of marine life in an area? Traditionally we have used cores, grabs, nets, hook and line, and filtering to obtain whole organisms; the problem is that these are very specific, just pinpricks, and taking a research vessel to sea is expensive so we could never get ideal coverage.' Building on techniques developed for use in fresh water, Genner and his colleagues hope to get a much broader idea, more cheaply and more accurately than from the current sampling methods. 'Fish swimming through an area will leave traces: skin, scales dropping, eggs for example. The cells in these remains all contain the tell-tail fingerprints, which point to particular species being or having recently been in the vicinity.' An essential ingredient of this technique is to have a library of known DNA 'signatures' for comparison. As Genner points out: 'We have pretty good coverage for many of the commoner species in UK waters but there are gaps. At the moment there are a number of databases, none of which are comprehensive, and often they have used different methods, so they are not always comparable'. The next phases of the research will continue with sampling in the Antarctic, in UK estuaries and at the long-established L4 monitoring site off the Devon coast in the Western English Channel. The aim is to further build the reference database and help to clarify how many eDNA samples are needed to accurately represent the fish fauna of a study site. So far, results are very encouraging and Genner is confident that it will not

be long before an analysis of fish in an area can be turned around while still at sea. This almost real-time data could become a valuable tool in species monitoring, conservation area assessments and fisheries management, and once the techniques are refined, could be done autonomously.

Seeking free DNA

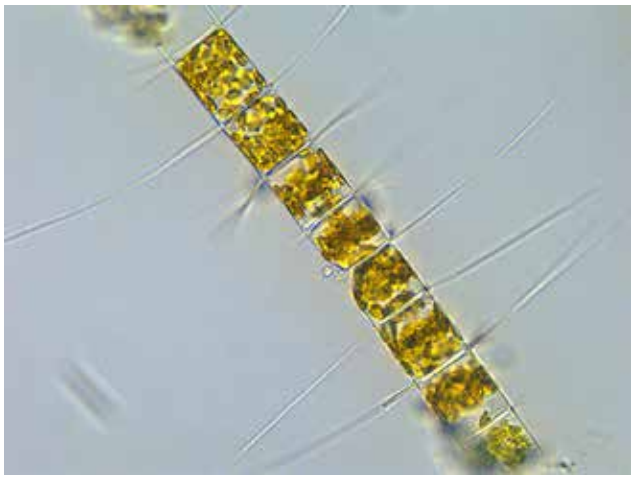
DNA packaged up in cells derived from fish or the myriad other organisms in the sea is only one source of eDNA. At the other end of the size scale is the so-called dissolved DNA, that which has been released from cells or viruses to float free in the water column.

Prof Willie Wilson of the Sir Alister Hardy Foundation for Ocean Science, who leads MARINe-DNA, likens these DNA traces to fossils in the sea: 'But unlike fossils in rock that can last for millions of years, our challenge is to work out how long the eDNA 'fossil record' lasts and how relevant it is as representative of the full spectrum of what has been there.' The two projects might be looking at different ends of the size spectrum of marine life but there will be room to compare results, as Wilson says: 'we'll be able to ground truth each other's results, especially at the L4 site where both will be sampling from the same location.

Of course, the sea is not static and DNA might have been brought in from outside of the area. So, an extra dimension will be added through marine environmental modelling of currents and tides, enabling the researchers to identify the origin in time and space of the body of water being sampled, which in turn may help to 'age' the DNA being collected. SeaDNA is conducting experiments to determine how long DNA can last outside of a fish, to give an idea of its longevity in the wild ocean. By working together, the two approaches will clarify this crucial piece of information.

an analysis of fish in an area can be turned around while still at sea

Wilson is convinced that by looking at free or dissolved eDNA in the water column there is another level of understanding to be gained about how the ocean functions: 'When you have free DNA in the water column, you have potential for genetic transfer into other cells and we know nothing about that, except that it has to be one of the drivers of biodiversity. How that DNA survives in the water column, is there a bias in the DNA that survives, how long does it last and can it be responsible for gene transfer, and how does that fit with viral DNA which we do know is actively transferring genes?' These are fascinating questions that are at the basis of understanding marine systems. The aim of both projects is to move towards real-time monitoring; MARINe-DNA partners at NOC Southampton are developing a 'lab-on-a-chip', that is small and durable enough to be used on marine platforms such as the Continuous Plankton Recorder (CPR). Such a technology would be of huge interest to management bodies like the UK's Defra, and Wilson expects to see that in general operation in less than a decade.



The diatom *Chaetoceros* spp., the dominant alga in the spring phytoplankton bloom of the Western English Channel. © MBA.

Near real-time analysis

Having this ability could give an almost instant indicator of the health of the area being sampled, but also could act as an early warning for such things as harmful algal blooms (HABs), which might impact fisheries, aquaculture and human health. Such a facility would also prove of immense value in picking up those indicator organisms of climate and other environmental changes that are likely to be missed by traditional sampling. Even without precise identification to species level the data is still useful and connections to ocean functions or phenomena can still be made; a particular group of 'unknowns' might always occur prior to a HAB, for example.

Bringing results together

The Marine Biological Association (MBA) is contributing to both SeaDNA and MARINe-DNA projects, and so is in a unique position to ensure the projects complement each other. A key role is in the collection of reference specimens (particularly fish) for DNA comparison in building the DNA databases; in MARINe-DNA MBA researchers are developing advanced molecular techniques that will aid the identification of the genetic material that is being collected. MBA Research Fellow Dr Michael Cunliffe is confident these techniques are the future for ecological surveys: 'The technology is here and we are devising new ways to apply it, refining techniques and building our experience. It will not be long before we will be able to take a seawater sample, filter it for DNA and make accurate assessments of what is or has recently passed through an area of sea. This should greatly improve our ability to monitor environments, and our understanding and ability to manage areas for conservation or fisheries could be greatly improved; it's very exciting.'

Kelvin Boot (kelvinboot@yahoo.co.uk)

Further reading

SeaDNA: https://goo.gl/Ufbfoo
MARINe-DNA: https://goo.gl/PWoU3U

Could studying marine biology at Hull be a gateway to your future?

Our series of articles on degree courses in marine biology aims to help you choose the right course in the right place. In this edition the spotlight turns to Hull in East Yorkshire, England. By **Sue Hull**.

The modern marine biologist is a multidisciplinarian; challenged by the need to conserve and manage marine resources effectively against a background of constant environmental change, both in space and time. He or she has to be able to identify and quantify marine organisms, describe habitats from the tropics to the poles and be competent at using a range of survey and data analysis techniques to assess and quantify marine biodiversity. But nowadays you need additional knowledge and skills up your sleeve too —knowledge of how the physical and chemical nature of the environment changes in space and time, an appreciation of social science, and of the legal and management frameworks involved in sustainably managing marine resources from a local to global scale. And having identified, quantified and described the marine organisms, you have to then make sense of the data using relevant analysis and presentation skills and place this data in context to inform management and the decision-making process. It's a lot to learn, but there are people out there happy to help you do it.

The North Sea, with its range of readily accessible natural environments and regional management challenges, forms the ideal backdrop for our degrees within the School of Environmental Sciences, making the University of Hull an ideal place to study marine biology. With access to internationally recognised research facilities—including the world's only submarium in The Deep—studying at Hull opens a range of opportunities to gain rich, hands-on experience as you learn. Well-known for its traditional candy floss and donkey ride seaside towns, wild coastal landscapes, seabird colonies and the occasional bungalow falling into the sea, the Yorkshire coast provides an ideal natural laboratory readily accessible from the campus. Between the major estuaries of the Tees and Humber, you can find a patchwork of unspoilt rocky shores and sandy beaches, conservation areas of international importance and major fishing grounds and sites for alternative energy generation, all easily reached from the School of Environmental Sciences.

Students exploring the shore. Fieldwork is a major part of a marine biology degree at Hull. © Sue Hull.

The study of our marine heritage—so evident in the city of Hull—continues the legacy of one of the University of Hull's longest-running areas of internationally renowned expertise, dating back to the early days of the institution. It also looks forward to the future of the institution by being closely aligned with the Energy and Environment research theme and the new Marine, Maritime and Blue Economy research institute.

There is a broad range of expertise and research interests within the School of Environmental Sciences, ranging from ecosystem function and dynamics, earth sciences and geography, sediment dynamics and flood management, conservation and fisheries biology to physiology, toxicology, zoology, social science and marine management. By linking all this knowledge and understanding of the subject alongside professional practice through the Institute of Estuarine and Coastal Studies, students gain a holistic, detailed and integrated understanding of current issues in the marine environment. We have close links with conservation bodies, fisheries organisations and local industry and we take into account the needs of employers when designing our degrees and developing core employability skills in our students.

Those studying marine biology in Hull certainly need waterproof clothing, wellies and a love of the outdoors, as fieldwork is a major part of what we do; we believe the hands-on approach not only helps students learn, but provides key skills for future employment.

The field and laboratory skills are

Dawn over the Yorkshire coast. © Sue Hull.

ideal preparation for scientific careers with organisations such as the Fisheries Agencies, and an understanding of marine management and environmental impact assessment may help towards a career in consultancy. Conservation biologists and education officers also require a multidisciplinary framework in order to undertake their roles, and obtaining diving qualifications may guide people towards scientific diving or dive instructor careers. Hull is one of the few universities to subsidise PADI and European Scientific Diver training as well as residential and overseas field trips.

Like many other universities offering degrees in marine sciences, Hull seems to be at the edge of nowhere, at the end of the M62 bordering the Humber estuary. However, the Humber gateway reflects the international nature of the city itself and the links it has with Europe and the rest of the world. Hull is a charismatic, lively, friendly city and the University mirrors this in its approach to educating the students who choose it as a destination. The teaching and friendly nature of the campus has often been referred to as 'one of the best kept secrets in higher education' and it is currently ranked second in a recent Department of Education report on employability (Department of statistics, 2015).

Walking to the shore. © Sue Hull.

The sea is no respecter of national and international boundaries and we have to think outside our local and regional areas in order to effectively manage and conserve our marine resources. In the School of Environmental Sciences we are passionate about passing on our skills and knowledge; we hope our graduates emerge from our degrees with that multi-disciplinary thinking and open-minded approach to their future careers and become valuable additions to the marine community.

Dr Sue Hull (S.Hull@hull.ac.uk)
School of Environmental Sciences, University of Hull, Hull, HU6 7RX

The National Marine Biological Library

Emily Miles and Barbara Bultmann describe developments at one of the largest marine reference libraries in the world.

The National Marine Biological Library (NMBL), based at the Marine Biological Association (MBA) in Plymouth, UK, supports marine biology and provides plentiful opportunities for outreach. A recent, large-scale programme has taken place at the NMBL to develop both the physical space and electronic resources. There are now a variety of inspiring spaces where visitors can read, learn, and work. In addition, digital resources have been developed, enhancing our online offerings to be enjoyed by our readers abroad, as well as by our more local stakeholders.

The Southward Reading Room, just one example of improvements to the physical space in the National Marine Biological Library. © MBA.

Public engagement

Library staff have initiated a number of outreach opportunities: for example, the next generation of marine biologists have been learning about the important role the NMBL plays in the life of a marine scientist through regular school visits and library-based activities. These visits are now an established feature of the MBA's British Science Week programme, with themes including communication techniques and the history of the MBA. The NMBL will be opening its doors to the public in 2018 as part of the Plymouth History Festival to share the MBA's heritage with a wider audience. Public engagement is also achieved by supplying material to other institutes and events: the Royal Albert Memorial Museum in Exeter, UK, exhibited two very rare books from the NMBL's special collection as part of the 'Sea Life: Glimpses of the Wonderful' exhibition in summer 2017. Furthermore, work is underway to make the MBA's institutional archive image collection more accessible to members and the wider public, although this depends on securing the necessary funding.

Physical spaces

A new, open-plan reception area now welcomes all library visitors. A generous legacy from Professor Alan Southward helped fund the new Southward Reading Room, which was officially opened in 2016 in the presence of the Lord Mayor of Plymouth and the Windsor Herald, who unveiled the MBA's new coat of arms. Funding from the Wolfson Foundation enabled the creation of the Wolfson Training Room, a state-of-the-art training and conference facility within the library. Following a condition survey, the rare books collection has been moved to a location that better meets its preservation requirements. The MBA Object Collection is now proudly on display, thanks to the help of numerous volunteers, and support from Arts Council England's PRISM Fund.

Global visibility

The electronic library resources have been rapidly developing since the library's catalogue was made widely available online in 2014. The NMBL's provision of a tailored service to its large constituent research community is highly regarded and has to be dynamic to keep pace with the changing needs of its modern user base. Library staff have been prominently involved in promoting best practice in Open Access issues and will, from 2018 onwards, be taking a leading role in systematically sharing the MBA's research output via its dedicated open-access repository, PlyMSEA. A new website will be launched shortly, making navigation and access to our resources even easier! The website will include our new online bookshop, selling duplicates and other titles of marine interest. The NMBL is also keen to work with international partners, and in 2016, organised and hosted the *DIGIMAR Future Course for Europe's*

Marine Libraries conference, which was well attended by national and European marine library representatives. This conference laid the foundations for a co-ordinated approach to digital marine library development.

Future development

There are numerous projects in the pipeline, such as the urgently needed restoration and conservation of selected rare books. Proposals are being developed to digitize selected books and archival data holdings, and to datamine from library collections; all highly skilled activities requiring funding. We are always looking for new and innovative ways of making our wonderful collection available for members located far and wide, so we will be fundraising to support these activities and others; any income from our Adopt-a-book initiative, second-hand bookshop or private donations will contribute.

If you would like to learn more or make a donation, please get in touch. The NMBL hopes to welcome you online or in the library soon!

Emily Miles (emimil@mba.ac.uk) and Barbara Bultmann (barbue@mba.ac.uk)

Schoolchildren enjoying the library during British Science Week. © MBA.

And the winners were ...

MBA student bursary awardees report on how the grants have helped them develop their careers.

The MBA 2017 Postgraduate Conference

This year's MBA Postgraduate conference was held in Cornwall, UK. **Sara Mynott** was on the organizing committee.

This year's postgraduate conference was held at the University of Exeter's Penryn Campus. With delegates from across the UK and Europe it was certainly a vibrant meeting.

We saw a great variety of postgraduate presentations from coastal ecology to fisheries and environmental change, and all were spectacularly delivered. Wiebke Schmidt, one of our judges, highlighted that 'the quality of the presentations was impressive throughout and the friendly atmosphere created by the organisers and students ensured a great exchange of ideas'. Tim Gordon took home the prize for best oral presentation, contrasting the sounds of a healthy reef with those of one in trouble. I was lucky enough to be awarded best poster for my work on shore crab (*Carcinus maenas*) camouflage.

Workshops on grant writing and marine policy were a conference first whilst a number of side events added to the experience. Thanks to the help of many guest speakers, delegates were able to take home tips on how to put together great grant proposals and find funding in unusual places. Our policy panel answered a fleet of questions about how postgraduates can inform marine policy, and showed how research is used to inform policy on a local and national level.

The conference finished on a high with two fantastic field trips. Ben Holt, Chair of Capturing Our Coast, took delegates to Gyllingvase beach to experience some of the best rockpooling in the country. Offshore, a second group joined AK Wildlife Cruises in search of sea creatures and the calm, cloudy conditions couldn't have been better, as described below.

Thanks to all our presenters for making the meeting such a wonderful experience and to our sponsors for making it all possible. We're looking forward to seeing everyone at MBA 2018!

Sara Mynott (s.mynott@exeter.ac.uk)

When applying for funding to attend a conference, one always highlights the importance of networking, but sparking up a conversation with a stranger is often easier promised than done. Not so at the MBA Postgraduate Conference. Perhaps it was the knowledge that everyone around you is your peer, or perhaps it was the Cornish sunshine streaming in through the windows, but I've never found it easier to talk to other conference attendees.

Beyond friendliness, the quality of talks was exceptional, with a broad range of topics never leaving room for boredom. The first keynote by Professor Brendan Godley set the tone for the conference: welcoming and funny, fascinating and inspiring. The keynotes that followed were all equally valuable and engaging. What stood out to me, however, were the student talks, as polished and intensive as any I've seen at larger conferences. The size of the conference, with a large range of expertise but small enough to fit into one room, allowed for a sense of communal, friendly engagement. Though I gave the last talk of the conference, I still had an attentive audience and plenty of questions.

In addition to the size, the structure of the conference (including frequent breaks!) allowed all of us to

feel comfortable with one another, increasing the utility of the workshops by facilitating our conversations during them. I'm sure this sense of community was also helped by the socials, though some of us may have been a little worse for wear after the conference dinner and festivities. Lastly, though this wasn't under the control of the organisers, our wildlife cruise was simply exceptional. Perfect conditions meant we saw a plethora of common dolphins, a couple of harbour porpoises, puffins, and even a minke whale.

I am beyond grateful to the MBA for the travel bursary that allowed

Delegates at the MBA Postgraduate Conference enjoy marine life in Cornwall, UK. © Billy Heaney.

me to attend and to the organising committee for such a great experience. Despite almost 12-hour trips to Penryn and back, I returned feeling invigorated and inspired, with new friends (or should I say professional contacts?), feeling ready to tackle the next three and a half years of my PhD.

Sophia Wassermann (s.wassermann1@nuigalway.ie)

46th Benthic Ecology Meeting, South Carolina USA

During the final year of my PhD, I had the chance to travel to the USA for the first time, to attend the Benthic Ecology Meeting in South Carolina. Luckily, this meeting is attended by friendly people, which made me less nervous about giving a talk for the first time at an international conference. I am relieved to say that my talk went rather well: I presented my research, which focuses on the impacts of climate change

Anaëlle Lemasson visits saltmarshes of the North Inlet-Winyah Bay National Estuarine Research Reserve. © Anaëlle Lemasson.

on oysters, including some results currently under review for publication. This was a great opportunity to promote and publicize my work, while getting some constructive feedback from the audience.

During the conference, I learned a lot about the ecology and functioning of a diverse range of habitats, and about survey designs and experimental techniques. The variety of ecological talks was impressive: from rocky shores to saltmarshes, mudflats, and of course, oyster reefs! It was apparent from the prevalence of talks and posters on the topic that oysters are a highly valued species there, and my research therefore fitted nicely with the conference programme. This led me to meet a lot of my fellow oyster-researchers, from PhD students to more accomplished scientists, and to discuss oyster reef restoration, their ecosystem service provisions, and how to tackle the many threats they are facing.

Finally, I was lucky enough to take part in a field trip to the Baruch Marine Laboratory and the North Inlet-Winyah Bay National Estuarine Research Reserve, where I got a first-hand experience of their beautiful saltmarshes.

Without the generous contribution from the MBA, I would surely have missed out on this memorable experience.

Anaëlle Lemasson (anaelle.lemasson@plymouth.ac.uk)

YMB
YOUNG MARINE BIOLOGIST

The number of under-18s joining the MBA has grown rapidly. In light of the enthusiastic participation and exciting plans, **Eliane Bastos** brings us a Young Marine Biologist update.

Launched in 2014, our Young Marine Biologist (YMB) membership has grown organically to 300+ under 18s. Membership comes with great benefits and represents the MBA's dedication to working as a catalyst for life-long engagement with our ocean.

Nurturing aspirations

As a YMB member, it is more than likely that you want to become a marine biologist and we are here to play a part in your exciting journey. Membership gives you access to courses: Stephen Cheung (17) of Lincoln, visited the MBA last November to take part in the Rocky Shore Species Identification course. He said, 'it was a great experience and has made me so excited to study [marine biology] at University next year!' Members are actively encouraged to participate in the exclusive Bulletin Blog. We have had great contributions from young marine enthusiasts like Jordan Havell (15), Katie Harris (10) and Henry Follett (10).

You receive an MBA pin badge when you contribute to the Blog! © MBA.

Moving forward

YMB has come a long way since 2014. We have been inspired and encouraged by your positive feedback as echoed by Dr Colin

YMB Katie Harris (age 10), told us of her summer adventures. © Katie Harris.

Munn, former Admissions Tutor for Undergraduate Marine Biology Courses at Plymouth University who said, "I read hundreds of personal statements from applicants every year. I've been really impressed in the past couple of years to notice how many applicants mention the MBA magazine as a source of inspiration [and how articles] fuelled their interest in different aspects of the subject and put them on the path to pursuing a degree in marine biology."

Our ambition is to go further and the YMB Summit 2017—an event exclusive to 12 to 18-year-old members consisting of talks and workshops delivered by experts and YMB members themselves, opportunities to meet scientists and other young marine biologists, and a careers Q&A session—reflects this commitment to continue nurturing your passion and enthusiasm for marine biology and help you take the first steps towards career development. Don't worry if you couldn't participate in 2017; our aim is to make this an annual event at different locations to meet as many of you as possible.

YMB Jordan Havell (age 15), shared with us his interesting finds. © Jordan Havell.

YMB Summit 2017

Over the coming year, we will be increasing our presence on social media, and expanding the benefit of free entry to aquaria and other venues (YMB members currently enjoy free entry to the National Marine Aquarium, Plymouth). Remember, this is your membership and we welcome your feedback and suggestions to make it exciting for you. To get in touch, email ymb@mba.ac.uk

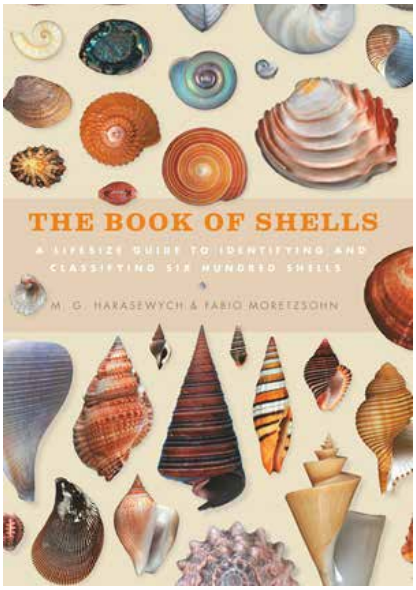
Eliane Bastos
(elibas@mba.ac.uk)

MBA academic publishing

The MBA publishes scientific journals in support of its charitable aims.
If you would like to publish original research or reviews in the MBA's journals,
please contact the editor:
Journal of the Marine Biological Association: Professor Christopher L. J. Frid c.frid@griffith.edu.au
Marine Biodiversity Records: Nova Mieszkowska nova@mba.ac.uk

Reviews

The Book of Shells: a lifesize guide to identifying and classifying six hundred shells.



Authors: M.G. Harasewych and Fabio Moretzsohn
ISBN: 9781782403562
Format: Hardback, 656 pages
Published by: Ivy Press

The Smithsonian Institution houses one of the world's largest collections of mollusc shells and it is from this resource that *The Book of Shells* is derived. As curator of invertebrate zoology, the co-author, Jerry Harasewych, studied, catalogued and photographed much of this collection, selecting 600 species for inclusion in this book.

Originally published in 2010, this 2017 edition has a subtly different layout and minor changes to the text, illustrations and species content. However, what has not been revised is the classification (pp. 646-649), which has not kept pace with the many changes that have taken place, particularly within the Gastropoda; the use of *Littorina littoralis* on page 277 (now considered to comprise two species, *L. fabalis* and *L. obtusata*) shows that this taxonomic confusion extends beyond the family level. This is unfortunate as the authors have made an effort, in the information that they provide for each species, to raise this book above the level of a 'coffee-table' book for shell collectors, many of which already crowd the shelves of bookshops world-wide.

A typical page for each species comprises a table providing family name, size range, distribution, abundance, depth, habitat and feeding habit. A global distribution map is also present. Each species is illustrated by a small line drawing and two photographs, one of which depicts the actual size of the shell; the photographs are superb. A short 'biography' is provided for each species, while a more comprehensive description is sufficient to aid identification; attention is also drawn to related species of similar appearance, though these are not illustrated. A range of gastropod and bivalve shell shapes are illustrated on pages 24 – 25 so that readers may locate specimens of interest within the book—this is not a key in the strictest sense, but, as the book title suggests, a guide directing readers to the appropriate families having this shell form.

The selection of species clearly targets the larger, more photogenic shells that might appeal to collectors and there are few examples of small-shelled species. Possibly reflecting the bias of shell-collectors, the Smithsonian being no exception, the geographical coverage favours more tropical and sub-tropical regions, with north-west European waters being poorly represented.

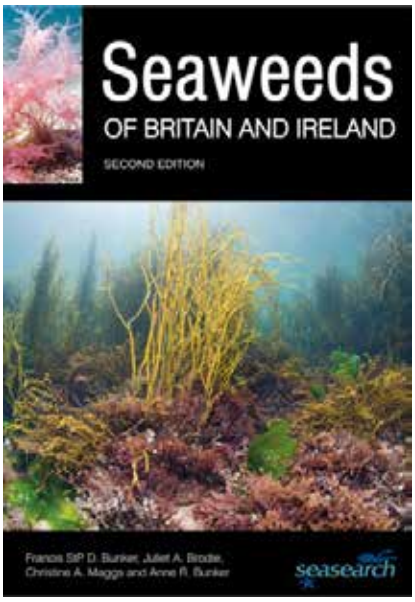
In all a very attractive book that should appeal to shell collectors.

Geoff Wigham
(geoff.wigham@plymouth.ac.uk)

Seaweeds of Britain and Ireland – second edition

Authors: Francis StP. D. Bunker, Juliet A. Brodie, Christine A. Maggs and Anne R. Bunker
ISBN: 9780995567337
Format: Paperback, 312 pages
Published by: Wild Nature Press

It is sometimes easy to forget the wealth of diversity and beauty of the 'smaller stuff' when it comes to seaweed, a problem more than remedied by this guide.



Over the course of my PhD I have been lucky enough to have had the opportunity, albeit at times a particularly head-scratchingly challenging one, to get to grips with a host of red algae from all around the UK. To stand a chance at identifying the samples set before me, I used the best resource I could get my hands on, which turned out to be the first edition of this guide. As a relative beginner in algae identification, it helped me to know where to start. The second edition expands on the first, and is better for it. Featuring 238 species, including the majority of the macroscopic green, brown and red algal species found both intertidally and sub-tidally around the UK, it is a truly valuable resource, either for those familiar with seaweeds, or for those starting to look seriously at seaweed identification.

A comprehensive introduction contains sections on seaweed names, a note on seaweed distributions, a great section on common seaweed habitats, and an all-important glossary to help you get your head around some of the more complex terminologies. The bulk of the book is made up of an easy-to-use identification key, which sorts seaweeds into broad morphological groups before getting down to the nitty gritty.

With beautiful colour photographs throughout, this is a great guide for all who love seaweeds, or for those who just enjoy being out on the shore.

Harry Teagle (hartea@mba.ac.uk)

In the Company of Seahorses

Authors: Steve Trewhella and Julie Hatcher
ISBN: 9780995567320
Format: Hardback, 240 pages
Published by: Wild Nature Press

In the Company of Seahorses is not a book of fiction, but a beautiful and scientific contribution to the marine conservation of the British Isles. The title will attract the attention of even those with a fringe interest in marine biology.

Whilst not a scientific documentation of the coastal marine fauna and flora of southern England, the book nevertheless adds to the evidence that the British Isles still harbour marine life as stunning as that around the coral reefs of the Indo-Australian-Pacific. Highlights for me are the photographs of Bargibant's pygmy seahorse with its coral-like red and white camouflage, the magnificent two-spot goby, and even the common prawn with its 'sparkling eyes'.

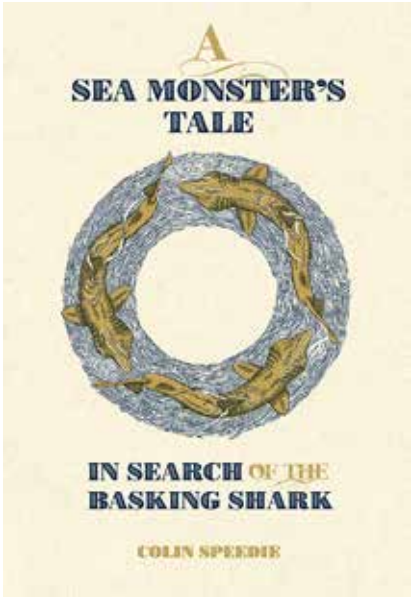
Each photograph is accompanied by informative text, often with a personal message, for example, 'The patterns on an Undulate Ray, outlined with rows of white dots, are reminiscent of Aboriginal art.'

The main text contains 60 pages devoted to detailed descriptions of seahorses and their habitats. The section 'In the company of seahorses' is devoted to other marine life, in particular pipefish, sticklebacks, rays, flatfish, gobies, wrasses, other fishes, crustaceans, bristle worms, cnidarians, molluscs, echinoderms and even wildfowl. There is a short glossary and the index is adequate and informative.

In the Company of Seahorses will be a must-have for marine conservationists and will interest most marine biologists. It should be in every marine biology library and on every coffee table. At such a low price, it would be an inexpensive but well-received birthday present for many.

Barrington (Barry) G. Woodcock
(woodcockbgscolopax@t-online.de)

A Sea Monster's Tale: In Search of the Basking Shark



Author: Colin Speedie
ISBN: 978-0-9573946-8-1
Format: Hardback, 296 pages
Published by: Wild Nature Press

Anyone lucky enough to come face to face with the world's second largest fish, the basking shark (*Cetorhinus maximus*) is unlikely to be untouched by the experience. When this plankton-feeding leviathan—growing to over 10 m long and weighing 6 tonnes when adult—swims past its presence doesn't first strike you as that of a fish, but rather has the impact of a monstrous submarine, powering relentlessly on its way to some secret (to us) location. Only when it flows past and an eyeball rotates marginally towards you does it fully dawn that this is both an incredibly beautiful and mysterious animal.

Like myself, the author of this highly readable book has spent a life captivated by the basking shark. In it he sets out to provide the reader with a full and rounded story of the species through time. There is a highly detailed account of the hunts and fisheries for basking sharks since the 18th century, to the first biological investigations through to modern scientific studies, and then to his own history of meeting basking sharks during his years running wildlife surveys from Devon to the Outer Hebrides. What results is an engaging and well-researched summary of what we know about this vulnerable shark.

It is clear that Speedie revels in the well-told adventures of shark hunters like Gavin Maxwell, Anthony Watkins and others, but for me the balance and flow of the story would have been helped by somewhat fewer quotations from these books.

The second half presents the author's own journey in pursuit of this enigmatic and difficult to study species. This part weaves well the emerging scientific discoveries of numerous modern scientists with his own hard-won observations from yacht-based surveys. The need for the new science and the surveys was driven by concerns that after decades of exploitation population levels of basking sharks were declining. The book does a good job of telling how from these new data and comprehensive reviews a small group of scientists, conservationists and policy makers were successful in achieving protection for basking sharks both in the UK and internationally, making it today one of the most protected sharks in the world. I would have liked a clearer telling of how new satellite tracking in 2001/02 using 20 transmitters (not five as stated in the book) debunked winter hibernation and showed regional philopatry, contributing to the successful CITES Appendix II listing in November 2002. However, these rare omissions will not impact this enjoyable read for the majority and will doubtless engender intrigue and wonder in equal measure for this wandering titan of the sea, as the book's author intends.

Professor David Sims
(dws@mba.ac.uk)
Marine Biological Association

Become an Environmental Management or Marine Science examiner with Cambridge

Cambridge Professional Development

Cambridge International Examinations is growing and over 10000 schools in more than 160 countries are now part of our Cambridge learning community.

To support our continued growth worldwide, we are expanding and strengthening our examiner network, and inviting teachers to develop their professional experience by becoming examiners for **Cambridge IGCSE Environmental Management** and **Marine Science**, **Cambridge International AS & A Level Environmental Management** and **Marine Science**.

Applicants should be experienced teachers and educated to degree level. Successful applicants will require a PC and broadband to allow them to access our on-screen marking systems.

Requirements are:

- Applicants should have teaching experience and be educated to degree level.
- Successful applicants will have a keen eye for detail.

We offer:

- a powerful insight into the teaching and assessment of Cambridge qualifications
- support in developing your own professional practice
- the highest standards of training and support
- freelance opportunities, based on contracts for services for each examination series, which fit around your existing commitments.

To apply, please visit
www.cie.org.uk/makeyourmark

CAMBRIDGE
International Examinations

Learn • Discover • Achieve

twitter.com/cie_education

Issue 10 of *The Marine Biologist*

The Marine Biologist

The magazine of the marine biological community

April 2018

www.mba.ac.uk/marine-biologist