Issue 7. October 2016
ISSN 2052-5273

The Marine Biologist

The magazine of the marine biological community

Do we want this revolution in aquaculture?

Plus

Moving sushi – the return of the bluefin

Mud, birds and poppycock

Brexit, fishing and the UK marine environment

THE MARINE BIOLOGICAL ASSOCIATION
Est. 1884
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Microplastics and pollution | Anti-ageing chemicals from the sea
Blue coral conservation

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

ISSN number: 2052-5273

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

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Editorial

In 2014, humans ate more fish raised on farms than fish caught in the wild. This huge shift slipped past largely unnoticed but it has massive implications for ocean and human health. In this edition we are delighted to present as our leading article two contrasting views of the aquaculture debate led by high-profile researchers at the University of California, Santa Barbara.

The harsh economic climate has bred a growth agenda under which the environment may be viewed by politicians as a source of problems and expense rather than a source of solutions and jobs. The decision by the UK to leave the European Union, commonly referred to as 'Brexit', may be a 'golden opportunity' for trade but when the dust settles, scientists, statutory agencies and non-governmental organizations need to be on the same page about which environmental legislation to keep, scrap or amend—and be ready with the evidence to support the government on amendments. Thanks to European Union (EU) law a whole generation has grown up with cleaner seas (and air) and this gives MBA Deputy Director Matt Frost reason to hope that the 'dirty man of Europe' will not stir in his grave (see page 20).

The UK fishing industry doesn't like the Common Fisheries Policy but now that the UK is set to regain control over its territorial seas, how does the industry see the opportunities and threats around managing fish stocks? To find out we interviewed Jim Portus, Chief Executive Secretary of the South West Fish Producers Organisation.

The Internet and social media are making access to information so easy that we can question our experts and engage in debates—a good example can be found on the website of *The Marine Biologist*, which was the forum in August for a debate between an expert on ocean acidification and a prominent journalist and climate sceptic. Read more in the In brief section.

As a society, we use products such as plastics and pharmaceuticals with little consideration of the environmental cost of their use. Fluoxetine is a common antidepressant that enhances feelings of wellbeing. Its use is such that it has been found in estuarine waters in the UK and US at levels that exceed EU-recommended safe limits. A University of Exeter, UK study[1] reported that ragworms (an important food source for wading birds) exposed to fluoxetine exhibited reduced feeding and weight loss. The same marine environment that has been shown to contribute significantly to human health and wellbeing is being negatively impacted by antidepressants. As the song goes, it's ironic.

1 http://pubs.acs.org/doi/abs/10.1021/acs.est.6b03233

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/marinebiologist

Front cover: A school of Atlantic bluefin tuna in a transport cage in the Mediterranean. Image: Roger Grace/Greenpeace.
Back cover: The cushion star, *Asterina gibbosa*. Image: Alix Harvey/MBA.

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Image credits top to bottom: Marco Carè/ Marine Photobank; Pennie Lindeque; John Goss-Custard; Mr Masahito Kamimura.

Warming seas are changing the Great Barrier Reef; 2016 has seen the third mass bleaching event to affect the reef. The image above shows bleaching at Heron Island in February 2016, which is close to the southernmost point of the Great Barrier Reef. Image: XL Catlin Seaview Survey www.xlcatlinseaviewsurvey.com

Can World Heritage site designation help the Great Barrier Reef?

The Great Barrier Reef is the Earth's largest living structure, visible even from space. It holds an astonishing diversity of marine life; including over 1,600 species of fish, 3,000 molluscs and 133 species of sharks and rays.

But the Great Barrier Reef is changing. Threats such as climate change, coastal development, declining water quality and unsustainable fishing practices are placing increasing pressure on the reef. 2016 has seen yet another mass bleaching event. Action is needed but does the reef's status as a World Heritage Site actually help protect it?

Former Great Barrier Reef Marine Park Authority (GBRMPA) director Jon Day believes the World Heritage Committee can help. "The Committee retains an overview and when the Committee feels [the reef] is under threat…they can put [it] on the World Heritage in danger list". Similarly, Michael Arvedlund, Associate Editor of the *Journal of the Marine Biological Association* states, "World Heritage sites have the world's attention. So when profit and greed threaten ecosystems … the Committee can take action".

However, in 2015 the Committee agreed not to place the reef on the in danger list. This was partly due to a decision to ban the dumping of spoil from port building in the World Heritage Area. Col McKenzie, Chief Executive of the Association of Marine Park Tourism Operators, says placing the reef on the list would have been "a major public relations disaster". Others believe it would have been a vital wake-up call.

Even with World Heritage status, practical management of the reef still lies with the Australian and Queensland governments. So what is being done? They have developed the Reef 2050 plan in response to Committee recommendations. The plan acts as a framework for protecting and managing the reef from 2015 to 2050, and sets strict targets. This sounds promising, however Day believes more action is needed. "The plan didn't really mention climate change, and yet it is clearly the number one threat".

World Heritage status shines attention on the reef. However, its future ultimately lies in the hands of the government. Perhaps the real question should be, with ever-increasing sea temperatures, is it too late for them to save it?

Sophie Thomas

Time to debate …

The scientific consensus is that climate warming and ocean acidification are real and a result of anthropogenic inputs of carbon dioxide to the atmosphere. In August we received a rebuttal by a climate scientist of an article by James Delingpole in *The Spectator* that dismissed ocean acidification as a scam. We published the rebuttal online (see: www.mba.ac.uk/marinebiologist/?p=1455) and it is fair to say the resulting debate was polarized—at one point Delingpole asked "who reads *The Marine Biologist* anyway?".

The scientific consensus should never be above scrutiny and if there are problems or issues then the marine science community needs to be able to produce responses to problems (and to commonly recycled myths, e.g. the Earth hasn't warmed since 1998) that are accessible at various levels.

We would encourage people to take part, to question experts and those who seek to influence public opinion. We also hope that this kind of debate will be accessible to the quieter majority who wish to expand their knowledge of these important issues. It has been a good example of how we see the role of the magazine and its website.

Chatting helps dolphins solve problems together

A recent study by Dolphins Plus research institute and the University of Southern Mississippi suggests that bottlenose dolphins have a special type of vocalization they use to cooperate when solving problems.

A canister full of food that needed cooperation to be opened was the basis of their study. Throughout the experiment only two of the six dolphins involved managed to complete the task, but their success rate was high, managing to crack the puzzle 83% of the time.

However the real surprise came from the vocalizations made by the dolphins during the task; they chatted considerably more when trying to open the canisters than any other time during the study, which was directly linked to the task and not social interaction with other dolphins.

This study points towards the possibility that dolphins possess a language that allows them to solve problems as a team.

Amy Coombe

Haddock hit by oil at vulnerable life-stage

Haddock (*Melanogrammus aeglefinus*) is one of Britain's most commonly eaten fish. Already with an International Union for Conservation of Nature and Natural Resources (IUCN) status of vulnerable, new research has identified that the species is more susceptible to oil pollution during early development than previously thought. Doctoral research by Elin Sørhus, University of Oslo has shown that small oil spills are negatively affecting the haddock larvae at their most important spawning ground in Norway's Lofoten archipelago.

The research exposed haddock roe to relatively low concentrations of oil for just 24 hours and saw serious injuries develop as a result, specifically heart deformities. Even when the roe are able to develop in clean water after oil treatment the injuries remain. Longer exposure time resulted in additional deformities in the cranium and jaw.

These findings are of particular concern because the Lofoten archipelago has more future oil production planned. The study highlights the serious short-term effects but Sørhus fears the impact long-term may resemble what happened following the *Exxon Valdez* tanker spill in Alaska, in 1989 when herring stocks collapsed three years after the spill, suspected to

be because of oil effects on the larvae.

The research provides important evidence to the Norwegian Government as they make difficult decisions concerning oil production in this region and the effects it could have upon this commercially and ecologically important fish species.

Charlotte Walker

Reasons to be cheerful for bleached coral?

In the last edition (White, M., 2016 Too hot in paradise? *The Marine Biologist* 6: 26) we heard that corals and clams, vital for the remote community of Tongareva Atoll, Northern Cook Islands, were suffering bleaching and mortality after sustained high sea temperatures related to the 2015-2016 El Niño event.

Cook Island corals recovering from bleaching, June 2016. The picture shows the coral health chart from the University of Queensland. Image: Michael White.

The lagoon began to cool in May and the news is that islanders have seen good recovery of corals and many new clam recruits. Marine zoologist Michael White says "we believe this has been possible because of the near pristine condition of our ecosystem, whereas it is pretty clear that the Great Barrier Reef hadn't recovered properly from the 1997-1998 El Niño—and is still being perturbed by coastal pollution and other impacts."

In addition, Dr White reports that many of the large seabirds which left while the lagoon was hot, have returned.

An ambitious and exciting project brings Ocean Literacy to Europe

Considering all the challenges facing our marine environment, wouldn't it be something if there were a project that aimed to bring about a fundamental change in the way Europeans view their relationship with the sea? Sea Change is that project, and it seeks to bring about that change by making Europeans 'Ocean Literate'.

In July 2016 Sea Change launched its public campaign which involves: the delivery of high profile events across Europe; the launch of a citizen science project to record the distribution of crab species; an Ocean Literacy MOOC (Massive Open Online Course) for teachers; and ibooks on Cold-water Corals and harmful plankton blooms to mention a few.

The next edition of *The Marine Biologist* magazine will feature an article on ocean literacy and the all-important link between the health of our seas and that of humankind.

Get involved in Sea Change via Twitter, Facebook and the project website. Sign up to the campaign and for updates on how you can bring Ocean Literacy to Europe so that citizens understand the ocean's influence on us and our influence on the ocean.

Sea Change is a three-year European Union H2020-funded project coordinated by the Marine Biological Association. The partnership includes major networks (World Ocean Network, UNESCO-IOC, Ecsite and EUROGEO) that are helping to disseminate the work of Sea Change to a wide and diverse audience.

www.seachangeproject.eu

SharkFest 2016

Bristol, Southwest England was host to the UK's first ever shark festival! SharkFest 2016 brought together conservation organizations, surfers, scientists, filmmakers, artists and shark fanatics from across the world, to encourage positivity, collaboration and active participation in marine conservation in the UK.

Organized by shark conservation organization FinFighters, the day included talks from The Shark Trust, producer Jennie Hammond from BBC Shark, The Gills Club and Sharks4Kids. Fin Fighters held a citizen science workshop to help volunteers fill in data gaps on shark population numbers, highlighting where protection or further assessments are needed. Stands and activities were also delivered by the Marine Biological Association, The Manta Trust, Surfers Against Sewage, the Marine Conservation Society and many more.

To conclude an exciting and inspiring day guests had the opportunity to watch an exclusive screening of David Diley's film—*Of Shark and Man*. The event was a huge success and will be running again next year—watch this space!

Jasmine Tribe

SharkFest 2016. Image: The Marine Biological Association.

Antarctic marine reserves deal within reach

An international agreement to protect some of Antarctica's unique and pristine marine ecosystems could be reached within a fortnight.

Delegates from 24 nations and the European Union gathered in Hobart on Monday at the annual meeting of the Commission for the Conservation of Antarctic Marine Living Resources.

If an agreement is reached, it would represent the first time a marine protected area was established in international waters by consensus.

There are signs Russia, which is chairing the meeting for the second year in a row, is prepared to make a deal to protect the Ross Sea and possibly East Antarctica.

Courtesy of Guardian News & Media Ltd.

Commitments from the third Our Ocean conference 2016

Participants in the third Our Ocean conference, held in September in Washington, D.C., announced over 136 new initiatives on marine conservation and protection valued at more than $5.24 billion, as well as new commitments on the protection of almost four million km2 of the ocean.

Highlights under the 'protecting ocean areas' theme were the announcement by the United States of the expansion of the Papahanaumokuakea Marine National Monument, Hawaii to cover an additional 1,146,798 km2, creating the world's largest marine protected area and permanently protecting pristine coral reefs, deep sea marine habitats, and important ecological resources.

Under the 'climate and ocean' theme, the US announced two global ocean satellite systems to monitor the health of our ocean ecosystems and to improve our understanding of ocean circulation and climate.

References and links for these stories can be found on *The Marine Biologist* website. With your smartphone, scan the QR code below to view the web page.

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

Image: Tom Horton.

MOVING SUSHI

Weighing in at several hundred kilograms, Atlantic bluefin tuna are able to regulate their body temperature and swim at up to 70 kmh. These awe-inspiring fish are the epitome of the apex predator. **Tom Horton** welcomes them back to UK waters.

Last August, a large shoal of one of the ocean's most highly prized fish, the Atlantic bluefin tuna, made a dramatic appearance in the waters of Mount's Bay, Cornwall, England. Their appearance, reported by a marine wildlife tour boat operating out of nearby Penzance, made national news amidst claims that a fleet of French vessels was hot-footing it to the area in order to exploit this multi-million dollar prize purse, as English boats lacked the quota to do so. Whilst the claims were largely untrue (there were no French boats en route to the scene), the ecological significance of the sighting fits amongst many other cases of distributional changes of marine species over the past two decades, all largely related to climate change. However, the nature and mechanisms of this change are unclear and are currently being explored by an international group of scientists, from the University of Exeter, the Irish Marine Institute, Cefas (Centre for Environment, Fisheries and Aquaculture Science), the Tag-a-Giant Foundation of Stanford University and the International Commission for the Conservation of Atlantic Tunas (ICCAT).

Atlantic bluefin tuna are the largest of all the tuna species, growing to lengths of over 3m and weighing more than 700 kg. They are well known for being voracious and highly-mobile predators, and adult fish regularly make trans-Atlantic migrations. They have the unique ability amongst teleosts of endothermy—the ability to maintain their body temperature at a metabolically favourable level, despite external temperature. This physiological trait results in an unusually broad thermal operating range of 0–30°C. By maintaining their internal temperature at an optimal level, bluefin are able to exploit extremely productive, but cold, high-latitude waters, and still return to breed in the warm waters of the Mediterranean and Gulf of Mexico. There are limits to this ability however, and the likelihood of bluefin occurring in the Atlantic reduces drastically as sea surface temperature (SST) falls below 7–10°C. So their latitudinal extent is thermally limited, and they can only exploit high-latitudes when water temperatures peak in the summer and autumn. In order to feed their high metabolic demand, they must consume 2–10% of their body mass in food daily (based on captive studies). Consequently, whilst adopting a fairly generalist diet, they show a strong preference for high-calorie prey, such as mackerel, sprat, herring and Atlantic saury.

In addition to their unique physiology, Atlantic bluefin tuna exhibit complex movement patterns, which vary with size (larger fish range further) and amongst individual cohorts of fish. There are at least two genetically distinct populations of bluefin in the Atlantic, defined by spawning region: the eastern stock, which spawns in the

Mediterranean, and the western stock, which spawns in the Gulf of Mexico. The eastern stock may well comprise other genetically distinct units in the Mediterranean and recent evidence has highlighted a new western spawning ground in the slope sea of the north-western Atlantic. Bluefin tuna show a high degree of natal fidelity, which maintains the genetic structuring, as research has shown that outside of spawning areas, both stocks mix widely throughout feeding grounds in the open waters of the Atlantic.

Fisheries for bluefin in the Atlantic and Mediterranean have existed for a thousand years, and catch records show a high degree of spatial and temporal variability. This has been hypothesized to reflect both long-term environmental change and the influence of large intra-population migratory 'groups' arising as a result of strong recruitment years, resulting in short-term colonization (and subsequent disappearance as the new 'groups' die or get fished) of 'new' regions. The poorly understood inter- and intra-stock migratory patterns of bluefin have largely precluded effective management of the species, as stock assessments (which currently rely on fisheries-dependent data) still cannot accurately assign catches to the correct stock. Consequentially, documenting and understanding bluefin migration is a research area of high importance.

The reappearance of bluefin tuna in the northeast Atlantic

Historically, seasonal aggregations of bluefin tuna were present in the waters around the British Isles. During the 1930s there was a burgeoning aristocratic sport fishery for 'the giant tunny' off the coast of Scarborough, and an English fisherman, Edward Peel, even held the world record for the species in 1932 (362 kg, beating the standing record of 344 kg; Nova Scotia). However, due to the rapid development and industrialization of the commercial herring fleet operating in the North Sea, the local herring stock collapsed and the giant tunny had all but disappeared by the early 1950s. Similarly, the waters off Ireland played host to the *ronnoch mor* (giant mackerel in Gaelic), and since the 1970s commercial pair-trawlers have caught them off County Donegal as bycatch. A dedicated fishery emerged in 1999, only to cease in 2006 due to a lack of fish. This was seen as symptomatic of the state of the stock at the time.

During the 1930s there was a burgeoning aristocratic sport fishery for 'the giant tunny' off the coast of Scarborough

Over the past three years bluefin tuna have been recorded with increasing regularity, and often in appreciable numbers, in places where they haven't been seen for as long as 50 years: southwest England; the Outer Hebrides, Scotland; and the whole of the west coast of Ireland.

Box 1: A most valuable fish

Single bluefin tuna can sell for astronomical amounts: in 2013 a fish weighing 222 kg sold for $1.76 m. It fetched an especially high price as it was the prestigious first fish of the 2013 trading season at Tsukiji fish market, Tokyo.

Skipper Adrian Molloy with his Irish record Atlantic bluefin tuna, caught on the 5th October 2001 at Raithlin O'Beirne Island, Donegal, Ireland and weighing 439 kg. Image: Adrian Molloy.

Why is this happening?

As is the case with any enigmatic species, the relatively sudden appearance of bluefin tuna has garnered a high degree of interest. The explanation is nuanced and involves multiple factors likely acting in concert; there are at least three mechanisms that may have contributed to the bluefin having repatriated our coastal waters:

i. Thermal Habitat. In terms of the species' environmental niche, there is no reason why bluefin shouldn't be in British waters, as is well evidenced by historical catches. At 62–65° N, the leading edge of bluefin tuna distribution is much further north than the British Isles. Historically, only large bluefin tuna (>200 cm CFL (curved fork length)) made long-distance migrations into cooler high-latitude waters, which included British waters. This is due to the inefficiency of heat retention in small fish, which have a larger surface-area to volume ratio. However, as the waters around the British Isles warm they will become suitable thermal habitat for a greater range of bluefin from different life stages and for longer, which may result in elevated catches and sightings. This is corroborated by recent sightings and catches of smaller bluefin, which were historically absent.

ii. Prey. Migrations by bluefin into the North Atlantic are driven by a constant need to forage, ideally on high-energy food. In turn, their fine scale distribution has been shown to be closely related to that of their preferred prey. The only recorded stomach content for a bluefin in the western English Channel, showed that the fish had been feeding solely on mackerel. The phenology, path and magnitude of the mackerel migration has changed considerably over the past decade, as have the spatial dynamics of other important prey such as herring and sprat. These changes will also likely play a structuring role in the fine-scale distribution of bluefin.

iii. Stock 'health'. Demand for bluefin has reached a record high over the past two decades as a direct result

An Atlantic bluefin tuna 'busting' clear of the water whilst feeding in Donegal Bay, Ireland. Image: Tom Horton.

of the growing sushi sashimi market in Japan, in which bluefin is most highly prized. The majority of bluefin caught are flash frozen and shipped to Japan for auction, where individual fish regularly sell for tens of thousands of dollars (See Box 1). Bluefin tuna is infamous for being over-exploited due to challenging management conditions and a combination of high market demand and consistent and extreme illegal fishing (e.g. the reported catch in 2006 was 31,000 t, but after including Japanese import records, it was found to be in excess of 50,000 t). In 2008, the eastern and western Atlantic stocks were estimated to be at 33% and 17% of 1950s spawning stock biomass respectively. However, the initiation of a recovery program by ICCAT in 2006, coupled with favourable recruitment appears to have resulted in a stock recovery; the 2014 ICCAT stock assessment showed a three-fold increase in eastern spawning-stock biomass in the period 2008-2014. So it could simply be the case that there are more fish to see, not just in British waters, but throughout the Atlantic.

In short, there is no simple answer, and there is no guarantee that bluefin will once again become a regular fixture on the 'resident species' list for our coastal waters. Our work aims to put these recent sightings into a historical context, and by using a multi-disciplinary approach, investigate the influence of climate and prey availability on bluefin tuna distribution. One thing that is abundantly clear is that the mechanisms of this change have far-reaching consequences. Understanding how apex predator distribution may alter as the ocean climate changes is vital, in order to understand and maintain ecosystem function, and to bolster effective fisheries management.

Tom Horton (t.horton@exeter.ac.uk) is a postgraduate student at the University of Exeter, UK supervised by Dr Matthew Witt, Dr Lucy Hawkes and Dr Barbara Block, investigating the spatial ecology of Atlantic bluefin tuna in the northeast Atlantic, with the Marine Institute in Ireland. Follow them and their work on bluefin tuna on twitter @t__horton, @mjwitt1, @DrLucyHawkes and feel free to contact with any queries.

Box 2. Bluefin in the UK – a timeline

- 1930: The rise of 'giant tunny' fishing off Scarborough
- 1933: Lorenzo Mitchell Henry sets the British bluefin record – 386kg caught off Scarborough
- 1950s: Extirpation of 'giant tunny' off the northeast English coast
- 1970s: First records of bluefin from commercial fishermen in Ireland
- 24th September 2000: Alan Glanville lands the first rod-and-line caught bluefin tuna in Irish waters, in Donegal Bay
- 5th October 2001: Adrian Molloy catches a fish weighing 439 kg and sets a new Irish record
- 2011: An 11 kg bluefin tuna was caught by a spearfisherman off the Dorset coast
- 2013-15: numerous bluefin tuna caught by rod-and-line off the Outer Hebrides, Scotland, including a 234 kg specimen in 2013 and three electronically tagged in 2014
- 2013-15: Bluefin records begin again from Ireland in 2013, and there were more records in 2015 than ever before, from around the whole coast
- 2015: Large shoal of BFT spotted multiple days in August, and multiple times in October by Marine Discovery, a wildlife tour operator in Cornwall
- 2015: Welsh shark fishermen catch two adult bluefin on the Celtic Deeps

Further reading

Block, B.A. et al. (2005) Electronic tagging and population structure of Atlantic bluefin tuna. *Nature* 434: 1121–1127.

Golet, W. J. et al. (2013) Changes in the distribution of Atlantic bluefin tuna (*Thunnus thynnus*) in the Gulf of Maine 1975-2005. *PLoS ONE* 8(9): e75480

Mackenzie, B. R. et al. (2014) A cascade of warming impacts brings bluefin tuna to Greenland waters. *Global Change Biology* 20: 2484–2491

Seeking the fountain of youth in the twilight zone

The ocean's little-explored mesophotic zone may yield substances that interfere with the ageing process. TASCMAR is a European Union project that is systematically investigating the possibilities. By **Jamal Ouazzani**, **Yehuda Benayahu** and **Ioannis Trougakos**.

TASCMAR is a European Union-funded research project that investigates the chemical potential of the ocean's mesophotic zone (see definition below). The goal is to develop sustainable methods for discovering chemical compounds that can be used for application in diverse fields such as health/nutrition, depollution and nature-based cosmetics. Within the key theme of anti-ageing the goal is to evaluate the extracts and pure molecules found on a set of biological assays that will reveal their potential to interfere with the processes of cellular senescence, *in vivo* ageing and angiogenesis.

As a starting bioresource, TASCMAR is collecting samples of marine invertebrates from biodiversity hotspots around the world. Special emphasis will be given to sustainable bioprospecting, going from collection to cultivation, and developing technologies for sustainable intensification of the active bioresource production.

the project is collecting samples of marine invertebrates from biodiversity hotspots around the world

Exploring under-investigated sea ecosystems

The mesophotic coral-reef ecosystem (MCE) has been defined as comprising the light-dependent communities of corals and other organisms found at depths between 30 and 150 m in tropical and subtropical regions. Due to technical and safety constraints, until the past decade most coral-reef studies have been restricted to the upper ~30 m and therefore data on MCEs have been sparse. Current technological advances, however, such as remotely operated vehicles (Fig 1), and closed-circuit re-breather diving, have now facilitated the investigation of MCEs.

Besides reef-building stony corals, octocorals, echinoderms, snails and sponges are common groups of marine invertebrates on many Indo-Pacific and Mediterranean ecosystems down to 30 m and are found to an even greater extent in MCEs. Several studies have been conducted on mesophotic octocorals but the majority of these have been limited to photographic recognition of the resident taxa and did not reveal their actual diversity and abundance. Interestingly, several recent studies indicated that taxa considered rare in shallow reefs might be widespread at mesophotic depths.

The northern Red Sea reefs have been quite extensively studied, albeit mostly confined to the reefs above 30 m. These studies have revealed vast octocoral richness in the Red Sea, as well as of other invertebrate species new to

Figure 1. The campaign to collect samples from the mesophotic ecosystem of the Red Sea, conducted by Remotely Operated Vehicle (ROV). Marine invertebrates were collected between 90 and 150 m depth.

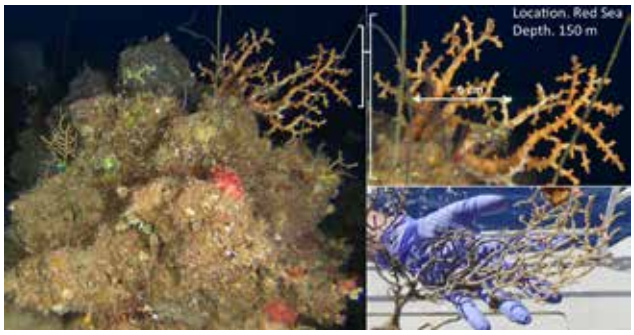

Figure 2. Mesophotic pinnacle at Eilat, covered by diverse gorgonian soft corals (left). Soft coral at the mesophotic reef of Eilat (right).

science, yet the MCEs of the Red Sea have remained understudied. Although situated at the northern-most boundary of coral-reef distribution, the coral reefs of the northern Gulf of Aqaba exhibit exceptionally high within-habitat species diversity (Fig 2). The same applies to other regions, such as Gulf of Thailand, Andaman Sea, eastern and western Mediterranean as well as Indian Ocean islands, whose mesophotic invertebrate species diversity remains unexplored.

MCE invertebrates have the potential to provide novel bio-resources. This, coupled with the scarce data available on MCE invertebrates and their associated microflora—particularly in Red Sea and Thai waters—influenced our decision to make MCE invertebrates the focus of the TASCMAR project.

From organisms to molecules, the need for chemical expertise

After the collection phase, we have a unique opportunity to investigate not only MCE invertebrates as holobionts (assemblages of different species that form ecological units) but also the associated symbionts. A particular focus will be on microorganisms, especially actinomycetes and fungi.

Invertebrates from various locations around the world (Red Sea, Mediterranean, Gulf of Thailand, Andaman Sea, Île de la Réunion and the islands around) will be chemically extracted by automated ASE technology (accelerated solvent extraction) in order to obtain homogenous samples, using a unique scale-up device called the Zippertex (Fig 3 right).

Figure 3. The Zippertex (right) is the only available prototype for scale-up high-pressure/high temperature static extraction. The Platotex (left) is the unique technology for scale-up agar-supported cultivation (Ag-SF).

Innovative methods for cultivation of microbial symbionts will be implemented, specifically the agar-supported solid-state cultivation (Ag-SF) coupled with solid-phase extraction (SPE) (see below). Ag-SF applied specifically to marine microorganisms will be scaled up during the project from laboratory to industrial level taking into account the constraints of marine microorganism cultivation and making use of the Platotex device (Fig 3 left), previously developed by the leading project partner, the National Center for Scientific Research (CNRS) in France.

Extraction of target compounds from microbial symbionts includes an innovative, environmentally friendly technology called SPE, in which target compounds are directly transferred from the microorganism to a trapping resin (Fig 4). One of the challenges in the project is to identify compounds produced in the invertebrate ecosystem which may act as a molecular network to stabilize the holobiont by inter- and intra-specific exchanges. This will involve metabolomic comparison between the whole invertebrate extracts and the isolated symbionts extracts. The TASCMAR project consortium counts two of the best-equipped laboratories in Europe, capable of analysis of complex mixtures and of elucidating the structure of challenging natural compounds. The extracts, fractions and pure compounds will be subjected to a panel of molecular, cellular and *in vitro* bioassays, all dedicated to the discovery of anti-ageing active compounds.

Ageing—a universal challenge, an urgent priority

Organismal ageing is a complex molecular process that relates to the decline of functional capacity and stress resistance leading to increased risk of morbidity and mortality. Given recent findings in model organisms it is evident that healthy lifespan can be prolonged, suggesting that animals have the potential to live longer than they normally do. The need to increase the number of healthy life years is becoming increasingly urgent from both an economic and health perspective and since genetic interventions cannot be applied in humans, many studies have been devoted to the identification of promising natural products. This is because the chemodiversity in nature is immense, meaning that there is great potential in natural sources for finding novel structures capable of modulating the signalling pathways involved in the regulation of ageing.

Across these lines of research, TASCMAR partners will screen ~3000 extracts that will be derived from marine organisms for their bioactivity against proteins known to be involved in the regulation and progression of ageing (see Fig 5). Particular focus will be given to skin extracts and/or pure compounds that promote skin whitening, inhibit wrinkle formation and can protect skin from UV-mediated photoageing. Additional targets will be the activation of cellular intrinsic antioxidant and/or damage-clearing molecular machineries together with tests that will reveal whether the isolated compounds can protect human skin fibroblasts from premature stress-related senescence. The compounds

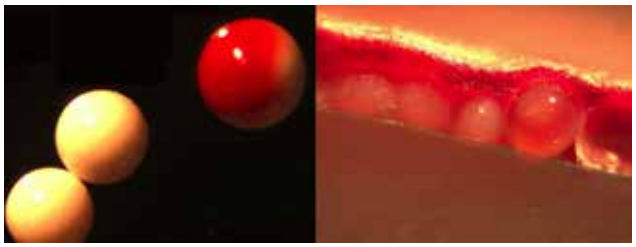

Figure 4. Solid-solid extraction, the resin beads intercalate spontaneously between the agar surface and the mycelium layer and directly trap the compounds secreted by the mycelium (right). Comparison between the initial resin beads and a resin bead accumulating the target red compound (left).

found to be most bioactive for anti-ageing in cell-based assays will then be tested, for example, *in vivo* in Drosophila flies for the preservation of neuromusculatory functionality during ageing, as well as for longevity-increasing effects.

Besides pharmaceutical activities, the TASCMAR project will also screen extracts and/or pure compounds for cosmeceutical and nutraceutical applications. Microbial symbionts will also be screened for their capacity to degrade chlorinated pollutants, meaning that they could be exploited for bioremediation.

Project coordinator Jamal Ouazzani said "*For me and the TASCMAR team, this is a really exciting project due to its global nature. Global because we're considering marine invertebrates as a whole ecosystem—both the invertebrate and the symbionts. Also global because we're focussing on diverse industrial applications, from pharmaceuticals and cosmetics to depollution and innovative bio-tech equipment. We're going to respectfully explore the biodiversity of different locations all around the globe and I can't wait to see the outcomes!*"

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TASCMAR is a collaborative research project funded by the European Union's Horizon 2020 programme for research and innovation (GA. 634674). The project involves 13 partners from eight countries among which are five academic institutions, six industrials, one non-governmental organization and a consulting company. With a total budget of €6.7 M, TASCMAR is responding to a key challenge set by the European Union 'Blue Growth' strategy: the sustainable exploitation of marine compounds.

Further reading

www.mesophotic.org

Argyropoulou A., Aligiannis N., Trougakos I.P., Skaltsounis A.L. Natural compounds with anti-ageing activity. *Natural Product Reports*, 2013, 30, 1412–1437.

Kahng S.E., Garcia-Sais J.R., Spalding H.L., Brokovich E., Wagner D., Weil E., Hinderstein L., Toonen R.J. Community ecology of mesophotic coral reef ecosystems. *Coral Reefs*, 2010, 29(2), 255–275.

Le Goff G., Adelin E., Cortial S., Servy C., Ouazzani J. Application of solid-phase extraction to agar-supported fermentation. *Bioprocess and Biosystems Engineering,* 2013, 36,1285–1290.

Meknaci R., Lopes P., Servy C., Le Caer J-P, Andrieu J-P, Hacène H. and Ouazzani J. Agar-supported cultivation of Halorubrum sp. SSR, and production of halocin C8 on the scale-up prototype Platotex. *Extremophiles*, 2014, 18(6), 1049–1055.

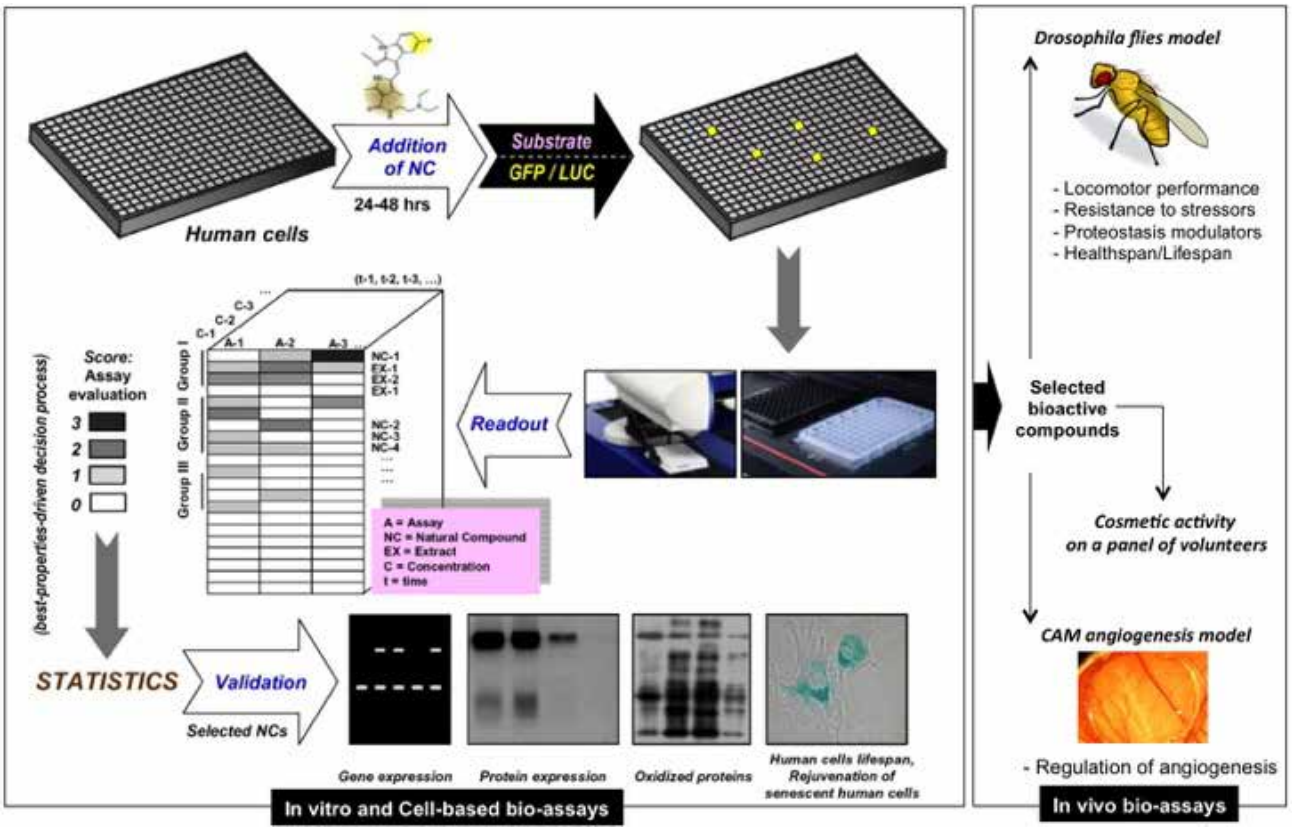

Figure 5. Anti-ageing compounds discovery pipeline of the TASCMAR project.

Two views on a revolution in aquaculture

By **Benjamin S. Halpern** and **Halley E. Froehlich**.

The human population is expected to grow to almost 10 billion people in the next 50 years. How are we going to feed all of those people, and do so sustainably? Aquaculture is not only necessary as part of the solution; it is likely the best way to meet this demand.

Already, food from fish has overtaken beef, and aquaculture (from the sea and land) has surpassed capture fisheries for the first time in history. In fact, the Food and Agriculture

Figure 1. Amberjack (or Seriola) farm offshore of Kona, Hawaii, USA. The cone-shaped net is the top of one of four submersible cages that has been raised for service. When all four cages are down only small floats are visible. Image: Michael Rust.

Organization (FAO) of the United Nations estimates aquaculture will increase production by 39% over the next decade—producing a whopping 102 million tonnes—while capture fisheries' outputs are projected to remain relatively unchanged. A large proportion (~40%) of the aquaculture growth will likely occur as 'ocean farming' or 'mariculture.' Most of it can occur completely out of sight, either with submersible technology (Fig 1) and/or offshore, hidden beneath the horizon.

These statistics are telling, yet critiques of aquaculture have been many and loud: mangrove habitat destruction, pollution, disease, genetic escapes, and depletion of wild fish for feed—many people equate farmed fish with the worst of human endeavours. So, is the growth in mariculture going to be a good thing or a bad thing for the planet and for humanity? There are three ways to frame this question: mariculture versus all protein-based food systems, mariculture versus conservation, and mariculture versus wild-caught fisheries.

Beyond global vegetarianism, the strongest case for mariculture comes when comparing it to all other protein food systems (e.g., beef, pork, chicken), even freshwater aquaculture. In fact, this is the fairest comparison to make as it puts everything on the same table for judgment. Efficiencies of converting feed to protein, per-kilogram of environmental impact, and health benefits are unmatched (Fig 2). This means a very high amount of protein can be produced with very little area, and thus reduced environmental impact. Even better, bivalve production is the only protein-based food system that is not only carbon-neutral but in fact a carbon sink. And with 200+ farmed marine species (Fig 3), we can diversify production and avoid the pitfalls of monoculture that plague the agricultural industry.

Mariculture can also be harnessed as a conservation tool—in fact it already is! Hatcheries are part of the aquatic farming domain, and without hatcheries salmon species would be a thing of the past in most regions of the world. Humans try to protect important terrestrial animals like the panda through captive breeding, and the same logic can be, and is being applied in the aquatic realm through aquaculture. In many cases, restoration is a form of mariculture.

Ultimately, most people simply want to compare fish

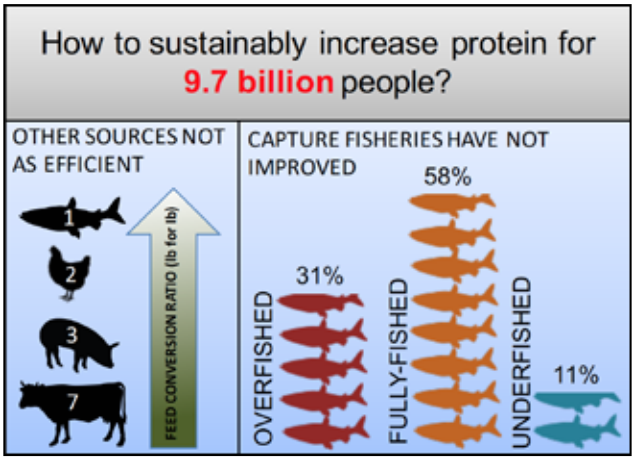

Figure 2. Left panel depicts feed conversion ratios (FCR) for the primary sources of animal protein. FCR represent the amount of animal feed needed (lb) for one pound of body mass. Right panel shows the current status of fish stocks as estimated by FAO (2016). Image: H.E. Froehlich.

to fish. How does mariculture stack up against wild fisheries? As a means to feed the planet and to reduce environmental impact, mariculture, in particular offshore mariculture, has the potential to outperform wild-caught fisheries. Globally, capture fisheries have stalled or declined, and there is a limit to the number of fish we can harvest (sustainably or otherwise) from the wild (Fig 2). Furthermore, overfishing, illegal fishing, bycatch, habitat destruction, and human-induced climate change have contributed to the deplorable state of many fisheries. While improved management can move towards sustainability (for example, in many US fisheries), the majority of the world's fisheries do not have the resources, interest, and/or incentive to reform. In contrast, offshore mariculture has essentially no limits to how much seafood can be produced, and most of the environmental risks are more easily mitigated —particularly pollution and disease.

Figure 3. Left panel shows a fish auction in Miyako, Iwate prefecture, Japan and the right panel a fish market display in San Sebastian, Spain exhibiting the diversity of consumed marine species. Image: Michael Rust.

Aquaculture has not yet eased the pressures on wild fish populations, but the majority of seafood did not come from aquaculture until now. A paradigm shift is occurring as more people and governments start to see the potential of ocean farming as a sustainable food source and viable livelihood option. Our colleges, McCauley *et al.*, point to the ecological cost of wild-based feeds, however this use is declining and alternative feed sources like Omega-3 algae—which launched commercially this year—insects, bacteria, and yeast can replace wild-caught meal and oil. Some mariculture does not even need to be fed; bivalves provide food and ecosystem services by filtering and cleaning the water for us. Entire mini-ecosystems can even be created where fish, seaweed, and bivalves grow, thrive, and are farmed together.

Fishing is the last of our commercial hunting practices. Imagine trying to feed the world on feral pigs and wild cows. Then why, particularly in the developed nations, are we still fishing out the oceans when we could be sustainably practising and perfecting ocean farming? Mariculture could provide better feasibility of monitoring and managing for the lowest possible impact on the environment and more control over the quality of conditions the fish are raised in.

Aquaculture is growing with or without the scientific community and public input, and its importance and application in fisheries science has been largely overlooked—until now. Aquaculture does not have to be ubiquitous, nor does it need to replace all wild-caught fisheries. However, it must be a major global priority for marine science, conservation, food provision and management in an ever-changing world.

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Ploughing under the ocean?

In Wildness is the preservation of the world. Henry David Thoreau

By **Douglas McCauley**, **Erin Dillon**, **Francis Joyce** and **Ashley Stroud.**

2014 was the first year ever in which our planet ate more fish raised on farms than fish caught in the wild. This is a turning point of great significance. This shift promises to be as transformative as when we switched on land from hunting and gathering food from the wild to farming domesticated plants and animals.

Flying over parts of the Midwest of the United States reveals a scene of circles and squares that resemble a Mondrian painting (Fig. 1A). It is easy to forget that this carefully sculpted geometric world of corn, wheat, and sorghum, only 150 years ago, was the Great Plains ecosystem: a hyperdiverse grassland traversed annually by 60 million migrating bison. Large communities of indigenous people and native predators fed off this wild bounty before exponential human growth in the Americas necessitated

the appropriation of this ecosystem for agriculture.

Mariculture (ocean aquaculture) has grown 1570% in the last 4 decades and growth is projected to continue. As scenes of mariculture reminiscent of flyover views of the domesticated Great Plains begin to appear in the oceans (Fig 1B), it is worth reflecting on what this explosive growth will mean for the ocean's future.

Early reviews of ocean farming highlighted some of the collateral damage caused by dirty aquaculture. Perhaps unsurprisingly, problems arising from poorly managed fish pens parallel those of ungulate feedlots: excessive pollution from effluent, genetic pollution and ecological damage from aquaculture escapees, disease, and habitat destruction.

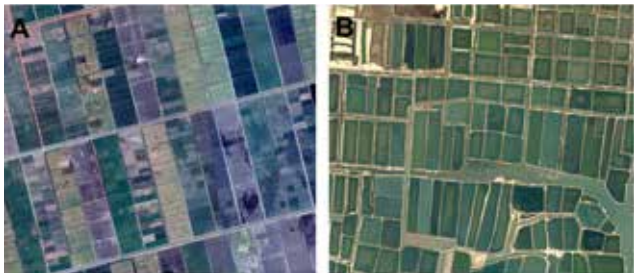

Figure 1. Left: Intensive agriculture (US Midwest), and right: Intensive mariculture.

Innovation in aquaculture has helped mute some of these problems. New mariculture tech, for example, has allowed fish farms to move farther offshore where higher rates of water flow help dilute pollution and moderate disease. It will be hard, however, to resolve some of the core trade-offs between a farmed and wild future for the oceans. An intelligently administered cattle ranch in the Amazon still fundamentally displaces forest just as a well-run shrimp farm in Myanmar still displaces mangroves—a critical nursery habitat for wild fish. Other zero-sum trade-offs abound. For instance, some of the most popular and profitable species being farmed in the oceans today are essentially underwater lions and tigers: salmon, jacks, cobia, and tuna. Farm raising predators is ecologically costly and requires large inputs of forage fish that might otherwise feed wild fish.

The privilege of harvesting wild foods from healthy ecosystems is one that we have largely forgotten on land and that we all too often take for granted in the oceans. Consider the case of Los Angeles (LA). Hunting and gathering in inner city LA is obviously not an option. But the long established poor, indigenous, and diasporic communities of the city actively go to public piers, beaches, and breakwalls to catch wild, free food from the ocean. Much of the wildness now extinct on the Great Plains still thrives below these high tide lines, feeding the hunger and imagination of coastal populations.

Human populations are expected to grow by up to 50% by the end of the century. Our colleagues Halpern and Froehlich very accurately point out that this growth, coupled with increasing wealth and subsequent spikes in demand for protein, will stress our global food production system. We question, however, whether these growth projections give us carte blanche to aggressively advance an agenda for ocean farming. This is particularly so when many already modified terrestrial systems are operating below their productive capacities, and changes in food consumption patterns (e.g. eating lower in food chains) offer pathways to help reduce food shortfalls.

The oceans today operate as one gigantic free-range organic farm. One that we don't need to water, fertilize, till, weed, or medicate. It takes care of itself and we harvest from it.

Yields from a wild ocean will never be as high as farmed ocean—because ocean ecosystems did not exist to generate ape food. Nevertheless, we generate millions of tons of highly nutritious wild seafood annually from the oceans. A century of experiments and mistakes in the management of wild fisheries have helped us identify strategies that can vastly increase these yields, if properly implemented.

In an increasingly crowded and hungry world it is legitimate to carefully explore new pathways to feeding ourselves from the ocean. However, overzealously and thoughtlessly marching forward this revolution in mariculture is likely to present major challenges to the future wildness of our oceans: the last of our planet's great ecosystems in which we get to have our biodiversity and eat it too.

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Further reading for two views on a revolution in aquaculture

Costello, C., D. Ovando, T. Clavelle, C. K. Strauss, R. Hilborn, M. C. Melnychuk, T. A. Branch, S. D. Gaines, C. S. Szuwalski, R. B. Cabral, D. N. Rader, and A. Leland. 2016. Global fishery prospects under contrasting management regimes. *Proceedings of the National Academy of Sciences* 113: 5125–5129.

FAO. 2016. *The State of World Fisheries and Aquaculture 2016. Contributing to food security and nutrition for all*. Rome. 200 pp.

Henry, M., L. Gasco, G. Piccolo, and E. Fountoulaki (2015) Review on the use of insects in the diet of farmed fish: Past and future. *Animal Feed Science and Technology* 203, 1–22. doi:10.1016/j.anifeedsci.2015.03.001.

Naylor, R. L., R. J. Goldburg, J. H. Primavera, N. Kautsky, M. C. M. Beveridge, J. Clay, C. Folke, J. Lubchenco, H. Mooney, and M. Troell. 2000. Effect of aquaculture on world fish supplies. ***Nature*** 405: 1017–1024.

Sarker, P.K., A.R. Kapuscinski, A.J. Lanois, E.D. Livesey, K.P. Bernhard, and M.L. Coley (2016) Towards sustainable aquafeeds: Complete substitution of fish oil with marine microalga *Schizochytrium* sp. improves growth and fatty acid deposition in juvenile Nile tilapia (*Oreochromis niloticus*). *PLoS ONE* 11, 6 e0156684. doi:10.1371/journal.pone.0156684.

Tilman, D. and M. Clark (2014) Global diets links environmental sustainability and human health. *Nature* 515, 518–22. doi:10.1038/nature13959.

Measuring 5,000 beasties a minute: Rapid zooplankton characterization at SAHFOS

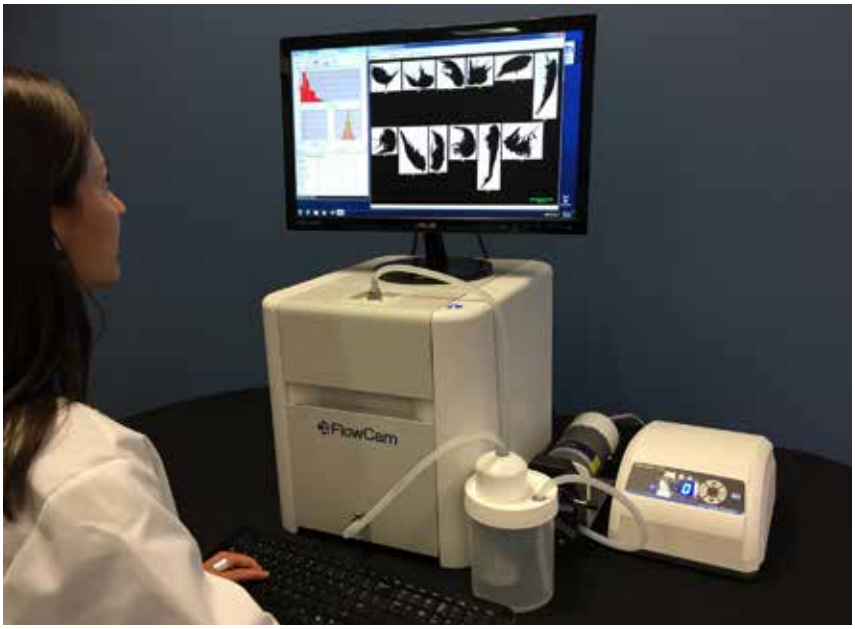
By Robert Camp, George Graham, Iain Vincent, Harry Nelson and Heather Anne Wright.

Zooplankton are a critical link between microscopic algae and larger organisms such as fish and certain whale species in the marine food web. Not only are they a major source of food for many organisms, but the majority of aquatic animals will spend part of their life history as zooplankton. Zooplankton also play a fundamental role packaging organic material in the biological pump, and are an important disease reservoir. The impacts of climate change and biodiversity loss fuel reductions in ecosystem health and functioning, and as zooplankton are highly responsive to changes in their environment (temperature, nutrient levels, light intensity, pollution, non-nutritious food, predation) species diversity, biomass and abundance can be used as indicators of the health of an ecosystem.

As part of the European Union project AtlantOS, the Sir Alister Hardy Foundation for Ocean Science (SAHFOS) are developing methods for rapidly providing estimates of zooplankton abundance and biomass from Continuous Plankton Recorder (CPR) samples for UK coastal and offshore waters. To do so, SAHFOS have recently acquired a laboratory-based particle imaging and characterization system—a FlowCam® Macro developed by Fluid Imaging Technologies—through the UK agent Planet Ocean. The system collects images of individual particles within a flowing stream of water, returning detailed measurements of size and shape at a rate of approximately 5000 particles per minute. The SAHFOS team are currently developing protocols for rapid, semi-automated analysis of zooplankton on CPR samples using the FlowCam Macro. Expert taxonomic analysts at SAHFOS are helping to develop species-specific image libraries in order to train the FlowCam's imaging analysis software to classify zooplankton with minimal user intervention.

A copepod—one of the tiny animals that make up the zooplankton—captured by Fluid Imaging Inc. FlowCam Macro.

FlowCam Macro in operation in the laboratory. Image: Fluid Imaging Inc.



Zooplankton are sensitive indicators of environmental change and ecosystem health, making rapidly reported measurements of zooplankton abundance and biomass crucial evidence inputs to the development of relevant marine planning policies and decision-making.

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1. SAHFOS
2. Planet Ocean
3. Fluid Imaging Technologies, Inc.

Plastics, plankton and pollution

Plastics are woven into the fabric of our lives but many of their virtues become vices in the marine environment. **Pennie Lindeque** looks at the growing problem of small plastic.

Figure 1. Small plastic litter visible amongst the strand line on an otherwise pristine beach, Cockleridge, Devon, UK. Image: Pennie Lindeque.

From drinks bottles and food wrappers to clothing and car parts plastics are durable, inexpensive and an inescapable part of modern life. However, plastic debris is also a widespread pollutant of the marine environment: step on to any beach around the world and you will almost certainly find plastic litter. Not only is this plastic an eyesore, but it also poses a distinct threat to marine life and in turn human wellbeing. However, research is now suggesting that it is microscopic sized plastic, the plastic we don't readily spot, that we should be really concerned about (Fig 1).

it is estimated that up to 10% of manufactured plastic ends up in the marine environment

Plastic in our society and in our seas

Large-scale production of plastics began in the 1950s, and has grown exponentially since then, with over 300 million metric tons currently manufactured globally each year. Although plastic can undoubtedly be of vast benefit to society, , it is increasingly used to manufacture single-use, throwaway products, such as food packaging and drinks bottles. Unfortunately, society has been slow to comprehend the pervasiveness and durability of plastic litter and waste management strategies have been equally slow to emerge. Through beach littering, road runoff, sewage and illegal dumping, it is estimated that up to 10% of manufactured plastic ends up in the marine environment where it may take centuries to degrade.

The effect that larger plastic debris has on wildlife is well documented. However, in recent years we are becoming aware that microscopic plastic litter—termed 'microplastics'—may pose an even more serious threat to marine life. Microplastics describe particulates and fibres <5 mm in diameter, of various shape, size, colour and composition. They are either manufactured to be of a microscopic size (e.g. microbeads used in shower gels, toothpastes and industrial abrasives); or are derived from the degradation of larger items through exposure to ultraviolet radiation from the sun, abrasion or by the action of washing synthetic clothing (particularly nylon or polyester) which can release thousands of plastic fibres into wastewater.

Small plastic, big risk?

Owing to their small size and abundance, microplastics are readily consumed by marine organisms, indeed, this kind of debris has been identified in the stomachs of over 200 different species, including seabirds, turtles, fish, shellfish and crustaceans. Studies have shown that microplastics can be directly ingested, or transferred to other organisms through the consumption of prey, animal carcasses or faeces. Studies have demonstrated that plastic debris can act like a magnet to other pollutants, including pesticides and industrial contaminants, present in the water: if eaten, there is concern such plastics might release these toxic compounds to the animal.

Our investigations into the risks microplastics pose to marine life have centred on zooplankton, small marine animals ubiquitous throughout our seas, which provide an essential link between primary producers (small marine plants such as algae) and higher trophic levels such as commercially important fish species and whales. Research conducted at Plymouth Marine Laboratory with the University of Exeter has demonstrated that a range of zooplankton, common in the northeast Atlantic, including copepods (Fig 2), the larvae of

Humans and marine litter: The culprit, the impacted and the solution

Responsibility for microplastics and marine litter more generally lies with humans. The problem is a consequence of our consumer demand, product use, political will, and the way we dispose of waste.

Marine litter is also harmful to people; research has found that littered coastlines are disliked and are detrimental to people's well-being. On the other hand, humans also hold the solutions and individuals can take action in a number of ways to help combat marine litter. For example, taking part in a beach clean not only benefits the environment directly, but has benefits to the individual (e.g. educational and well-being value) and to the environment indirectly by promoting other pro-environmental behaviours.

Kayleigh Wyles

Figure 2. Polystyrene microplastics ingested during laboratory experiments and visible in the intestinal tract of the marine copepod, *Calanus helgolandicus*. Scale bar is 100 µm. Image: Dr Matthew Cole.

bivalves (mussels, oysters etc.) and juvenile decapods (crabs, lobsters, etc.), all have the capacity to ingest microplastics. Tiny plastics can also get trapped on the appendages of these animals, potentially affecting their movement and ability to detect predators and prey.

To better understand the consequence of microplastic ingestion in zooplankton we conducted in-depth experiments on copepods, a dominant group of zooplankton. Compared with microplastic-free controls, copepods exposed to polystyrene microplastics ingested fewer algae and also showed a shift in preference to smaller algae prey, resulting in a 40% reduction in energy consumed. Over time, microplastic-exposed copepods showed reduced reproductive outputs and survival. Similar adverse health effects have been observed in fish, polychaete worms, mussels and oysters.

The problem of microplastic ingestion by zooplankton doesn't end there. Recent studies have also shown that microplastics in copepod faecal pellets result in the pellets having less structural integrity. Additionally, if the egested microplastics were low density (e.g. polystyrene) then the faecal pellets sank more slowly. We suggest this will increase the chances of them being eaten by other marine animals, resulting in the movement of the plastics through the food chain. The problem is two-fold: first, moving the plastics through the food chain further disperses their potential to have negative effects; and second, this may reduce the organic matter reaching the seabed and increase the amount of particulate matter in the water column, with possible repercussions for wider marine ecological processes, and even the ocean's climate control capacity.

Beyond the laboratory in the marine environment itself, it is currently unclear to what extent zooplankton will be affected by microplastic pollution. To address this knowledge gap we have been undertaking an annual sampling programme based around the Western Channel Observatory in the English Channel to determine the extent of microplastic ingestion by zooplankton, including fish larvae, in the natural environment (Fig 3). Results from the laboratory and field-based studies are being used in conjunction with mathematical models to determine the impact of microplastics on zooplankton and marine ecosystems; including the potential to affect the food chain.

Studies have demonstrated that plastic debris can act like a magnet to other pollutants

With rates of manufacture rapidly increasing and long degradation times, marine plastic litter is expected to be a growing issue over the next century. We don't yet know the full extent of the impact of microplastics on the health of the marine environment or humans, but the growing body of evidence suggests microplastic pollution is a cause for environmental and economic concern.

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Figure 3. Whiting *Merlangius merlangus* (12 mm) post-larval stage caught at Station L5, Western English Channel (www.westernchannelobservatory.org.uk) with a blue fibre (circled, 310 µm x 30 µm) dissected from the intestinal tract. Image: Madeleine Steer.

Further reading

Cole M, Lindeque P, Fileman E, Halsband C, Goodhead R, Moger J, Galloway TS (2013) Microplastic ingestion by zooplankton. *Environmental Science and Technology* 47: 6646–6655 doi 10.1021/es400663f

Cole M, Lindeque P, Fileman E, Halsband C, Galloway TS (2015) The impact of polystyrene microplastics on feeding, function and fecundity in the marine copepod *Calanus helgolandicus*. *Environmental Science and Technology* 49: 1130–1137 doi 10.1021/es504525u

Cole M, Lindeque PK, Fileman E, Clark J, Lewis C, Halsband C, Galloway TS (2016) Microplastics Alter the Properties and Sinking Rates of Zooplankton Faecal Pellets. *Environmental Science and Technology* 50: 3239–3246 doi 10.1021/acs.est.5b05905

Clark J, Cole M, Lindeque PK, Fileman E, Blackford J, Lewis C, Lenton T, Galloway TS (2016) Marine microplastic debris: a targeted plan for understanding and quatifying interactions with marine life. *Frontiers in Ecology and Environment* 14: 1–8 doi 10.1002/fee.1297

Wyles, K. J, Pahl, S., Thomas, K., & Thompson, R. C. (2015). Factors that can undermine the psychological benefits of coastal environments: Exploring the effect of tidal state, presence, and type of litter. *Environment & Behavior*. Online.

Brexit and the UK marine environment

The need to understand pressures and impacts on the marine environment will continue regardless of the political context, says **Matt Frost**.

And so it happened. Despite the confidence of many in government including the (Ex) Prime Minister of the UK David Cameron for a 'remain' vote, the British public voted on June 23rd 2016 for the UK to leave the European Union (EU). Powerful environmental non-governmental organizations spoke out in favour of remaining in the EU[1] as they felt that EU membership was largely beneficial for the UK environment, including its seas and beaches. Memories of untreated sewage pumped into seas before EU directives came into force are still vivid for sea-users in the 1970s[2].

Key questions now are what are the implications of the UK exiting the EU and can there be an outcome based on the long-term sustainable use of UK seas? The focus of much discussion post-referendum has been on trying to work out exactly what environmental regulation would stay in place depending on the eventual exit scenario. For example, if the UK chooses to stay in the European Economic Area it will have to retain a number of environmental regulations although major directives such as the Habitats Directive are not included. There is then the issue of how to deal with legislation that has built up over many years and is highly interconnected with national legislation delivering EU and international policy aims (a point made in the now infamous 'horrendogram')[3].

In the long-term however it is important to note that there are many things that won't change at all—the range of pressures the marine environment in the UK and elsewhere is subject to continues to grow and the need to understand the impacts of climate change for example will continue regardless of the political context. These pressures have driven the development of national legislation in the UK for marine conservation and planning. The aim to have healthy seas is enshrined in national policy—not just 'handed down from Brussels' and even in the event of the UK leaving the single market there is no absolute requirement to repeal European directives that have been transposed into UK law. The government should be conscious after all that the current regulations are a result of billions of pounds of investment in science, monitoring, mitigation and other measures aimed at ensuring the sustainable use of the marine environment for generations to come. How will it balance this against pressure for short-term economic gain?

Meeting European standards for water quality can help beaches obtain the coveted 'blue flag' award. Image: Rob Bishop.

It could also be pointed out that the positive influence of EU regulation can allow some significant weaknesses to be overlooked. The Common Fisheries Policy for example is one area that even the most ardent Europhiles have struggled to always paint in a positive light and there is no reason a better system that puts science at the heart of long-term sustainability of commercial fishing can't be developed. Also, there has been some concern over whether the EU was going to water down its environmental commitments as part of its bid to revive a flagging EU economy although this relies on a false dichotomy of environment vs economic gain whereas in fact the former is vital for the latter in the long term.

Ultimately, the fate of the marine environment, as for the environment as a whole, will be related to what the public (and therefore the politicians) finds acceptable. Will people really want to go back to a time when the UK gained its infamous moniker 'the dirty man of Europe'? The sea-using public are now used to cleaner seas and beaches and it is this fact that may provide some grounds for optimism and why we in the marine community have a duty to help make clear arguments for the marine environment and continue to provide high-quality science to decision-makers.

Matt Frost (matfr@mba.ac.uk) is Deputy Director at the MBA.

Sunstar (*Crossaster papposus*) and black brittle star (*Ophiocomina nigra*) at the Horn, St Abbs, within Berwickshire and North Northumberland Special Area of Conservation, a European Marine Site designated under the EU Habitats Directive. Image Keith Hiscock.

1 https://www.theguardian.com/politics/2016/jun/02/rspb-wwf-urge-vote-remain-eu-referendum-protect-uk-wildlife.
2 http://www.bbc.com/news/uk-england-devon-37198688
3 Marine legislation – The ultimate 'horrendogram': International law, European directives & national implementation. Boyes, S.J. & Elliott, M. *Marine Pollution Bulletin*, 86 (2014) 39–47

Brexit and the UK fishing industry

After 43 years of European Union membership, the UK fishing industry welcomed the Brexit vote. *The Marine Biologist* interviewed **Jim Portus**, Chief Executive Secretary of the South Western Fish Producers Organisation (SWFPO) for his view of the future of the UK's fishing industry and marine environment.

What are the main threats and opportunities for the industry?

There are risks in the Brexit negotiations of the industry being worse off. We have to make sure that benefits go to UK fishing, not to other industries. We mustn't relive the '70s when the industry was a political pawn to be bargained away. British fishing was sold down the river. So long as industry is consulted and the Minister responsible for fisheries takes notice there are golden opportunities.

Specific changes the industry wants to see include improved access to quota species, exclusive access to the 12-miles zone, and for the UK to get a seat at the North East Atlantic Fisheries Commission (which decides allocation of North Sea mackerel amongst other things).

What parts of the CFP will you be most pleased to see the back of?

The industry is not anti EU but the CFP has damaged UK fishing communities. Brexit needs to end the allocation system of relative stability. It seems reasonable to fish within MSY (Maximum Sustainable Yield) limits, but the UK must have preference to harvest stocks found primarily in UK waters. The UK should also dictate the pace to MSY and ensure the Landing Obligation, if it is retained, cannot cause more harm than good.

Are there any aspects of the CFP future UK legislation should keep or learn from?

The value of crabs and scallops has gone up and the static and mobile parts of the fleet have grown to appreciate the benefits of limits on days at sea, making money efficiently when price and quality of fish is right. Effort limitation may be a better control mechanism than fish quotas.

Another aspect of the CFP to keep or copy is the Common Market Organisation. Currently the UK producers organizations, like SWFPO have a legal identity in the EU, but not in the UK. Industry would like to see transfer of legal identity into UK legislation.

We mustn't relive the '70s when the industry was a political pawn to be bargained away. British fishing was sold down the river.

How is the industry progressing on developing its vision for fishing post Brexit?

There are differences of opinion between Scotland and England (and the same goes for Wales and Northern Ireland) as fisheries have been a devolved competence for several years. Recently, a House of Commons Committee heard from the National Federation of Fishermen's Organisations and from the Scottish Fisheries Federation, about their aspirations for the industry. In the view of the Scottish industry, the UK should ensure that all fish in the UK EEZ are available for UK fishers (meaning less for other EU nations) and for there to be negotiated access for foreign vessels. The NFFO has a more measured approach, with the view that the industry post-Brexit is likely to continue on the same trajectory as at present. For SWFPO the retention of the status quo as NFFO envisages would betray the millions who voted for Brexit.

Is the government looking to industry for input?

Finding common ground between what the industry wants and what other member states will accept is going to be a long, drawn-out process.

Image: Keith Hiscock

The UK wants to continue trading fish in the EU and beyond. The industry would urge politicians not to trade away geographical access to fisheries in exchange for access to markets, unless there are equal, reciprocal access arrangements.

What effect do you think Brexit will have on the relationship between the UK fishing industry and marine science?

Historically the fishing industry has had good relations with the academic sector, but I have seen that get smaller as research institutes and statutory agencies have suffered cuts in money and human resources. In particular I would like to see the relationships with Cefas and Marine Scotland be pumped up again.

We really do need to support our research institutions, they need to flourish and we need to influence politicians in where they put the money that went to Brussels.

Let us not forget that each fishing vessel is a potential research platform, and fishers are willing to play their part as amateur fisheries scientists.

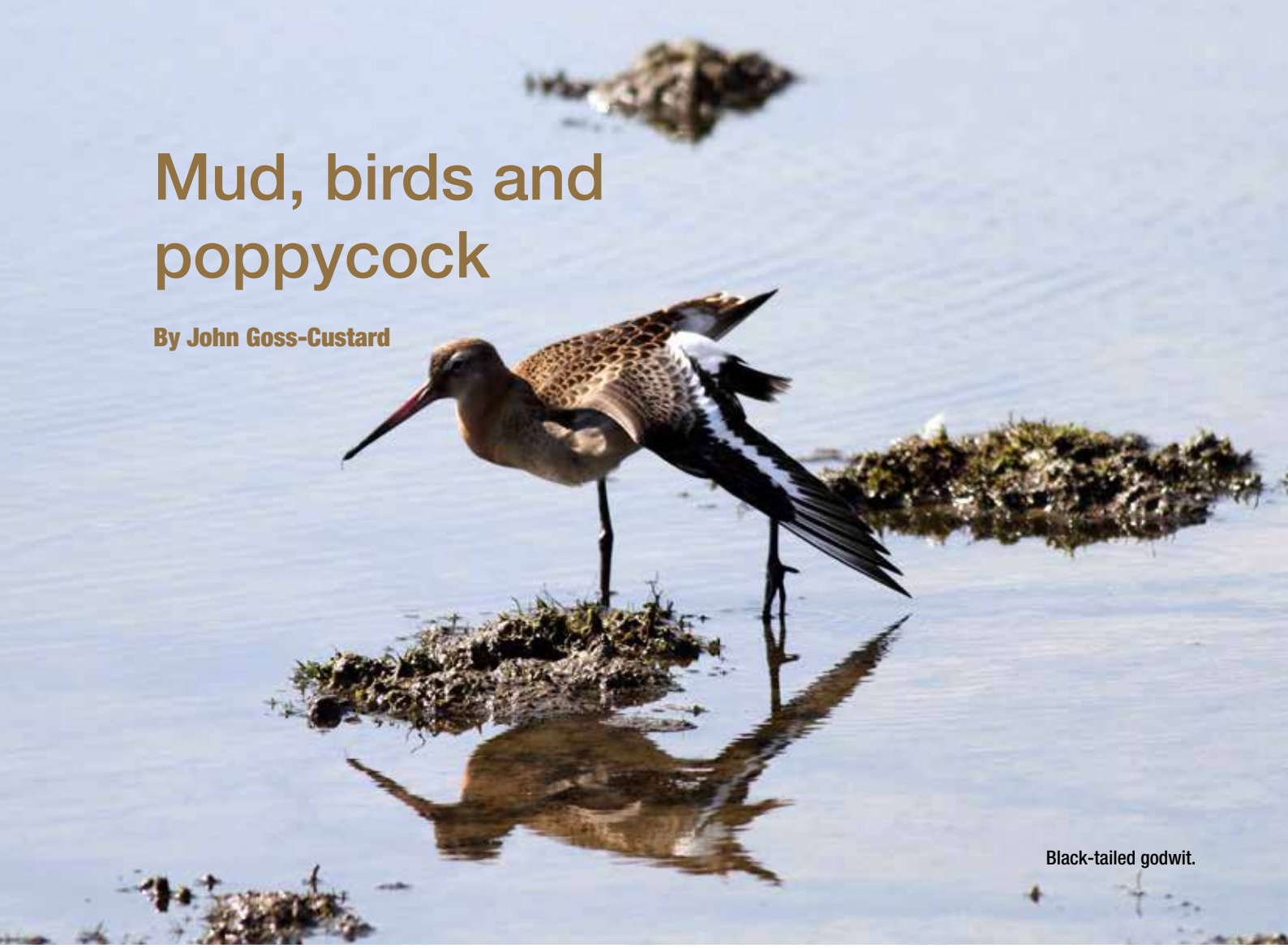
Overall, do you think Brexit will be good or bad for the UK marine environment ?

Overall, I am optimistic for the catching sector, and the maintenance and improvement of the marine environment.

Jim Portus (swfpo@btopenworld.com)

Mud, birds and poppycock

By John Goss-Custard



Black-tailed godwit.

Are all human activities on the coast damaging to nature? Shorebird scientist, **John Goss-Custard** says that conservation dogma and inappropriate application of European Union rules have sidelined good science and distorted the system for assessing impacts and risks.

Shorebird conservationists insist correctly that our coastal flats are vital to the survival of hundreds of thousands of shorebirds, and the UK is committed to their protection by EU Directives and national legislation. Unfortunately, the regulations are sometimes applied in a way that suggests that many shorebird conservationists have come to believe that any human activity on the coast is bound to be detrimental. Although anthropogenic activities can indeed degrade shorebird feeding grounds, this does not mean that all human activities necessarily do so, every time and everywhere.

Most shorebirds occur in the UK from August to April when on migration or over-wintering. When exposed by the receding tide, intertidal flats provide food: most wildfowl eat invertebrates but some are herbivorous. Perhaps the best environmental management issue with which to illustrate the culture that underpins the approach of many shorebird conservationists is disturbance due to dog-walking, kite-surfing, etc. These activities are often viewed as self-evidently damaging to shorebirds. As a result, Environmental Impact Assessments (EIAs) seem more often designed to collect enough information to support a preconceived concern than rigorously to test the hypothesis that disturbance actually harms shorebirds, which is what good ecological science should do.

This is the biology of the issue. Shorebirds must survive until spring with sufficient body reserves to migrate to their breeding grounds. Birds that fail to do so may not even survive the journey let alone breed successfully. Disturbance during the winter could reduce survival and body condition as follows: flying uses energy, so being disturbed into flight increases birds' daily energy demand; as shorebirds cannot feed while flying, disturbance reduces the time available for feeding, and disturbance concentrates birds in disturbance-free areas—often of poorer quality than the ones vacated —where the increased density may intensify competition. Disturbance therefore increases the birds' energy requirements while making it harder for birds to meet them.

Acknowledging that disturbance affects the birds does not mean, however, that it necessarily has a significant

impact, that depends on the severity of the disturbance. One occasional dog-walk may momentarily affect the behaviour of nearby birds but would be too trivial to have a significant impact on their survival and body condition. But if dogs occurred continuously in all areas, night and day, it almost certainly would. Whether there is an impact depends on the amount of disturbance—its frequency, intensity and duration. And if there is no impact, the so-called and much-debated notion of the 'integrity' of the site—invoked to protect the site's features of interest (e.g. shorebirds)—will not be affected either.


A curlew feeding on a ragworm.

The main challenge for the objective shorebird ecologist is to identify the threshold at which increasing disturbance (or other environmental change) begins to have an impact rather than merely an insignificant effect. This approach is by no means always adopted. Often, only eye-catching behavioural effects are measured, like the distance at which birds take flight as people approach and how far they then fly. Frequently disturbed patches of mud are shown to have fewer birds than undisturbed ones without any attempt being made to assess whether this re-distribution has a significant impact on the birds. Maps show that one kite-surfer may range over a large area, the untested implication being that much foraging space is thereby denied the birds for significant amounts of time. Observations show that flocks of shorebirds may make a major disturbance flight about once every daylight hour without testing whether this causes the average bird to lose significant amounts of time and energy. The inference from all these observations is that the natural activities of the birds are so badly affected by disturbance that there simply must be an impact on the birds' survival and body condition.

Environmental Impact Assessments seem more often designed to collect enough information to support a preconceived concern than rigorously to test the hypothesis that disturbance actually harms shorebirds

This approach can give a distorted impression of the disturbance experienced by shorebirds. It focuses attention on the occasions where people and birds occur together while overlooking the sometimes many other circumstances where they do not. Most shorebirds feed for most of the time in places and at times where the risk of being disturbed is low. Most feed in the muddy areas that most people avoid. Over high tide when most water sports are carried out, most shorebirds are feeding or roosting elsewhere because the tide covers their feeding grounds. Few people visit intertidal flats at night when most shorebirds also feed—some preferentially. Disturbance often makes a bird bring forward a flight it would have done later anyway to reach better feeding areas downshore as these become exposed on the receding tide. Once birds have been disturbed from an area by the first few people to arrive, there are few, if any, left to be disturbed subsequently, however many more people arrive. A false impression is often given that shorebirds and people are not as segregated in time and space as actually they often are.

How has such questionable research come to be accepted as sufficient for devising policies to 'manage' recreation disturbance in coastal areas? I believe that there are three reasons: (i) the culture of many conservationists and their supporting ecologists; (ii) the ecological and scientific naivety of some decision-makers, and (iii) the over-enthusiastic application of the Directives' precautionary principle.

i. Culture

Perhaps exacerbated by the assertions of powerful, single-issue pressure groups, the constant repetition of the mantra that shorebirds are 'sensitive' and live in 'fragile' habitats has fostered the belief that anything people do simply must harm the birds. The evidence shows that this is by no means always the case: indeed, human activities on estuaries can sometimes benefit shorebirds and can even be managed to do so, as the farming of intertidal mussel beds in the Menai Strait has demonstrated. Yet many shorebird ecologists seem to feel that their research should support the preconceived concerns of shorebird conservationists. Conservation is the good cause that provides a shared *raison d' être* for many shorebird ecologists and conservationists.

An anecdote illustrates the expectation some conservationists have of their scientific colleagues. I advised that the removal of Cardiff Bay mudflats under a fresh-water lake created by a barrage across the mouth of the River Taff would put at risk the shorebirds that fed there, even though they could feed on the adjacent Severn estuary. I was asked whether anything could be done to mitigate this impact. My solution was to puncture a nearby seawall alongside the main Severn estuary to convert the adjacent field into a mudflat. This 'lagoon' would have remained accessible to the birds for some 30–40 minutes after the estuary itself had been covered at high water on spring tides because its narrow entrance would have delayed the incoming tide. This would have extended the birds' intertidal feeding time, probably to their great benefit. After a public consultation meeting, I

was berated long, hard and very publically by three enraged conservationists; apparently I should never have proposed anything that might have undermined their case against the barrage. Such arrogance! As a scientist, I had no right to attempt to distort public decision-making by selective use of knowledge that had been largely acquired at public expense.

ii. Decision-makers

The second reason that this doctrine has taken hold is the naivety of some of those making decisions on matters that demand a good grasp of the science. It is not difficult to raise doubts that the 'science' is uncertain when some of them seem to know rather little about the scientific method in general and shorebird ecology and population dynamics in particular. See, for instance, some cases histories in Jones, G. (ed.) 2012. *The Habitats Directive: a Developer's Obstacle Course?* Hart Publishing.

the precautionary principle loads the dice in favour of those who view human activities on estuaries as inevitably damaging to shorebirds

iii. Precautionary principle

The last and, I suspect, over-riding reason lies with the EU Directives themselves, and in particular, the precautionary principle. This loads the dice heavily in favour of those who view human activities on estuaries as inevitably damaging to shorebirds. In scientific research, conclusions are presented in probabilistic terms. Scientists know that new ideas or new data may at any time challenge their current understanding. In such an open, self-critical and self-effacing intellectual climate, it is not difficult to raise enough doubt for the precautionary principle to be invoked.

This is the fundamental contradiction: the Directives require that science be used to evaluate an impact but don't encourage the use of a fundamental concept of scientific judgement—probability. A very strong scientific case that there is minimal risk of significant damage to the birds can be ignored simply because someone says: 'We hear what you say but we have to be precautionary. Sorry!'

The precautionary principle is all well and good when there is uncertainty about impacts, when the risk, though low, is not negligible and the potential cost to conservation is high. But to apply the principle without a careful balancing of the magnitude of the risk against the magnitude of the consequences is an abuse of the principle—and it is not what it is meant to achieve. Its use is supposed to be 'proportionate' whereas, in practice, its use can seem absolutist instead. To demand, in effect, zero risk simply demands impossible science.

In fact, it sometimes feels as if just enough research is done to raise sufficient doubt to enable the precautionary principle to be invoked. On these occasions, contrary scientific evidence appears to be something to get around rather than to be used to assess risk. The approach of the objective scientist, however, should be rigorously to test the hypothesis that bird survival and body condition are likely to be decreased by disturbance and, importantly, to evaluate the risk that this will happen. But too often, discussion descends into a legalistic concocting of just

Greenshank.


Oystercatcher.

believable scenarios rather than an objective appraisal of the evidence. This is made possible by the exaggerated implementation of the precautionary principle. The process seems often to be more of an exercise in absolutism than an objective assessment of the magnitude of the risk.

An example: On the Exe estuary, a levy is being charged on every new dwelling built within 10 km of the estuary to provide 'mitigation'—of questionable and (to a scientist, disgracefully) untested effectiveness—for the impact that additional disturbance from the new householders may have on shorebirds. This has caused extra costs and delays in the provision of much-needed dwellings. What worries me most is that it also increases the frustration with shorebird conservation.

My own independent and self-funded research has thrown overwhelming doubt on whether any mitigation is necessary because so little shorebird feeding is done in places and at times when there is a risk of disturbance. Additionally, Bournemouth University's (rightly cautious) model of shorebird disturbance in a Southampton Water—in terms of shorebirds, very similar to the Exe—showed that it would require huge numbers of people for there to be a significant impact on the Exe estuary shorebirds. It would take 15,000–30,000 people to visit the Exe estuary regularly to reduce shorebird survival; that is 10–20% of the entire population of the region. Needless to say, nothing like this number has, or ever will, occur there. Instead of employing an over-precautionary approach, the risk to shorebirds should have been assessed as being so minute as to be, for all practical purposes, non-existent.

Ecologists should have no tolerance for this culture of blinkered eco-negativism. It infringes the civil rights of people if they are prevented without good reason from carrying out otherwise perfectly legitimate activities on the coast. Objective, hypothesis-testing, ecological science should always be done to make intelligent risk-assessments of where mitigations really are both necessary and effective. Members of the public are becoming increasingly sceptical that mitigation funded by an enforced levy and restrictions on their activities are justified by the evidence: 'Why are birds more important than people' I often hear said. Such mounting anger threatens long-term support for a good cause.

John Goss-Custard (johngc66@googlemail.com)

John Goss-Custard BSc PhD DSc was a professional shorebird scientist for 40 years, for most of that time being employed by the Natural Environment Research Council, latterly as senior Individual Merit scientist. Over thirty years, he and his colleagues developed and tested individual-based models of shorebird populations that predict the impact of a whole range of human activities—ranging from shellfishing through barrage construction to recreational disturbance—on the birds' survival and body condition over the non-breeding season. He has described this approach in a non-technical account 'Birds and people: resolving the conflict on estuaries' which can be downloaded to an iPad, Kindle etc. at: http://www.amazon.co.uk/dp/B00JMCBBQO/ After his retirement, he became Visiting Professor in the School of Applied Sciences at Bournemouth University, where the models are continuing to be developed and applied to a much wider range of animals and issues by the research team led by Professor R A Stillman.

Acknowledgements: the title was inspired by *Mud, Blood And Poppycock* by Gordon Corrigan, with permission from The Orion Publishing Group.

This article was first published in the *Bulletin of the British Ecological Society* (BES), June 2016. I am grateful to the BES for permission to reprint it.

I would like to thank Professor Mike Begon of Liverpool University for excellent advice on how to improve the wording. Also, my grateful thanks to the 20 or more very experienced colleagues who read various drafts, with especial thanks to those (about half) who replied, all of whom said that their experiences coincided with mine. Thanks also to the other half who did not reply and so did not retort that I must have been unlucky and my experiences singular.


A redshank struggling with a large ragworm.

A diver recording in the Manacles Marine Conservation Zone, Cornwall, UK. Image: Mark Webster www.photec.co.uk

Seasearch: a shift in focus

Seasearch volunteer divers provide a valuable service, increasing our knowledge of the UK's sublittoral and supporting the Marine Conservation Zone process. By **Chris Wood**.

The UK has created a, sometimes bewildering, range of mechanisms to manage and protect marine habitats and species: Marine Nature Reserves, Special Areas of Conservation (SAC), Natura 2000 sites, Marine Conservation Zones (MCZs) in England and Northern Ireland, Marine Protected Areas (MPAs) in Scotland and Ramsar sites all play or have played their part in the aim of creating an 'ecologically coherent network of Marine Protected Areas'. The major part of many of these designations lies underwater but the collection of anything other than broad scale data about them remains both expensive and incomplete.

Seasearch is a volunteer-based programme for recreational SCUBA divers which collects sublittoral habitat and species data and makes it widely available to government, managers, non-governmental organizations, academics and the general public. Since its inception in 1988, involving cooperation between the Marine Conservation Society, the former Nature Conservancy Council and Scottish Natural Heritage, Seasearch volunteer divers have provided 480,000 species and 59,000 habitat records from over 16,450 survey dives all around England, Wales, Scotland, Northern Ireland, the Isle of Man, the Channel Islands and the Republic of Ireland.

The volunteers have two main motivations in taking part. One is to learn more about the marine environment they enjoy as divers and the other is to contribute something useful to its protection. Seasearch aims to meet both aspirations. It provides the learning experience divers are looking for through its training programme and qualification process, as well as by providing identification guides and access to a network of experienced recorders. Divers contribute to protection by joining targeted surveys organized by the project and receiving feedback on the results.

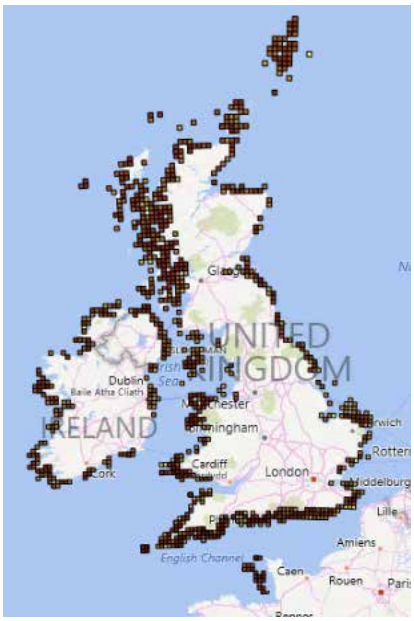
Because of the low level of information available, the initial focus for recording was to fill gaps in existing knowledge. In some areas (notably much of the eastern coasts of England and Scotland), all the information was new. Elsewhere, particularly in south and south-west England, the priority was to fill in gaps between the better-known areas. This data has been a valuable contribution to informing the process of SAC designation and the MCZs/MPAs processes in England, Scotland and Northern Ireland. Seasearch data was one of the more detailed sources available to the four regional MCZ bodies set up in England and has

allowed the formulation of third party proposals by the Marine Conservation Society and others in Scotland and by Seasearch itself in Northern Ireland. The availability of Seasearch data has also helped the formulation of management measures to protect sites from trawling and dredging.

Now the focus is changing to providing data to assist in the surveillance and management of the network of MPAs. The level of funding of 'official' monitoring programmes will only provide a picture of the success or otherwise of management measures at long intervals. Volunteer divers can provide eyes and ears on what is taking place at more regular intervals and allow both the agencies responsible for management and the non-governmental bodies to act or lobby for action as appropriate.

Volunteer data needs to be credible if it is to be useful. The Seasearch training programme helps to establish and maintain standards and concentrates on the recording on habitats, whilst the series of identification guides and informal network of experts are invaluable to obtaining accurate species data. Data is validated locally, entered into the Marine Recorder database by experts, and verified nationally before being released both to the government bodies and to everybody else via the National Biodiversity Network (NBN).

An example of how this new role can work in practice came in 2015 when there was a proposal for substantial harbour works associated with the re-opening of a stone quarry on The Lizard Peninsula in Cornwall, within a MCZ. The MCZ was intended to protect both rock and sediment habitats and contained a number of important species including pink sea fans, sea fan anemones, spiny lobsters, stalked jellyfish and maerl. The MCZ focused on the Manacles Rocks, for which there was much Seasearch and other data, but the area which could be potentially directly impacted by the proposals was less well known. Seasearch worked together with Porthkerris Divers (a local dive operator), the Marine Conservation Society, Cornwall Wildlife Trust and Exeter University to undertake a series of diving surveys specifically aimed to increase the data available. 40 dives were undertaken and new sites for all of the priority species and habitats were identified by the volunteer Seasearch divers. At the time of writing the proposed development has not been pursued, but the new data is being incorporated into a Seasearch Report of the survey, which will be available to all, and go directly to Natural England to inform any actions that may need to be taken in the future.



National Biodiversity Network (NBN) map of Seasearch and Marine Conservation Society data 1977–2014.

Whilst collection of data using volunteer divers is apparently very cost-effective, it depends entirely on the motivation of the divers themselves and their ability to put their own time and money into surveying. It is essential to maintain a training system, organize diving surveys, have a rigorous quality assurance and data entry process, and distribute the data. Seasearch receives support at national level to meet these costs from Natural England, Natural Resources Wales, Scottish Natural Heritage and the Marine Conservation Society, and at local level from all of these as well as County Wildlife Trusts and a variety of other local funders. However, funding to maintain a now long-established project has become more difficult rather than easier and external support has reduced rather than increased in recent years. The divers remain as enthusiastic as ever.

Chris Wood (chris@seasearch.org.uk) former National Coordinator for Seasearch at the Marine Conservation Society.

Spiny Lobster (*Palinurus elephas*), a species for which the aim of Marine Conservation Zone (MCZ) designation is to 'recover to a favourable condition', near Dean Quarry, Manacles MCZ, Cornwall, UK. Image: Chris Wood.

Can Okinawa's blue corals be saved?

Bonnie Waycott reports on efforts to conserve a unique marine community of Ishigaki Island, Japan.

Shiraho village in Okinawa's Ishigaki Island is known for its 12 km stretch of coral reef. The ecosystem is home to a variety of species, including a community of blue coral that is said to be the oldest in the northern hemisphere. Glass-bottomed boats are a regular sight, while snorkelling trips are a popular activity.

Locals call the reef by two different names: the Sea of Treasure, because it was a rich source of food after the war; and the Sea of Survival, highlighting its struggles against human activity and climate change. The reef plays a big part in the locals' lives. It is celebrated at traditional rituals and

festivals, it's a natural form of protection during typhoons and pieces of dead coral have long been used as building materials, for example in walls surrounding homes.

Natural influences on the reef include typhoons, coral bleaching and crown-of-thorns starfish. But human impacts, for example, excessive nutrients, increase of household effluents, land reclamation and tourism have had a significant negative impact on the ecosystem. Of particular concern are the impacts of Ishigaki Airport, which opened in 2013, with reports of noise pollution, chemical waste and a loss of coastline vegetation. Despite government information that marine life is not affected, many at Shiraho are doubtful. Another grave threat is farming along a nearby river. Vast tracts of wild vegetation have been replaced by agriculture, and heavy rainfall leads to a run-off of red soil into the sea. Since Okinawa's return to Japan in 1972 there have been an increasing number of public works projects, including agricultural land improvement schemes in Shiraho, further worsening the reef's condition.

In response, WWF (World Wildlife Fund) Japan inaugurated the Shiraho Coral Reef Conservation and Research Center, or Shiraho Sangomura (Shiraho Coral Village) in 2000. Staff and volunteers have been investigating species diversity and monitoring red soil run-off by testing water samples. They have also launched a programme to plant shellflower or getto, a species of ginger (*Alpinia speciosa*), to stop red soil from flowing into the sea. Locals have even used the plant to develop a fragrant room spray, selling it at a regular Sunday market. Also on offer are local delicacies as well as ornaments made from shellfish and coral, with part of the proceeds going towards coral conservation. The reef has been restocked with giant clam juveniles from a hatchery to increase the area's resources and provide an attraction for snorkellers, while regular meetings provide an opportunity to think about balancing the conservation and sustainable use of resources in areas where human interaction with the ecosystem is significant. Attendees are encouraged to share their own ideas as an example of regional and community cooperation. Tourism guidelines and lecture programmes have also been established and protected areas created.

Although much time and effort is required to ensure the reef's survival, Shiraho Sangomura hopes that its work will serve as an example to the rest of the world, and that people will continue to appreciate its precious ecosystem in the days and years to come.

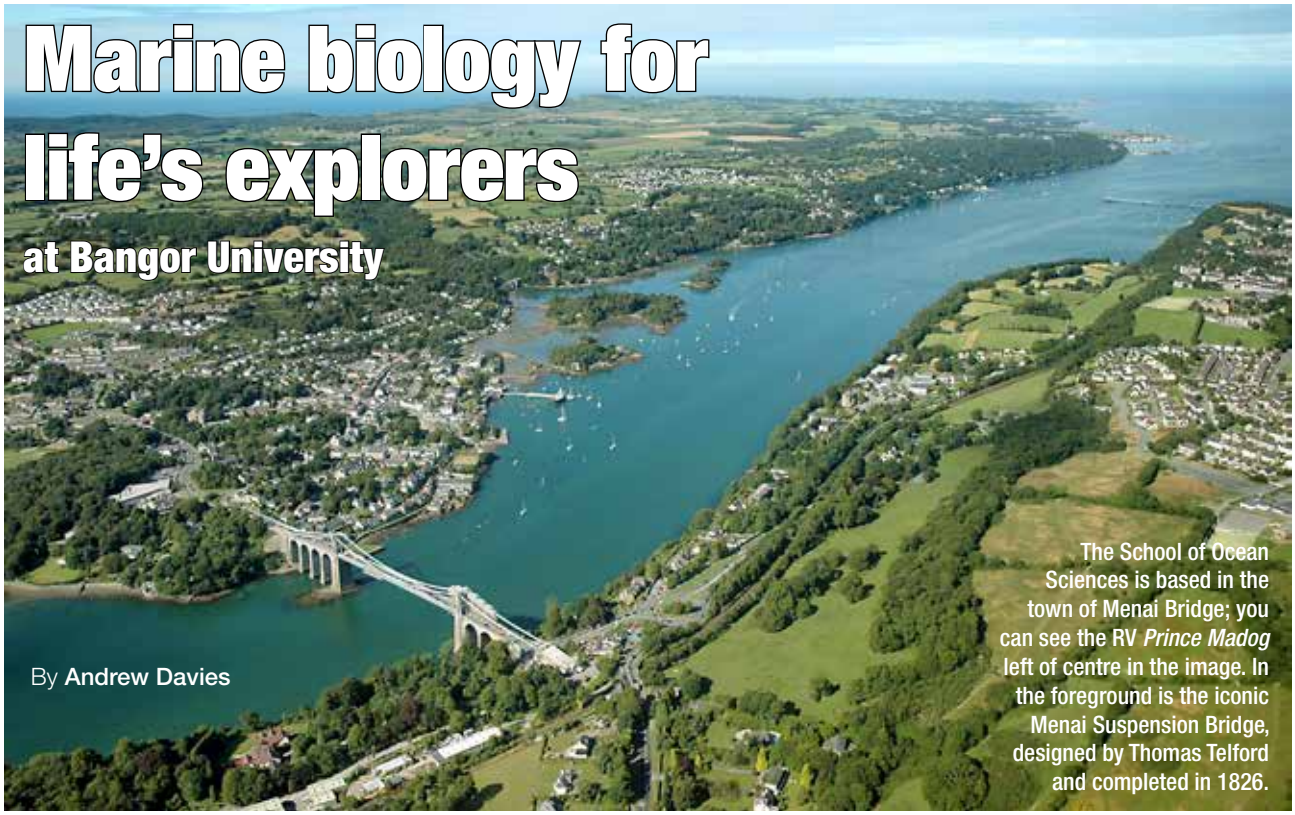
Bonnie Waycott (bonniewaycott@gmail.com), Mem.MBA

Studying marine biology

As part of our regular series on where best to explore marine biology, Senior Lecturer Dr Andrew Davies describes what's in store for undergraduates at the School of Ocean Sciences at Bangor University.

Marine biology for life's explorers

at Bangor University



The School of Ocean Sciences is based in the town of Menai Bridge; you can see the RV *Prince Madog* left of centre in the image. In the foreground is the iconic Menai Suspension Bridge, designed by Thomas Telford and completed in 1826.

By **Andrew Davies**

Nestled between the mountains of Snowdonia and the award-winning blue flag beaches of Anglesey, the School of Ocean Sciences at Bangor University offers one of the most picturesque university settings in the UK.

We have offered courses and conducted research across the spectrum of marine sciences for over six decades, in a truly multidisciplinary department that hosts academics from the fields of chemistry, physics, geology, geography and biology. It is this combination of location, multidisciplinarity and long-term experience that has led to The School of Ocean Sciences (SOS) educating and guiding many successful graduates, 3,000 of whom we remain in contact with through our vibrant alumni community.

SOS prides itself on combining world-leading and novel cutting-edge research with exciting and engaging teaching, that combined, produce students that have been trained to become the next generation of marine scientists with the knowledge and skills to build successful careers in the marine science sector.

The RV *Prince Madog*, Bangor University's ocean-going research vessel.

Location and facilities

Location is pivotal when it comes to the study of the marine environment. SOS is a stone's throw away from the Menai Strait, where we live and breathe the sea every single day. Our research vessel, the RV *Prince Madog*, is moored on our pier and is a prominent presence in the waters of the Irish Sea. On Anglesey, we have access to a beautiful rural coastline with sandy beaches, rocky shores, dramatic cliffs and small bays, each with their own enigmatic organisms from crabs to limpets to seabirds and marine mammals and dynamic oceanographic and geological conditions. A short walk over the iconic Menai Suspension Bridge leads to Bangor, a small and safe city that offers many of the amenities found within larger cities.

Whilst North Wales may seem remote, Bangor is actually very well connected to main transport routes though regular trains to London (3.5 hours) and the A55 dual carriageway that is connected to the M56/M6 motorways (Manchester 1.5 hours by car).

SOS comprises a cluster of buildings, nestled amongst the bustling town of Menai Bridge, that have been there since the 1950s. This now

Students learning how to survey a rocky shore in north Anglesey.

includes the new Marine Centre Wales, recently opened by HRH the Prince of Wales, and is a unique focal point for the marine business sector in Wales. Its lecture theatre hosts some second and third year undergraduate teaching, whilst practical work is accommodated in large and well-equipped light and airy dedicated teaching laboratories in the Craig Mair Building. Students make the most of being based so close to the sea as they regularly collect organisms for observation, either by walking to the shores in the Menai Strait or by short coach journeys around the island and thus maximizing time in the field and in the laboratory. Being local drastically reduces our carbon footprint whilst ensuring that collected living material is studied in pristine condition.

SOS is one of the few university departments in the UK to house a wide spectrum of aquaria supplied with flowing seawater directly from the sea, not recirculated, providing an excellent environment for maintaining and growing marine organisms. These facilities are available for student research projects, summer bursary placements and the volunteer schemes that are run to enhance student experience and skillsets.

SOS is also one of the few university departments in the UK with its own dedicated ocean-going research vessel. Our vessel supports our seagoing scientists and is a vital tool used in our teaching. During a degree at SOS, you will have the unique opportunity to gain real seagoing experience on board the RV *Prince Madog*. Depending on your degree you will conduct fish surveys, deploy oceanographic sensors, learn about marine mammal monitoring and/or undertake multidisciplinary research.

Teaching key interdisciplinary skills

SOS staff place great emphasis on teaching our students practical skills, as well as literacy and numeracy, ensuring that they leave with the skillsets that are in demand by employers and that they have built the confidence to use these in their future careers. These include computational, observational and experimental skills, and depending on degree, may include elements such as taxonomy, designing experiments and using state-of-the-art oceanographic and geophysical equipment. Our degrees can be categorised into biological (e.g. Marine Biology, Marine Vertebrate Zoology, Applied Marine Biology, Marine Biology and Zoology), physical/geological (e.g. Geological Oceanography, Marine Geography, Ocean and Geophysics, Physical Oceanography) and multidisciplinary (e.g. Marine Biology and Oceanography, Marine Environmental Studies, Ocean Science), and can be taken as three-year Bachelor of Science, or as a four-year extended degree such as Master of Science or research experience with industry (Applied Marine Biology). All our degrees can be combined with an international year abroad.

Over many decades, SOS has developed into a truly unique learning environment. It is collegiate, cohesive and inclusive across everyone in our department, from staff to students. Our academics are highly approachable and supportive, and build lasting academic relationships with our students. After all, we all share a passion for the marine environment.

We are well aware that the landscape of universities and careers is changing, so we place an emphasis on employability, offering careers advice, CV writing workshops, interview skills training and we frequently invite alumni to SOS to enlighten our undergraduates about the latest developments in national and international industries, placements and research.

Bangor is amongst a select group of universities that achieve excellence in both teaching and research. Three years in succession we have been rated amongst the top 15 universities in the UK for student satisfaction in the National Student Survey, with high scores for our provision of teaching, academic support, personal development, and assessment and feedback. We offer free membership to Bangor's Students' Union's clubs and societies, and with over 150 of them there is bound to be something to everyone's taste. We also guarantee a room in our student halls of residences to all first-years who apply before the given UCAS deadline. In addition, market research shows that the cost of living in Bangor is much lower than in other parts of the UK—Bangor has been described as "one of the cheapest places in Britain" to be a student (The A–Z of Universities and Higher Education Colleges). Finally, our research excellence has been confirmed in the national assessment of research quality (REF 2014), in which 77% of Bangor's research was rated either world-leading or internationally excellent, ahead of the average for all UK universities.

For those of you who are thinking of undertaking a degree in marine science, consider what you want to gain from university. If you want to experience excellent teaching and research within a unique setting and be part of a substantial and successful alumni, then Bangor may be a destination for you. You are the future of our discipline and our aim is to train you to be the next generation of gifted marine scientists.

Andrew Davies (andrew.j.davies@bangor.ac.uk)
School of Ocean Sciences, Bangor University,
Menai Bridge, LL59 5AB, Wales

And the winners were ...

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

Can we all just get along? Fiddler crabs show us how.

On a small and remote island in the Wakatobi National Park, Indonesia, ten species of fiddler crab have been found living on the same mudflat; one of the highest species diversities ever recorded.

This remarkable level of biodiversity has been used by researchers at the University of Portsmouth to understand the mechanism of this coexistence and use this knowledge to further conservation of delicate and complex ecosystems in a time of rapidly changing climates and seas.

A male fiddler crab *Uca tetragonon*. Image: Laura Michie.

Fiddler crabs are gregarious animals which are often found living in groups of hundreds or thousands. They are most often characterized by their bright coloration and the extreme claw asymmetry exhibited by males. Through studying their morphology, behaviour, and the habitat structure in the Indonesian National Park, researchers found that these crabs occupy separate niches whilst still existing in close proximity. The success of this coexistence is helped by minor differences in the mouthparts which results in each species feeding on different substrates. This type of resource partitioning is a stabilizing mechanism whereby competition between species is reduced because they compete for different resources. Fiddler crabs, being deposit feeders, obtain their food from sifting through sediments and extracting organic matter. This research site is at the fringe of a mangrove and on the edge of a small village. Due to this close proximity to the local village, the substrate has a high organic content, meaning a greater food supply and the crabs can even be seen living underneath the stilted houses. The human exploitation in this area is directly altering the environment, allowing crabs to dwell in places that would otherwise be uninhabitable. This stabilizing mechanism is supported by behavioural observations, showing very little competition between species, despite overlaps in territory.

This high level of diversity shows that when considering species conservation options, an entire ecosystem must be investigated.

Laura Michie

MICRO 2016, Lanzarote, Spain

MICRO 2016 was an experience of many firsts: my first conference, presenting the work from my first paper, and the first international conference dedicated purely to microplastics. The conference was set in beautiful Lanzarote in the Canary Islands. The venue, which was only a stone's throw from the ocean, hosted scientists and activists alike to discuss the ever-growing microplastic issue. Microplastics in the environment are making the ocean into what some have termed a 'plastic soup'. Here they have the potential to transport pollutants or be ingested by marine biota, with no current solution for their remediation. The conference provided

Delegates at the MICRO 2016 conference, Lanzarote, Spain 25–27 may 2016.

an opportunity to share available knowledge, identify new questions and research needs, and explore solutions.

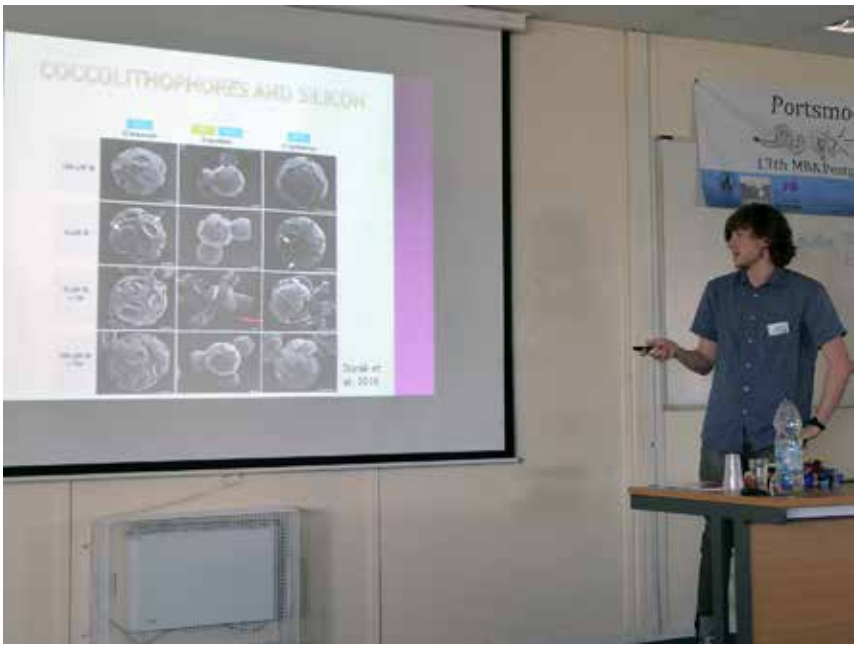
At the conference, I was able to present my work on 'The Characterisation, Quantity and Sorptive Properties of Microplastic Extracted from Cosmetics'. It was a fantastic opportunity to publicize the research that the marine litter research team have done at Plymouth University, and also network with others working on similar research. There was a lot of variety between the sessions, which included presentations on the involvement of citizen science and exploring the public's perception of microplastics in the news. All the work presented was then used to form the Lanzarote Declaration, which summarizes all the research from the conference, specifically highlighting the need to research more solution options.

Overall, my expectations of this conference were more than exceeded. I am extremely grateful to have been involved in the first microplastic conference, and I have left with a feeling of great motivation to continue microplastic research!

Imogen Ellen Napper

The 13th MBA Postgraduate Conference, Portsmouth

I used the MBA student bursary fund to help fund my attendance at the 13th MBA Postgraduate Conference, hosted by the University of Portsmouth. Friends of mine had attended the previous year's conference in Belfast and spoke very highly of it so myself and six of my course mates registered to attend and present the results of our master's research projects. The conference was a very well organized event by the PhD students of Portsmouth, with talks and posters presented by students intermixed with keynote speakers and workshops focusing on how to successfully utilize social media as a scientist. A great diversity of talks and poster presentations were on show, addressing a range of questions from mapping sharks in the Irish Sea and



fiddler crab diversity in Indonesia to investigating the effects of radiation on crustaceans and the potential identification of new species of diatom and mussel. Mostly very different from my own research knowledge but similar talks were grouped together usefully to allow a greater degree of comprehension. Talking to the student and keynote presenters afterwards was also highly beneficial in giving an insight into academia at different points of a scientist's career and advice for how to progress in the field.

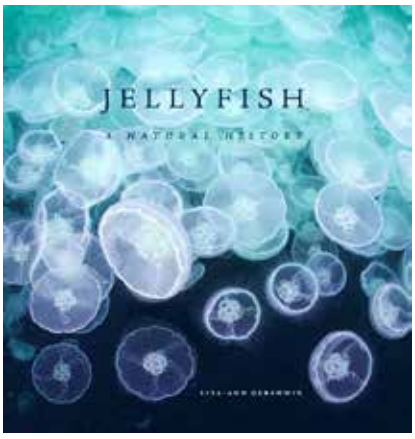
For me, the highlight was the chance to give a talk on my master's research project, 'Do Foraminifera need silicon to calcify?'. This was the first time I had presented work to a majority unknown audience. While initially unnerving, I enjoyed the opportunity and I received a positive reception to my talk and useful feedback regarding possible areas of investigation for my project and presentation style. I now feel much more able to give future presentations and able to communicate my findings more clearly.

In conclusion, attending the conference was a great success and I look forward to attending more scientific conferences which hopefully will be just as successful as this one.

Jack Dickenson

Reviews

Jellyfish: A Natural History



Author: Lisa-Ann Gershwin
ISBN:13:978-0-226-28767-6
Published by: University of Chicago Press

I think I have been stung by jellyfish more times than not when going for a swim in UK waters, perhaps more so in the Mediterranean, and when it comes to the Pacific nothing could match the swipe of tentacles of the Portuguese-man-o'war (not strictly a jellyfish), the pain of which threw me out of the water. Despite a feeling of being persecuted by jellies throughout my life I still find them fascinating

and beautiful. They are also very much misunderstood often hitting the headlines for all the wrong reasons. My first close-encounter-of-the-jelly-kind was in the chilly waters of the Northumbrian coast where I learned to swim as a child. Moon and compass jellies were regularly stranded, they were beautiful enough but it was the first time I witnessed the balletic swimming of a live jelly that caused fascination to take root. *Jellyfish: A Natural History* could have been written for me and it delivers what the title promises. Five chapters and more than 200 pages float from Jellyfish anatomy, through life histories, to taxonomy and evolution with a close look at their bewildering diversity of ecologies and finally wash up on our relationship with jellies. *En route* we meet many species and are guided along through Lisa-Ann Gershwin's style that is as fluid as the creatures she so obviously loves, and is as authoritative as it is entertaining, while 290 stunning photographs and 140 effective line drawings ensure that readers will be engaged and entranced on every page. This is a book you may read from cover-to-cover or you may simply dip into it now and again, but it is a book you simply have to have.

Kelvin Boot (kelvinboot@yahoo.co.uk)

The Marine World: A Natural History of Ocean Life

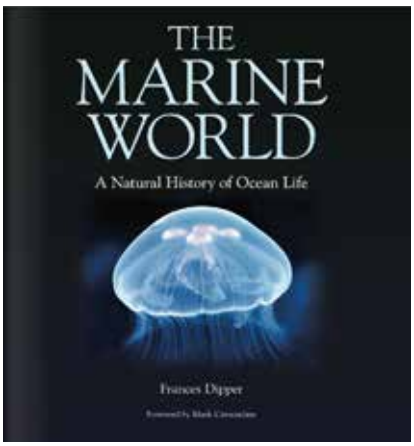
Author: Frances Dipper
ISBN: 9780957394629
Published by: Wild Nature Press

This momentous book covers so much ground that it is very difficult to do the range and appeal of its contents justice with a short description. Sections describe the physical nature of the oceans and the different environments they support before leading into very much the largest part which highlights the staggering diversity of marine life from lichens, rotifers and sponges to blennies, dugongs and terns. The marine life chapters display examples of individual species in each group from UK seas and further afield with concise but informative descriptions. For me, however, their greatest interest lay in the superb descriptions of aspects such as the stinging cells of cnidarians, the similarity in the hunting methods of mantis shrimps and other animals, and the wide range of interrelationships between different organisms, to name just a few of many. It's also great to see there's room for a section on the vital subject of marine protected areas too.

Although I've been fascinated (obsessed to be more accurate) by the sea and its inhabitants since first putting my face beneath the surface over 40 years ago, I was learning more within seconds of starting to leaf through the book. From the high carbon monoxide content of some giant kelp gas bladders to the crab co-dwellers of red bandfish burrows and the phylogeny of brachiopods, there was a wealth of new information and novel ways of presenting it. The photographs, drawn from a wide range of sources, and the illustrations are excellent.

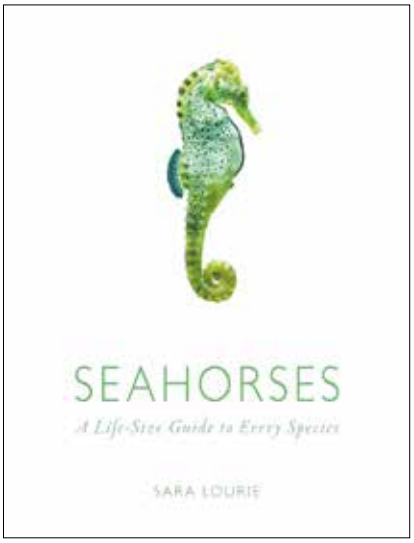
While packed full of facts, a friendly writing style ensures that they aren't overwhelming. For example, the section describing the biology of sea squirts starts with: 'Life for tunicates is one long meal' and a piece on the surprisingly sophisticated vision of box jellyfish includes the (not very comforting) thought that, if you bumped into one, 'it might be your fault and not the jellyfish's'.

From marvellous descriptions of oceanographic basics, to fascinating nuggets of animal behaviour, there is something here for everyone. I always thought I would hesitate to say this, because there is such a wide range of good publications out there, but here is one book that really should be by the side of every marine biologist.



Paul Naylor (paul@marinephoto.co.uk)

Seahorses: A Life-Size Guide to Every Species



Author: Sara Lourie
ISBN: 978-1-78240-321-0
Published by: University of Chicago Press

Upon receiving a review copy of Sara Lourie's *Seahorses*, I couldn't help but feel a sense of anticipation for the celebration of the Syngnathidae family I was holding.

Lourie is a leading specialist in seahorse taxonomy and approaches her subject from an interdisciplinary tack, elucidating not only the more scientific aspects of seahorses, pipefish, and sea dragons (for instance morphology, evolution, behaviour, and reproduction), but also touching upon their place in mythology. Each of the 57 members of the Syngnathidae family is given a page spread incorporating not only a vibrant accompanying photograph, but also a distribution map and life-sized silhouette of the creature. These silhouettes are an effective and enjoyable reminder of the size range of these fascinating creatures: from less than an inch, to over a foot in length. The descriptions of each species afford the opportunity to learn not only about their biological traits, but also their ecological importance. A section of the book is dedicated to the threats seahorses face, through destructive

fishing, aquarium trades, and use in some traditional medicines. From this, Lourie then signposts readers towards Project Seahorse www.projectseahorse.org (of which she is a research associate), and other such campaign groups.

Seahorses is not only informative, but also a crucial resource which serves as a reminder of the wonder of these creatures, and the ever-present need to protect them. A gem of a book to be enjoyed by armchair marine enthusiasts, conservationists, and divers alike.

Emmie Readman (emirea@mba.ac.uk)

The Activist

Author: Alec Connon
ISBN: 978-1-901514-25-4
Published by: Ringwood Publishing

The Activist is a novel about a young man from a Glasgow estate and his journey of environmental activism. From his epiphany with a dolphin in Belize, we follow Thomas Durant as he battles whalers on the high seas, falls from grace in Japan and has a showdown on live TV.

The story really takes off when he joins Sea Shepherd and campaigns to end 'scientific whaling' in the Southern Ocean. The protagonists exchange torrid tales of environmental destruction but life aboard Sea Shepherd's vessel must become trying in the absence of anyone to disagree with. There is a hint of hypocrisy as well—Durant is not a vegetarian and I found myself wondering why whales and dolphins deserve such fanatical protection but it is okay to intensively farm and eat terrestrial animals.

Fact and fiction are entwined, so there are plenty of references to real people and organizations, and a whole flotilla of disturbing facts about what Man has done to the oceans drawn from well-thumbed scientific papers.

In places the writing is clunky and there are many passages that ring a bum note; the Mediterranean sea is 'tropical', a dive instructor who refers to his 'flippers', and a dolphin that keeps both eyes on him as it swims past—I don't know if a dolphin can do that but these things distract the (more pedantic) reader from the story.

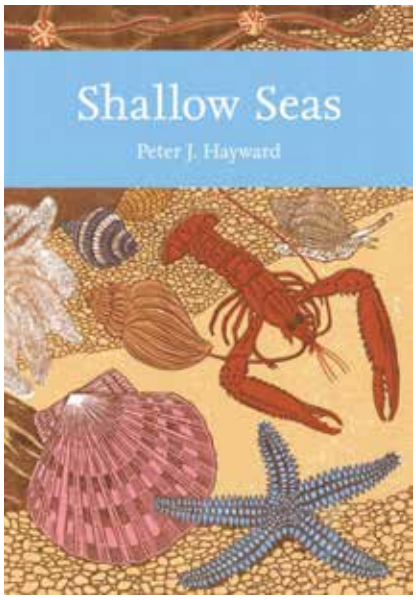
Connon is not one to pull his emotional punches; *The Activist* is not subtle and is unlikely to appeal to those who prefer the evidence-based approach to influencing behaviour. However, despite the corny moments it is earnest in its intentions and is a rousing tale, told with passion and pace.

Guy Baker (guba@mba.ac.uk)

Collins New Naturalist Library: Shallow Seas

Author: Peter Hayward
ISBN: 9780007307302
Published by: Harper Collins

I am a big fan of the New Naturalist series, cherishing copies of the other 'marine' volumes. I often turn to Sir Alister Hardy's *The Open Sea* for inspiration and to enjoy his stunning water colours of plankton. Peter Hayward's previous New Naturalist volume *Seashore* is also a great read, so I welcomed the opportunity to review his new book *Shallow Seas*. You should never judge a book by its cover, however, other New Naturalist fans will know that the cover artwork is always a joy, and Peter's new book does not disappoint with a vibrant cartoon illustration of some of the characters discussed in the volume. The book is distinctly benthic,



using a combination of excellent photographs, diagrams and figures of scientific data to illustrate the chapters covering the range of shallow sea ecosystems, including both hard grounds and soft sediments. Focus is given to the shallow sea 'key habitats': kelps, seagrass meadows, maerl beds, and biogenic reefs. The final chapter of the book is dedicated to discussing how shallow sea ecosystems are changing, including the expansion of non-native taxa and impacts of human activities. Highlights for me include a great summary of the history of UK marine biology, including the establishment of the Marine Biological Association (MBA) in Plymouth and the university-associated marine laboratories. However, on page six, the author makes the (understandable) error of confusing the MBA with Plymouth Marine Laboratory (PML), another of the seven Plymouth marine research institutions. As with *Seashore*, I particularly like the explanation of the physical environments of shallow sea ecosystems and the impact on the biology and ecology of the fauna that reside there. If you are a fan of the New Naturalist series, then this book is for you, both easy-reading and informative. If you have never read a New Naturalist book before, then *Shallow Seas* is also for you, for both the familiar expert and the unfamiliar novice.

Michael Cunliffe (micnli@MBA.ac.uk)
Marine Biological Association & Plymouth University

Are you a marine postgraduate student? Come and join us in Cornwall, UK next year for the 14th Marine Biological Association Postgraduate Student Conference! The meeting will be held in April 2017, at the University of Exeter's Penryn Campus.

This is the first time the meeting has been held in Cornwall, and postgraduate students from the University of Exeter are putting together an exciting programme of student talks, keynote speakers, workshops, field excursions and nightly social events. The team—Bethany Clark, James Duffy, Billy Heaney, Callum Laver, Jen Lewis, Sara Mynott and Sarah Nelms—are studying a broad range of marine topics, including movement ecology, remote sensing, fisheries, climate change, sensory ecology, and pollution.

The nearby town of Falmouth boasts the world's third largest natural harbour, and has grown into a busy port over the last 400 years. Alongside the economic prosperity brought by the town's relationship with the sea, Falmouth is a hugely popular sailing and leisure destination. Rich history, great atmosphere and beautiful scenery make the location a perfect place for a marine conference.

Please keep an eye on the website, which will be updated as the programme gets finalized, and get in touch if you would like more information! We look forward to welcoming you in Cornwall next year.

Jen Lewis (Jen.Lewis@exeter.ac.uk)

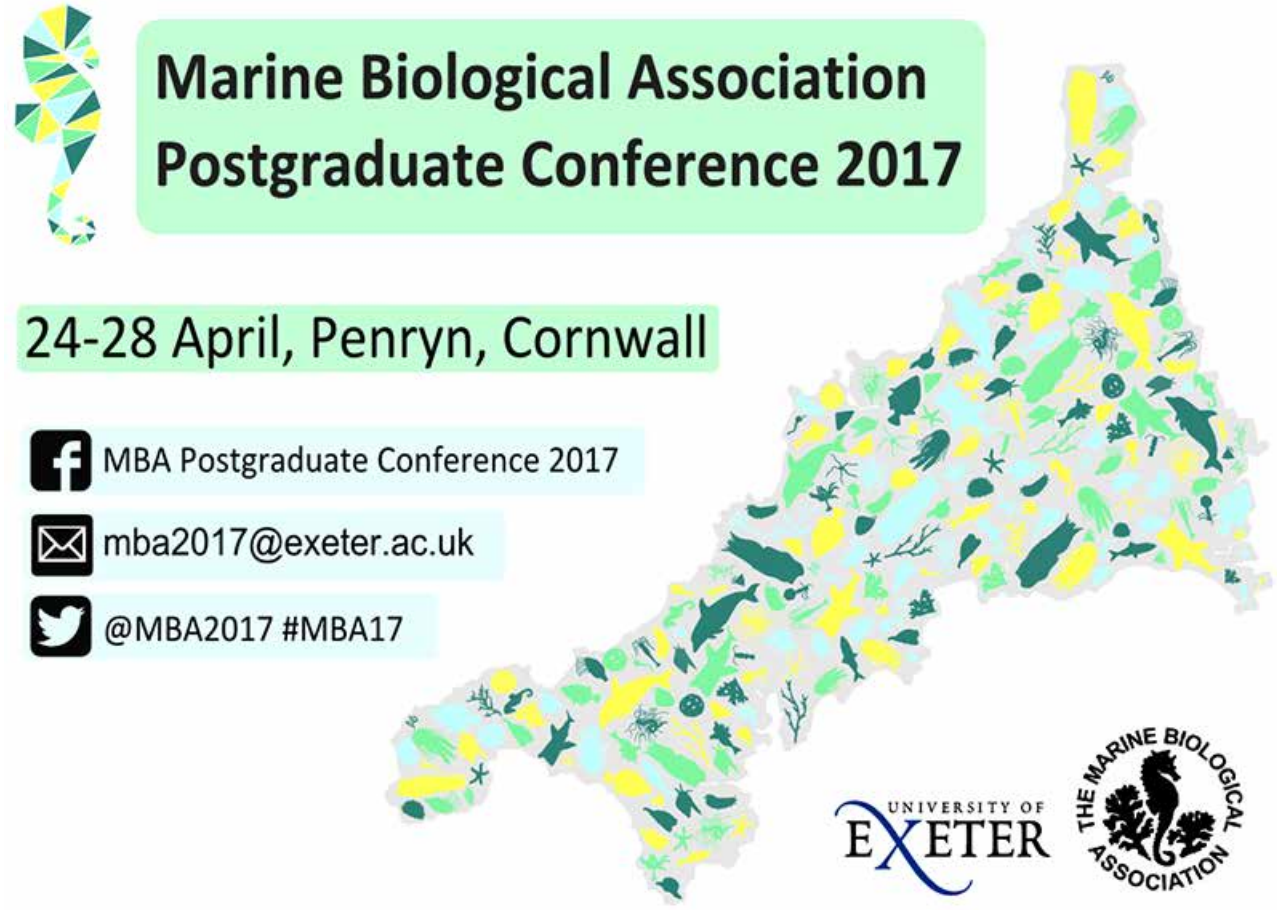



Image: Sean O'Hea

Why the world needs trained marine biologists

In the last few months I've met many people who, once they became aware that I was heading to study a master's degree in marine biology in Plymouth, asked me what does a marine biologist usually do?

Marine biological studies include, amongst other subjects, the role of the oceans in the cycling of matter, for example oxygen. The Earth's oxygen is supplied in great quantity by tiny ocean plants such as phytoplankton. Most of the Earth's oxygen comes from these phytoplankton that live near the water's surface and drift with the currents.

Mariano Peruzzo won an MBA student bursary to present at the 13th MBA Postgraduate Conference in Portsmouth. He is pictured here with some of his artworks; the can whale is being auctioned to help the MBA support marine biology students.

The fact is that more than 70% of the planet's surface is covered by oceans, and this affects the global equilibrium in temperature ranges, global migration of heat energy such as the Gulf Stream in Atlantic waters, and the general ocean circulation which is still under study.

One of the key challenges is that we need to understand how the composition of the atmosphere, in particular carbon dioxide absorption and storage, will change in the future with increasing temperatures and how this will affect the oceans.

Comprehending large-scale fisheries and overfishing is a big challenge! Conflict between ecological and economic interests creates a lot of social and environmental pressure. The four most important marine fish species on the world sea food market are cod, salmon, tuna, and sea bass. We need to determine how fish farming and sustainable exploitation of wild stocks will help to feed a growing world population.

Pollution, such as plastics and contaminants are a global issue, and worldwide concern has grown considerably in recent decades. Harmful levels of pollutants in the biota mean hazards for humans and raise questions that need answers as soon as possible.

Other human impacts include oil and gas exploration and extraction, sea floor mining, fisheries, and intensive aquaculture. Conservation of marine biodiversity can play a role in dealing with the negative impacts our way of life have on the oceans.

We bio-prospect chemicals from algae and invertebrates like sponges, worms and snails. These have been used as active compounds in drugs and therapies against diseases including cancer. The oceans are a promising source for the next generation of pharmacological treatments.

We are keen to invest money in training doctors and nurses who provide our healthcare; do we apply the same standards to training marine biologists, with their knowledge and skill in the areas mentioned above that help us understand the oceans that feed us, give us fuel and maintain the air we breathe? If not, why? Funding research is the key to increasing our knowledge to benefit everyone on the planet. Training scientists is expensive but the benefits for society have to be worth the initial expense, not just in monetary terms, but also in health and wellbeing. A minimal contribution through everyone's taxation has to be the easiest way to provide the funding required in order to train the people who can make such a positive contribution to your world and your future: marine biologists.

Mariano Peruzzo Mem.MBA

Biegelmeyer R *et al.* (2015) Sphingosines derived from marine sponge as potential multi-target drug related to disorders in cancer development. *Marine Drugs*. 25;13 (9): 5552–5563. doi: 10.3390/md13095552.

Kark S, Brokovich E, Mazor T, Levin N. (2015) Emerging conservation challenges and prospects in an era of offshore hydrocarbon exploration and exploitation. *Conservation Biology*: doi: 10.1111/cobi.12562. [Epub ahead of print]

Lozier MS. (2010) Deconstructing the conveyor belt. *Science*: 328 (5985):1507–1511. doi: 10.1126/science.1189250.

Quaas MF, Reusch TB, Schmidt JO, Tahvonen O4, Voss R. (2015) It is the economy, stupid! Projecting the fate of fish populations using ecological-economic modeling. *Global Change Biology*: doi: 10.1111/gcb.13060. [Epub ahead of print]

Richardson TL and Jackson GA (2007) Small phytoplankton and carbon export from the surface ocean. *Science*: 838–840. doi: 10.1126/science.1133471

Shim WJ, Thompson RC. (2015 Oct) Microplastics in the ocean. *Archives of Environmental Contamination and Toxicology*: 69 (3):265–268. doi: 10.1007/s00244-015-0216-x. Epub 2015 Sep 2.

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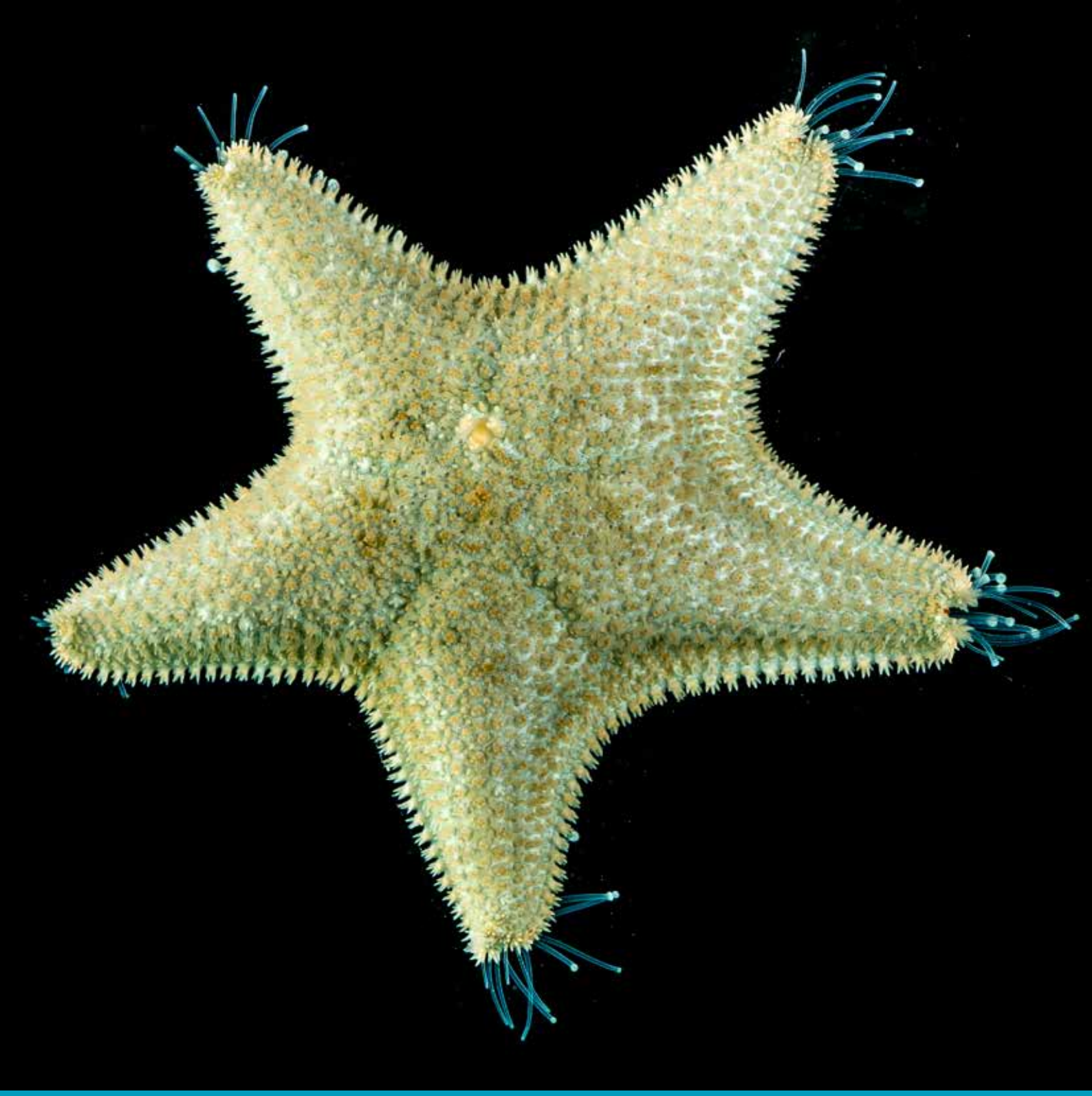

Issue 8 of *The Marine Biologist*

The Marine Biologist

The magazine of the marine biological community

April 2017

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