

BULLETIN of the PORCUPINE MARINE NATURAL HISTORY SOCIETY

Autumn 2018 — Number 10



Bulletin of the

Porcupine Marine Natural History Society

No. 10 Autumn 2018

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Porcupine MNHS welcomes new members - scientists, students, divers, naturalists and lay people. We are an informal society interested in marine natural history and recording, particularly in the North Atlantic and 'Porcupine Bight'.

Members receive 2 Bulletins per year (individuals can choose to receive either a paper or pdf version; students only receive the pdf) which include proceedings from scientific meetings, field visits, observations and news.

Membership fees: Individual £18 Student £10

 <http://www.facebook.com/groups/190053525989>

 [@PorcupineMNHS](https://twitter.com/PorcupineMNHS)

 www.pmnhs.co.uk





Porcupine M... · 13/03/2016 ✓

7.30am and the porcupines are doing what they do best. Head down hunting on the shore! [#PMNHS16](#)



Editorial

Twitter. What does Twitter have to do with Porcupine? Although I have used Facebook for a few years, I had never been drawn to Twitter and, up until 2016, I didn't really see why I would want to be drawn into more social media. Our conference in Millport changed all that as I agreed, without thinking, to tweet and retweet the 'live' happenings of the conference using the hashtags [#PMNHS16](#) and [#PorcupineMNHS](#). It was a fast learning curve to understand what a hashtag is and, for those who are unfamiliar, the hash sign (#) is used to identify messages on a specific topic.

Moving forward to 2018, my main activity on Twitter is still related to Porcupine and our annual conference and, new for this year, [#30DaysWild](#). You could say that I am not a regular tweeter but I am a lurker and retweets by [PorcupineMNHS](#) on other "live" events have had me captivated. Images from the recent *RV Celtic Explorer* expedition to the Porcupine Bank show, with remarkable clarity, diverse deep-sea communities and extraordinary organisms such as the narrow nose chimaera, *Harriotta raleighana* Goode & Bean, 1895. The excitement in these tweets is palpable and has had me wondering what else will cross in front of the camera.

Following the hashtag [#WormWednesday](#) also delights and I know Porcupines regularly contribute to this initiative and many others.

We live at a time where it is becoming increasingly easy to share our explorations of the sea and Twitter presents an opportunity to follow, not only experts in various fields, but also projects, expeditions and anyone who has a passion and love for marine natural history.

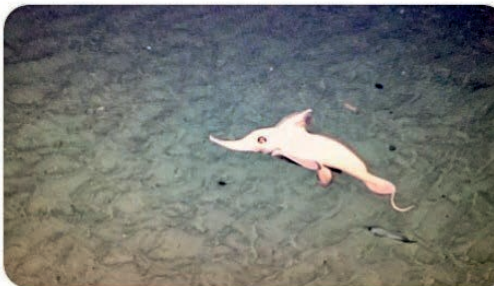
Of course, not all wish to immerse themselves in social media and although Porcupine is able to connect with an ever widening community of like-minded folk through Facebook and Twitter, the Bulletin is also important in inspiring others to share their knowledge, enthusiasm and curiosity. With this in mind the autumn 2018 Bulletin contains a diverse array of articles: from Paul Brazier reporting on Porcupines braving an Edinburgh shore in March, Sheilagh Openshaw enlightening us with an article titled "Overfishing and chips", to the detailed and systematic work on the *Jaera* genus by David Fenwick. Enjoy, and maybe take a peek at the Porcupine Marine Natural History Society Twitter account by searching for [@PorcupineMNHS](#). You may be surprised by what you discover!

Vicki Howe, Hon. Editor



Jamie Maxwell 🇮🇪 @... · 5d ✓

This guy nose how to make an impression. A narrownose chimaera (*Harriotta raleighana*) at 1300 m. [#CE18012](#) [#DeepSea](#) [#PorcupineBank](#) slope [@PorcupineMNHS](#)



Porcupine M... · 19/03/2018 ✓

A huge thank you to all the wonderful speakers, Porcupines & soon-to-be Porcupines who joined us for [#PMNHS18](#). We hope you enjoyed the conference & look forward to seeing you all at [#PMNHS19](#) next year!





Porcupine Bulletin Prize 2017

The winner of the 2017 Porcupine Student Prize is Katherine Whyte for her article *A year in the life of a saline lagoons trainee*, published in Porcupine Autumn Bulletin, No 8. Well done Katherine. The prize was £100 and one year membership of the Society.

Frank Evans Memorial Prize 2018

The Bulletin Prize has now been re-named the 'Frank Evans Memorial Prize' in honour of Frank Evans, a long term member and contributor to the Society who died last year. The prize will be awarded to the best article published in the Bulletin by a student or amateur enthusiast (i.e., not professionally employed in the marine field), as judged by a subcommittee of the Council. The prize will consist of £100, plus 1 year's membership.

There are no exclusive themes. An article could be on a project or thesis you are working on, a visit or field trip you have made to a shore or dive site or a particular marine organism you are interested in and have been researching (in the field or desktop) etc. There are many examples you can draw on for inspiration in past Newsletters and Bulletins. We ask only that there be no multiple authors.

To be considered for the prize, please make your status clear on submission of your article to the Honorary Editor – Vicki Howe, editor@pmnhs.co.uk. The PMNHS looks forward to your contributions.

Porcupine Small Grant Award 2018

The Porcupine Small Grant Award scheme has now been re-opened with up to £500 available for suitable projects connected with the aims of the society (e.g. recording). It is a condition of these grants that the work is written up and submitted for publication in the Bulletin. For details please check the website at: www.pmnhs.co.uk

8th Unknown Wales

A day to celebrate Welsh wildlife

Amgueddfa Cymru-National Museum Wales,
Cardiff, Saturday 27th October 2018



Cynhadledd
Cymru Anhysbys
Unknown Wales
Conference



This one-day meeting celebrates Welsh wildlife, highlighting the icons as well as the less well-known flora and fauna. The day will showcase new discoveries and new thinking on nature in Wales, whether on land or in the sea, through a series of short talks.

Details of the conference will be uploaded as they are available at: <https://www.welshwildlife.org/unknown-wales/unknown-wales-2018/>

Marine Conservation Society



A Big Marine Conservation
Night Out At The Museum

Amgueddfa Cymru-National Museum Wales,
Cardiff, 6th November 2018, 5.30 pm

Celebrating 30 years of Seasearch, 25 years of Beachwatch and 3 years of Capturing Our Coast as well as being VisitWales 'Year of the Sea', the Marine Conservation Society AGM will also be held as part of this event. Guests include naturalist and TV presenter Iolo Williams, with Paralympic Gold medallist Susannah Rodgers MBE, and presenter Lizzie Daly.

Tickets cost £12 and include a meal. Discounts available for Sea Champions, Beach Clean organisers and Seasearch divers. See <https://www.mcsuk.org/news/big-night-out> for details and to book.



MBA Short Courses, Plymouth

Introduction to Scientific Illustration

17th-18th November 2018

An introduction to scientific and natural history illustration using a variety of drawing techniques and materials. The course will also discuss how and why to use illustration to help document scientific observations and show concepts and processes.

The course will include a combination of life drawing from specimens and microscopy, as well as basic introductions to: digitisation of sketches; drawing materials and equipment; the history of scientific illustration.

Suitable for anyone with an interest in drawing wildlife for personal interest or scientific record taking or interpretation.

Visit <http://www.mba.ac.uk/events> for further details and how to book.

National Biodiversity Network Conference 2018

The NBN in a changing climate

Albert Hall, Nottingham
21-22 November 2018

The 2 day conference will cover topics such as data from citizen science, data for delivering environmental planning, the importance of Traineeships, tools for online resources, "life" in changing environments, using species and habitat data to prioritise biodiversity action, improving biodiversity on farms and much more! Booking is open and a draft programme is available. See website for more details <https://nbn.org.uk/news-events-publications/nbn-conference-2/nbn-conference-2018/>

The *UK Awards for Biological Recording and Information Sharing* will be held in the evening of the first day.



Porcupine Annual Conference 2019 - Field Day Amgueddfa Cymru-National Museum Wales, Cathays Park, Cardiff

Friday 22 March 2019

The Annual Conference (see next page for details) normally features a day of fieldwork and recording at a local shore for those interested. However, the South Wales shores, while striking and of geological interest, are estuarine and not renowned for their diverse marine life! Therefore, this year we are offering several options but not planning on formally organising any shore recording:

Field visits

There are several shores with striking geology, such as Monk Nash, which participants may want to visit for personal interest. There is unlikely to be diverse wildlife to record although many South Wales shores, e.g. Southerndown, Nash Point, feature substantial *Sabellaria alveolata* reefs and the shore at East Aberthaw, visited during the Conference in 2003, boasts a population of *Symsagittifera roscoffensis* (Graff, 1891), the bright green mint-sauce worm (marine flatworm). If interested, the organisers can suggest places to visit and provide directions.

Collections Tours

Tours of the Natural Sciences collections at National Museum Wales in the centre of Cardiff (Cathays Park) will be available on the Friday afternoon. Tours will be free but will need to be booked in advance. Details will be available when registration opens.

Mollusca & Polychaete Workshop

A closer look at many of the molluscs and polychaetes encountered on the shore and by divers with a particular focus on those most often enquired about. The workshop will include both presentations and practical work using museum specimens. Participants will also be able to bring specimens or send questions in advance for consideration and discussion. Cost: to be confirmed.

national
museum
wales
amgueddfa
cymru



Porcupine Annual Conference 2019

Amgueddfa Cymru-National Museum Wales

St Fagan's National Museum of History, Cardiff

23-24 March 2019



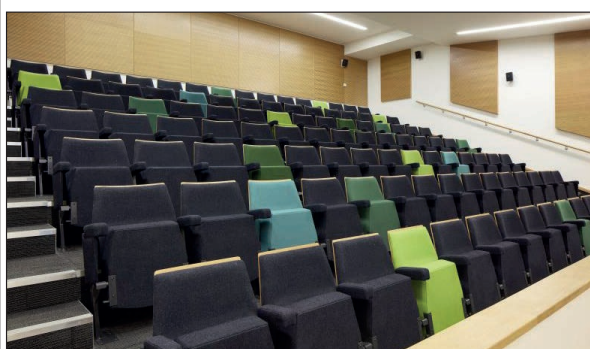
Following our return visit to National Museums Scotland, Edinburgh in 2018, we return to our 2003 host city of Cardiff for 2019. The Museum of Welsh Life is part of Amgueddfa Cymru-National Museum Wales and has recently been re-developed, boasting a brand new entrance building housing the galleries, restaurant, shop and a learning centre complete with new lecture theatre and a large studio space that we will be using for posters and refreshments. It is located in the countryside just north of the city centre which has many options for accommodation available. Although there is no public transport available to the site, we hope to be able to provide some for any delegates without their own transport

The conference itself will be held over the weekend of 23-24th March. A field visit is not planned (see previous page) but we can offer suggestions on where to visit for those whose conference is not complete without searching out marine life on the shore. On the Friday (22nd), a workshop looking at mollusc and polychaete identification is planned as well as tours of the Natural Sciences collections in the afternoon, including the Mollusca and marine invertebrate collections. Both will be held at National Museum Wales in the city centre.

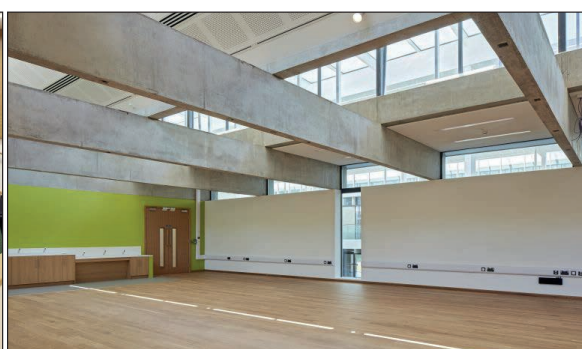
Look out for further details on the website and in emails.



The Mollusca collection at Amgueddfa Cymru, 2nd largest in the UK



The new lecture theatre



Studio space for posters and refreshments

Porcupine Marine Natural History Society

**Minutes of the 41st Annual General Meeting
Saturday 18th March 2018**

National Museums Scotland, Edinburgh

1. Apologies for absence:

Shelagh Smith

2. Matters arising from and agreement of the Minutes of the 40th AGM

There were no matters arising. The Minutes were agreed and signed as a true record.

3. Officers' Reports

The Hon. Treasurer's Report (Jon Moore):

Copies of the accounts for the year to 31 December 2017 were made available and shown on the screen. Membership subscriptions were the highest ever received thanks to the membership secretary Roni Robbins and income from the Plymouth conference was high (a substantial bill for catering is still awaited from the MBA). Bulletin costs were similar to the previous year. A professional accountant was engaged in autumn 2017 to assist with corporation tax return (at a cost of less than £100). The small grants scheme currently remains on hold. The total in the bank stands at £9099.

Acceptance of the report was proposed by Steve Jarvis, seconded by Sarah Bowen. Jon Moore was thanked for his sterling service of 27 years. Nick Light was thanked for his work over many years in examining the accounts.

The Hon. Membership Secretary's Report (Roni Robbins):

Total membership stands at 205 and is stable, with only a small number of members still paying an incorrect subscription rate.

The Hon. Editor's Report (Vicki Howe):

Two Bulletins are produced and this year both have been stable in length and content. The Bulletin is all about observations, field work, research, data, species descriptions, discussions and even anecdotes - all articles are based around marine natural history. Frank Evans, who died last year, submitted material for every issue. The Bulletin depends on a team of proof readers. Thank you to Teresa, Anne, Paul, Tammy, Jon and Peter. Others are welcome to join the team. As well as papers from the conference, any stories, articles, reviews or anything else of interest to Porcupine members, are welcome. Deadlines for material are the end of the first week in June and the same in December.

The Hon. Web-site Officer's Report:

Tammy Horton was not available to give a report but the website and social media are all working well.

The Hon Record's Convenor Report (Julia Nunn):

The recording scheme is a small one and is mostly used for PMNHS field trip records. This year records from 2017 (Northumberland field trip) and 2016 (Staffa) have been added. The database now holds 69 surveys with 25,134 species records. A snapshot of the data was sent to JNCC in 2018 but the route for finally getting the data onto the NBN is not clear. The Marine Recorder species dictionary was upgraded, but there appear to be technical issues with synonymy not being implemented. The implications of this were briefly discussed.

The Hon. Chairman's Report (Susan Chambers):

Porcupine depends on its members for support in terms of running the society and offers to stand for Council, or help out with new input, are always needed and welcome. With the annual conference and field trips, the Council always tries to arrange different venues around the country, to give all members (and others)

the chance to attend. The field trips hopefully give those in 'labs' and 'at desks' the chance to get out and do some recording. Any other ideas connected with the annual conference or suggestions for other pertinent PMNHS activities are welcome.

4. Porcupine Grants Scheme and Bulletin student prize.

A grant of up to £500 is available for suitable projects connected with the aims of the society (e.g. recording). It is a condition of these grants that the work is written up and submitted for publication in the Bulletin. The student prize for the best paper published in the Bulletin each year by a student has now been re-named the 'Frank Evans Memorial Prize' in memory of Frank Evans and will be open to all contributors to the Bulletin.

5. Election of Officers and Council.

Anne Bunker, Dawn Powell and Seamus Whyte stood down and did not make themselves available for re-election. All other Council Members were available for re-election. Becky Hitchin (who had been co-opted to help the Council during the year) wished to stand for Council. Jon Moore stood down as Hon. Treasurer but made himself available for re-election as an Ordinary Member. Following discussions at previous council meetings, Fiona Ware had agreed to take over as Hon. Treasurer and therefore made herself available for election as such.

Agreement was requested and received from the members present to elect the Council as presented. This was proposed by Sheila Openshaw and seconded by Paul Brazier. The Council for 2018-2019 was therefore duly elected as follows:

Office Bearers:

Hon. Chairman Susan Chambers

Hon. Secretary Frances Dipper

Hon. Treasurer Fiona Ware

Hon. Editor Vicki Howe

Hon. Membership Secretary Roni Robbins

Hon. Records Convenor Julia Nunn

Hon. Website Officer Tammy Horton

Ordinary Members of Council:

Peter Barfield

Sarah Bowen

Fiona Crouch

Teresa Darbyshire

Becky Hitchin

Jon Moore

6. Future conference and field meetings

There will be two field trips this year as follows: Lyme Bay May 16-19th 2018 and Mullet Peninsula, Ireland September 8-15th 2018. Subject to confirmation, the 2019 conference will be held in Cardiff.

7. Raffle prizes

The raffle was drawn and the prizes awarded (chosen by winners)

8. AOB

The Bulletin student prize was awarded last year to Katherine Whyte.

PORCUPINE MNHS
RECEIPTS AND PAYMENTS ACCOUNT

Year to 31 December 2017

Year to 31.12.16			Year to 31.12.17
£	£		£
		RECEIPTS	
76		2015 & earlier	24
2810		2016	66
101		2017	3204
0		2018 onwards	98
	2987		3392
	0	Bank Interest (gross, both accounts)	0
	(0)	Tax deducted	(0)
	318	Raffle	360
	30	Contribution	7
	3335	Total Receipts	3759
		PAYMENTS	
(1528)		Bulletin- Printing	(1596)
(404)		Postage & other expenses	(379)
(1932)		Total Bulletin Costs (1975)	
(13)		Web site expenses	(144)
(74)		Council meeting expenses (travel/catering)	(92)
(0)		Accountancy fees	(125)
	(2019)		(2335)
	1317	SURPLUS BEFORE MEETINGS & GRANTS	1424
2422		Annual Conferences – Millport (2016)	44
0		– Plymouth (2017)	3602
0		– Edinburgh (2018)	(720)
0		Field meetings – Staffa (2016)	(648)
0		– Wembury (2017)	70
0		Porcupine grants	0
(50)		Bulletin prize	(50)
(0)		Charitable donation	(50)
	2372		2248
	3689	SURPLUS FOR THE YEAR (before tax)	3672
	0	Corporation Tax	0
	3689	SURPLUS FOR THE YEAR (after tax)	3672
	1737	BALANCE BROUGHT FORWARD	5426
		BALANCE CARRIED FORWARD	
5282		Current Account	8928
144		PayPal Account	171
	<u>5426</u>		<u>9099</u>

Jon Moore, Hon Treasurer
20 March 2018

J. J. Moore

Report on the Annual Conference Edinburgh, 17th-18th March 2018

Marine Biology of the NE Atlantic

Fiona Ware

National Museums Scotland

In March 2018 the Porcupine Annual Conference returned to its 1977 birthplace at the National Museum of Scotland in Edinburgh. This spectacular Victorian building houses treasures from Scotland and around the world giving us the opportunity to explore the wonders of nature, art, design & fashion, science & technology and the Wildlife Photographer of the Year exhibition during breaks in the busy two-day programme (Figure 1).

Ninety people from across the UK attended the conference (Figure 2) and were treated to an excellent line-up of speakers on the theme of *Marine Biology of the Northeast Atlantic*. Over half the delegates were non-members with particularly good representation from Scottish students. Our social media feeds continued to go from strength to strength during the event with a record breaking 32,000 impressions on Twitter and attracting our 1000th follower shortly afterwards.

The first day focussed on a wide variety of Scottish-themed topics including seagrasses (A. Lyndon, Figure 3), microplastics (M. Hartl), marine conservation (T. Proud & M. de los Rios), native oysters (W. Sanderson), biological recording (P. Kingston, P. Léon & P. Cowie) and impacts of offshore industries (K. Scott & D. Paterson). Wildlife photographer and filmmaker Richard Shucksmith closed the day with stunning images of *Shetland beneath the waves* and incredible footage of orcas hunting seals amongst the kelp forest.

The Conference Dinner was held at popular Italian restaurant *Vittoria on the Bridge* where we enjoyed tasty food, good company and a fiendish but hugely enjoyable marine natural history quiz from Vicki Howe and Becky Hitchin (Figure 4) – Which committee member's names would be accepted as valid names of genera in WoRMS?¹ And did you spot the 3 camouflaged molluscs? (Figure 5) – not me!

On Sunday we woke up to blustery, snow-covered streets but another convivial day of marine natural history beckoned. Jon Moore led an engaging observations session and presentations on serpulid reefs (D. Harries), saline lagoons (S. Angus), macroalgae (A. Sampedro-Fernandez), shovel head worms (K. Mortimer-Jones), Seasearch (C. Bolton & N.



Fig. 1: Window on the World, Grand Gallery, National Museum of Scotland ©National Museums Scotland



Fig. 2: Delegates in the auditorium ©Richard Shucksmith

Hirst), NBN Atlas (P. Lightfoot & C. Johnston) and PMNHS fieldwork (F. Dipper) informed and inspired us. A personal highlight was Lisa Kamphausen's *Expedition to the sea caves of St Kilda and North Rona* – an entertaining tale, great memories and yet another visual treat!²

Thank you to all the speakers, poster presenters, PMNHS committee & members, delegates and colleagues at National Museums Scotland for making it such an enjoyable and successful weekend. Bring on Cardiff #PMNHS19!

¹ Julia (gastropod) & Fiona (nudibranch)

² see <https://www.flickr.com/photos/snh-iyb2010/albums/72157658628218282>



Fig. 3: Alastair Lyndon presenting the opening talk

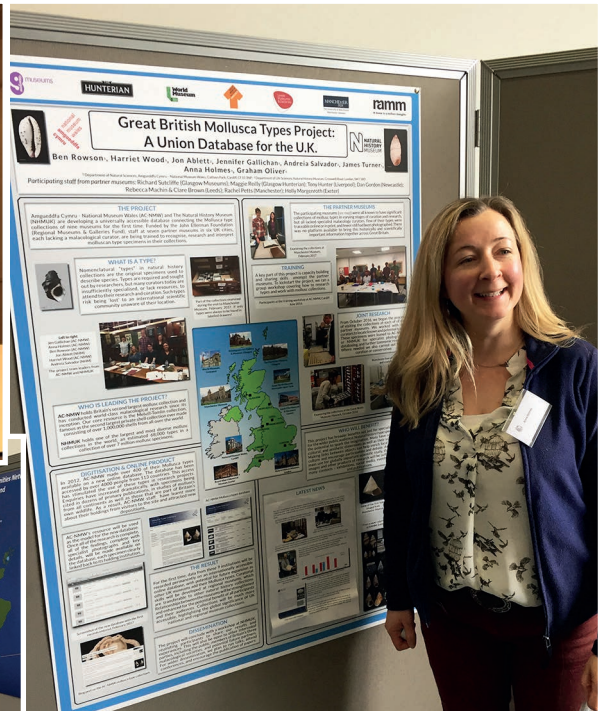


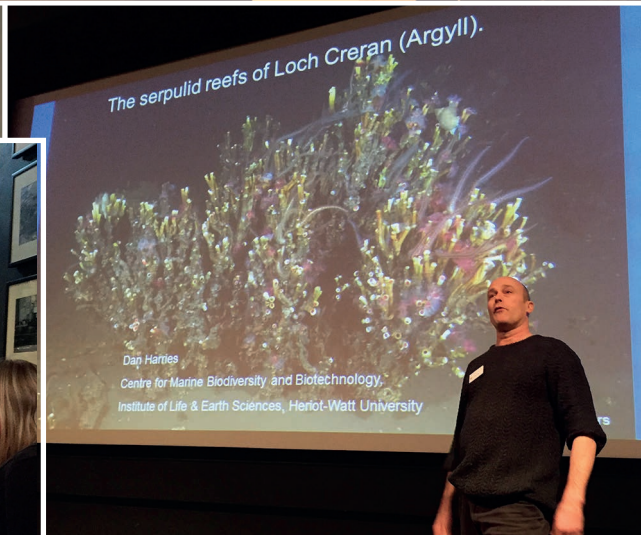
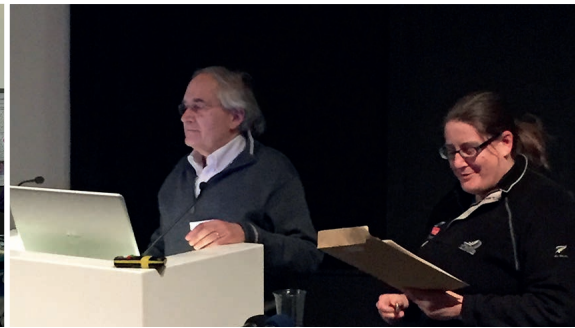
Fig. 4: Tackling the after dinner quiz



Fig. 5: There are 3 molluscs in the picture... spot them!

Next page double spread: Images from the conference and conference dinner (Photos: Teresa Darbyshire, Fiona Ware).





Field Visit to Yellowcraig, Dirleton, East Lothian, 19th March 2018

Paul Brazier

A team of robust marine biologists ventured out to Yellowcraig (Broad Sands) rocky and sandy seashore to complete the weekend of the annual conference in Edinburgh. The intertidal and dune systems here are part of the Firth of Forth Special Site of Scientific Interest, for the importance of bird species and their habitats, sand dune vegetated communities and sand dune invertebrate species. It is also a Special Protection Area (SPA) to give greater protection to wintering populations of divers, waders and other shore birds.



Fig. 1: View of Fidra from the shore (Photo: Susan Chambers)

Fortunately, the snow had moved on, allowing a flurry of Porcupines to hit the beach, but the biting cold wind still brought out the thick gloves and Michelin-man style outfits. Eleven dedicated surveyors met at the car park, cut through the sand dunes and promptly headed to the white pearly surf that heralded the boundaries of survey for the day. It was already low water tide and the laminarians were showing, but few Porcupines risked filling their boots by going to the frothy edge. The view was of a substantial rocky platform and to the north-west, the distinctive island of Fidra (Figure 1), of volcanic origin and now a RSPB reserve; home to over 1000 breeding pairs of puffins during the summer. The wind chill hovered around -2°C , whilst the seawater felt like $4 - 5^{\circ}\text{C}$, not greatly appreciated by those who had travelled from the south and west of the UK.

The upper shore consists of well drained coarse sand, feeding the low sand dunes that back the shore. Going by the substantial amount of fucoid seaweeds poking through the sand, the levels of sediment had been pushed up by the wave action from the easterly winds over

the previous weeks. Further evidence of the recent storm-force easterlies were the many turned boulders along the lower shore and a considerable strand of kelp stipes, along with an assortment of subtidal rocky habitat species that had been washed in. Porcupines quickly dispersed to seek out marine species from the variety of habitats, including:

- midshore craggy rock (Figure 2) with fucoids and barnacles with many unscoured rockpools,
- steep and creviced low shore bedrock and
- extensive low shore boulder fields with many rockpools.



Fig. 2: Sue and Jane in action surveying the midshore (Photo: Paul Brazier)

The bulk of the fucoid cover across the shore was of bladder wrack, *Fucus vesiculosus*, and serrated wrack, *Fucus serratus*, with a fairly dense population of acorn barnacles, *Semibalanus balanoides*, beneath and on pinnacles of rock. A surprise to the more experienced marine biologists was the extensive cover in the mid and lower shore of a crust of honeycomb reef worm, *Sabellaria* sp. A specimen, preserved in vodka, was confirmed by Salma Shalla to be *S. spinulosa* (Figure 3). Considering the extent across and up the shore, this puts into question records that are exclusively of *S. alveolata* in this



Fig. 3: *Sabellaria spinulosa* crust on rock surface (Photo: Jane Pottas)

area – they are likely to include *S. spinulosa*. The non-native barnacle *Austrominius modestus* was found on the midshore, but only rarely. On more damp open rock, a thin turf of red seaweeds, including ‘bunny ears’, *Lomentaria articulata*, was found (Figure 4).



Fig. 4: *Mastocarpus stellatus* and *Lomentaria articulata* turf on the lower shore (Photo: Paul Brazier)

The main interest, on the shore, since the low shore was in the surf, was a number of midshore rockpools (Figure 5) with a mixed turf of red and green algae and dense edible winkles, *Littorina littorea*. Some of these had suffered severe scouring, denuding the rock of everything other than red and pink algal crusts. Of these, the *Lithothamnion glaciale* was particularly attractive, with its knobbly surface. However, a considerable species list was gathered from the less scoured areas. Deeper clefts in the bedrock had a greater density of keel worms *Spirobranchus* sp., barnacles (including *Balanus crenatus* and *Verruca stroemia* - Figure 6), breadcrumb sponge, *Halichondria panicea*, the non-native seasquirt, *Corella eumyota*, anemones, *Actinia equina* and *Urticina felina*, and dogwhelks, *Nucella lapillus*. Surprisingly, only 2 species of sponge were found; *Halichondria panicea* and

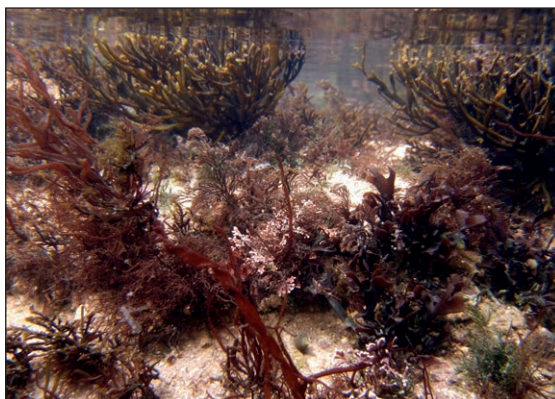


Fig. 5: Rockpool algae garden with filamentous red algae and shortened *Halidrys siliquosa* (Photo: Paul Brazier)



Fig. 6: Scale worm, *Polynoidae* amongst the barnacle *Verruca stroemia* (Photo: Jane Pottas)

Halisarca dujardini, highlighting perhaps the more western distribution of another common intertidal sponge, *Hymeniacidon perleve* (that was not recorded on this occasion), which, like *H. dujardini* are known more from subtidal records north of Beadnell on the east of the UK (source - NBN Atlas). Midshore pools that were present all the way up to the edge of the rock sand interface had dense sea oak, *Halidrys siliquosa*, with an understory of black siphon weed, *Polysiphonia fucoides*, green branched weeds, *Cladophora* spp. and other filamentous red seaweeds. In the very shallow pools (10-25 cm deep), the sea oak persisted, but had a cropped appearance, where it came into contact with the pool surface.

Of the macrofauna, the rockling, *Ciliata mustela* and the guillemot, *Uria aalge* had succumbed to the bad weather, but two young lobsters tucked under some boulders in a low shore rockpool appeared to be in good condition. The shore is highly recommended for a further visit on a calm and sunny day with a good low tide!

The weather and rising tide promptly drove the surveyors from the shore, and a quick decision was made to head to the Scottish Seabird Centre (conservation and education centre) at North Berwick, where plenty of hot tea and meals were taken. The assembling of a joint species list started at this point, to produce a single species list, to be entered into Marine Recorder (see Table 1). I would like to acknowledge all of the field surveyors for their input into this article, their pictures and the ultimate species list: Terry Holt, Peter Garfield, Julia Nunn, Jon Moore, Susan Chambers, Lily Pauls, Anne Bunker, Vickie Howe, Jane Pottas, Robert Walsh, Paul Brazier and lab work up by Salma Shalla.

Phylum	Taxon	Authority	Notes	Specimen (initials)	Photo (initials)
PORIFERA (sponges)	<i>Grantia compressa</i>	(Fabricius, 1780)			JP
	<i>Halichondria (Halichondria) panicea</i>	(Pallas, 1766)			JP
	<i>Dysidea fragilis</i>	(Montagu, 1814)			
	<i>Halisarca dujardinii</i>	Johnston, 1842			
CNIDARIA (hydroids, anemones)	<i>Dynamena pumila</i>	(Linnaeus, 1758)			
	<i>Alcyonium digitatum</i>	Linnaeus, 1758	Dead, strand		DPB
	<i>Actinia equina</i>	(Linnaeus, 1758)			JP
	<i>Urticina felina</i>	(Linnaeus, 1761)			
SIPUNCULA (peanut worms)	<i>Nephasoma (Nephasoma) minutum</i>	(Keferstein, 1862)	Lab identified in <i>Sabellaria</i> sample		
ANNELIDA (segmented worms)	Polynoidae sp.				JP
	<i>Sabellaria spinulosa</i>	(Leuckart, 1849)	Lab confirmed		JP
	<i>Spirobranchus</i> sp.				SC
	<i>Spirorbinae</i> sp.		on <i>F serratus</i>		SC
	<i>Spirorbis (Spirorbis) spirorbis</i>	(Linnaeus, 1758)			
	<i>Spirorbis (Spirorbis) tridentatus</i>	Levinsen, 1883			
CRUSTACEA (barnacles, shrimps, crabs, lobsters)	<i>Verruca stroemia</i>	(O.F. Müller, 1776)			SC
	<i>Semibalanus balanoides</i>	(Linnaeus, 1767)			AB
	<i>Balanus balanus</i>	(Linnaeus, 1758)			
	<i>Balanus crenatus</i>	Bruguère, 1789			
	<i>Austrominius modestus</i>	(Darwin, 1854)			
	Gammaridae sp.				
	<i>Idotea</i> sp.				SC
	<i>Homarus gammarus</i>	(Linnaeus, 1758)			AB
	<i>Galathea strigosa</i>	(Linnaeus, 1761)			AB
	<i>Pisidia longicornis</i>	(Linnaeus, 1767)			JP
	<i>Porcellana platycheles</i>	(Pennant, 1777)			JP
	<i>Cancer pagurus</i>	Linnaeus, 1758			JP
	<i>Necora puber</i>	(Linnaeus, 1767)			JP
	<i>Carcinus maenas</i>	(Linnaeus, 1758)			DPB
MOLLUSCA (snails, slugs, clams, squid)	<i>Lepidochitona cinerea</i>	(Linnaeus, 1767)			DPB
	<i>Patella vulgata</i>	Linnaeus, 1758			DPB
	<i>Patella pellucida</i>	Linnaeus, 1758			JP
	<i>Steromphala cineraria</i>	(Linnaeus, 1758)			JP
	<i>Lacuna pallidula</i>	(da Costa, 1778)			
	<i>Littorina littorea</i>	(Linnaeus, 1758)			DPB
	<i>Littorina fabalis</i>	(W. Turton, 1825)			
	<i>Rissoa parva</i>	(da Costa, 1778)			
	<i>Lamellaria latens</i>	(O. F. Müller, 1776)			
	<i>Nucella lapillus</i>	(Linnaeus, 1758)	eggs		JP
	<i>Nucella lapillus</i>	(Linnaeus, 1758)			
	<i>Buccinum undatum</i>	Linnaeus, 1758	dead		
	<i>Tritia incrassata</i>	(Strøm, 1768)			JP
	<i>Goniodoris nodosa</i>	(Montagu, 1808)			
	<i>Onchidoris bilamellata</i>	(Linnaeus, 1767)			

Phylum	Taxon	Authority	Notes	Specimen (initials)	Photo (initials)
	<i>Onchidoris bilamellata</i>	(Linnaeus, 1767)	spawn		
	<i>Cadlina laevis</i>	(Linnaeus, 1767)			
	<i>Doris pseudoargus</i>	Rapp, 1827			
	<i>Mytilus edulis</i>	Linnaeus, 1758			
	<i>Mytilus edulis</i>	Linnaeus, 1758	spat		
	<i>Talochlamys pusio</i>	(Linnaeus, 1758)			
	<i>Anomia ephippium</i>	Linnaeus, 1758	dead		
	<i>Heteranomia squamula</i>	(Linnaeus, 1758)			
	<i>Mactra stultorum</i>	(Linnaeus, 1758)	dead		
	<i>Spisula solida</i>	(Linnaeus, 1758)	dead		
	<i>Ensis magnus</i>	Schumacher, 1817	dead		
	<i>Venerupis corrugata</i>	(Gmelin, 1791)	dead		
	<i>Mya truncata</i>	Linnaeus, 1758	dead		
	<i>Sepia officinalis</i>	Linnaeus, 1758	dead		
BRYOZOA (sea mats)	<i>Alcyonidium hirsutum</i>	(Fleming, 1828)			
	<i>Flustrellidra hispida</i>	(O. Fabricius, 1780)			
	<i>Membranipora membranacea</i>	(Linnaeus, 1767)			
	<i>Electra pilosa</i>	(Linnaeus, 1767)			
ECHINODERMATA (starfish, brittlestars, urchins)	<i>Henricia</i> sp.				AB
	<i>Asterias rubens</i>	Linnaeus, 1758			
	<i>Ophiothrix fragilis</i>	(Abildgaard in O.F. Müller, 1789)			
	<i>Amphipholis squamata</i>	(Delle Chiaje, 1828)			
	<i>Psammechinus miliaris</i>	(P.L.S. Müller, 1771)			
TUNICATA (seasquirts)	<i>Didemnidae</i> sp.				
	<i>Didemnum maculosum</i>	(Milne Edwards, 1841)			
	<i>Corella eumyota</i>	Traustedt, 1882			JP
	<i>Asciidiella scabra</i>	(Müller, 1776)	Dead, strand		
	<i>Botryllus schlosseri</i>	(Pallas, 1766)			JP
	<i>Botrylloides leachii</i>	(Savigny, 1816)			
PISCES (fish)	<i>Ciliata mustela</i>	(Linnaeus, 1758)	dead		
	<i>Taurulus bubalis</i>	(Euphrasen, 1786)			AB
RHODOPHYTA (red algae)	<i>Porphyra dioica</i>	J.Brodie & L.M.Irvine, 1997		DPB	DPB
	<i>Porphyra</i> sp.				
	<i>Rhodothamniella floridula</i>	(Dillwyn) Feldmann, 1978			DPB
	<i>Gelidium crinale</i>	(Hare ex Turner) Gaillon, 1828		AB	AB
	<i>Gelidium pulchellum</i>	(Turner) Kützing, 1868		DPB	
	<i>Gelidium pusillum</i>	(Stackhouse) Le Jolis, 1863		DPB	JP
	<i>Palmaria palmata</i>	(Linnaeus) Weber & Mohr, 1805		DPB	JP
	<i>Rhodophyta</i> sp.		dk red crust	JP	
	<i>Dilsea carnosa</i>	(Schmidel) Kuntze, 1898			JP
	<i>Dumontia contorta</i>	(S.G.Gmelin) Ruprecht, 1850			DPB
	<i>Corallinaceae</i> sp.	Lamouroux, 1812	crust		JM

Phylum	Taxon	Authority	Notes	Specimen (initials)	Photo (initials)
	<i>Corallina officinalis</i>	Linnaeus, 1758		DPB	JP
	<i>Ahnfeltia plicata</i>	(Hudson) E.M.Fries, 1836			JP
	<i>Phyllophora pseudoceranoides</i>	(S.G.Gmelin) Newroth & A.R.A.Taylor, 1971		DPB	JM
	<i>Mastocarpus stellatus</i>	(Stackhouse) Guiry, 1984		DPB	SC
	<i>Mastocarpus stellatus</i>	(Stackhouse) Guiry, 1984	Petrocelis		
	<i>Chondrus crispus</i>	Stackhouse, 1797		DPB	DPB
	<i>Plocamium lyngbyanum</i>	Kützing, 1843			JP
	<i>Cystoclonium purpureum</i>	(Hudson) Batters, 1902		DPB	
	<i>Lomentaria articulata</i>	(Hudson) Lyngbye, 1819			JP
	<i>Ceramium nodulosum</i>	Ducluzeau, 1850		DPB	
	<i>Ceramium shuttleworthianum</i>	(Kützing) Rabenhorst, 1847			AB
	<i>Halurus flosculosus</i>	(J.Ellis) Maggs & Hommersand, 1993		DPB	
	<i>Plumaria plumosa</i>	(Hudson) Kuntze, 1891			
	<i>Membranoptera alata</i>	(Hudson) Stackhouse, 1809			JP
	<i>Phycodrys rubens</i>	(Linnaeus) Batters, 1902			JP
	<i>Osmundea hybrida</i>	(A.P.de Candolle) K.W.Nam, 1994			DPB
	<i>Osmundea osmunda</i>	(Hudson) Stackhouse, 1809		DPB	JP
	<i>Osmundea pinnatifida</i>	Greville, 1823		DPB	
	<i>Polysiphonia</i> sp.				
	<i>Vertebrata fucoidea</i>	(Hudson) Kuntze, 1891			
OCHROPHYTA (brown algae)	<i>Cladostephus spongiosus</i>	(Hudson) C.Agardh, 1817		DPB	
	<i>Laminaria digitata</i>	(Hudson) J.V.Lamouroux, 1813			DPB
	<i>Laminaria hyperborea</i>	(Gunnerus) Foslie, 1884			
	<i>Fucus serratus</i>	Linnaeus, 1753			SC
	<i>Fucus spiralis</i>	Linnaeus, 1753			JP
	<i>Fucus vesiculosus</i>	Linnaeus, 1753			
	<i>Pelvetia canaliculata</i>	(Linnaeus) Decaisne & Thuret, 1845			JP
	<i>Halidrys siliquosa</i>	(Linnaeus) Lyngbye, 1819			JP
CHLOROPHYTA (green algae)	<i>Ulva intestinalis</i>	Linnaeus, 1753			
	<i>Ulva</i> sp.	Linnaeus, 1753	stringy?		
	<i>Ulva lactuca</i>	Linnaeus, 1753	flat		
	<i>Chaetomorpha linum</i>	(O.F.Müller) Kützing, 1845			
	<i>Chaetomorpha ligustica</i>	(Kützing) Kützing, 1849			AB
	<i>Chaetomorpha melagonium</i>	(F.Weber & Mohr) Kützing, 1845			
	<i>Cladophora rupestris</i>	(Linnaeus) Kützing, 1843		DPB	DPB
	<i>Cladophora sericea</i>	(Hudson) Kützing, 1843		AB	
LICHEN	<i>Verrucaria</i> sp.		spp		

Table 1: Total species list for the whole site at Yellowcraig.

Scottish seagrass: beyond the Forth dimension!

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Introduction

Seagrasses are the only higher plants found growing entirely submerged in marine environments. Although they are often associated in the popular imagination with tropical climes, they in fact have a widespread global distribution from Greenland to New Zealand (Orth *et al.* 2006). They are thought to be important for several reasons including habitat provision for fish and crustaceans, carbon fixation and storage ('blue carbon'), sediment trapping and stabilisation and coastal protection. Nevertheless, they are declining at an alarming rate, estimated to be as much as 7% per year (Waycott *et al.* 2009). Seagrasses belong to 3 families, only one of which, the Zosteraceae, is represented in the UK, with two (or perhaps three – see below) species found here (Figure 1). Whereas most seagrasses in warmer climes are subtidal, remaining submerged all the time, in the UK there are two species which occur intertidally, *Zostera noltii* Hornemann, 1832 and *Z. angustifolia* (Hornemann) Reichenbach, 1845 (classified in most other countries as an ecotype of *Z. marina* Linnaeus, 1753), both typically found in estuarine environments. *Zostera marina* sensu stricto ("in the strict sense"; subtidal and stenohaline) also occurs in the UK, with Scotland having substantial beds particularly in the Western and Northern Isles.

Cleator (1993), in a review of Scottish seagrass for Scottish Natural Heritage (SNH), identified several research priorities which are as relevant today, 25 years later, as they were then (Table 1). Recent work at Heriot-Watt University has concentrated on distribution surveys, population monitoring and associated biodiversity, with a focus on intertidal species.

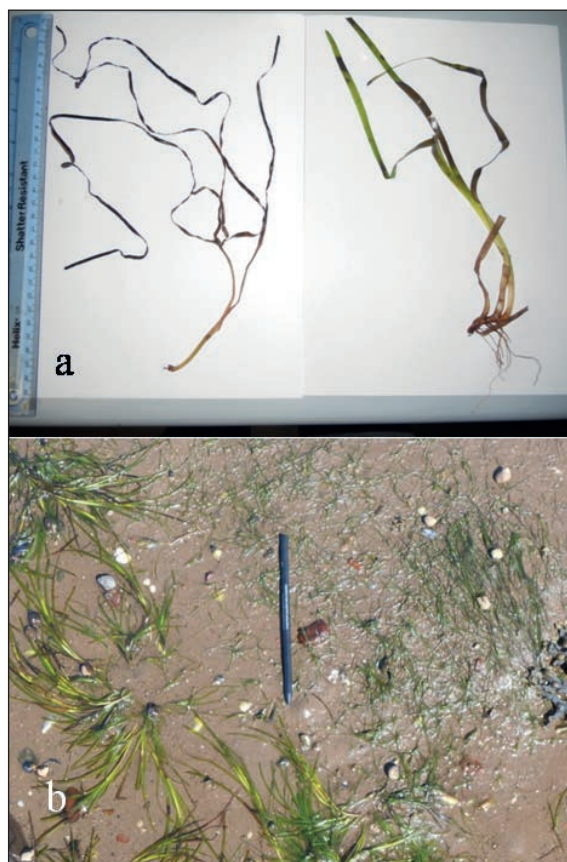


Fig. 1: Species of *Zostera* in the UK. a) *Z. marina* (both specimens, showing variation in leaf width). Ruler is 30 cm. b) *Z. angustifolia* (bottom left) and *Z. noltii* (top right). Pencil is 17 cm long.

In part this was stimulated by a surprising lack of information on present-day distributions which was required, amongst other things, for regulatory purposes under the EU Water Framework Directive. More recently, there has been increasing interest in taxonomic issues, particularly surrounding the status of *Z. angustifolia*.

Dimensions of seagrass: first and second dimensions

The first and second dimensions are, of course, length and width, measurements of which enable calculation of area. In monitoring of seagrass, the areal extent of beds/meadows is a key variable. However, it comes with attendant problems, since a seagrass meadow is not like a lawn, instead occurring patchily over the area of the bed, with many gaps. Thus, a line taken around the periphery of a seagrass bed will inevitably give an overestimate of absolute cover. Is this important? It could be argued that, although patchy, the peripheral

Priority area	Specific requirements
Increased awareness	Better understanding of <i>Zostera</i> spp. in a Scottish context
Taxonomy	Clarification of <i>Z. angustifolia</i> cf. <i>Z. marina</i>
Distribution	Systematic surveys Central data catalogue Remote sensing development Identification of threats
Ecology	Influence on sediment transport Contribution to primary production Associated communities Reproductive strategies Ecotypic plasticity
Monitoring	Population size (extent and density) Prevalence of wasting disease (<i>Labyrinthula zosterae</i>) Water quality in relation to seagrass Contaminants in seagrass

Table 1: Research priorities for Scottish seagrass identified by and adapted from Cleator (1993) and still relevant today.

line delineates an area of suitable habitat, and that changes in this crude extent measure may still be useful in determining current status. This would seem a pragmatic and reasonable approach. Nevertheless, there can also be issues at the periphery, where isolated patches may occur (Figure 2). In mapping these, it

could be that a substantial area is added to the bed area by one recorder, which might be excluded by a subsequent one, giving an erroneous perception of change over time.

Third dimension (depth)

Depth or, more usefully, density is also an

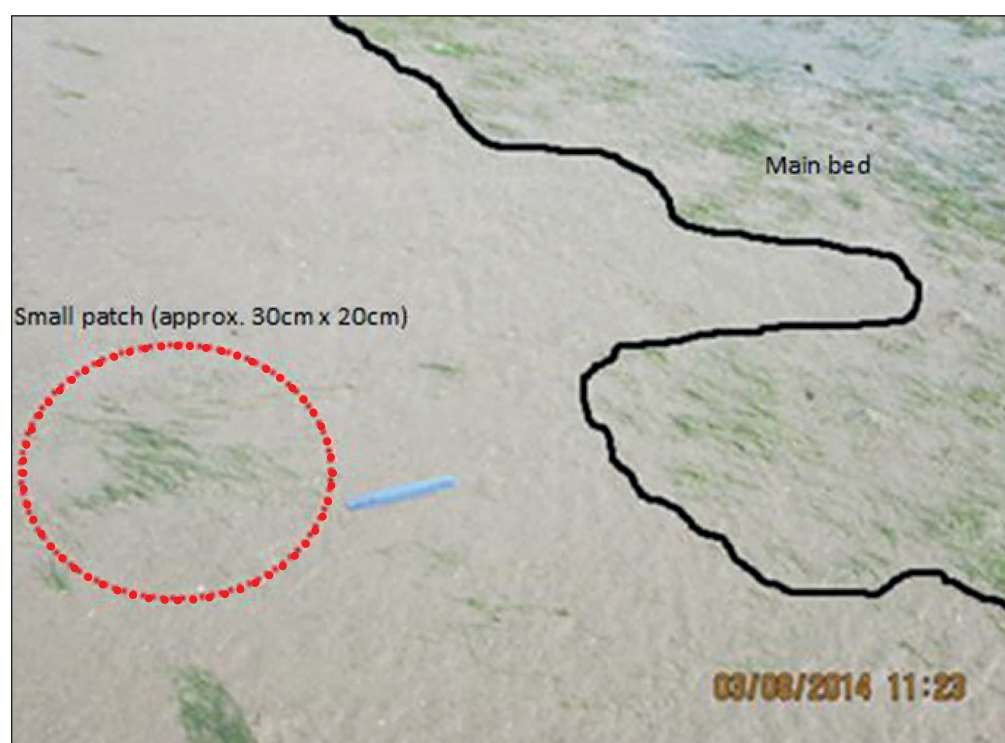


Fig. 2: Diagrammatic outline of edge of seagrass bed with an outlying clump. Joining-on or excluding the outlier will alter the recorded bed area, and could lead to discrepancies between recorders.

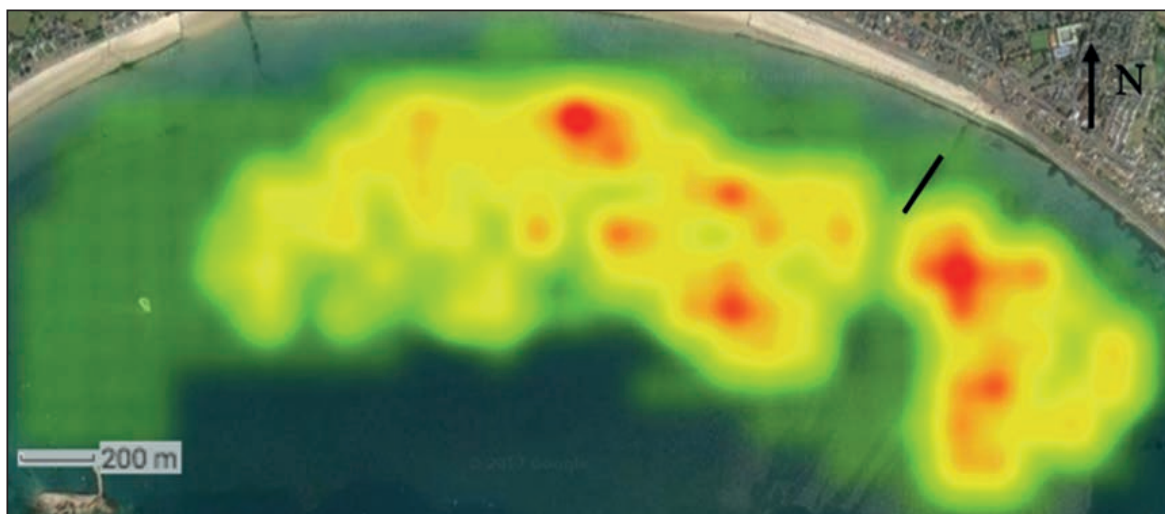


Fig. 3: Heat-map of *Z. noltii* bed density (% cover) from St Aubin's Bay, Jersey, CI, 2016 (Sinclair 2017).

important measure of seagrass status. As noted above, seagrass beds are almost always patchy, resulting in differing densities of plants and leaves across the bed (Figure 3). How this varies with position in the bed is at present uncertain, but is certainly not a simple function of distance from the bed edge, as might simplistically be expected. However, human impacts can have direct effects on bed density.

Fourth dimension (time)

The degree of temporal variation in seagrass beds is also a key research question, both in relation to bed persistence (are they transient or long-lived features?) as well as area and density. Although there is good evidence for global decline in areal cover of seagrasses, there is little information on natural fluctuations in extent or density. In part this results from the relative inaccessibility of seagrasses (most are in shallow subtidal habitats, making remote sensing challenging, if not impossible), as well as the only very recent (10 years) availability of accurate portable mapping methods (e.g. small, inexpensive, but accurate (within 0.5 to 3 m) GPS receivers). Intertidal seagrasses are often additionally difficult to access, owing to their occurrence on muddy intertidal flats. However, intertidal species in temperate climates are particularly interesting in relation to changes over time, as they are seasonally deciduous, losing much, if not all, of their above ground foliage over winter. This

provides a key advantage over tropical species in assessing factors important for determining spatial extent and foliage density, since the latter retain their foliage year-round. Hence the surprise (and shock!) of tropical seagrass researchers when they see the apparent carnage on a temperate intertidal bed over winter (Figure 4).

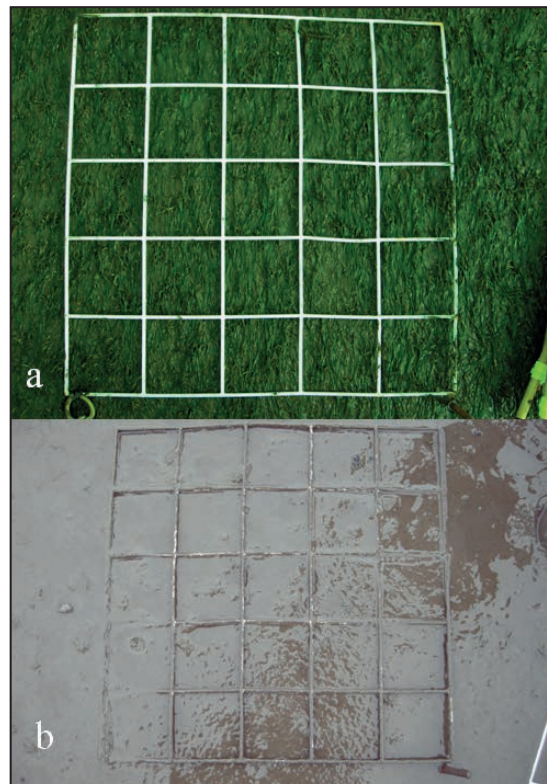


Fig. 4: Loss of foliage by *Z. noltii* with onset of winter, as seen from a fixed quadrat at Carriden in the Forth estuary, 2017. a) *Z. noltii* cover ("dense") 27 Sept; b) *Z. noltii* cover ("zero foliage") 21 Nov.

Scottish seagrass species: is *Z. angustifolia* just an ecotype of *Z. marina*?

There are two undisputed *Zostera* species present in Scotland's coastal waters: *Z. marina* Linnaeus 1753 (eelgrass; grass wrack) and *Z. noltii* Hornemann 1832 (dwarf eelgrass). In many parts of the world, and indeed parts of the UK, *Z. angustifolia* (Hornemann 1845) (widgeon grass; narrow-leaved eelgrass) is considered to be an ecotype of *Z. marina*, displaying a different growth form in littoral environments compared to sub-littoral locations. However, there is inconsistency between taxonomic databases, with the Plant List (<http://www.theplantlist.org>), supported by Kew Gardens, London, indicating that *Z. angustifolia* is the name of a clearly defined species, whereas AlgaeBase, also displayed through the World Register of Marine Species (WoRMS), state that it is a junior synonym of *Z. marina*. However, recording of intertidal *Z. marina* sensu lato ("in the broad sense") may cause confusion where both types occur in proximity to one another. This is a problem with many older records in Cleator (1993), where it is often unclear whether they refer to sub-littoral or littoral habitats. This poses a challenge

for analysis of changes over time. From a pragmatic perspective, it makes sense to record *Z. angustifolia* as a separate taxon, since it can readily be combined with *Z. marina* sensu stricto records if necessary. Whereas separating specimens of *Z. marina* sensu lato may prove impossible, without herbarium specimens (which emphasises the value and importance of the RBGE and other botanical collections). What evidence is there that *Z. angustifolia* is, in fact a good species? Consistent morphology across varying habitats, from estuarine mudflats to open-coast rockpools with coarse sediment and across a wide salinity range from almost freshwater to hypersaline tends to argue against an ecotype, which would be expected to vary between different conditions. In addition, in Loch Ryan, it is possible to find *Z. marina* sensu stricto plants growing intertidally in pools alongside *Z. angustifolia* (Figure 5). Again, this tends to argue against an ecotype explanation for *Z. angustifolia*. However, to date, molecular analyses (specifically 18s rDNA sequencing) have failed to differentiate the two. It is intended to collaborate in future with Royal Botanic Gardens Edinburgh (RBGE) to examine a wider range of genetic markers to better illuminate this question.

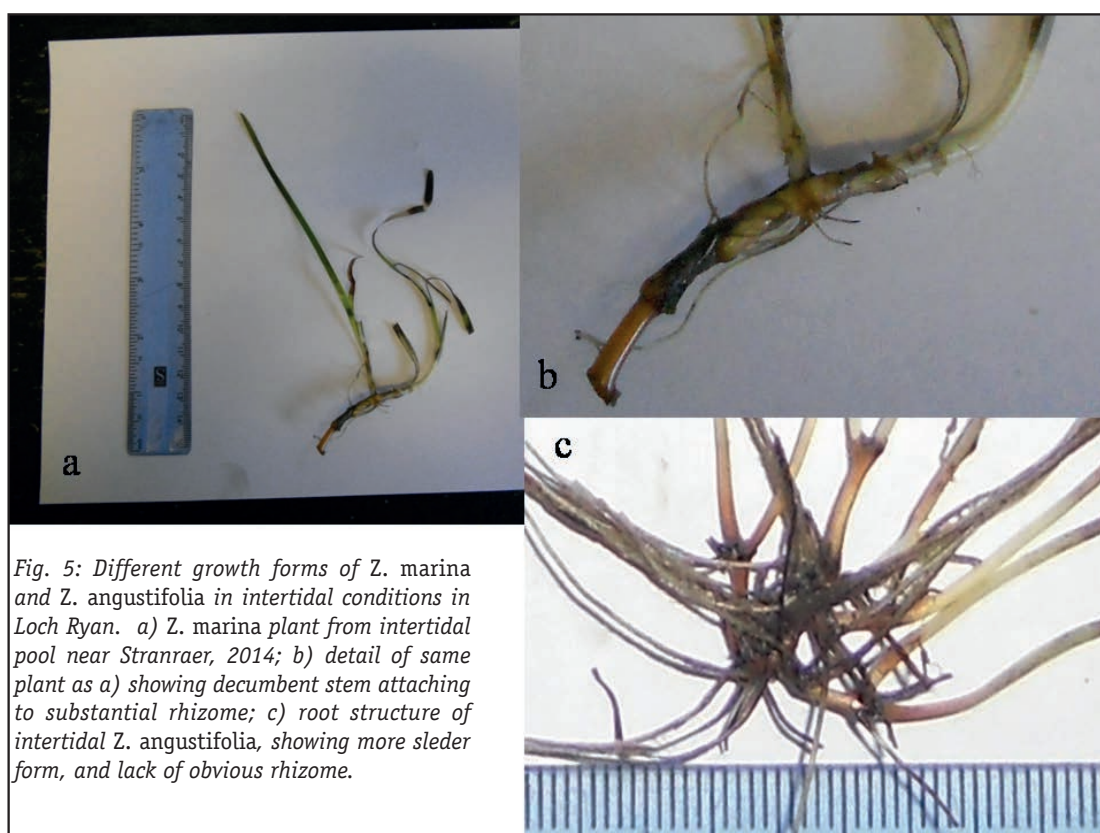


Fig. 5: Different growth forms of *Z. marina* and *Z. angustifolia* in intertidal conditions in Loch Ryan. a) *Z. marina* plant from intertidal pool near Stranraer, 2014; b) detail of same plant as a) showing decumbent stem attaching to substantial rhizome; c) root structure of intertidal *Z. angustifolia*, showing more slender form, and lack of obvious rhizome.

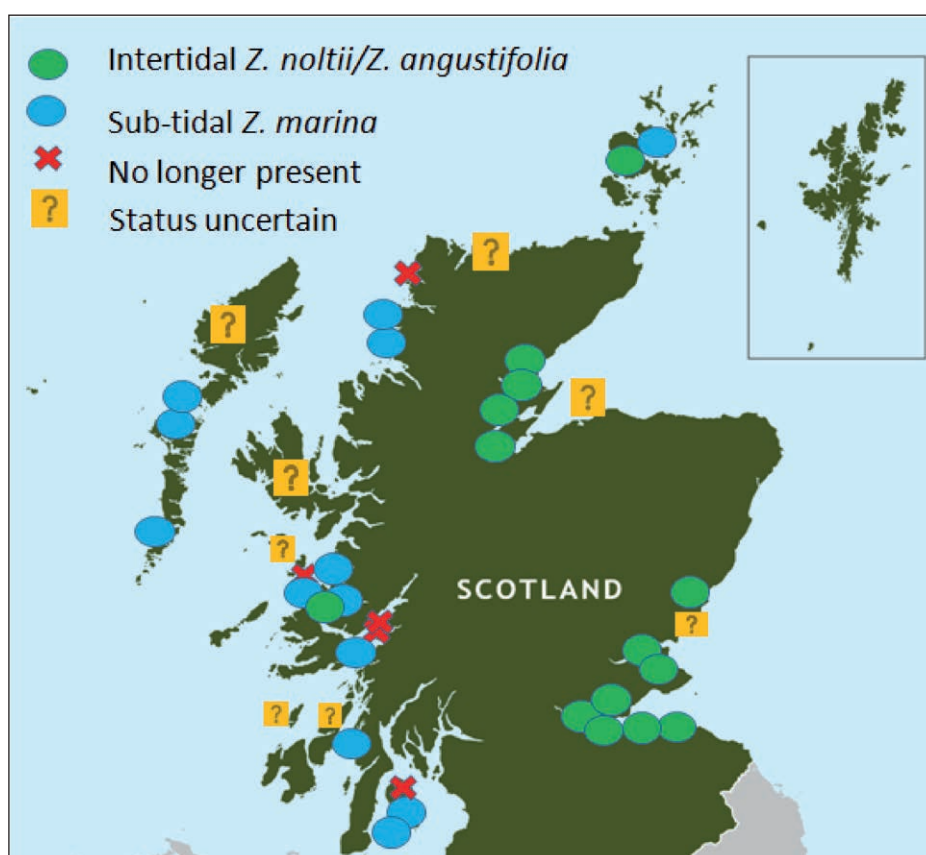


Fig. 6: Current distribution of the three *Zostera* species native in Scotland. Note the largely western occurrence of *Z. marina* and the greater preponderance of *Z. noltii* and *Z. angustifolia* in the east. After Lyndon (2016).

Forth dimension

One aspect of the temporal variation of seagrasses, as noted above, is the persistence or otherwise of seagrass beds. In this respect, the Firth of Forth and Forth estuary are an interesting case as a result of the close proximity of the RBGE and more particularly their herbarium collection, which contains seagrass accessions dating back to 1825. Perhaps unsurprisingly, most are from Scotland (~90%), with a large proportion (35%) of these from the Forth area. This makes the Forth a good place to assess the occurrence of seagrass in particular places over reasonably long time-scales (decades to centuries). Also, the availability of herbarium specimens crucially enables identification of the seagrass species involved, despite variations in naming practice over the last 200 years: historically, many specimens were automatically registered as *Z. marina*, as the diversity was not widely appreciated until recently. However, a note of caution is needed, since without continuous

records, we cannot be certain that seagrass beds are not transient. Nevertheless, the repeated occurrence of seagrass in the same places over time, gives as good a proxy as we can manage at the moment for long-term persistence of seagrass. What do we find? The oldest herbarium record in the Forth is from Burntisland in 1825, this specimen being compatible with the morphology of *Z. angustifolia* (although the accession is labelled as *Z. marina*). Subsequent Burntisland records for *Z. angustifolia* (verified by the authors) are found from 1833, 1874, 1903 (herbarium), 2011 and 2014 (direct observation) representing a span of some 120 years. Frustratingly, there is a long gap through the 20th Century, which may represent a true absence, or merely a lack of interest in recording. Nevertheless, there has clearly been a long history of a suitable habitat, implying some degree of spatial consistency in the occurrence of *Z. angustifolia* at this location. A similar pattern is seen elsewhere in the Forth, with three of five sites with 19th Century records still supporting

seagrass in 2014-2018. Of the two which do not support seagrass, one is now under Leith Docks, indicating one of many pressures on seagrass habitats and the other ("Gullane") is uncertain as to its exact location, so may be rediscovered. It should also be noted that some older records might relate to drift specimens, although this information may not always have been included on the label.

During the 20th Century, eight sites in the Forth recorded seagrass (including the three mentioned above), and all of these still had seagrass present in 2014-18, whilst into the 21st Century, there are now 13 sites in the Forth area supporting intertidal seagrass. Does this represent a real increase in seagrass distribution in the face of a global decline? Or is this a function of increased interest and, therefore, effort? The likelihood of the latter is supported by informal records of *Z. noltii* at Brucehaven, near Limekilns, since 1983 (T Leatherland, pers. comm.), although this bed was not officially recorded until 2011. So perhaps not the miraculous turn-around that we might have wished, but nevertheless a sign of increasingly good coverage of a previously patchily recorded habitat.

Beyond the Forth dimension!

Looking beyond the Forth, interesting patterns become apparent across Scotland (Figure 6). Generally, the two intertidal species are more often found on the East coast, perhaps reflecting the extent of estuarine habitats here. There is a lesser concentration in the Solway and Clyde areas, also consistent with estuarine conditions. In contrast, subtidal *Z. marina* is largely confined to the West coast and the Western and Northern Isles. This likely reflects water clarity, as the East coast is generally more turbid (partly as a result of the preponderance of estuaries). So in summary, there appears to be an East-West split between intertidal and subtidal seagrass species. However, this may be misleading, as there are many areas of the West coast which have not been recently surveyed, especially for intertidal species. Interestingly, the few places where seagrass has definitely been lost over the last 50 years or so are mainly on the West coast, perhaps counterintuitively, given

the lower human population and presumably lower impacts. Again, this may reflect poor historical data in places where seagrass was under recorded due to lack of interest or effort.

Conclusion

The status of seagrass in Scotland is now clearer than it was a decade ago. In most places where there are historical records, seagrass still persists today, which is encouraging, given the decline seen at a global level. However, there is still a dearth of detailed mapping information in many places regarding the first three dimensions alluded to above, to allow a confident analysis of the fourth dimension (trends over time). The analysis will include herbarium specimens which will be deposited in botanical collections. It is hoped that the Forth dimension will provide further insights underpinning a much better understanding of Scottish (and other) seagrasses!

Acknowledgements

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Understanding the effects of electromagnetic field emissions from Offshore Renewable Energy Devices (OREDs) on the commercially important Edible crab, *Cancer pagurus* (L.)

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Abstract

Stress related parameters (L-lactate, D-glucose, haemocyanin and respiration rate) along with behavioural and response parameters (antennular flicking, activity level, attraction/avoidance, shelter preference and time spent resting/roaming) were assessed in the commercially important decapod, the edible crab, *Cancer pagurus* L., during exposure to electromagnetic fields (EMFs). EMFs originate from sub-sea power cables associated with Offshore Renewable Energy Devices (OREDs), and consequently affect large areas of benthic habitat commonly occupied by *C. pagurus*, resulting in a high chance of exposure. EMF exposure had no significant effect on respiration rate, haemocyanin concentration, antennular flicking rate or activity levels. EMF exposure disrupted the haemolymph L-lactate and D-glucose natural circadian rhythms. Crabs showed a clear attraction to EMF during shelter preference experiments at the cost of natural roaming behaviour. These results show that EMF emitted from OREDs detrimentally affects *C. pagurus* on both a physiological and behavioural level. This suggests that the impacts of EMF on crustaceans must be considered when planning, constructing, and operating OREDs.

Introduction

The predicted decline in non-renewable energy sources (Pimentel *et al.* 2002) results

in increasing demand for sources of renewable energy. Offshore Renewable Energy Devices (OREDs) are devices that harness kinetic energy (wave, tidal, wind) from the ocean and are regarded as abundant, inexhaustible, and non-polluting resources. The UK is the largest global producer of electricity from offshore wind farms. Scotland currently has 197MW operational offshore windfarms and over 4GW of offshore wind generation has been granted (Smith *et al.* 1999; Crown Estates 2017). Renewable energy deployment proposals are based on current knowledge and assessments of the local environment, despite relatively little being known about the ecological effects and impacts of such developments on marine benthic organisms.

Electromagnetic fields

Electromagnetic fields (EMFs) are associated with OREDs. Industry-standard subsea power cables can be effectively insulated to prevent electric field (E-field) emissions but not magnetic field (B-field) leakage (Gill 2005). Standard cable configurations combined with the existing B-field creates induced electromagnetic fields (iEM fields) (Gill 2005). The magnetic field leakage has been shown to be of concern as it can alter activity patterns, behavioural responses, delay development, suppress melatonin levels, divert migration routes, and interfere with larval settlement of aquatic species (Rommel *et al.* 1973, Zimmerman *et al.* 1990, Woodruff *et al.* 2012).

European edible crab

European edible crab (*Cancer pagurus* Linnaeus, 1758), are found throughout Western Europe from Norway to northern France. Edible crabs are a heavily exploited commercial species (Bannister 2009) with £23 million annual value in Scotland (Mesquita *et al.* 2013-2015). They are commonly found from the shoreline to offshore depths around 90m. There is a high probability that this species will encounter sub-sea power cables and could be exposed to EMFs. Decapod crustaceans are known to be magneto-sensitive, yet information available on the effects of electromagnetic fields emitted from OREDs is scarce (Figure 1).



Fig. 1: Operational offshore windfarm (top left, Photo: Erica Chapman). Offshore wind operational sites and planned sites around Scotland (right, Photo: Offshore Wind Scotland). Edible crabs seeking shelter under imitated power cable (bottom left).

The aim of the present paper was to determine any physiological and/or behavioural effects EMFs could have on edible crabs, using a combination of different stress parameters. Several studies (Taylor *et al.* 1997, Durand *et al.* 2000, Bergmann *et al.* 2001, Lorenzon *et al.* 2007) have shown that haemolymph L-lactate, D-glucose and haemocyanin concentrations are useful measures of stress in crustaceans. Respiration rates in marine organisms are also reliable indicators of certain environmental stressors (Paterson & Spanoghe 1997, Doney *et al.* 2012, Brown *et al.* 2013). It is also known that behavioural and response parameters (attraction/avoidance, antennular flicking rate, and activity level) can be affected by stressors (Stoner 2012).

Materials and Methods

Intermoult edible crabs were obtained from local fishermen within the St Abbs and Eyemouth Voluntary Marine Reserve (St Abbs, Berwickshire, UK) and kept at ambient conditions, in 1000L holding tanks at St Abbs

Marine Station. The marine station research aquarium has a minimal electromagnetic footprint achieved using non-ferrous glass reinforced plastic (GRP) material, making it well suited to conduct electromagnetic studies.

Upon arrival each crab was sexed and based on carapace width, crabs were categorized into three size groups: 10-79mm – small, 80-120mm – medium, 121mm+ – large.

For physiological analysis haemolymph samples were taken from crabs exposed to EMFs after 0h, 4h, 8h and 24h. The EMF was produced by four solenoid magnets (24V) connected to variable power supplies (Figure 2). The magnets created an electromagnetic field (peak 40mT) which fully covered the experimental area (Figure 1). The experiment was repeated using a lower strength EMF (peak 2.8mT) to correspond with the expected levels on the surface of a sub-sea power cable and correspond to those predicted in previous studies (Bochert & Zettler, 2006). Tank temperature, salinity, dissolved oxygen, and light conditions were monitored throughout.

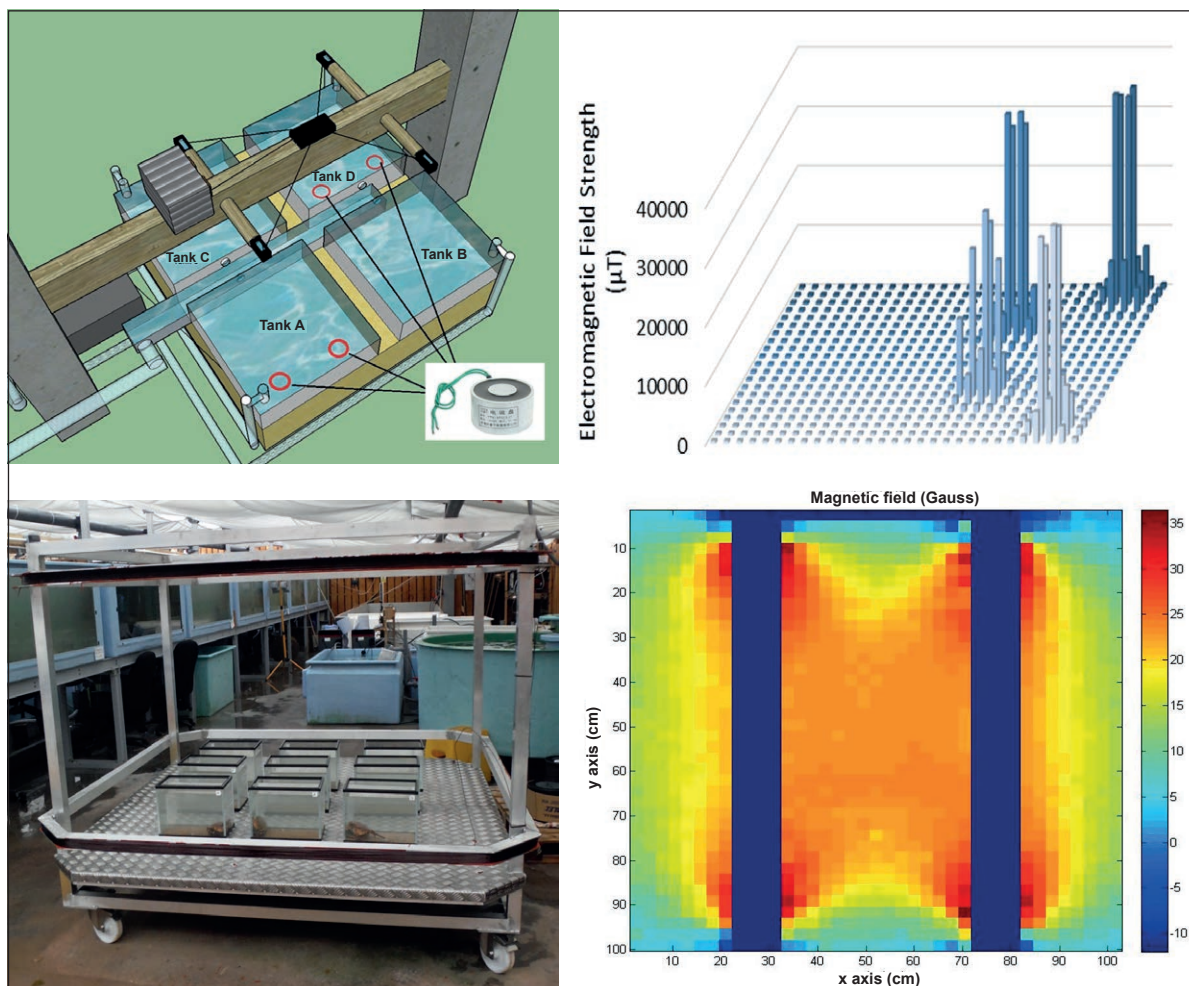


Fig. 2: EMF sources and measures strengths. Solenoid magnets under the test arena (top left), strengths of EMF in the test arena (top right) created by the solenoid magnets. Helmholtz coil experimental set up (bottom left), strengths of uniform, static electromagnetic field in the test arena between the two coils (bottom right).

To test whether antennules are utilised in the detection of EMF, crabs were recorded for 10 minutes under control conditions, then a further 10 minutes with an EMF present (2.8mT). After each trial, the tanks were sterilised and underwent a full water change to reduce chemical cues which may affect antennular flicking rates. The video data was then post-processed with flicking rate counted twice for both antennules by three trained people to reduce individual variations.

Oxygen consumption of thirty juvenile intermoult crabs were measured with and without exposure to 2.8mT strength EMF, created by a Helmholtz coil (Figure 2). An optical oxygen meter was used to measure oxygen levels (detection limit 15ppb). The percentage air saturation was recorded for each individual and converted to oxygen consumption (mg/g/h).

To detect any changes in activity level of crabs and potential attraction or avoidance of EMF, crabs were video recorded overnight in 70L experimental tanks, half exposed to EMF created by solenoid magnets at a strength of 2.8mT and 40mT. Each video file was broken down to still images at 1-minute intervals for the duration of the trial. The position of the crab in each image was analysed and a movement index was created depending on whether any movement has been detected compared to the previous image. Analyses were conducted to determine the percentage of time each crab spent on either side of the tank (magnet or non-magnet). This was used to indicate an attraction to or avoidance of the EMF.

To further determine the effects of EMFs on behaviour, crabs were offered shelters within

the experimental tanks, with or without EMF. In the dual shelter set up one of the shelters' electromagnets was turned on with the other remaining off as a control. In the single shelter set ups half of the tanks had the magnets switched on with the other half acting as a control with the magnets off. Crabs were recorded overnight with infrared cameras, and the video files post-analysed to determine the percentage of time spent in the shelters or free roaming within the tank. The purpose of setting up single shelter tanks was to determine how the crab would interact with the shelter under control conditions, and to determine how the crab would act if the only shelter available is subjected to an EMF. The dual shelter tanks were set up to determine if, where there were two identical shelters available, crabs would be drawn to or repelled by the EMF and to determine how their shelter seeking and roaming behaviour would be affected.

Haemolymph samples were collected with a syringe through the arthrodial membrane at the base of the fifth walking leg. Samples were flash frozen in liquid nitrogen and stored until further analysis. Haemolymph D-glucose, L-lactate and haemocyanin concentrations were measured spectrophotometrically.

Absorbance of diluted haemolymph samples was measured at 335nm to determine haemocyanin concentration (mg/ml) as previously described by Harris & Andrews (2005).

D-Glucose concentration of deproteinated haemolymph samples was measured using a D-glucose assay kit (Barrento *et al.* 2011). L-Lactate concentration of deproteinated haemolymph samples was measured using L-lactate assay kits (Barrento *et al.* 2011).

Results

Antennular flicking rates were unaffected by EMF exposure and remained constant at an average of 22 ± 4 flicks/min pre-exposure and 24 ± 4 flicks/min during exposure.

Respiration rates remained unchanged during exposure to EMF at an average of 0.05 ± 0.006 mg O₂/g/h.

Activity levels were unaffected by EMF exposure.

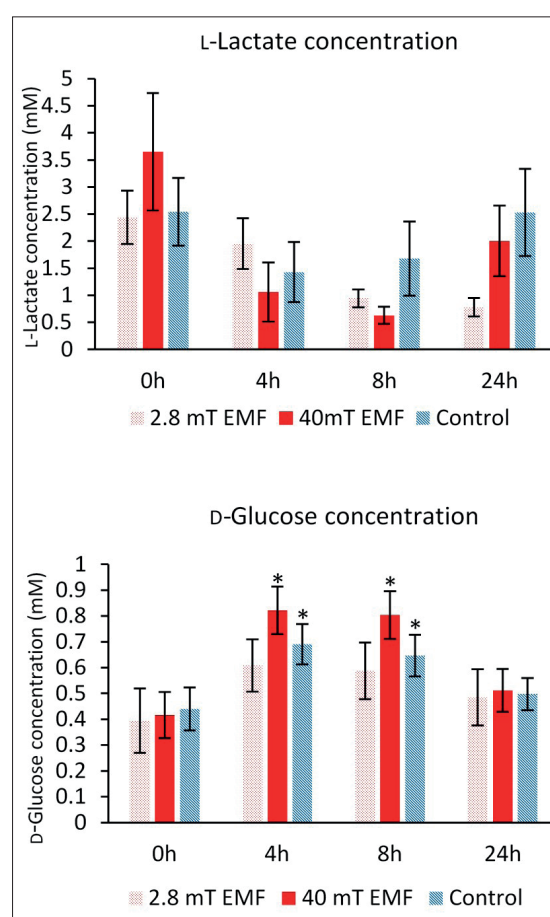


Fig. 3: Haemolymph L-Lactate and D-Glucose levels over a 24-hour period during control conditions and exposure to low strength (2.8mT) and high strength (40mT) EMF.

Under control conditions crabs spent significantly more time on one side of the tank ($32-68 \pm 5.9\%$) ($p < 0.05$). During EMF exposure there was no clear side selection made ($44-56 \pm 5.9\%$) resulting in a significant difference between treatments ($p < 0.05$).

During single shelter trials, crabs spent significantly more time within a shelter when it was exposed to an EMF (69%) than in control conditions (48%) ($p < 0.05$). In dual shelter experiments under control conditions there was an equal amount of time spent within each shelter and out in the open (35%, 31% and 34% respectively). During EMF exposure this significantly changed ($p < 0.01$) with a clear preference for the EMF shelter (69%) compared to the control shelter (9%) and out in the open (22%).

Exposure to EMF had a significant effect on both L-lactate and D-glucose levels within the haemolymph. At 40mT exposure the

L-lactate levels followed the same pattern as the control with a gradual decrease during the day, however, the concentration at 4h ($p<0.05$) and 8h ($p<0.05$) were significantly lower compared to the 0h, unlike the control which showed no significant changes during the 24 hours. D-Glucose concentration remained unchanged at 40mT. At 2.8mT L-lactate levels were significantly lower over the 24h compared to control which showed no significant changes ($p<0.05$). D-Glucose concentrations during 2.8mT exposure did not show the significant rise leading up to peak locomotory activities after 8h that was found under control conditions (Figure 3).

Exposure had no effect on the remaining haemolymph parameters. Hemocyanin levels remained constant ($44.08\pm1.01\text{mg/ml}$) throughout the trials, with no significant variation over time or with crab size.

Discussion

The lack of change in the number of antennular flicks during EMF exposure suggests that the antennules may not be utilized in the detection of EMF in this species, or as a reliable indicator of detection. Woodruff *et al.* (2012) reported similar results in Dungeness crab, (*Metacarcinus magister* Dana 1852), during exposure to EMF at 3mT strength.

Although increased oxygen demand, high gill ventilation rate, and increased haemocyanin levels typically occur in crustaceans subjected to stressors (Jouve-Duhamel & Truchot 1985, Paterson & Spanoghe 1997), EMF exposure did not affect O_2 demand or haemocyanin concentration and appears to cause no oxidative stress.

Exposure to EMF did not have significant effects on the overall activity level of *C. pagurus*. This suggests that if there is a behavioural change during exposure to EMF it may be more subtle than basic movement levels. Although overall activity levels were not affected by EMF exposure, the distribution of time spent in specific locations within the tank and between resting and roaming behaviours were. The ability of crabs to select a site to rest was affected by EMF exposure.

EMF exposure inhibited a clear side preference

within the tank which resulted in an approximately equal amount of time spent between the two sides of the tank, potentially reflecting shelter seeking behaviour.

During shelter trials in control conditions crabs spent equal amounts of time inside and outside the shelters. This suggests that without environmental stressors crabs will spend equal portions of time resting in a shelter and surveying their environment, exhibiting roaming behaviour. In the presence of EMF, the amount of time crabs spent outside the shelter, significantly decreased in both single and dual shelter trials. It was determined that there was a clear preference for EMF exposed shelters, suggesting an attraction to EMF. This has clear implications on the *Cancer pagurus* population within areas surrounding OREDs. Crabs will be drawn to the source of EMF emission and will spend significantly more time within the affected area. Crabs will spend less time foraging, seeking mates and finding suitable shelter, which will potentially lead to higher predation rate, increased death due to starvation and decreased number of successful matings. Many offshore sites have introduced no-take zones around turbine arrays. The reduced fishing pressure combined with habitat enhancement in the form of scour protection blocks could potentially increase species diversity and density around windfarms (Langhamer & Wilhelmsson 2009). These results highlight the potential lack of spill-over effect from these areas due to a high attraction to the emitted EMF.

EMF disrupted the circadian rhythm of haemolymph L-lactate and D-glucose levels. In crustaceans, haemolymph glucose and lactate levels are affected by various environmental conditions and stressors (Kallen *et al.* 1990, Reddy *et al.* 1996, Chang *et al.* 1998) and should cycle together under normal, unstressed conditions. The L-lactate circadian rhythm was shifted by exposure to 2.8mT EMF. It showed a continuous decrease and significantly lower values after 24 hours. Exposure to 40mT EMF resulted in much lower concentrations of L-lactate after 4h and 8h despite following the same trend found in the control results. D-Glucose levels followed a similar circadian rhythm in control and 40mT EMF exposed crabs, with significant increases towards peak

locomotor activity, while 2.8mT exposed crabs were lacking this increase and showed no significant elevation after 8h. Melatonin, a hormone present in crustaceans, can cause changes in L-lactate and D-glucose cycles (Tilden *et al.* 2001). Several studies have shown that EMF can alter the circadian rhythm of animals by altering melatonin levels (Reiter 1993, Schneider *et al.* 1994, Levine *et al.* 1995). This suggests that exposure to 2.8mT electromagnetic fields, the predicted strength around ORED sites, could affect crustaceans at hormonal level.

Berried female edible crabs incubate their eggs offshore for 6-9 months (Naylor *et al.* 1997). Given the proven attraction of *C. pagurus* to EMF sources, incubation of the eggs may take place around areas with increased EMF emissions. Long term studies are needed to investigate the effects of chronic EMF exposure and the effects of EMF on egg development, hatching success and larval fitness.

In this study it was shown that exposure to electromagnetic fields, at the strength predicted around sub-sea power cables altered *C. pagurus* behaviour and had a significant physiological effect. Natural roaming behaviour has been overridden by an attraction to the source of the EMF. The potential aggregation of crabs around benthic cables and the subsequent physiological changes is a cause for concern.

With the recent large scale renewable energy developments, in planning and completed, around the UK, there is a clear need for research to determine the effects of such deployments on the marine ecosystem and to fill in the gaps in the knowledge of the effects of the associated stressors.

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New insights into the lives of British Shovelhead Worms (Annelida: Magelonidae)

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Amgueddfa Cymru–National Museum Wales

Introduction

The Magelonidae is a relatively small family of annelid worms containing 68 species in two genera: *Magelona* F. Müller, 1858 and *Octomagelona* Aguirrezabalaga, Ceberio & Fiege, 2001. The family has a worldwide distribution, burrowing in muds and sands, generally at shallower depths (< 100 m). They are slender and beautiful worms that are usually less than 10 cm in length. The characteristic flattened head used for digging in sediments gives rise to the group's common name—the shovelhead worms. Magelonids possess two long feeding palps, arising ventrolaterally and adorned with papillae. The body is divided into distinct regions: the head (prostomium and peristomium), an achaetous first segment, a thorax of eight or nine chaetigers, and an abdomen consisting of many chaetigers, terminating at the pygidium.

There are currently five magelonids known to occur in British waters: *Magelona mirabilis* (Johnston, 1865), *Magelona johnstoni* Fiege, Licher & Mackie, 2000, *Magelona filiformis* Wilson, 1959, *Magelona alleni* Wilson, 1958 and *Magelona minuta* Eliason, 1962.

Very little is known about the behaviour of these annelids, although previous observations made by McMahon & Jones (1967) and Jones (1968) on an undescribed species from Woods Hole, USA, and early studies by W.C. McIntosh (1877, 1878, 1879, 1911, 1915, 1916) add much needed information on their natural history. Despite this work, several questions about their mode of life remain unanswered.

Observations and Discussion

Amgueddfa Cymru - National Museum Wales has been observing British shovelhead worms in aquaria since 2012, particularly *M. johnstoni* and *M. mirabilis*, and to a lesser

extent *M. filiformis*. Mortimer & Mackie (2014) published initial results from these observations, in which *M. johnstoni* was principally observed to surface deposit feed. This consisted of animals collecting particles of administered invertebrate aquarium food (a suspension predominately composed of algae and essential nutrients) and detritus from the sediment surface, and using papillae to manipulate selected particles. These particles were transferred along the palps towards the mouth in 'conveyor belt' like motions. Suspension feeding was also observed to a smaller degree, whereby suspended particles were captured within the water column and transferred towards the mouth in the same manner as surface deposit feeding. Animals burrowed more or less continuously through the sediment (with palps trailing behind), only bringing their palps to the surface when food was administered into the tank. While feeding observations for *M. johnstoni* were in



Fig. 1: Juvenile *Magelona alleni* from Jennycliffe Bay, Plymouth Sound (photo: Andrew Mackie)

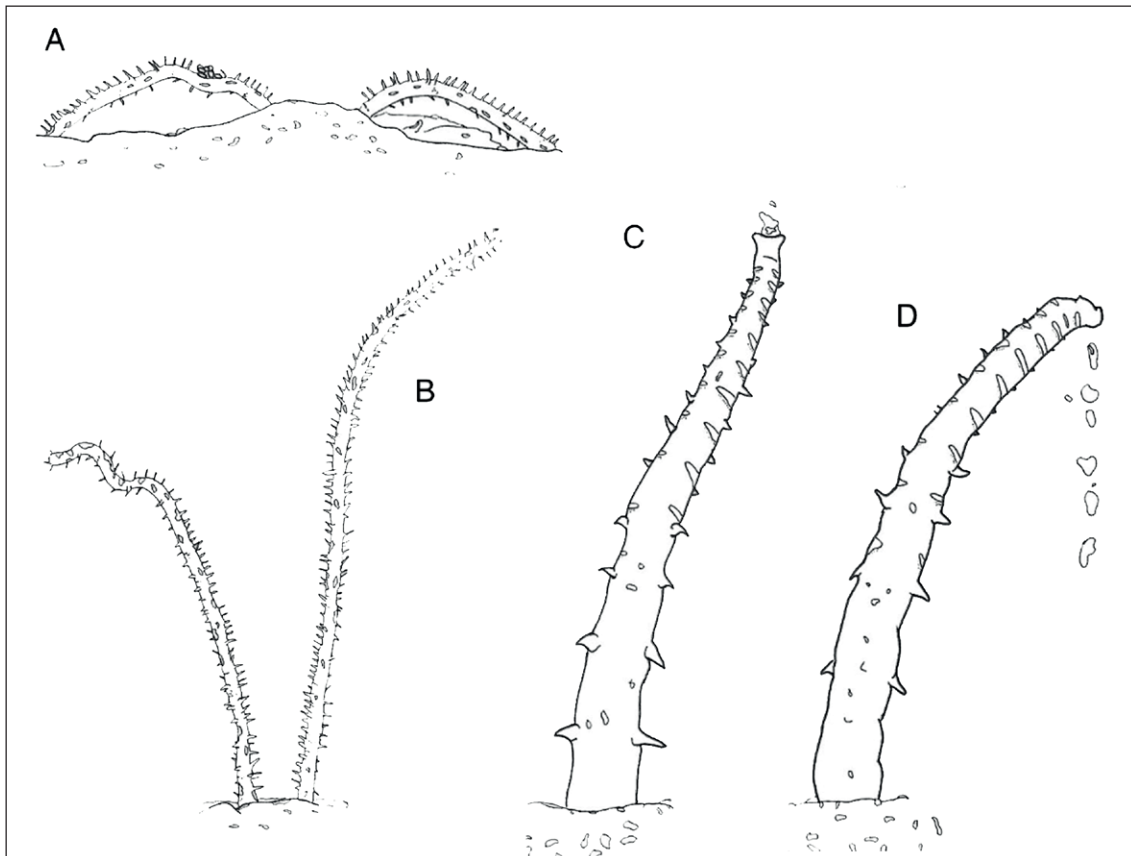


Fig. 2: Feeding and sand expulsion in *Magelona alleni*. A: medial palp regions emerging from burrow, showing collected particles along palp length; B: palps within water column, left-hand palp showing cupping formation used to carry particles along the palp in a conveyor belt like fashion; C: tail end emerging from burrow showing sand expulsion; D: sand grains expelled from tail end.

line with those made by authors such as Jones (1968), those for *M. mirabilis* were less clear. Despite being observed for over two years, direct observations of feeding for the latter species were limited, and filter-feeding on tiny particles and/or bacteria is a possibility that needs further investigation. Given that Jumars *et al.* (2015) also indicated sub-surface feeding and carnivory may occur within the family, the results strongly suggested that interspecific variation in feeding modes is present within the family.

More recent observations focused on *M. alleni* collected from Jennycliffe Bay in Plymouth Sound. Animals were collected using a short arm chain rigged Van Veen grab from the Marine Biological Association's R.V. *Sepia* in March 2017 and later transferred to observation tanks at National Museum Cardiff. The experimental set-up and methodology was as utilised in Mortimer & Mackie (2014). Observations were carried out over a seven-month period using

time-lapse photography and through a low-power microscope held horizontally.

These results have been extremely interesting, lending further support to the idea of interspecific variation. In stark contrast to *M. johnstoni*, *M. alleni* did not burrow continuously through the sediment. The species alternatively built pitchfork-shaped burrows lined with parchment-like tubes, which were inhabited for many weeks/months at a time. *Magelona alleni* is one of the few magelonid species known to build these distinct, papery, multi-layered tubes covered in an outer sediment coating (see Mortimer, 2017 for a full list). These tubicolous magelonids tend to have a relatively lower number of chaetigers, be particularly stout and carry a pigment band in the posterior thorax (Figure 1).

Although feeding methods were similar to that described for *M. johnstoni*, two major differences were noted—Firstly, the palps of

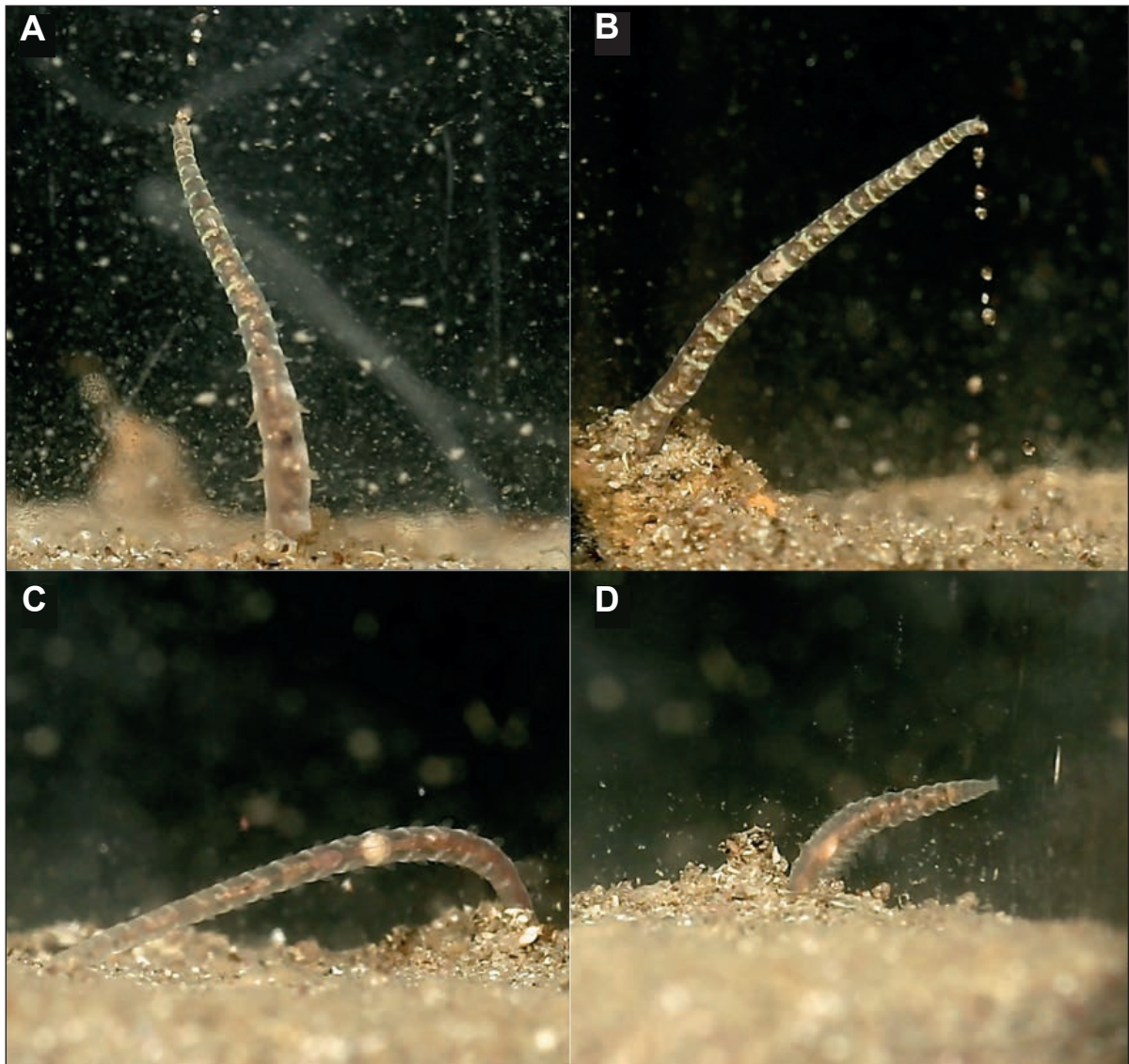


Fig. 3: Various time-lapse captures of the posterior region of *Magelona alleni* extended from burrow into water column during sand expulsion events. A: sand expelled upwards from pygidium; B: sand expelled downwards; C, D: relaxed posture of the posterior region towards the end of an expulsion event.

M. alleni were observed to spend the majority of time within the water column (Figures 2A, 2B), unlike *M. johnstoni*, which only placed them in the water column in response to administered food. Variation in burrowing activity may explain this difference, since palps are known to trail behind the body during the almost continuous burrowing of the latter species, while burrowing for the former species was limited. However, it has previously been suggested that magelonid palps have a secondary respiratory function (McIntosh 1911; Jones 1968) and thus the placement of palps more or less continuously above the sediment-water interface by *M. alleni* may

aid respiration in this tube-dwelling species. The second notable difference concerns the variation in diet between *M. alleni* and *M. johnstoni*. *Magelona alleni* consumed mostly large quantities of sediment, and to a lesser extent, foraminifera and administered aquarium food. Although this diet has been suggested for other magelonid species (McIntosh 1911; Hunt 1925; Mare 1942; Dauer 1980; Magalhães & Barros 2011), this is in stark contrast to the selective feeding on algae and detritus observed for *M. johnstoni*.

Perhaps the most intriguing finding was based on defecation, which has not been previously documented in magelonids. Defecation was

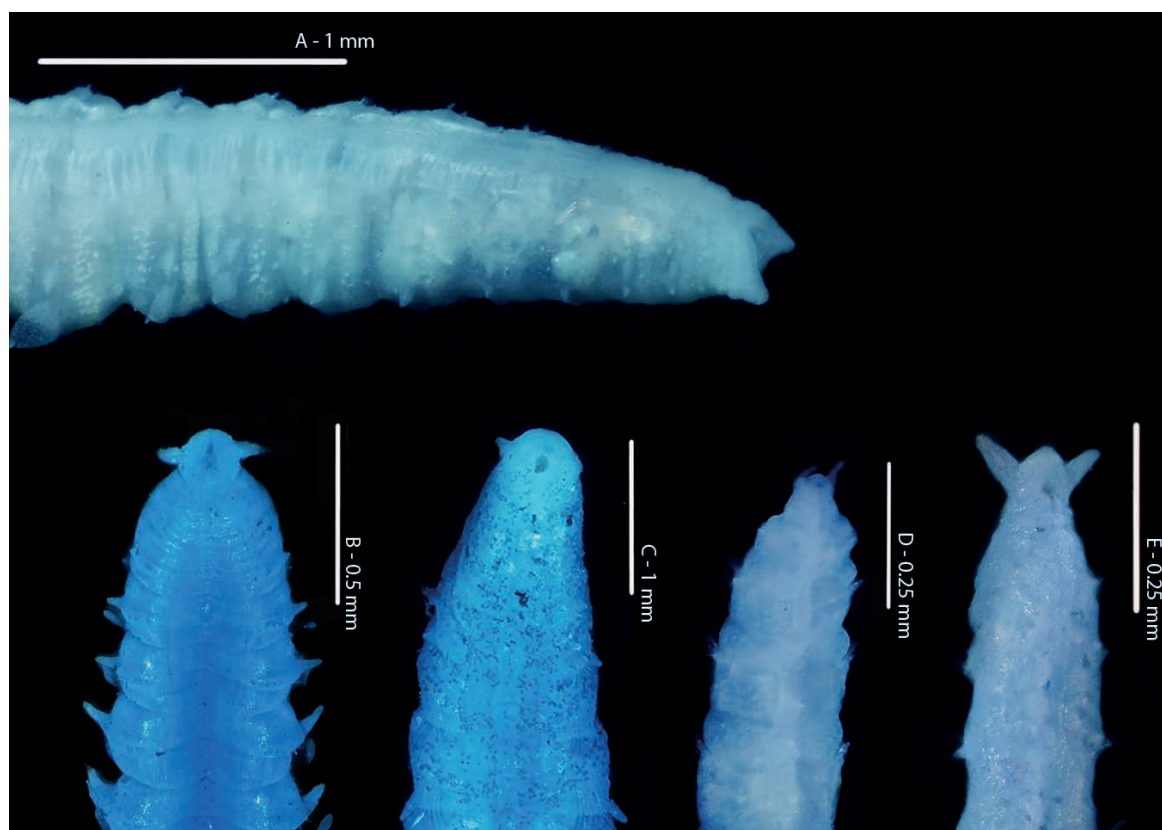


Fig. 4: Variation in the posterior regions and pygidia of European *Magelona* species. A: *Magelona johnstoni* Berwick-upon-Tweed (ventral view); B: *Magelona mirabilis* East Sands, Fife, Scotland (ventral view); C: *Magelona minuta* Irish Sea (ventro-lateral view); D: *Magelona filiformis* Outer Bristol Channel (ventro-lateral view); E: *Magelona alleni* paratype (ventro-lateral view). All methyl green stained.

not observed in either *M. johnstoni* or *M. mirabilis* during five years of observations. However, *M. alleni* was frequently observed to turn around in its network of burrows from a head-upwards to a head-downwards position. The posterior end would be placed out of the burrow for approximately 15–20 chaetigers and would conspicuously expel large volumes of sand grains into the water column (Figures 2C, 2D & 3), whilst moving laterally from side to side. It was evident that mucus was involved in this sand expulsion behaviour, and almost string-like strands of sediment were deposited on tank walls (Figure 3D). The animal would then use its pitchfork-shaped burrow to turn back to a head-upwards position and place its palps back within the water column. It could be postulated that the lack of observations regarding defecation in *M. johnstoni* and *M. mirabilis* may be due to waste products being excreted during burrowing. However, a tubicolous species must remove waste from its tube, something well documented in other annelid groups, such as Arenicolidae (Darbyshire 2017) and Sabellidae (Rouse 2001).

Hence, further investigations in other tubicolous magelonid species are warranted.

These new defecation observations led us to think about the morphology of magelonid species, particularly the posterior region. Unfortunately, little to no attention has previously been given to the posterior end of magelonids. In part, this is due to the fragility of these animals, which often break upon collection, resulting in many species being described from anterior ends only. It has generally been assumed that the tail end of magelonids is relatively uniform, and this is certainly true for four British species: *M. johnstoni*, *M. mirabilis*, *M. filiformis* and *M. minuta*. Although a small degree of variation exists, they all have a small central anus surmounted by two lateral digitiform anal cirri (Figure 4A–D). In contrast, *M. alleni* has a large terminal anus with two stout lateral projections (Figure 4E), which may be related to diet and the expulsion of large volumes of sediment during defecation. To corroborate

this idea, the examination of additional species is needed.

In summary, long-term observations have provided new information on feeding, burrowing, and now tube building and defecation for magelonid worms. There are clearly behavioural differences between species and thus a generalized mode of life for shovelhead worms cannot be assumed. The diet and habitats of further *Magelona* species need to be studied and observed in comparison to morphological differences. It is likely that the resulting information from future studies will be important for our understanding of the family as a whole and may provide useful characters for cladistics analyses of the group.

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Seasearch – Opening up data for marine conservation

Charlotte Bolton

National Seasearch Coordinator,
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Many of the readers of this article may not have heard of Sir John Sulston who died earlier this year, the joint winner of the 2002 Nobel prize in Physiology or Medicine for his work on the nematode *Caenorhabditis elegans* (Maupas, 1900) (Figure 1a). However, readers will undoubtedly remember the Human Genome Project (HGP) which began in 1990 and was declared formally complete in 2003, having published the first working draft of a reference human haploid genome in February 2001¹ (Figure 1c). Sir John Sulston (Figure 1b) was Director of the Sanger Centre, part of the international consortium working on the HGP. One of the fundamental concepts underpinning this amazing endeavour was the principle of Open Data, embodied in the Bermuda Principles published in 1996, which stated that all the sequencing data generated by the HGP partners should be placed in the public domain within 24 hours. Without this commitment to sharing, the HGP would not have succeeded. John Sulston had a personal belief in what has been described as ‘ignorance-driven science’, whereby data is shared amongst the community such that anyone can use that resource to test their own hypotheses.

Nowadays this tenet seems less radical than in the final years of the 20th century, though

there are still battles to be won. We are all familiar with the cost of collecting marine data, and the guiding rule of ‘collect once, use many times’ is now widely accepted. The Open Government Licence of 2010 has given access to datasets previously hidden in proprietary databases and archives, and funding bodies such as the Heritage Lottery Fund and the Natural Environment Research Council now routinely require that not only should results be published in Open Access journals (rather than hidden behind paywalls or inaccessible to those unable to afford expensive subscriptions) but that the raw data should also be freely and publicly available. Here in the UK we have the National Biodiversity Network (NBN) to fulfil the vital role of collecting, collating and distributing our biodiversity data over the internet as a node of the Global Biodiversity Information Facility (GBIF). Of course, this infrastructure for disseminating and archiving data costs money, and the NBN receives support via a subscription model. Seasearch is one of over one hundred and forty data partners many of whom are also corporate members of the NBN. Data is available to download from the NBN under one of four licences, giving clear guidance on how the data can be used; Seasearch data is shared under the Creative Commons Attribution licence, CC-BY, which basically just means that you have to acknowledge where it came from – there are no onerous terms and conditions.

As a result of our commitment to Openness, Seasearch was honoured to receive the John Sawyer Open Data award at the NBN Conference in November 2017 (Figure 2a) (Paula Lightfoot also received the David Robertson Adult Award for recording marine and coastal wildlife



Fig. 1: Composite pic of a) the nematode (*Caenorhabditis elegans*), b) Sir John Sulston, and c) the cover of *Nature* volume 409 (15/02/2001)

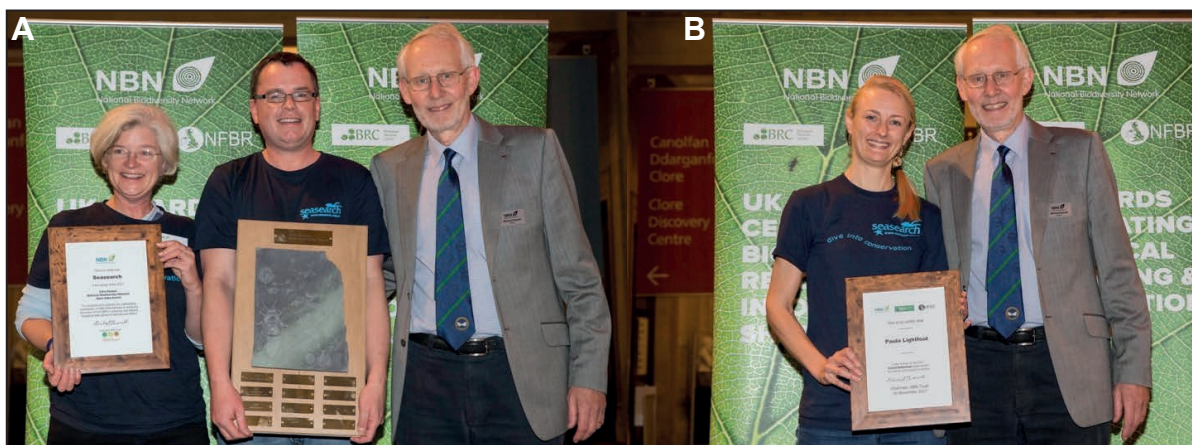


Fig. 2: a) Charlotte Bolton, David Kipling and NBN Chairman Michael Hassell with the NBN Open Data award; (b) Paula Lightfoot and Michael Hassell with the David Robertson Adult award (Copyright Mark Hawkins²)

(Figure 2b), not just for her work as Seasearch Coordinator for North-East England but for her myriad other activities (I don't know how she fits it all in...)).

This aligns with the majority opinion of the volunteers who responded to a survey in February 2013, asking how we should make our (their!) data available. Over 90% agreed or strongly agreed with the statement "I would like all organisations [my emphasis] who make decisions that could affect the marine environment to have free and full access to my records", and over three-quarters of respondents were neutral or agreed with "I would consider it a waste of time [again, my emphasis] filling in Seasearch forms if my records weren't made fully publicly available".



Fig. 3: Sarah Bowen's reaction to the Open Data award announcement (Copyright Mark Hawkins)

All of this would be commendable but ultimately insignificant if Seasearch datasets didn't comprise approximately 17% of marine data on the NBN, making us the second-largest supplier behind the Joint Nature Conservation Committee (JNCC, mostly as a result of the Marine Nature Conservation Review (MNCR) which concluded in 1998) and just ahead of the Marine Biological Association (MBA). It's imperative that marine data should be publicly available and easy to access if we want the marine environment to be properly 'managed' (for spatial planning, protected areas, monitoring for Good Environmental Status and so on). The phrase "A decision taken in the absence of information is basically just a guess..." resonated with the audience at the NBN Conference last November³ and should be prominently displayed in many (un-named) offices! In the absence of Open Data we cannot complain about bad decisions.

But as well as being open and accessible, we should ensure that our data is robust and as accurate as possible (within the bounds of human endeavour...!). The workshop at the NBN conference last November entitled "How-can-the-NBN-Atlas-work-better-for-marine-data?" (see <https://nbn.org.uk/news-events-publications/nbn-conference-2/nbn-conference-2017-presentations-photos/nbn-conference-workshops-2017/> for the collated notes) was a timely and very engaging opportunity to address issues with the new Atlas infrastructure and wider data sharing issues within the marine data community. As part of

the agreed pilot project to ascertain the scale of inaccurate records, there are gratifyingly small numbers emerging. Of course, no marine dataset manager likes to find terrestrial records lurking within their data, but we have the tools and processes to deal with these instances and prompt action can only reinforce confidence in our records as a reliable resource.

Allied to the public clean-up activity of marine data, here at Seasearch we've undertaken an internal review of our QC procedures and circulated a survey to our more experienced volunteers (those qualified as the higher-level Surveyors and/or who have been involved over a number of years) to ascertain any perceived gaps or weaknesses in our training materials. Many long-serving volunteers asked for more and ongoing feedback and mentoring support after qualification, and for more context for their recording efforts to maximise the value of the forms they were submitting. As a result, the Surveyor course itself has been updated over the winter, and we are also running local/regional 'recorder workshops' (not limited to Surveyors) to address the first point. No-one

can really put their hand on their heart and say that they enjoy spending hours filling in forms after a dive, but at least we can try to ensure that the resulting data is as accurate and usable as possible. And of course it's always a good excuse for a get-together and fancy-dress party (Figure 4)!

Finally, I urge any Porcupines who have spotted 'issues' with Seasearch data on the NBN to get in touch with me and I will ensure that the errant records are investigated and removed or updated.

¹ See <https://www.nature.com/nature/volumes/409/issues/6822> and links to articles therein.

² Mark Hawkins (Composed Images) NBN Conference images at <https://www.flickr.com/photos/152472562@N06>

³ Courtesy of Barnaby Letheren from Natural Resources Wales



Fig. 4: Pembrokeshire recorders' workshop and sea-squirt-themed party, January 2018 (Copyright Rik Girdler).

The NBN Atlas and Data Quality

Paula Lightfoot

The NBN Atlas is a wonderful resource for those who collect and use marine biodiversity data. The ability to contribute to knowledge of species distributions and to see our own records in the context of others is a great motivating factor for recorders. Although marine species represent only a small proportion of the total data available through the NBN Atlas, the volume of marine data is steadily growing. By bringing together data from multiple sources, including statutory nature conservation bodies, research institutions, conservation NGOs, national recording schemes and local environmental records centres, the NBN Atlas is a convenient 'one-stop-shop' providing access to data for research, conservation and of course for general interest.

The datasets on the NBN Atlas are provided by over 120 different organisations. These data partners are responsible for quality controlling the data they share and for providing information about data collection and verification procedures. This information can be viewed on the metadata pages for each dataset on the Atlas. Despite data providers' best efforts, some errors do inevitably slip through the net. The appearance of records outside a species' expected distribution (or worse still, records of marine species on land!) is confusing and can undermine confidence in the data. Once added to a database, errors can persist for years and cause considerable frustration.

The NBN Secretariat, in consultation with data partners, has been taking steps to tackle this very important issue. All species records now have a verification status which can be used to filter records for view and download, e.g. to eliminate unconfirmed records from a distribution map. By default, both accepted and unconfirmed records are mapped on the NBN Atlas species pages, but unconfirmed records are shown in a different colour. The ability to annotate individual records, for example to notify a data partner of potential errors in their dataset, is planned as a priority for future development. Until then, it is possible to contact data partners using the contact details provided on their profile page on the Atlas.

As some readers know from personal experience, managing a species database is always a work

in progress. Making data publicly available for peer review is a wonderful way of improving data quality. Drawing potential errors to the attention of the data partner enables them to take action to correct or remove the record. If no action is taken, the annotated record will be classified as unconfirmed and can therefore be filtered out of maps and downloads.

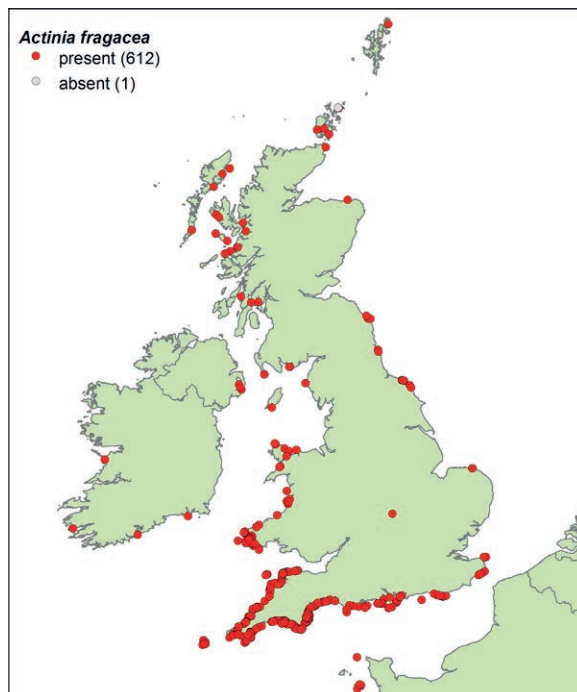
Peer review of species records can be carried out by individuals in an *ad hoc* way, simply notifying data providers of potential errors as and when they are spotted. However, during a workshop on marine data at the NBN Conference in Cardiff last November, we discussed whether the marine community could get together to review data on the NBN Atlas in a more coordinated way. We could start by drawing up a manageable shortlist of priority species to tackle based on concerns about the accuracy of their distribution data and the importance of knowing their distribution, e.g. climate change indicators, non-natives, conservation priorities or species which have undergone recent taxonomic revision. We would assess distribution data and contact data providers about potentially dubious records. This could improve data quality for a small (but important!) set of marine species, and would also provide insight into the scale of the problem and the effort needed to tackle it. It may even inspire others to take a more active role in improving data quality!

You can read the complete set of notes from the workshop on marine data here:

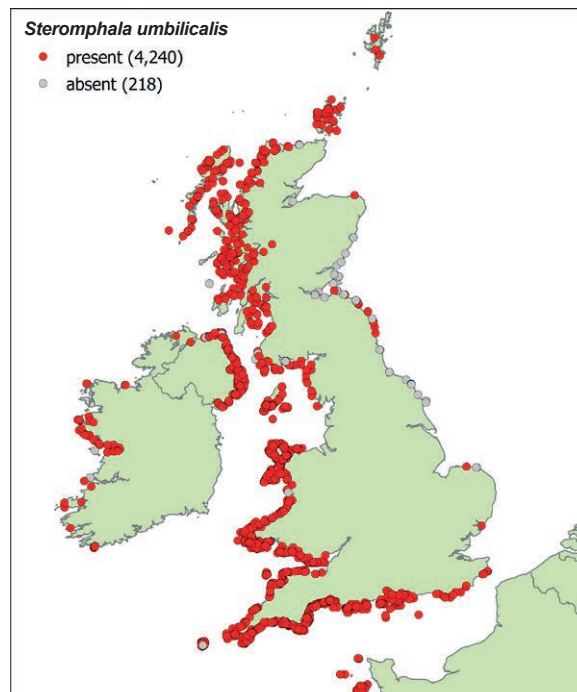
<https://nbn.org.uk/wp-content/uploads/2018/01/Workshop-1-write-up-How-can-the-NBN-Atlas-work-better-for-marine-data.pdf>

We have probably all spotted potential errors in species distribution data on the NBN Atlas or NBN Gateway at some point, but perhaps didn't know that we could do anything about it. We, the wider NBN community, can and should take action to ensure the data on the NBN Atlas are as accurate and reliable as possible, thus ensuring that the NBN Atlas reaches its full potential as a valuable resource for all of us.

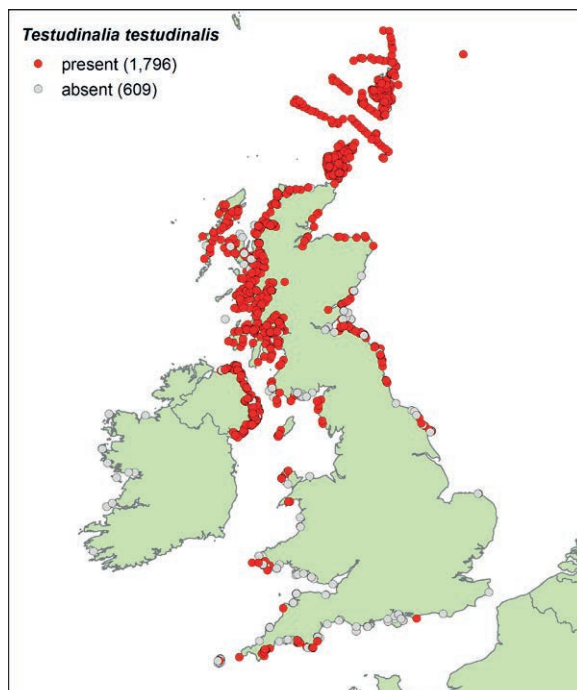
If you would like to be involved in a project to 'clean up' marine data on the NBN Atlas or would like more information, please contact me on p.lightfoot@btinternet.com



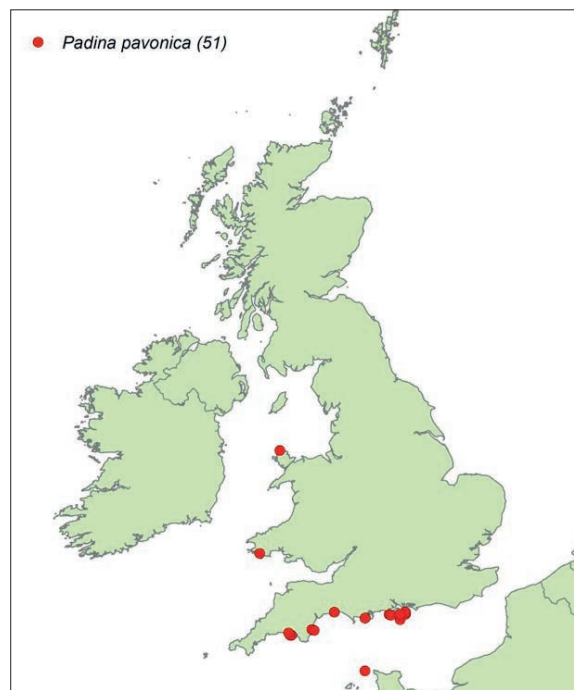
Actinia fragacea Tugwell, 1856 is thought to be confined to the south and west coasts of Britain (MarLIN 2018) but the NBN Atlas has 36 presence records from the east coast and 1 from Coventry! These are supplied by Natural England (18 records), Seasearch (7 records), JNCC (4 records), the MBA (4 records), Scottish Natural Heritage (2 records), Porcupine MNHS and the Highland Biological Recording Group (1 record each).



Steromphala (formerly *Gibbula*) *umbilicalis* (da Costa, 1778) is thought to be absent from the North Sea coast and eastern English Channel (MarLIN 2018) but the NBN Atlas has 31 presence records for this species on the east coast, supplied by JNCC (14 records), the MBA (10 records), the Conchological Society (2 records), the ERIC North East (2 records), the National Trust, Seasearch and Yorkshire Wildlife Trust (1 record each).



Testudinalia testudinalis (O.F. Müller, 1776) is a northern species, thought to be absent from the south coast of England (MarLIN 2018) but the NBN Atlas has 55 presence records for this species on the south coast provided by Natural England (26 records), JNCC (17 records), the MBA (6 records), Natural Resources Wales (4 records) and Seasearch (2 records).



Padina pavonica (Linnaeus) Thivy, 1960 is recorded along the south coast of England although it has been recorded from Ayr in Scotland in the 19th Century (MarLIN 2018). The NBN Atlas has a presence record from North Wales, although that record is attributed as 'unconfirmed' using the NBN's new system of verification status attributes.

The NBN Atlas and Marine Data

Christine Johnston

NBN Scottish Liaison Officer

Introduction

The NBN Atlas is the UK's largest collection of shared biodiversity records, and currently holds over 219 million occurrence records, supplied by 129 data partners. It was launched on 1 April 2017 and is the replacement for the NBN Gateway. The need for a new infrastructure for sharing data was identified during the NBN's 2014-15 strategy consultation with our broad partnership of members, data users and data providers, and the Atlas concept was developed on the Atlas of Living Australia open source infrastructure model.

The NBN Atlas is currently in the first phase of the development. Updates and changes to the NBN Atlas will be continuous, and driven by the needs of the data community, subject to resources and capacity.

Exploring the NBN Atlas

The NBN Atlas is a very different interface (Figure 1) to the NBN Gateway, with a

different look, feel, and range of capabilities, and it provides functionalities for searching, filtering, mapping, analysing and downloading records. To get started with using and searching the NBN Atlas we recommend you look at the 'How to' videos in the relatively new NBN Atlas Documentation and Help Portal (Figure 2), which is accessible from the Help tab on the home page.

Data searching

There are many different routes and ways of searching for NBN Atlas data and it is possible to do so without logging in, although you do need to log in to download data. Initial exploratory searches are possible for specific species, locations and sites, and terrestrial habitats. You can also search by dataset or data partner. Advanced searching of the site, using multiple criteria, is also possible, and all the searches can be accessed through the home page.

Filtering, mapping and analysing

Figure 3 shows the Porcupine dataset 'Marine flora and fauna records from the North-east Atlantic' mapped on the interactive map where records can be filtered, mapped in different ways and downloaded. The column on the left-

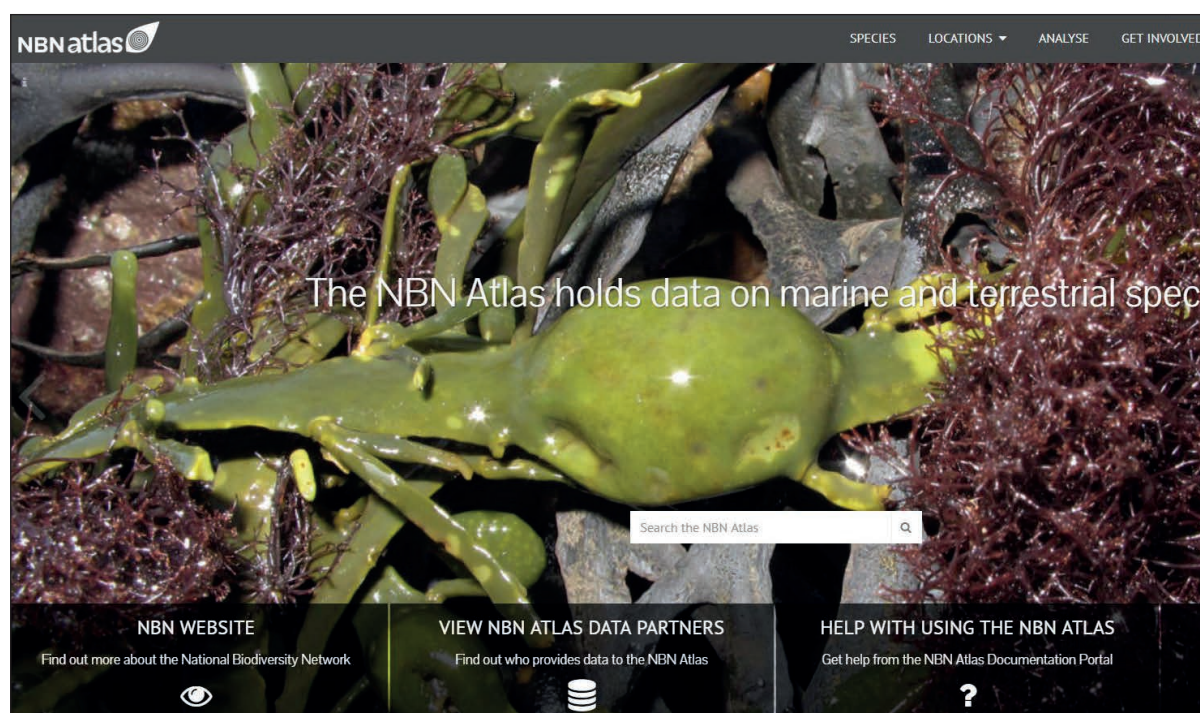


Fig. 1: The NBN Atlas home page

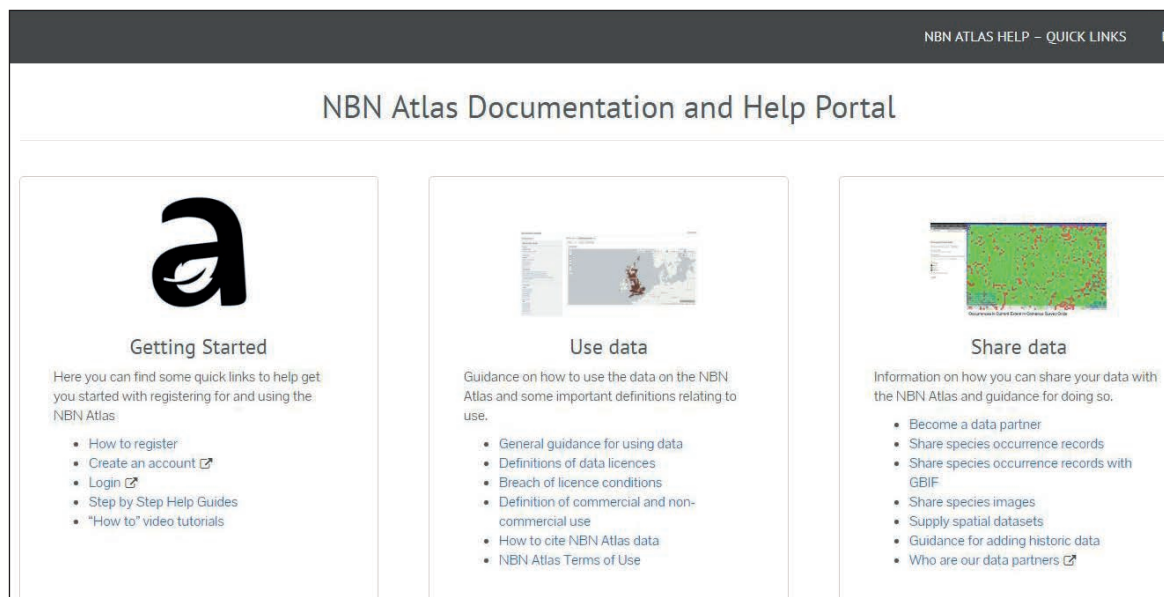


Fig. 2: Part of the Quick Links section of the NBN Atlas Documentation and Help Portal

hand side provides initial filters that enable you to Narrow your Results and the Customise filters button opens out more filtering options, such as by date or resolution. Controls to change the appearance of the points, and to pan, zoom and select from the map are at the top of the map, and the tabs across the top of the window enable the switching of views to Records, Charts or Record images.

Displaying records

Records can be displayed and filtered by verification status. Verification flags have now

been added to each record to improve visibility of data quality. There are two levels of flags:

- Level 1 (required for each record): 'Unconfirmed' and 'Accepted' which map to Marine Recorder's 'Uncertain' field
- Level 2 (optional for each record): 'Accepted – correct', 'Accepted – considered correct', 'Unconfirmed – plausible' and 'Unconfirmed – not reviewed'

Records can be displayed as grids or as points. Currently, however, the grid map display will only display records that are supplied with an

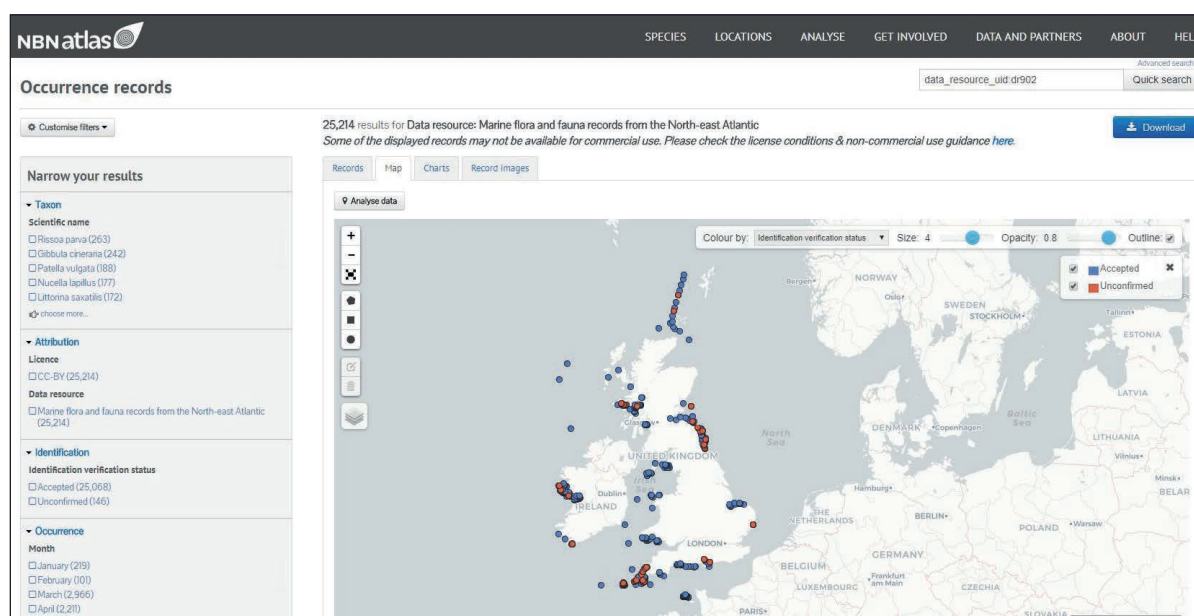


Fig. 3: The Porcupine dataset mapped in the interactive map

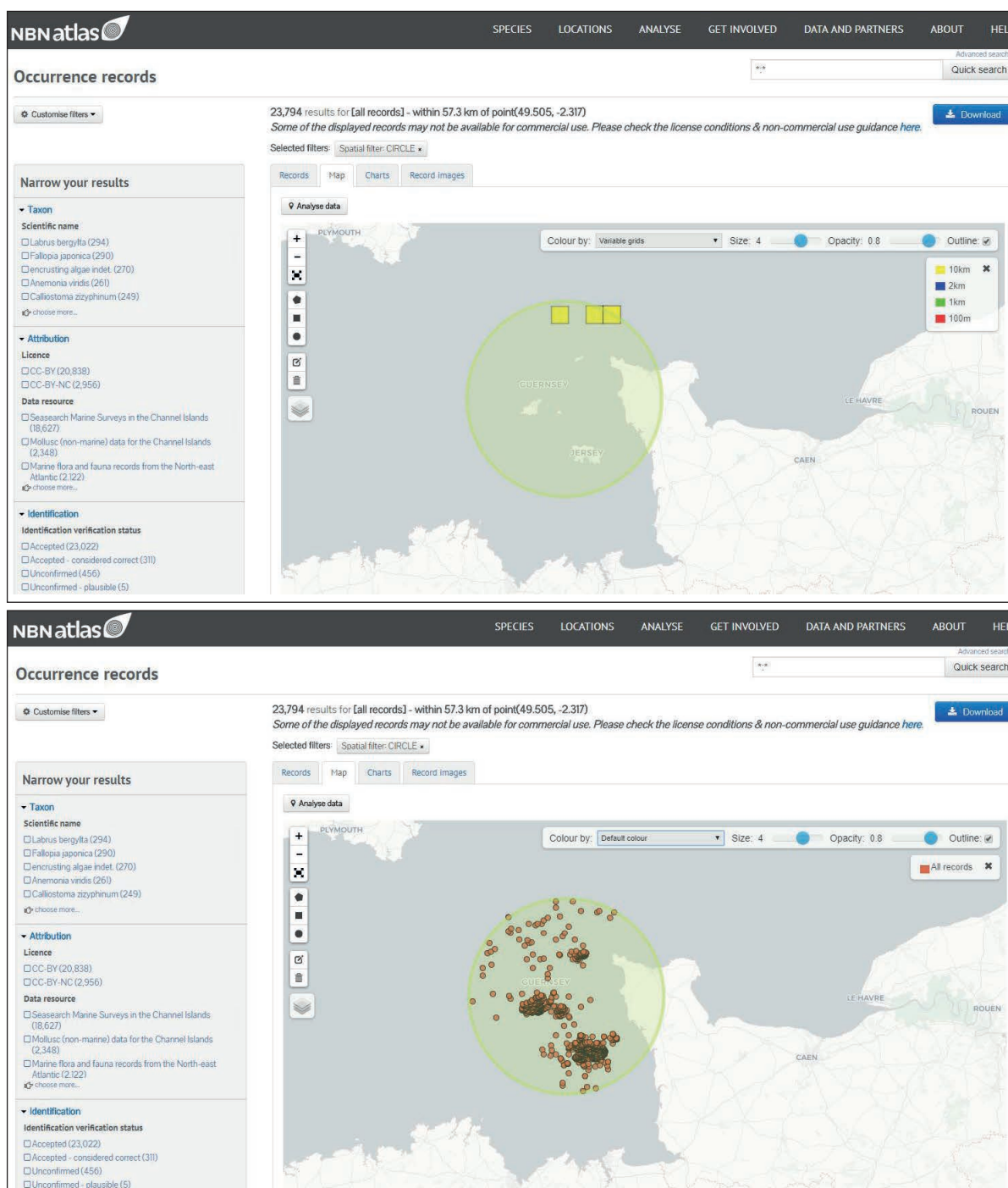


Fig. 4A (top): Grid map display of records from around the Channel Islands; B (bottom). Point map display of the same records in A.

Ordnance Survey grid reference, consequently any records that are supplied with latitude / longitude references (as is often the case with marine data) will not display. However, all the records from the search will still have been accessed and are downloadable whether or not they are visible on the map. If the records are displayed as points ALL records will display. The reason for this is that the conversion from

a latitude / longitude reference to an OSGB reference will result in the allocation of a less precise reference which can be misleading when downloaded.

Using an example of records from around the Channel Islands, Figure 4a shows the grid map display and Figure 4b the point map display of the same records.

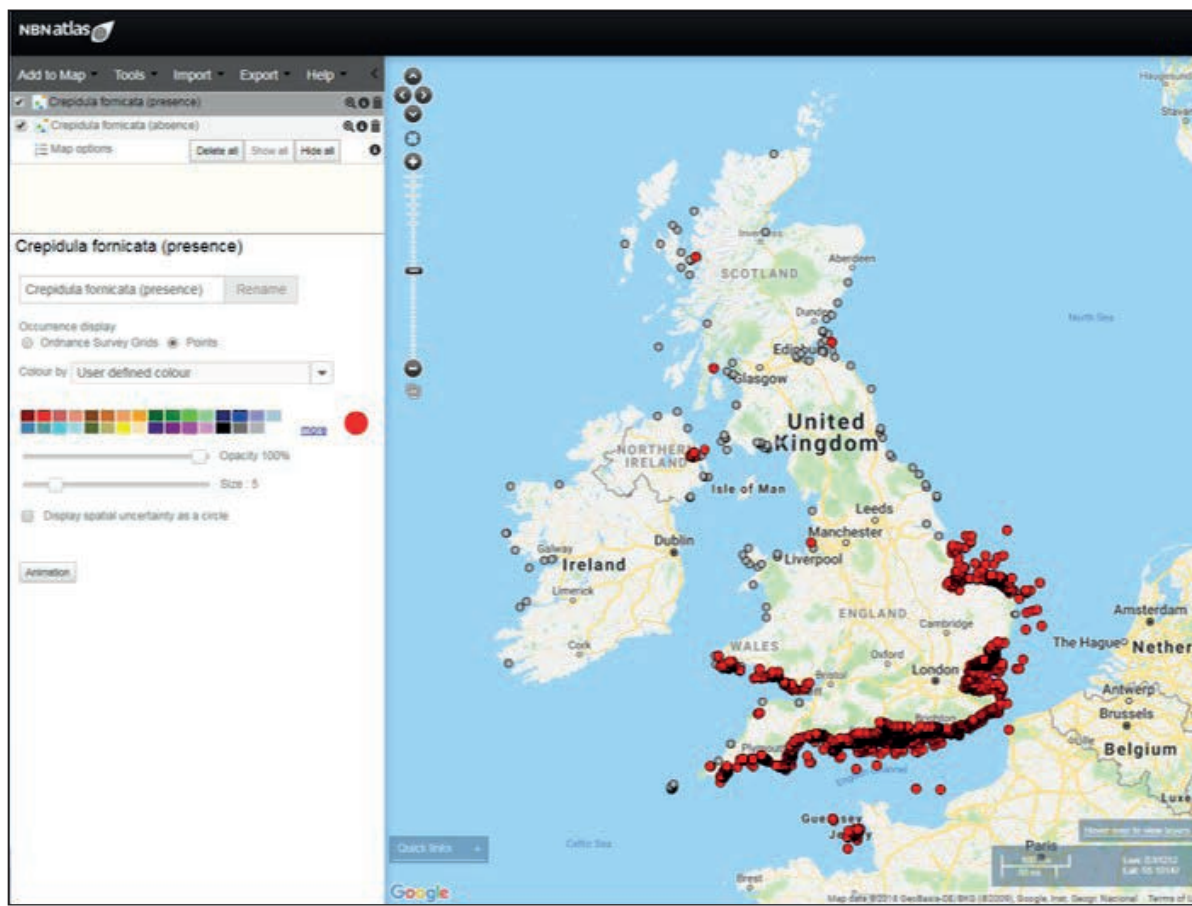


Fig. 5: The Slipper limpet mapped by presence and absence in the spatial portal

Records can be categorised for display by presence or absence. Figure 5 shows the Slipper limpet (*Crepidula fornicata* (Linnaeus, 1758)) distribution displayed in the spatial portal. The red dots are presence records and the open circles are absence records.

Downloading

The Download button, which is available on each search results page, links to the download page where various options for download are offered. You must be logged in to download datasets. You can choose to download the species records or a species checklist, and download formats include .csv or shapefiles (.shp). Recent improvements to the download process include the queuing of dataset downloads within the NBN Atlas to help with managing large numbers of requests, and you are now sent an email containing a download link when it is ready.

Developing the NBN Atlas and improving data quality

We have a great interest in trying to ensure that the data on the NBN Atlas are of as high a quality as possible so that data users can have confidence in the data. Data quality is the responsibility of all of us, and on the front line are recorders and data partners, with whom the data flow commences.

The recently launched Atlas Documentation and Help Portal, which is intended to improve the amount of easily accessible help available to users, and the implementation of verification flags for records, are two key changes that will have a positive impact on data quality.

Proposals for developments to improve the visualisation of all data, including marine data, and tools to facilitate the understanding of, and to assist with improving data quality, are in the pipeline for the future. These proposals have been developed in consultation with data users as part of our ongoing engagement with NBN Atlas stakeholders.

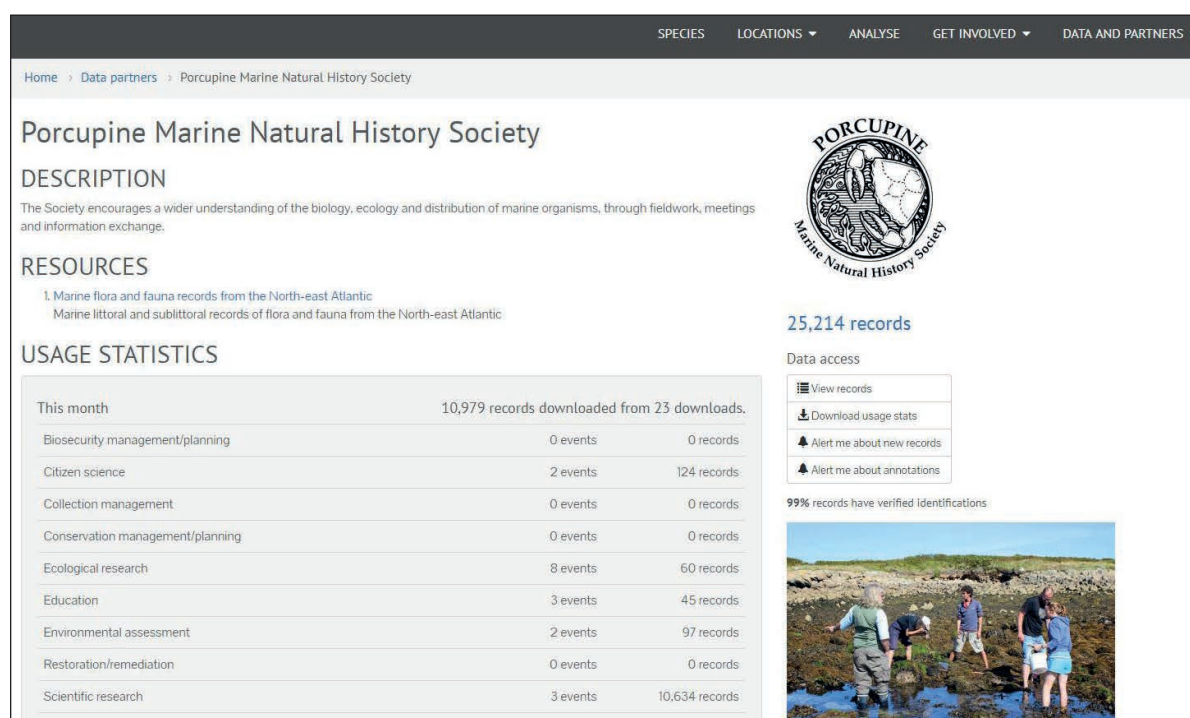


Fig. 6: The Porcupine Marine Natural History Society data partner page

The developments we are working on, with an indication of their priority, are:

Nearing completion:

- Testing of an automated export of records from iRecord to the NBN Atlas, which will improve the flow of records.

Ongoing work:

- Adoption of the global Darwin Core format for biodiversity species description for both upload and download. This format facilitates onward sharing with GBIF. We are actively working with data partners to work towards sharing data in the Darwin Core format, but we are continuing to accept data supplied in the NBN Exchange format.
- Making extra attributes available for download, such as the ability to download the 'specimen' attribute.
- Collaborating with Edinburgh University on a research project to investigate if we can automate spatial layer harvesting and use these layers for analysis. This work will help to improve data currency and hence data quality.
- More regular updating of the UK Species Inventory (UKSI).

- Sharing marine data with DASSH (with the permission of the data partner and where the data is not already in DASSH).

Longer term plans:

- Implementing additional filtering options, for example:
 - o Filtering of species by 'marine', 'terrestrial' and 'freshwater' categories.
 - o Filtering by a 'native/non-native' flag based on the GB Non-native Species Information Portal list in the UKSI.
- Sourcing suitable marine base and habitat layers. We know the current base mapping detail is deficient and we are happy to work with data suppliers to rectify this.
- Developing the comment facility at record level, which will also help users see that errors have been noted.
- Consulting users on which fields should feature in the records preview table.

NBN Atlas data partners

We greatly value our data partners as their work and support is crucial to the success of the NBN Atlas. The Atlas enables each data partner to publicise their work, datasets, and

contact details in their own data partner page (Figure 6). A rolling carousel on the home page provides a prominent position for data partner logos and links to their data partner pages.

The NBN Atlas family

The infrastructure offers the ability to build bespoke portals that share access to the NBN Atlas's single database of records and functionalities, but which provide a web interface that focuses on that particular part of the country. To date we have created NBN Atlases for Scotland, Wales and the Isle of Man, all of which are accessible via the Choose Atlas drop down menu on the NBN Atlas home page.

Sharing species records with the NBN Atlas

To share your species records we need two files: the metadata for your dataset, and the occurrence records themselves. Templates for both these files, and detailed instructions, can be found in the Help Portal at <https://docs.nbnatlas.org/share-species-occurrence-records-with-the-nbn-atlas/>. If you are unable to supply in Darwin Core (the Darwin Core is a body of standards) we will accept records in the old NBN Data Exchange format.

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Capacity for Corals to Acclimate to a Mobile Lifestyle

Dan MacRae, Sebastian J. Hennige, Heidi L. Burdett

Abstract

Coralliths are mobile, free living colonies of corals which are found in a wide range of tropical reef habitats. Through these mobile lifestyles they have been hypothesised to establish pioneer communities in sedimentary areas, allowing other corals to then become established on this solid substrate. A predominant example of this is *Porites* spp. where planulae settle onto coral rubble and develop into spheroid coralliths. Other corals have also been shown to form coralliths through fragmentation, however, the mortality rate of these examples is highly varied. This presents a gap in the knowledge in terms of how well corals can acclimate to this unusual lifestyle. Three reef building corals (*Porites cylindrica* Dana, 1846, *Seriatopora hystrix* Dana, 1846 and *Acropora* spp.) are compared. Physiological stress is being measured through respiration rate and PAM Fluorometry assays. The results from this study aim to improve our understanding of how well corals can acclimate to these conditions and what physiological stress occurs during this process. Note: this study is still ongoing, therefore this article discusses the methods which have been used, and notes the general observations made so far. No conclusive results have been obtained at present.

Introduction

Tropical coral reefs across the globe are not only biodiversity hotspots (Knowlton *et al.* 2010), they also provide a range of services including coastal protection (Cesar 2000), economic benefits from tourism (Driml 1994) and are an essential source of food for many coastal communities and developing nations (Best & Bornbusch 2001). However, in recent years these vital ecosystems have been put under considerable stress through anthropogenic interferences. These impacts and the effects they have on corals have been documented and researched extensively, yet the drivers of reef growth and recovery have received significantly

less attention. To mitigate the degradation of tropical reefs, a focus into how reefs grow and recover is therefore vital.

Reefs grow and recover from damage through a variety of natural means, most of which are well documented. One such example is planula settlement; most corals feature broadcast spawning at specific points of the year (Harrison *et al.* 1984). Large quantities of planula larva develop in the pelagic zone before settling on areas of reef, allowing for new juvenile corals to grow in any available space, however current knowledge of planula survival rates is scarce with the exception of laboratory based investigations (Graham *et al.* 2008). Tropical coral genera have also been observed to reproduce asexually through physical fragmentation of colonies (Ayre & Hughes 2000). Having a range of reproductive strategies proves advantageous, especially in rapidly changing ecosystems where sexual reproduction may be limited for periods of time (Foster *et al.* 2007). Fragmentation success rates have previously been believed to rely on a suitable solid substrate for the fragment to settle and adhere to and this has been demonstrated for most genera, with higher mortality rates found amongst fragments which fall onto a mobile substrate (Highsmith 1982).

A mobile substrate is a challenging environment for most reef building scleractinians. However, the tropical coral *Porites lutea* Milne Edwards & Haim, 1851 has recently been shown to not only tolerate this lifestyle but may also thrive and construct new areas of reef. This process is termed the “free-living stabilization hypothesis” (Hennige *et al.* 2017). The process involves planula settlement on dead coral fragments then encrusting the fragment to form a spheroid shape. This spheroid coral is called a “corallith” (Figure 1). The corallith is subsequently moved by wave action and continues to grow. Eventually a critical mass is reached and the corallith is no longer able to be moved but continues to grow, providing a suitable substrate for secondary corals to then settle on (Hennige *et al.* 2017). This method of pioneer community establishment brings together the wide range dispersal of planula settlement, yet also the further step of local dispersal through corallith mobility. This is a

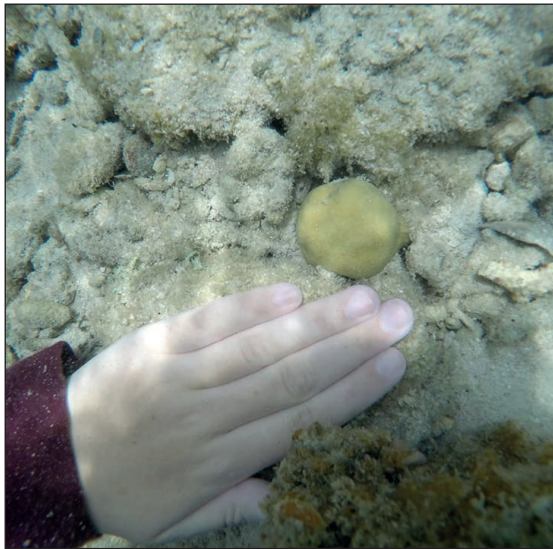


Fig. 1: Example of a *Porites* spp. corallith located around Bidong Island, Malaysia (Photo credit Zoë Lawrence)

major step forward in understanding how reefs recover and develop over time, warranting extra research effort into the ecological role of this process.

This opens a critical gap in the knowledge of reef recovery and development. What allows *P. lutea* and other corallith forming corals to tolerate the harsh conditions of a mobile lifestyle? During this mobile phase, the corallith will be subjected to sediment scour and rapid changes in light intensity, both of which have been shown to cause significant stress to many coral genera (Weber *et al.* 2006; Abrego *et al.* 2008). To answer this, a selection of corals will be subjected to the stress of a mobile lifestyle within controlled laboratory conditions. This will provide a high-resolution view of the physiological stress that occurs during this mobile phase, to further understand why mobile coralliths are only found in select genera.

Fragmentation and aquarium conditions

Three tropical coral genera were selected for the study: a prominent corallith former through planulae settlement (*Porites cylindrica*), a branching and stress susceptible coral (*Acropora* spp.) and a third major reef building coral (*Seriatopora hystrix*). The two latter genera have previously been shown to form coralliths through fragmentation (Roff 2008) (*Acropora* coralliths having high mortality, *S. hystrix*

coralliths having intermediate mortality) yet not through planulae settlement as far as current knowledge stands. The selected species were purchased from Tropical Marine Centre (TMC) as colonies and fragmented within the lab with coral clippers. Twelve fragments of each genus were used (6x mobile, 6x control). The fragments were left to recover for two weeks while they settled into aquarium conditions at 26°C.

Six fragments of each genus were placed on a 2 cm deep sedimentary substrate of coral gravel (grain size ~5mm) inside two established aquaria (volume 70 litres). Treatment fragments were manually turned every 24-hour period; controls remained unturned for the duration for the experiment. To eliminate variability of separate aquaria, the fragments were randomly distributed across the entire system, with stickers to indicate which fragments would be turned. Lighting consisted of an LED unit (Aquaray white flexi LED Twin, TMC) on a 12:12h photoperiod. Light intensity was measured using a PAR sensor, water was further circulated with V2 Powerflow 1000 circulation pumps (TMC, UK). Salinity, temperature and pH were monitored for the duration of the experiment.

Pulse Amplitude Modulated Fluorometry

Following methods from Hennige *et al.* (2008), photosynthetic efficiency was assessed through Pulse Amplitude Modulated (PAM) Fluorometry. Rapid light curves (RLC) were performed on both the light exposed and shaded sides of the mobile phase fragments for



Fig. 2: A rapid light curve being performed on a *Seriatopora hystrix* fragment. (Photo credit Dan MacRae)

each genus ($n = 6$) and the control fragments for each genus ($n = 6$) during the middle of the light phase within the aquarium using a Diving – PAM Fluorometer (Waltz) every week. To eliminate the influence of daily photoperiod, the order the fragments were read was randomized using a number generator within R Statistical software.

Respiration Rate

Methods adapted from Hennige *et al.* (2015). Coral fragments ($n=6$) were placed into 200ml respiration chambers featuring oxygen optodes connected to a temperature-compensated oxygen analyser (Oxy-4 Mini with Temp-4, Presens & Loligo systems). Sensors were calibrated using air-saturated and oxygen free water. Magnetic stirrers were used to keep oxygen concentrations homogenous within each respiration chamber. A central controller was used to ensure flow rates were the same across all the chambers. All chambers were filled with aquarium water. Four chambers were filled with aquarium water and left without fragments for use as controls, compensating for background changes. Fragments were recorded for 30 minutes under light for net photosynthesis, and 30 minutes in dark conditions for respiration rate.



Fig. 3: A fragment of *Acropora* spp. within the respiration chamber. (Photo credit Dan MacRae)

First Observations

Although the PAM Fluorometer and respiration data is still in the process of being collected, interesting general observations have been made during the first few weeks into the investigation.

Firstly, both the treatment and control *Acropora* spp. have shown zero mortalities, with no signs of bleaching or tissue degradation. Furthermore, the exposed skeleton from where the fragment was cut has completely healed over with new polyps growing (Figure 4). Although simply an observation it may suggest that *Acropora* is highly tolerant of mechanical stress within laboratory conditions. This is a contrast to what is observed in the field, with *Acropora* fragments featuring a high mortality rate. Therefore, the observations shown suggest that there may be other stress factors which result in mortality. Factors could include predation, sediment settlement or changes in local hydrology, rather than just the mechanical stress alone.

The same observations were made with *S. hystrix* with no mortalities observed across the treatment and control fragments, however the rate of recovery observed did not seem as rapid as that amongst *Acropora* spp. This further suggests that the ability to tolerate a mobile lifestyle on an abrasive sedimentary substrate is not conserved within genera, and that most corals may be tolerant of this unique mechanical stress. In addition, there may be other factors that cause mortality rates amongst fragments across reefs to be not only high but varied between genera and species.

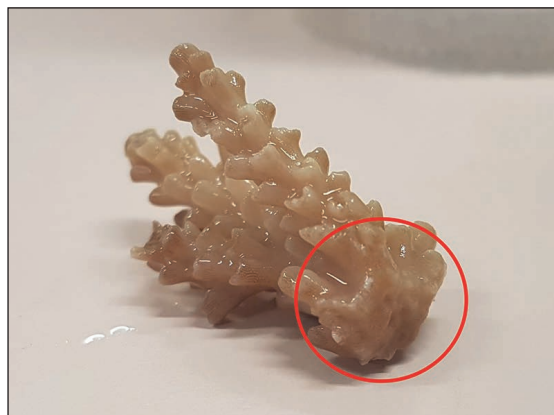


Fig. 4: A fragment of *Acropora* where the original cutting (circled) has healed over. (Photo credit Dan MacRae)

P. cylindrica, on the other hand, has featured a 37% mortality rate amongst the mobile fragments, with others showing signs of rapid deterioration as well. The control *P. cylindrica* fragments have so far experienced zero mortalities; however, they also appear to be degrading with localised bleaching and tissue necrosis. This is not only unusual but the opposite of what was initially hypothesized. In field studies *Acropora* has demonstrated high mortality rates through fragmentation while *Porites* spp. has shown high tolerance. However, the opposite seems to be true when under laboratory conditions. To gain the full picture, however, the PAM and respiration data will require analysis.

Discussion

The initial run of this investigation has already shown that tropical corals are highly varied in terms of their tolerance and sensitivity to stress. *Porites* spp. are popular model organisms for coral studies within laboratory conditions and are fairly tolerant of typical coral stressors including temperature (Nordemar *et al.* 2003). However, within the first run of this investigation they have shown to be the most sensitive to mechanical stress. One reason for this may be due to the recovery time which was allocated to the fragments before the investigation began. Two weeks is usually a sufficient time to allow for recovery after fragmentation with some studies even only allowing days for recovery (Muehllehner & Edmunds 2008, Nyström *et al.* 2001), however with *Porites* spp. being a much slower grower than the other genera selected (approx. 1 cm per year for *Porites* spp. compared to 10 cm per year for *Acropora* spp.) (Lough & Barnes 2000) (Shinn 1966) it may have been appropriate to allow *Porites* spp. a longer time to recover from fragmentation before beginning the investigation. The observed mortality rate may have been caused by the stress of fragmentation in conjunction with the stress of being on a sedimentary substrate. Allocating the three genera the same recovery time would be required to reduce bias within the results, however, it is suggested that if *Porites* spp. is required in future studies then a longer recovery time is used across all the genera of corals involved.

Another factor is that *Porites* spp. may not be as tolerant at withstanding fragmentation stress as other hermatypic corals. *Porites* spp. fragmentation depends on growth morphology, with massive and submassive colonies being more prone to movement of the entire colony rather than fragmentation (Highsmith 1982). Furthermore fieldwork has shown that *Porites* spp. rely more on sexual reproduction rather than fragmentation (Boulay *et al.* 2012), supporting the idea that the formation of coralliths may be a key reproductive strategy for localised dispersal. This investigation involved the physical fragmentation of corals which may not be a stressor which *Porites* spp. can cope with, however being able to obtain coralliths which have developed through planulae settlement would not be possible. It is therefore suggested that further research effort should be made into whether *Porites* spp. can form coralliths through fragmentation in the field. *Acropora* spp., *S. hystrix* and other delicate, highly branched corals are, however, prone to fragmentation during severe weather patterns. Fragmentation may even play a crucial reproductive strategy for those species, with mortality rates in the wild being caused by other factors such as predation (Wallace 1985). Further study into other stressors endured during the mobile phase of fragments is therefore required to understand the limitations of corallith formation.

Conclusions

The formation of Coralliths may be a significant driver for reef growth and recovery; therefore, research into the limitations of this unique strategy is vital to gain a further understanding of the process. Initial results of mobile stress within laboratory conditions suggest that other environmental factors may be involved with the high mortality rate of *Acropora* spp. and other branching coral fragments in the field. Furthermore, *Porites* spp. may be significantly less successful when forming coralliths through fragmentation rather than planulae settlement, although further investigation both within the laboratory and field is required to reach a full conclusion on this. When working with a range of tropical coral genera within the laboratory it is crucial to ensure that recovery times are adequate for

all involved, and it may take several runs to ensure that results are due to treatment and not fragmentation stress. This study suggests that a standard procedure for coral recovery is required to ensure reliability across individual laboratory investigations.

Acknowledgements

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Investigations into the little known and under-recorded isopod genus *Jaera*

David Fenwick

Introduction

The purpose of this article is to report the differences between the species in the *Jaera albifrons* group and to encourage the collection of higher value data.

I have been interested in isopods since reading the section on *Jaera* Leach, 1814 in *Synopses of the British Fauna: Intertidal Marine Isopods* by Ernest Naylor and Angelika Brandt (2015). This led to me checking the status of members of this genus in Cornwall and I looked at Cornish records on the ERICA database. There were 26 records of *Jaera albifrons* Leach, 1814, one for *Jaera forsmani* Bocquet, 1950, one for *Jaera praeheirsuta* Forsman, 1949 and three for *Jaera nordmanni* (Rathke, 1837). There were no records for *Jaera ischiosetosa* Forsman, 1949 on ERICA. There is probably a disproportionate amount of records for *J. albifrons*, now used as a collective name for a group of four species. *Jaera* individuals are not rare, they are actually very common. Males are smaller than females at around 2 mm in length, so specimens need to be identified using a microscope. It is their small size that probably inhibits identification and recording.

Identification history

Jaera albifrons was divided by Forsman, 1949 into three distinct species, *J. albifrons*, *J. praeheirsuta* and *J. ischiosetosa*. A fourth species, *Jaera forsmani* was described by Bocquet, 1950 and named to honour Forsman. Thus, the *Jaera albifrons* group in the UK, is a group of four species. The species *Jaera nordmanni* is a distinct species and not part of the group as it does not share the same shaped praeoperculum as members of the *J. albifrons* group.

It is disappointing that in nearly 70 years since the publication of the very first 'Synopsis' (by the Linnean Society) we have not improved identifying and accurately recording species of the *J. albifrons* group. *Jaera* sp. has become acceptable for recording.



Fig. 1: *Jaera nordmanni*

Collecting and examination techniques

As *Jaera* spp. are known to be abundant at certain sites, specimens were collected to look at in more detail. *Jaera* were found on rocks with wet undersides, or fringing shallow pools in the mid-shore. *Jaera* were washed off the rocks into a bucket of seawater, then retrieved using a small plastic sieve. This method was later improved to save time on visually looking for samples. A suitable rock was identified and washed in a bucket of sea water before replacing it in the original position. All sites chosen were quite sheltered from wave exposure.

A good sample of over 20 specimens is needed to increase the probability of acquiring males. At Hannafore, Looe, all 20 specimens were



Fig. 2: *Jaera albifrons* (top: male, bottom: female)

female which cannot be used to identify the species. Only males have useful characters. Males can be separated from females visually, as they are usually smaller and darker but juvenile females require a stereomicroscope to separate them. In any one sample, there will likely be more females than males. Many of the females collected were berried with either eggs or developing young in their brood pouch. A greenish tint can usually be seen on the dorsal surface of sexually mature females, which is the colour of the eggs and developing young. It is best practice to return females to the sea as soon as possible because they are not needed for identification.

Examine male specimens using a compound microscope at magnification of x100. A small number of male specimens can be checked at the same time by placing individuals in a drop of seawater on a microscope slide, a small cover slip is usually enough to immobilize animals without harm. Invert the slide to examine the pereopods on the ventral side of the animals. For a larger number of specimens, it is advisable to dispatch specimens in ethanol then place them on a slide, turning specimens onto their dorsal surface using a fine acupuncture needle, and adding a cover slip to help splay the pereopods.

Males within the *Jaera albifrons* group are defined by the shape of the praeoperculum, which is located at the posterior end of the animal, under the telson. It is often described as 'T-shaped', however, it is more like an old-fashioned moustache. *Jaera nordmanni* has a very different praeoperculum but could appear in samples with members of the *Jaera albifrons*

group because the species can tolerate low levels of salinity.

If a male specimen has a praeoperculum as seen in the *J. albifrons* group, then pereopods 1-2 (legs, anterior) and 6-7 (legs, posterior) must be examined to determine the species. The position of setae, the sparsity of curved setae, number and position of spines, and the shape of parts that make up the pereopod (carpus, propodus, ischium and merus) are used to determine the species. Figure 5 below shows the notable differences between the pereopods of the species within the *albifrons* group.

Collecting *Jaera* records in Cornwall

In early December 2017, *Jaera forsmani* was identified in a sample of washings taken from a rock crevice at Little London, Marazion, Cornwall. It was finding and identifying this species that encouraged me to look for other species of the genus.

In January 2018, a sample was collected from under stones next to where a fresh water stream flows down the shore, at Wherry Town, Penzance, Cornwall. Males were examined, and all were found to be *Jaera ischiosetosa*, a species not listed on the Cornish ERICA database. This species was found to be abundant at the site, and at other sites where water flows down the shore, at one site on the River Fal it was found to be superabundant.

In late January 2018, a colleague sent me a *Jaera* from Poole Harbour, Dorset, which I identified as *Jaera albifrons* sensu stricto. A few days later while washing stones from pools under the bridge that crosses Penzance

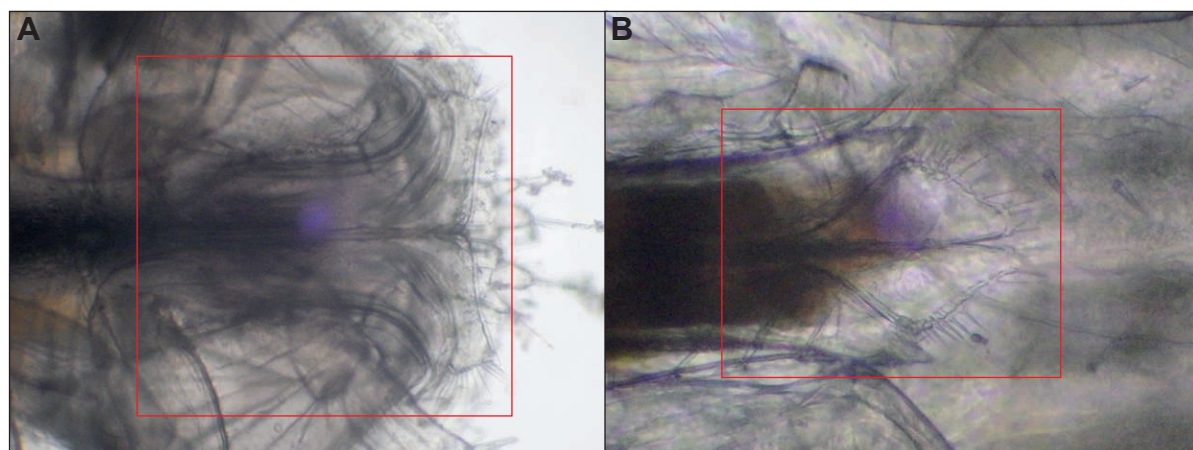


Fig. 3: A. Praeoperculum, *Jaera albifrons* group; B. Praeoperculum, *Jaera nordmanni*



Fig. 4: A. *Jaera forsmani* habitat (Little London reef, Marazion); B. *Jaera ischiosetosa* habitat (Wherry Town, Penzance); C. *Jaera albifrons* habitat (Penzance Harbour); *Jaera prae-hirsuta* habitat (Restrouquet Passage, Penryn - note, all species in group found here).

Harbour, Cornwall, I also found *Jaera albifrons* sensu stricto. This species also occurs at Restrouquet Passage in large numbers.

In early February 2018, during a visit to Hannafore, Cornwall, I took a sample from the same site where I had previously collected 20 females. The site is beside the storm drain, where a stream runs down the shore. Males were collected and were identified as *Jaera ischiosetosa* which was also found to occur on the lowershore at Hannafore.

Numerous other sites were examined around Penzance, Cornwall and the most common species was, without doubt, *Jaera ischiosetosa*, although it must be noted that collection was a result of stone-washing and not weed-washing. Weed-washing at different levels of the shore may give different results with other species found to be equally abundant.

There was one record for *Jaera prae-hirsuta* on the ERICA database found at Restrouquet Passage, Mylor Bridge, near Penryn, Cornwall

in September 1990. No other *Jaera* species were recorded at this site. On 22 February 2018 samples were collected at Restrouquet Passage to look for *Jaera prae-hirsuta*. The same technique was used as previously; washing small rocks and stones, anything less than 3/4 diameter of a bucket was considered. Some stones had fucoid algae attached. On straining the sample, it was easy to see that numerous individuals had been collected and that *Jaera* specimens were potentially superabundant at the collection site which was just in front of the Pandora Inn. Juvenile females were removed using a stereomicroscope. Males were then turned on to their backs using a fine acupuncture needle and their pereopods examined using a compound microscope. *Jaera ischiosetosa* and *Jaera albifrons* dominated the sample, and only a single *Jaera forsmani* was also found. *Jaera prae-hirsuta* probably represented approximately 2% of the entire sample. More importantly, however, all four species of the *Jaera albifrons* group were found

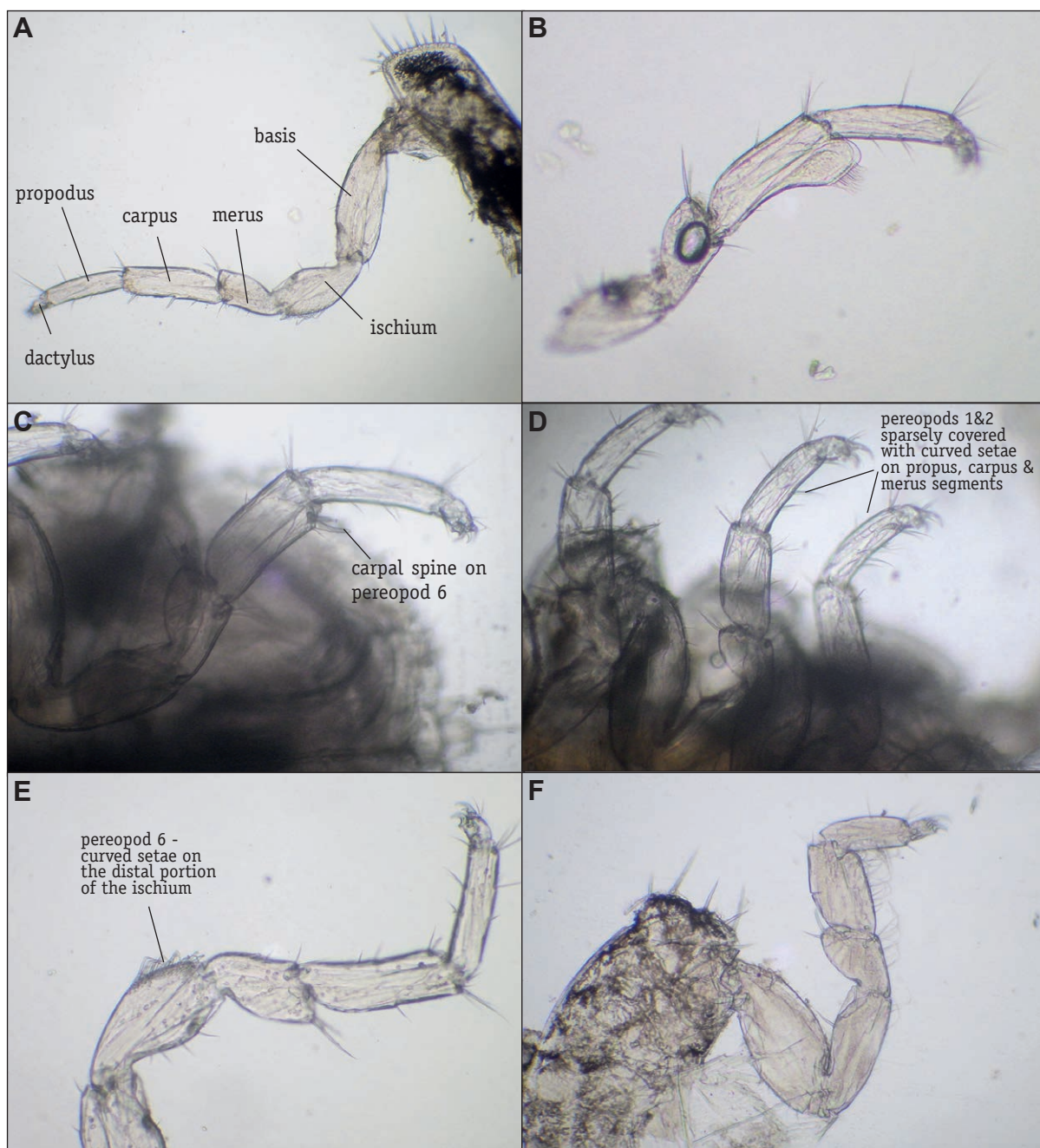


Fig. 5: Pereopod anatomy. A. *Jaera ischiosetosa*; B. *Jaera albifrons*, pereopod 6; C. *Jaera forsmanni*, pereopod 6; D. *Jaera forsmanni*, pereopods 1 & 2; E. *Jaera ischiosetosa*, pereopod 6; F. *Jaera praeheirsuta*, pereopod 2.

at this location. All four species collected together in a sample means attention to detail is required. On determining the first specimen one should not assume that all the rest will be the same, a lot more patience is required.

To accurately record this common but overlooked genus successfully specimens from areas such as the Fal, Camel, Helford, Lynher, Tamar and East Looe rivers need to be examined closely. Habitats such as brackish pools on and above high water, freshwater streams running down the shore, estuaries and

fully saline areas of sheltered coasts need data for an accurate record of species distribution. Although in estuaries and probably some very sheltered shores it is likely all the species will occur together, as in Restronguet Passage.

Jaera can be found on algae such as Serrated Wrack, *Fucus serratus* (*Jaera praeheirsuta*), and Bladder Wrack, *Fucus vesiculosus* (*Jaera albifrons* s.s), but specimens can be found in the same zones under pebbles, stones or rocks with damp / wet under surfaces. It is easier to wash stones than to cut and wash algae

and is far less destructive. *Jaera* is similar to barnacles, and like barnacles, species of *Jaera* tend to have a preference for different zones on the shore, although it would seem that this is not an absolute rule.

One species not dealt with here is *Jaera hopeana* Costa, 1853. It was found living as an ectocommensal on the isopod *Sphaeroma serratum*. It has been recorded at Wembury in Devon since the 1930s, and could be present in Cornwall especially towards the east of the county.

Comments on identification

I examined highly detailed photographs of *Jaera* to see if I could identify the species from the images. The only species that could be identified from these images was *J. nordmanni*, all the other images could only be assigned to the *Jaera albifrons* group. Many images were of the larger females of the group. This means that *J. nordmanni*, and other species included in the *Jaera albifrons* group can only be verified from images using a microscope. Habitat details cannot be used for species identification because all four species can be found together.

Members of the genus *Jaera* are particularly easy to collect and commonly occur on the shore near areas of either freshwater or seawater seepage.

The reason why they are not recorded more often is due to the fact that *Jaera* cannot reliably be identified *in situ* on the shore, although sexing individuals may be possible with a magnifying glass, loupe or head magnifier and some experience. Specimens need to be examined under a microscope. The process of identification is complex and beyond the scope of Citizen Scientists or recorders who do not possess microscopes. This should not prohibit their collection and samples could be sent to specialists for identification.

Only male specimens should be used for identification, verification and photography. Good images of the praeoperculum is a primary consideration, as this would prove if a specimen was in the *J. albifrons* group or not. If within the *J. albifrons* group then pereopods 6 and/or 7 are important for *J. forsmanni*, *J. ischiosetosa* and *J. albifrons*; pereopods 1 and 2 are important for the determination of *Jaera praeohirsuta*.

In some examples of *J. ischiosetosa* the setae on pereopod 7 had worn off, they were found to be in better condition and easier to see on pereopod 6.

To prepare microscope images for validation, pereopods need to be carefully dissected, placed on a slide with a cover slip and the setae on the pereopod in position and focussed.

A quick guide to *Jaera* pereopods

J. nordmanni: Oval shaped body, praeoperculum parallel sided, acutely pointed.

J. albifrons group: praeoperculum T / stalked moustache shaped.

J. praeohirsuta: Pereopods 1-4 with curved setae on propodus, carpus and merus.

J. albifrons: Pereopods 6 and 7, distal region of carpus with spined lobe.

J. ischiosetosa: Pereopods 6 and 7, curved setae on the distal portion of the ischium.

J. forsmanni: Pereopods 1-4 are sparsely covered with curved setae on the propus, carpus and merus segments; pereopods 6 and 7 have well developed carpal spines.

Acknowledgements

I rarely produce articles nowadays because of cognitive issues so thanks go to Professor Michael Guiry for his assistance in helping produce something readable.

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- Haywood, P.J. & Ryland, J.S. 2017. *Handbook of the Marine Fauna of North-west Europe*. Oxford University Press.
- Naylor, E. & Brandt, A. 2015. *Synopses of the British Fauna Volume 3: Intertidal Marine Isopods: Keys and Notes for the Identification of the Species*. Field Studies Council.

Online resources

- APHOTOMARINE: <http://www.aphotomarine.com/isopoda.html>
- Marine Species Identification Portal, Macroenthos of the North Sea - Crustacea: http://species-identification.org/index.php?groep=Crustaceans&selectie=6&hoofdgroep_pad=%2C1%2C6
- WoRMS: <http://www.marinespecies.org/aphia.php?p=taxdetails&id=118364>

Overfishing and Chips

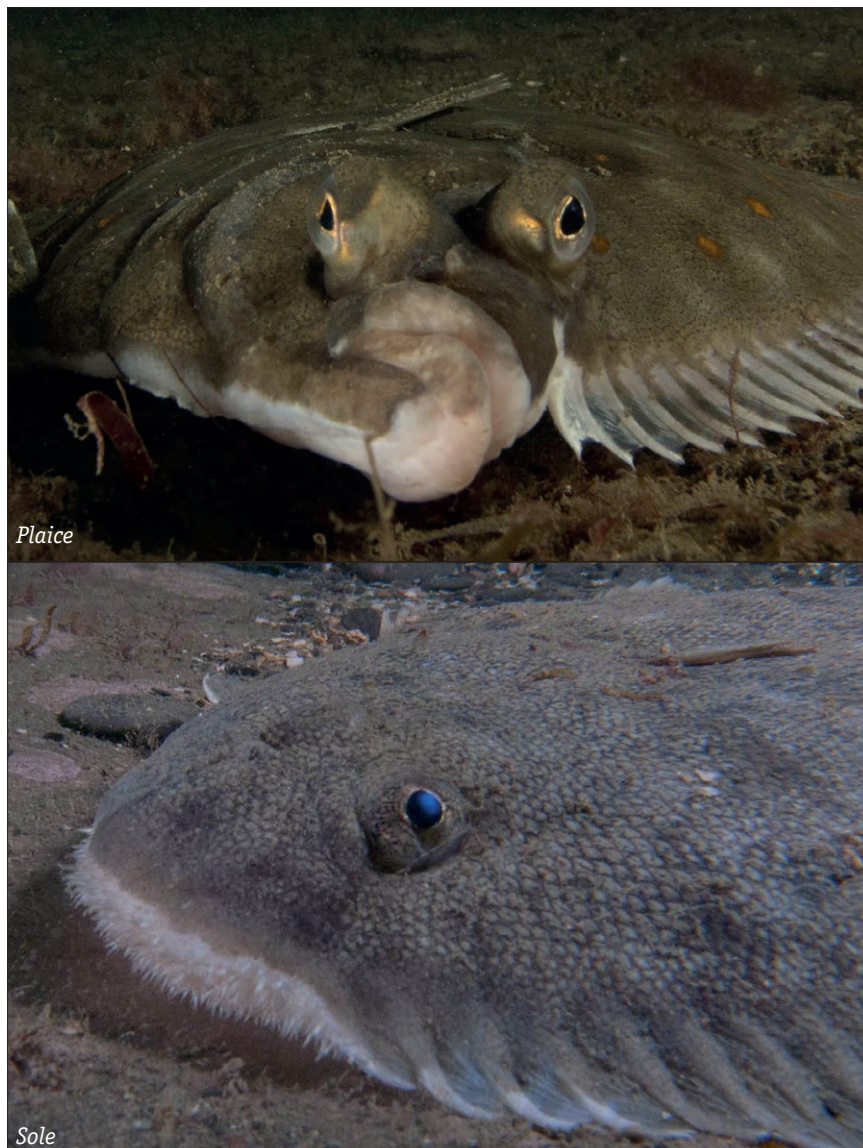
Sheilah Openshaw

Reaching the harbourside after a day's diving the hungry diver is tempted by the great British meal of fish and chips. Most of us have grown up assuming that a plate of cod and chips is something that has been with us since the Norman Conquest. Whilst we may worry that diminishing fish stocks will make that tradition obsolete, we seldom think about the history of the meal.

Had the hungry diver been sitting on the quay as recently as 1878, fish and chips would have been a novelty and it is doubtful whether it would even have been an option. The diver would have had to settle for a pie or a baked potato, the street food of the day.

Accompanying the meal may have been the smack of the sail, the sound from which fishing boats got their name. One such fishing boat was built in Dartmouth in 1877 and then worked as a trawler out of Hull for 20 years before becoming a coastal trader. In 1908 she sank near Weymouth, ironically providing a home for conger eels and bib.

At the time she was built, demand for building sailing boats was already declining because, thanks to the opening of the Suez Canal in 1869, it was more profitable to use larger steam ships. In fact, the fishing trawler was one of the last ships built by this particular Dartmouth shipbuilder whose business was devastated by an underinsured fire. The father retired and the two sons went their separate ways, one to build steamships in Canada and



the other to become a wholesale fish merchant in Exmouth.

When first built, she was first employed as part of the huge fleet of East Coast trawlers in exploiting the 'Great Silver Pits' which were well known in the North Sea for their abundance of flat fish (mainly plaice and sole). A crew of five men would sail from port for 6 weeks, living on board in tiny crew quarters in the middle of the North Sea. With no refrigeration and a day's sailing from East coast ports, fish were not caught in such great quantities because they would have rotted before they could be brought to market and cooked. Instead, the crew would transfer their day's catch to whichever ship was returning to port that day until it was their turn to return. Some enterprising fish wholesalers bought steam vessels which travelled daily to the fishing grounds and bought the catch direct from the fishermen to supply the great fish markets of Billingsgate, Grimsby, Hull and Lowestoft, amongst others.

The opening of the railway to Hull in 1854, along with greater industrialisation and larger ships, allowed fish to get to market and on to consumers within 3 days of being caught. This turned what had been a local fishing trade into a major industry in the space of a few years. People migrated from not only all parts of the UK, but Scandinavia, Germany and France to get work on the trawlers. Shipbuilders switched from schooners and brigantines to fishing smacks (replacing the orders which the Suez Canal had made redundant). The ice trade from Norway became a major industry too: in 1886 1 million tons of ice left Norway, much of it to keep fish fresh.

Meanwhile, industrialisation also affected people's eating habits. A mass move from the country into towns and cities to seek work meant that people now had to buy food instead of producing it themselves. The pies and baked potatoes eaten by the diver on the quay in 1878 would have been typical fare.

Pogroms, the forerunner of the Nazi Holocaust in nineteenth century Russia (the first in 1821), caused many Jewish refugees to escape to Britain. In an effort to earn a living they bought fish and fried it in batter. Like

the baked potatoes and the pies, they were sold from trays in the streets and pubs. As the frying equipment developed the double cauldron enabled potatoes to be fried and sold alongside the fish direct from the shop or warehouse.

It is debatable whether the first 'chippy' was opened by Mr Lees in Oldham or Mr. Malin in London, but both date from the early 1860's. The British national dish quickly changed from roast beef (which few could afford) to fish and chips, a filling meal for a few pennies. In these early days of the 'chippy' the fish would be mainly fried plaice and sole.

Of course, the Great Silver Pits were not inexhaustible, but there was cod to replace the flatfish, so the industry simply swapped species. Technology also changed; steam trawlers replaced the sailing ships that allowed the fishermen to go further afield and find more cod. There was no 'closed season', there was no Ministry of Fishing, and no control on the numbers, or sizes, of fish caught. No-one considered that the rate at which they were being caught was unsustainable.

The Dartmouth shipbuilder's son became a very successful fish merchant, supplying lobsters to Paris and New Zealand and herring in large quantities to London. Writing in 1932, he lamented in the local paper about the failure of the fish stocks that had made him and his son wealthy businessmen:

"As one contemplates the future, the outlook as regards the fish trade is dark and depressing. Since the war, owing to sunken wrecks and other causes, the supplies of fish have diminished to that extent that sooner or later, like the old sailing ships, there will be a total collapse beyond the wit of man to counteract."

During the late nineteenth century, there was no appreciation that North Sea fish stocks might be limited; in the early twentieth century there was little understanding of the cause of fish stock declines. Even today, few people realise that the great British fish and chips is just another acquisition of our past that we are likely to lose because we still haven't learned the lessons of the past.

Porcupines at the Palace

Sheilah Openshaw

When Matt Doggett gave his talk on *The Black Bream Project* at the 2017 Porcupine Conference, time and modesty did not permit him to tell of the honour we were awarded for our research. BSAC's Jubilee Trust had provided a small grant to help cover some of the diving expenses. As part of the report's submission, a question was asked about whether the team was applying for the Duke of Edinburgh's Prize, awarded to the best underwater scientific work that year. The forms were duly filled in and returned to the Jubilee Trust. I did wonder whether drysuits would be suitable attire for a visit to Buckingham Palace!

The next I heard was Matt's phone call telling me (with a barely suppressed giggle) "I've got some bad news for you, (pause) you're going to need a new frock. We will be going to Buckingham Palace on the 8th November 2016 to receive our award, we won first prize!"

So the three of us rocked up at the Palace (as you do), wearing two new suits and a new frock. We walked along the corridor where the princes played cricket and up the stairs to 'The Centre Room', which is the one behind the balcony where the Royals come out to wave to the crowds. However, they didn't let

us anywhere near the windows! The room is grandly furnished in the Chinese style with artefacts from the Brighton Pavilion. You could probably comfortably fit a Porcupine conference dinner in the room.

Prince Philip came and greeted us, the runners up and the highly commended teams and presented us all with certificates. Matt, as team leader was presented with a medal in a presentation box. HRH was very concerned to show how the presentation box fitted together so that it didn't get damaged; he said he had seen it happen. We had a ten-minute conversation with him in which he asked some insightful questions (obviously well briefed). He then talked to the other groups and returned to us for another, longer, chat.

Then it was time to leave, off in good Porcupine fashion to the pub, where we could buy a drink for Simon Rogerson of Scuba Magazine who was the only person allowed in with a camera. Each team shared the quips for which the Duke of Edinburgh is famous, such as "Here's your certificate – you have to buy your own frame!"

It was rewarding to be recognised for the work on the bream, the morning in the palace, talking to Prince Philip and follow-up champagne courtesy of BSAC was a fantastic treat.

Photo © Simon Rogerson



A Wriggling Success

Kate Mortimer

*Amgueddfa Cymru — National Museum Wales,
Cathays Park, Cardiff CF10 3NP*

Back in July 2016, National Museum Cardiff launched a brand new family-friendly exhibition entitled *Wriggle! The Wonderful World of Worms*, delving into the world of earthworms, leeches, polychaetes and their allies. I think it's fair to say that worms probably wouldn't have been at the top of everyone's list for a block-busting exhibition, but the Marine Invertebrates team at National Museum Wales were convinced that the interesting and varied natural histories of worms would make an exhibition enjoyable by all. With three polychaete scientists (Andy Mackie, Head of Marine Invertebrates at the time, now Honorary Research Fellow, Teresa Darbyshire and myself) and a collection of over 500,000 polychaete specimens (from British waters and much further afield) we had a strong basis for an exhibition. As an added bonus, the exhibition was ready for the Museum to hold the 12th International Polychaete Conference (IPC12) in August 2016.

The exhibition was divided into six distinct areas covering different topics. The first booth was called Awesome Worms (Figure

1) and detailed some of our favourite worm stories, from ice-worms living in glaciers to worms living in the boiling temperatures of hydrothermal vents. Closer to home it covered the humble sea mouse, *Aphrodita aculeata* Linnaeus, 1758 and its photonic crystals, and the symbiotic relationships between the scaleworm *Acholoe squamosa* (Delle, Chiaje, 1827) and the Sand Starfish *Astropecten irregularis* (Pennant, 1777) and the ragworm *Neanthes fucata* (Savigny, 1822) and the Common Hermit Crab, *Pagurus bernhardus* (Linnaeus, 1758). To supplement the latter story an aquarium tank with hermit crabs and their hitch-hiking friends was included. Of course this section would not be complete without Bone Eating Snot flowers, otherwise known as *Osedax*, and the spine-chilling Bobbit worm, *Eunice aphroditois* (Pallas, 1788).

The next area was designed to highlight the sheer diversity and beauty of worms (Figure 2). Polychaetes were featured highly in this section with some outstanding photographs taken by Andy Mackie and Fred Pleijel amongst others, many specimens and also beautiful videos from Monterey Bay Aquarium Research Institute (MBARI). I think this area proved extremely useful in expanding people's ideas about what worms can and do look like. The centre piece of this zone was a spectacular



Fig. 1: Awesome Worms zone and aquarium tank with Hermit Crabs and their hitch-hiking worms



Fig. 2: The diversity and beauty of worms zone

model of a Strawberry Spaghetti worm, *Eupolymnia nebulosa* (Montagu, 1819) (Figure 3) specially made for us by 10tons (<http://www.10tons.dk/eupolymnia-nebulosa1>). An interactive 'Worm, not a worm' quiz also completed the area.

The third zone, From Fossils to Fantasy, looked at worms as inspiration for books (such as Roald

Dahl's *The Twits*), movies (such as *Star Wars* and *Tremors*) and various myths. However, it also featured worm fossils including Machaeridians and the fossil bobbit worm *Websteroprion armstrongi* Eriksson, Parry & Rudkin, 2017, and included a model of the fossil worm *Kallopriion kilmisteri* Eriksson, 2006, named after Lemmy from Motorhead (Figure 4)! This zone featured the game *What worm are you?* based on a series of questions about diet and mobility and introduced palolo worms eaten by Indonesian People as a delicacy (video courtesy of Joko Pamungkas). The fourth zone highlighted the varied size range of worms and included the nermertean Bootlace Worm, *Lineus longissimus* (Gunnerus, 1770), which has been recorded to huge lengths (over 50 m!), alongside a Giant Gippsland Earthworm (*Megascolides australis* McCoy, 1878).

The fifth zone detailed the taxonomic research that goes on behind the scenes at the Museum on polychaetes via morphology and DNA, benthic biodiversity work mapping the seabed around Wales, and lastly the Marine Invertebrate Collections. This section included an interactive microscope to view various worm species and a virtual slide microscope allowing users to explore some of our slide collections. An associated table encouraged children to draw worms and write what they thought of their exhibition experience.



Fig. 3: Strawberry Spaghetti Worm model, *Eupolymnia nebulosa*

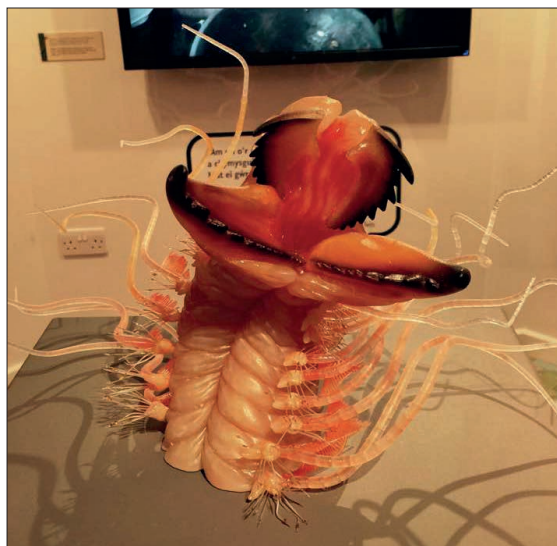


Fig. 4: Lemmy Worm model, *Kallopriion kilmisteri*

The last zone and the centre piece of the gallery was the Wriggloo (Figure 5), an area designed to allow gallery visitors to experience life as an earthworm. This included avoiding predators such as seagulls and badgers and to meet some of the creatures which would share your underground home. This included a large wormery with several species of earthworm.

Whilst, this may not have been everyone's choice of topic to begin with, Wriggle! has proven to be one of our most successful natural history temporary exhibitions to date. It has been enjoyed by families, adults and the 200 visiting polychaete academics (attending IPC12)! It even earned the accolade: "one of the best museum exhibits in Europe" – by USA



Fig. 5: Wriggloo

Today. In total, nearly 300,000 people have enjoyed this exhibition and its popularity saw it extended to two years. It proves that even the so-called challenging/difficult topics can be made accessible and enjoyable for varied audiences. Topics which are so vitally important to disseminate to our audiences can be successfully done and enjoyed. I believe that the success of Wriggle! comes from scientists working alongside learning staff and exhibitions team, drawing on each individual's experiences and ideas. However, testing with the target audience throughout the process proved to be invaluable. Hopefully Wriggle! has inspired the next generation of polychaetologists to take up the mantle and learn more about these wonderful creatures.

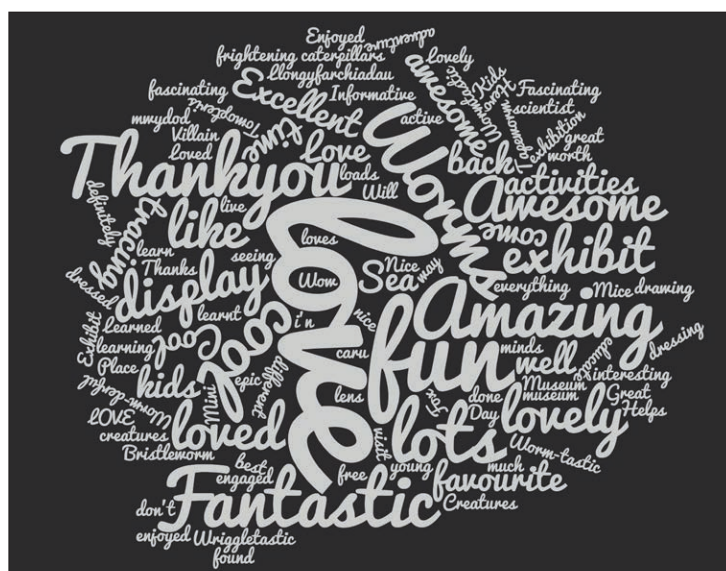
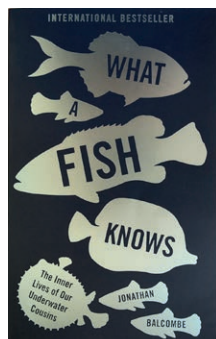


Fig. 6: Word cloud showing visitor's reactions to the gallery

What a Fish Knows, The Inner Lives of Our Underwater Cousins – Jonathan Balcombe

One World Publications, 2017. 304pp
ISBN: 9781786072092



Book review by Paul Naylor

To those of us who are enthusiastic observers of fish and their fascinating behaviour, it's always been obvious that there's much more to these 'cold-blooded' vertebrate relatives of ours than they are usually given credit for. Even for us, however, this book is an absolute revelation. In the words of the author, a behavioural biologist, it 'aims to give voice to fish' by exploring what they perceive, feel, think and know.

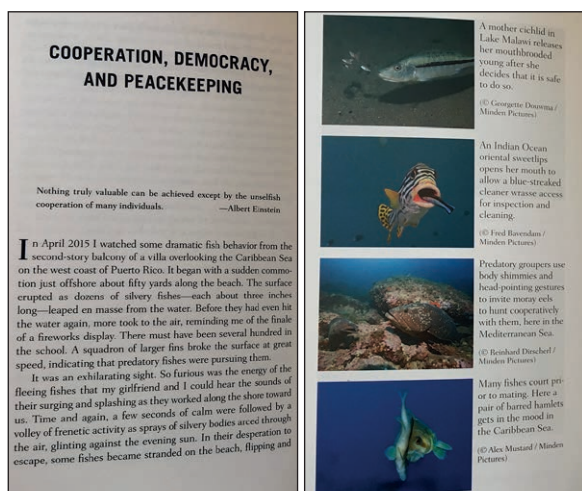
It is based on and written around scientific evidence, sprinkled with anecdotes, and is a very good read. There is excellent information on topics such as the sophistication of fish senses and their impressive hunting talents (including tool use) and I found the examples of mental ability particularly striking. One of the most remarkable and well known of these is the frillfin goby that makes mental maps. It stays in rock pools when the tide goes out and,

if threatened by a predator such as an octopus or heron, leaps into an adjacent pool. It avoids getting stranded on exposed rocks by swimming over the rocks and memorising the layout of depressions at high tide. This isn't speculation; experiments with an artificial reef showed that a 'high tide learning session' changed the rate of 'safe leaps' from a chance 15% to 97%, and the gobies remembered their escape routes 40 days after a single review. In fact the old chestnut of a goldfish's '3 second memory' is totally blown out of the water. Goldfish used in a simple university course experiment, where individuals learnt to associate a particular colour with food, remembered their own correct colour when the following year's students did the experiments! Deliberate studies on memory have shown fish can learn an escape technique and remember it 11 months later as well as if they had just learned it. Numerous other examples of fish cognition and learning are given for a wide range of species including sharks and rays.

The section on relationships between cleaner fish and their clients is similarly mind-boggling. Individual cleaners that are less 'honest' (nipping mucus rather than parasites more often) soon get a reputation and are shunned by clients. Cleaners give a better service with new clients or when they are being watched - remind you of anything?

What I particularly like about the book is that the author doesn't just describe an aspect of behaviour and leave you to be impressed, he makes reference to the evolutionary pressures that would explain the development of the relevant skills. This is well illustrated by examples where closely related species, or even members of the same species from different habitats, show marked differences in certain cognitive abilities.

Jonathan Balcombe's underlying argument is that if we start understanding fishes (he prefers this plural to 'fish') as conscious individuals, we will develop a different and less exploitative relationship with them. The book, a paperback with a central section (8 pages) of colour plates, looks unassuming but it certainly enthralled me. If you're looking for a fascinating and inspiring read or a present for the fish enthusiast in your life, I highly recommend it.



WoRMS: The World Register of Marine Species [<http://www.marinespecies.org>]

Website review by Jon Moore

CALM Ltd., jon@ticara.co.uk

Do you write about marine species, using their latin names? Yes? OK, then I assume you use WoRMS. No! Why not? It's not just for taxonomists. Perhaps you are fed up with name changes (e.g. Velvet swimming crab: named *Cancer puber* by Linnaeus, became *Portunus puber*, then *Macropipus puber*, then *Liocarcinus puber*, and currently *Necora puber*, or has it changed again?) and you're pretty sure that everyone knows the entity you are talking about. Well, I can relate to that, but we should all accept that our current classification of organisms is incomplete and the study of phylogenetic relationships between taxa is also developing. At least with WoRMS we have a reliable and simple way to keep up to date with the nomenclature.

If you have never been on to the website I encourage you to do so; and if you haven't been on to it recently you should take another look – it's had a revamp. I can't remember

precisely what was and wasn't available before, but the new website contains a lot of interesting and useful information: including literature, photographs, specimen details and some identification keys. You can also learn about LifeWatch and other programmes that are linking up large databases of taxonomic, biogeographic, ecological, genetic and literature information from around Europe.

But the core of WoRMS is its database of marine taxonomy. For taxonomists there are instructions and editing tools, but for ecologists like myself or anyone compiling long species lists, the Taxon Match Tool is a godsend. You compile your list of species in a spreadsheet, upload it to WoRMS and download a new spreadsheet with the currently accepted names. It's quick and easy to use; the instructions are easy to follow, with some examples, and you can include a lot of additional useful information. You will inevitably go through a learning process as you compile and upload your first list, but errors are highlighted and quick to fix. I use it frequently.

Given everything I have said, it seems mean to highlight its limitations, but I will mention two. Firstly, for me, and I know many others in the marine benthic survey community find the same, I wish it provided a code to sort

The screenshot shows the 'WoRMS Taxon match' tool interface. At the top, there's a navigation bar with links like Home, About, Subregisters, Users, Photogallery, Documents, Lifewatch, and Contribute. Below this is a search bar and a menu with options like Taxa, Literature, Distribution, Specimen, Editors, Statistics, Tools, Manual, and Log in. The main content area is titled 'WoRMS Taxon match' and contains instructions on how to use the tool. It includes a file upload section with a 'Choose file' button and a file name 'MenaiTaxaList.xlsx'. Below this, there are settings for 'Row delimiter', 'Column delimiter', 'Match authority', 'Match upto', 'Limit to', and 'Output'. The 'Output' section has checkboxes for various fields: AphidID, LSID, TSN, ScientificName, Authority, Accepted name, Classification, Qualitystatus, Taxon status, Environment, and Citation. A 'Next >' button is at the bottom of the form.

taxa into the conventional taxonomic order I am used to from my biological training – i.e. Protozoa, then Porifera, then Cnidaria etc. I still use codes based on those from the *Species Directory of the Marine Fauna and Flora of the British Isles*, which has an alphanumeric system in the order I can relate to. I have developed my own lookup system to add those codes to the WoRMS output, but I keep hoping that WoRMS will provide one.

Secondly, and this is getting very picky, the way that the Taxon Match Tool deals with homonyms could be easier. A homonym is a taxon name that has more than one entry in the WoRMS database – usually because two taxonomists have given the same name to two different entities. The Tool deals with these by telling you if a name is ambiguous and offering you a drop-down list from which you select the taxon you are referring to – if you know which one to choose. And there is the difficulty – if you're a jobbing ecologist without much taxonomic expertise in that particular group you will need to spend some time manually checking the different names. Thus, when my list includes the coralline alga *Corallina*, the Tool offers me *Corallina* Linnaeus and *Corallina* (sensu Ellis, 1755). I'm now used to that one and I select the former, because I remember that the latter refers to a sabellid polychaete described from Malta. However, I don't remember some others, like the red alga *Ceramium virgatum*. That name was used by Roth, 1797 and J.D.Hooker & Harvey, 1848. In this case a search of WoRMS finds that both are currently accepted entities with the same parentage. Which one have I got? So, I go back to the lab and check the *Ceramiales* guide or I go onto AlgaeBase which explains that the latter entity is *Illegitimate: later homonym*. It doesn't take long, but could be a stumbling block to an inexperienced user. So, this is not a criticism, because the Tool has already saved me many man hours, but I'm hoping that one day it will provide a bit more information to aid selection of homonyms.

In conclusion, the WoRMS website is extremely useful and I suggest you have a link to it in your browser. It's also continuing to develop and we can expect more great things.

Would you like to contribute to the next *Porcupine Bulletin*?

- We are always open to offers of book reviews, website reviews and reviews of mobile apps!
- Interesting or topical sightings of marine life, or stories of your fieldwork experiences are always enjoyed;
- Informative line drawings of marine life are great for filling in small spaces at the end of articles;
- Articles on any subject relevant to marine natural history
- or anything else that you feel would be of interest to the readership!

In the first instance, please contact Vicki Howe with what you would like to offer. Guidelines to Authors are printed on the back page of the Bulletin, please take note of these when writing your article and particularly with reference to any images you wish to have printed.

Deadlines for contributions are:

Spring 2019 issue - Friday 8th December 2018

Autumn 2019 issue - Friday 7th June 2019



How I became a marine biologist....

(Now I'm a retired marine biologist,
or The road to resortsnorkeller.com)

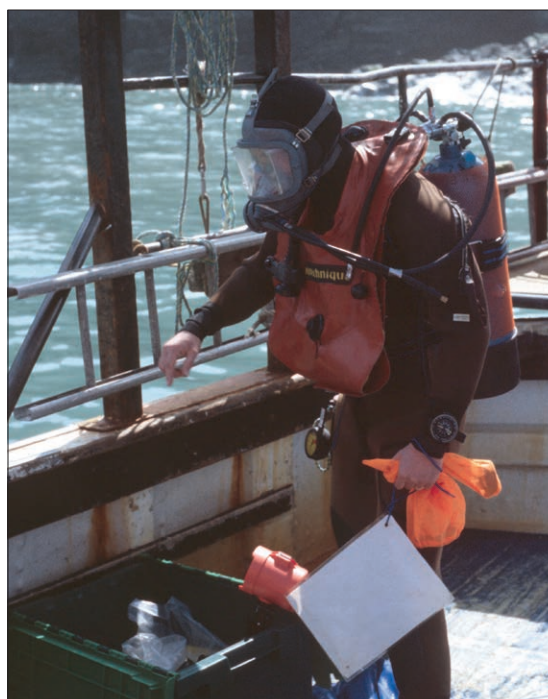
Nigel Thomas

www.resortsnorkeller.com
hello@resortsnorkeller.com



A fellow PhD student and I were down to our last 20p in The Ferry Boat Inn, when he stated, in a despondent voice, that being a Marine Biologist was truly a vocation, because “you’ll never make a career out of it”. Fortunately for me, he was wrong about the career bit, but he was right, it is a vocation.

I, like many others of my generation, was inspired by Cousteau, Hans and Lotte Hass and, in my case, Flipper and James Bond (Thunderball in particular!). I dreamed of diving in crystal clear waters, surrounded by dolphins, returning to the sun-drenched back deck of a well appointed dive boat, where I would be handed a vodka martini (shaken, etc....) by a sun bronzed goddess! To follow this exotic dream I embarked upon a PhD on the subject of intertidal soft sediment ecology (worms in mud!). Something was not quite right. I did have a brief sojourn on Lundy, courtesy of Keith Hiscock *et al.* where the diving was brilliant and I lived the life of the warden from Flipper, although James Bond’s



Cambourne, 1996

sun bronzed goddesses were in short supply and I’m pretty sure they didn’t know what a vodka martini was in the Marisco Tavern. However, the muddy PhD stood me in good stead, as intertidal and subtidal benthic ecology became a hot topic, particularly after several EU directives were introduced that affected the water industry and used this type of data. This coincided with my middle son being diagnosed with autism, resulting in a domestic instruction to “get a proper job”. So I ‘happily’ entered the world of commercial marine biology with Southern Water and after several years of benthic grabbing and diving in effluent, a group of us bought ourselves out and set up Emu Ltd. There followed many more years of benthic grabbing and diving, fortunately not always in effluent, until we, in turn, were bought and I was told my services were no longer required. Although my emotions were divided I was, ultimately, happy to take early retirement.

So now that I am retired, I can pursue my vocation, unhindered by the encumbrance of being paid for it! Of course I also do all the usual retired person things, although I have found retirement to be a slightly odd state to adapt to. I realized that I had been dropped into a different demographic; on shopping trips

I am surrounded by 'old people' and I spend lots more time at the doctors, again surrounded by old people. However, we also enjoy looking after our granddaughter and trying to stay fit, by swimming and playing badminton, (the latter often resulting in more trips to the doctors) as well as DIY and gardening. Gardening is almost a full time occupation. My wife, who is French, insisted after 35 years of "was that it" for the English summer, that we buy a house in France. So we now have a house on a nice plot of land down near Toulon, (quite close to Cousteau's original dive sites), which requires a lot of upkeep. To be fair I only have to cut the grass twice a year, thereafter it is too dry to grow, but the gentle chatter of Hampshire lawnmowers has been replaced by the zizz of the trimmer and angry buzz of the chain saw. This is part of the densely forested, high fire-risk area of Provence and we are subject to local bye-laws forcing us to cut back undergrowth. I regularly take down small Oaks (the deciduous Downy Oak, *Quercus pubescens* Willd and the evergreen Holm Oak, *Quercus ilex* Linnaeus) but they still keep growing back with renewed vigor. I like to think that I am doing my bit for CO₂ absorption by allowing them to grow wild and this also reduces my guilt about my final, massive CO₂ producing, retirement activity, which is travelling.

My wife, Sylviane, and I missed out on the gap year generation, we were both school, college, university then work. I travelled a little with work, while Sylviane travelled a lot, but we were both left with a desire to see more. Visiting exotic locations to go diving and take lots of photos was a primary objective for me, but, initially, it had to be tied in with the need to keep our three boys entertained. As a result we visited hotel resorts, which had something for everyone. Sylviane also learnt to dive but is not what you would call an enthusiast. Once the boys grew up we carried on going to resorts but I have changed my view on diving. Not diving in general but the type of diving offered at holiday resorts. I think this was because we became part of the tourist diving, sausage factory. Their main interest being to get as many punters onto their boats as possible, then take them to a location far from the resort, to dive in less

than pristine conditions, surrounded by scores of other divers, and then charge them lots of money. Of course not all resorts are like this but several experiences turned me away from diving of this kind.

I had a revelation while visiting a resort in Mexico (it was called the Copacabana Beach Resort, where they played Barry Manilow music incessantly, driving everyone from the pool area!). Having spent lots of money visiting a couple of OK dive sites I asked why they didn't dive more on the reef, in front of the resort. The stock response was, "nothing to see there". That's like a red rag to a marine biological bull. There is always something to see, even if you have to work hard to find it. As it turned out the reef directly off the beach was excellent, with many forms of coral, including some large areas of Elkhorn Coral, *Acropora palmata* Lamarck, 1816, Sea plumes, *Pseudopterogorgia* spp. and Sea Fans, *Gorgonia* spp. Plentiful fish species as well, particularly Doctorfish, *Acanthurus chirurgus* (Bloch, 1787), Ocean Surgeonfish, *Acanthurus bahianus* Castelnau, 1855 and Blue Tang, *Acanthurus coeruleus* Bloch & Schneider, 1801, mixed together in large shoals. It was also a good location to see Blue Spotted Rays, *Taeniura lymma* (Forsskal, 1775) and one of the few sites where I have seen Eagle Rays, *Aetobatus narinari* (Euphrasen, 1790), close to shore. So I started to make photo records while snorkeling (see one of my initial snorkeling shots, Figure 1), although I was using rather a simple Sea & Sea at the time, that used film, yes cellulose acetate!



Fig. 1: Shoal of Doctorfish, *Acanthurus chirurgus*, Ocean Surgeonfish, *Acanthurus bahianus* and Blue Tang, *Acanthurus coeruleus*, off Copacabana Beach Resort, Riviera Maya, Mexico. 2004.



Fig. 2: *Geometric Encrusting Tunicate, Botryllus sp.* Caneel Bay, USVI. 2015.

A couple of birthdays later and I had graduated to digital and it was a remarkable transformation in quality. I estimated that one in 36 shots was good from film, while, with digital, given an improvement in my technique, a bit of cropping, sharpening, contrast modification, etc. I had changed the ratio to as high as one in 10.

I also started to become more discerning in terms of resorts to visit after that, using aerial/satellite photos, Google Earth, etc. to select good snorkeling areas first, before the resorts were

vetoed or OK'ed by Sylviane, mainly based on the menus from their restaurants (she is French after all). I made a few faux pas' along the way, once due to a scaling error, with the estimate for the location of the reef edge in Cozumel over 500m out and across a busy boating area. I like to think I'm courageous but not stupid. I also had a think about what I would do with the photographs, which would otherwise have stayed hidden on my computer. I started out by producing leaflets for the resorts, which received a varying degree of success. Getting them to take them seriously was the first stage, with one resort completely ignoring my efforts. I then tried to find the most relevant person at the resort to talk to before spending time on the leaflets, but staff turnover also seemed to be an issue. I finally got an inroad via a PR company representing a chain of resorts. I sent them a prepared leaflet, but they dumped all my photos, which I agree weren't brilliant but were an accurate representation of the conditions at the resort (which weren't good), and replaced them with lots of idealized Getty images, reformatted it completely, put all the locations in the wrong places, used my text and then failed to acknowledge me!

The next step was taken after visiting a resort in the U.S. Virgin Islands (Caneel Bay)

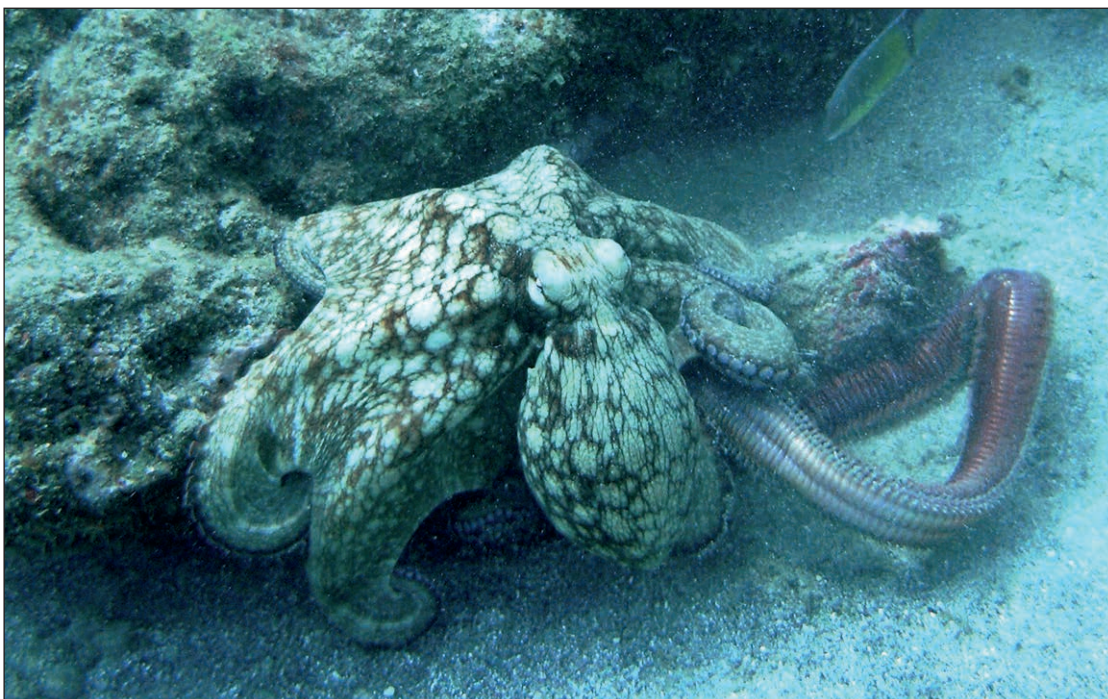


Fig. 3: *Common Octopus. Octopus vulgaris* observed in conflict with a *Bobbit Worm, Eunice aphroditois*. Anse Chastenet. St. Lucia, 2014. Yes, it was a big worm!

where the marketing manager told me it was a brilliant idea (typical marketing) but what he really needed was something digital as he had abandoned paper in all rooms as far as possible. So I forked out for a website, completed it for several resorts, including his and Anse Chastenet (see example images, Figures 2 and 3, respectively), only to be told his IT policy forbade him from having any interaction with anything that wasn't part of their resort chain group.

At this point I think I just decided to do it for my own interest but the website www.resortsnorkeller.com does have several objectives. One of them is entirely shallow, if you forgive the pun, which is to get heavily discounted holidays, but the rest are totally serious:

- To encourage snorkelling, particularly for those people who don't want to, or can't dive (my wife is a real enthusiast).
- To educate snorkelers about the marine life at the resort they are visiting. If I can take a photo of it, they can probably see it themselves. I realized that very few places have anything other than generic literature.
- To get some buy-in from the resorts themselves, in relation to management of the marine environment off their stretch of coast. Most, of course, have no ownership of the coastal and marine areas but they can, at least, influence local government thinking.

- Finally to increase overall knowledge of the marine environment. I try very hard to get my identifications correct (with assistance from experts in various species groups), they are all geographically well defined and the dates are accurately recorded, although I have, admittedly, been a bit lazy with authorities!

I have had some success with the third item, working with a resort in St. Lucia, who wanted leaflets, a webpage, photos for the room iPads (see a couple of examples in Figures 4 and 5) and a poster for a local school they were sponsoring. They also squeezed me for a report about the impacts of excessive snorkeling/boating activity in the vicinity due to the enormous numbers of vessels visiting from cruise ships, and used this in discussions with the government in St. Lucia.

The final part of the resort snorkeler idea is to get further sites included from other enthusiastic snorkelers. It turns out there is a small world of us out there and I intend to include links to some of these as one of my next tasks. So if you have an underwater camera, like snorkeling and go to resorts (anywhere in the world) or even vaguely in the vicinity of a resort (see Peter Barfield's photos from Santa Marina Salina), then get in contact (hello@resortsnorkeller.com or nsthomas1856@gmail.com). All image rights are respected (by me at least), but all marine life images have to be taken while snorkeling!! I should point out however, that I don't pay anything. A bit like being retired!



Fig. 4: Common Octopus, *Octopus vulgaris*, in a fairly agitated state. Sugar Beach Resort, St. Lucia. 2017.

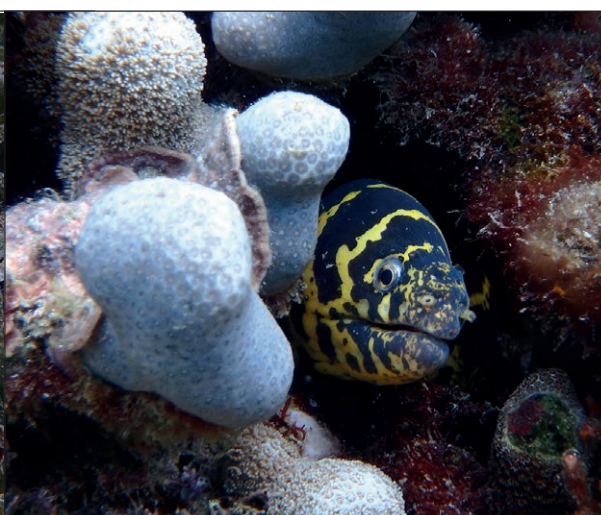


Fig. 5: Chain Moray, *Echidna catenata*. Sugar Beach Resort, St. Lucia. 2017.

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Latin names should be italicized. The entire scientific name should be given in full the first time it is mentioned, but thereafter the genus can be abbreviated — except at the beginning of a sentence. Authorities for taxa follow standard taxonomic guidelines, with a comma before the date; e.g., *Zeuxo holdichi* Bamber, 1990; *Melinna albicincta* Mackie & Pleijel, 1995; *Neanthes irrorata* (Malmgren, 1867).

References

- Do not leave a line space between references. Journal titles should be cited in full.
- Citations in text:Brown & Lamare (1994)...or... (Brown & Lamare 1994)..., Dipper (2001)... or...(Dipper 2001).
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Brown, M.T. & Lamare, M.D. 1994. The distribution of *Undaria pinnatifida* (Harvey) Suringar within Timaru Harbour, New Zealand. *Japanese Journal of Phycology* **42**: 63–70.

Dipper, F.A. 2001. *Extraordinary Fish*. BBC Worldwide Ltd, London. 96pp.

Ellis, J.R., Lancaster, J.E., Cadman, P.S. & Rogers, S.I. 2002. The marine fauna of the Celtic Sea. In J.D. Nunn (Ed) *Marine Biodiversity in Ireland and adjacent waters. Proceedings of the ECSA Conference, 26-27 April 2001*. Ulster Museum, Belfast. pp. 83-82.



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