

BULLETIN of the PORCUPINE MARINE NATURAL HISTORY SOCIETY

Autumn 2015 — Number 4



Bamberene Staples, 2014
Bamberene dorsospina (Clark, 1963)

Bulletin of the

Porcupine Marine Natural History Society

No. 4 Autumn 2015

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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 which include proceedings from scientific meetings, plus regular news bulletins.

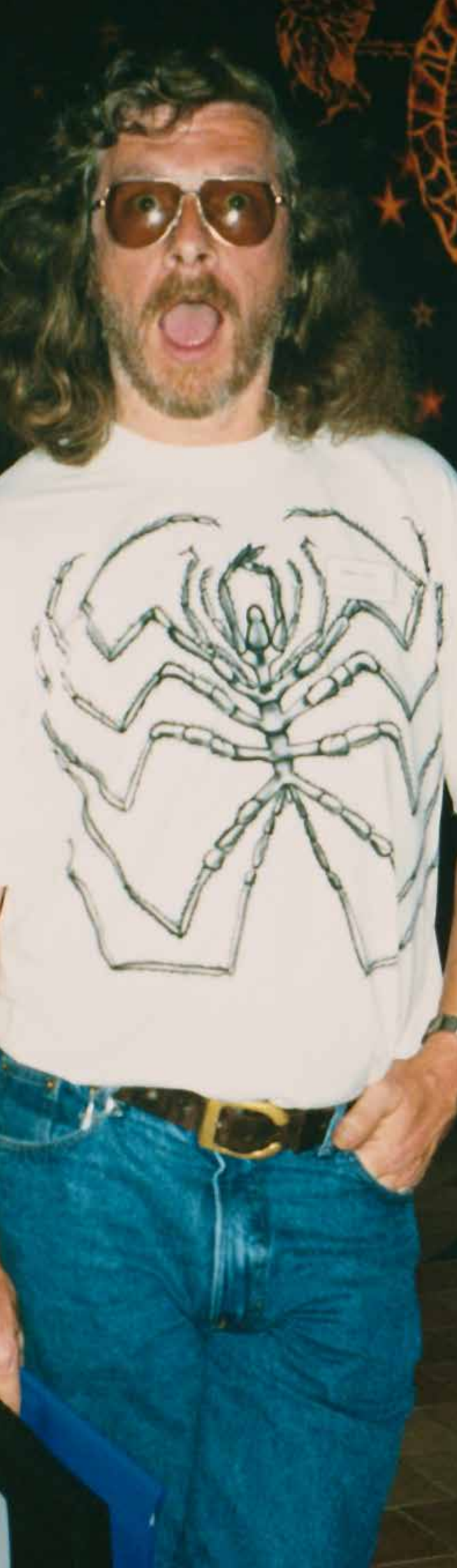
Membership fees: Individual £18 Student £10

 www.pmnhs.co.uk

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

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Editorial

Welcome to the autumn Edition of the *Porcupine Bulletin*.

In honour of a Porcupine who contributed to the Society in many ways (and guises) you will find a section dedicated to the late, great Roger Bamber. It was with some sadness and many smiles that the editorial team selected the photographs of Roger, and I hope that these along with our choice of words provide a fitting tribute to an unforgettable, unique, funny and extremely knowledgeable man. Some of you may know that Roger had an alter ego – C. T. Canon. C. T. Canon has been a regular contributor to the *Porcupine Newsletter*, the first reference in a letter in PN Vol. 1, 5, p.89. In it he asks about the type status of the living offspring of a mollusc holotype. This letter is considered by David Heppell and R. V. Melville in PN 1, 7, pp. 126-7 and further mentioned in PN 2, 6, p.135 under *Thalassiohystris scuba*, where a similar problem is encountered. The problem is again considered in PN 2, 8, p.208 by David Heppell. C. T. Canon writes again in PN 3, 1, p.19. (Thank you to Frank Evans for this information). He most recently wrote of his reminiscences of Porcupines in the field, regarding the Scilly Isles Field trip in 2010 which featured in PN34 p.80.

In keeping with Roger's interest in scientific names, we have a review of a book which explores Latin names, "The Naming of the Shrew – A Curious History of Latin Names" by John Wright. Although it does not focus specifically on marine taxa it provides a good background to nomenclature and taxonomy and has furthered my curiosity; maybe there are Porcupines who are keen to share names that they have created or that have piqued their interest?

The Bulletin also includes a number of papers from the conference in Portsmouth earlier this year and two other diverse articles which I feel demonstrate what Porcupine is all about.....I'll say no more.

Vicki Howe

Hon. Editor



Porcupine Annual Conference 2016



Millport, Isle of Cumbrae,
Scotland

March 11–13, 2016

The next Porcupine Marine Natural History Society Conference will take place at the Field Studies Council centre at Millport, Isle of Cumbrae in Scotland from 11th to 13th March 2016. Further details will be posted on the website as soon as they are released.



Marine Conservation Society Members Evening & AGM



Royal Academy of
Engineering, London
Wednesday 11th November

An evening with radio and television presenter and SCUBA diver Miranda Krestovinkoff. Miranda will take the audience around the UK coastline taking in some of the best stories she has filmed for the BBC series "Coast" and "The One Show" with a behind the scenes view on how some of the items are filmed and what happens when it all goes wrong!

For details and to book, go to http://www.mcsuk.org/shop/index.php?route=product/product&product_id=82&search=agm+2015

New Porcupines!

24th May 2015 was a momentous day for two Porcupine Council members with two new Porcupines both arriving on the same day. Congratulations to Angie Gall and Chris on the birth of Eleanor and to Teresa Darbyshire and Brendan on the birth of Megan.

Bioblitz: July 2016

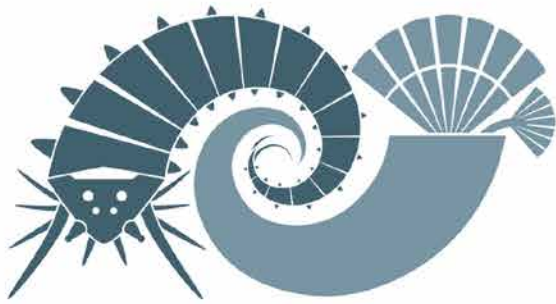
The National Trust are running a Bioblitz event at Lundy Bay near Polzeath, North Cornwall, from 1pm Saturday 2 July to 1pm Sunday 3 July 2016. Porcupine members have been specifically invited to go along and take part.

Sarah Stevens, who is running the event has said "I really want as many local experts, enthusiasts and groups involved as possible, because it's about all of us wildlife enthusiasts sharing our love of wildlife with the wider public. We're deliberately holding this event outside of the school holidays as our aim is to help local people understand and get excited about their local environment."

"For those who don't know Lundy Bay, it's a fairly small site on the coast with lots of habitats packed in. We already know it's a diverse site, but we want to get the facts and figures. We intend to find out more through: daytime intertidal and rockpool surveys, a night-time rockpool ramble, moth traps, small mammal traps, ink traps, pit fall traps for beetles and other insects, as well as bat detecting, pond dipping, bug hunts and recording the plants, trees, fungi, lichens, butterflies, dragonflies, bumblebees, reptiles and amphibians, birds, including dawn chorus and a 'sit, watch and listen' for our night life to discover badgers, foxes, deer and owls."

A timetable of the sessions everyone, including the public, can get involved in will be drawn up nearer the time. If you can volunteer to help, please let Sarah know if you can lead sessions, on what species and if you have a preference for what time of day.

Sarah can be contacted on 01208 863821 or by email at SarahE.Stevens@nationaltrust.org.uk



IPC12

12th International Polychaete Conference
National Museum Wales, Cardiff | 1-5 August 2016

Amgueddfa Cymru —
National Museum Wales
is honoured to be hosting the
12th International Polychaete Conference
31 July (registration) to 5 August 2016
at the National Museum Wales in Cardiff



We aim to make this a
conference that honours
the spirit, character
and inspiration of
Kristian Fauchald

www.museumwales.ac.uk/ipc2016

Follow Conference updates on Twitter
<https://twitter.com/IPC2016>



Porcupine Marine Natural History Society

**Minutes of the 38th Annual General Meeting
Saturday 28th March 2015.**

Portsmouth University

1. Apologies for absence were received from Jon Moore, Fiona Crouch, Dawn Powell and Pamela Thompsett.

2. Matters arising from the Minutes of the 37th Annual General Meeting, as published in the PMNHS Bulletin 2.

The Minutes were accepted with no corrections or additions. There were no matters arising.

3. Officers' Reports

The Hon. Treasurer's Report was presented by Andy Mackie on behalf of the Hon. Treasurer Jon Moore. The accounts are published here.

The accounts recorded a balance of £2009 at the end of 2014, a slight increase on the balance of £1969 at end of 2013. Costs of printing the Bulletin in colour have significantly increased our printing costs and there are difficulties in ensuring everyone is paying by standing order at the current rates. Although this year there has been an increase in membership income as a result of efforts to contact members to change their subscriptions, overall there is a continued shortfall of income over expenditure.

Acceptance of the Hon. Treasurer's report was proposed by Roni Robbins and seconded by Tammy Horton and carried with no votes against.

The Hon. Membership Secretary's Report was presented by Séamus Whyte.

Membership figures stand at 160 full current subscription members, 182 total members (includes unwaged, libraries, life members). The drop in the figures this year is a more accurate picture of current membership

numbers than in previous reports. This results from following up members who had not paid for a year or more, some made back payments for the years they had not paid. These figures reflect only people who have paid this year. Inclusion of membership within the conference fee has led to a high turnover of members in the past and we have not taken that approach in 2015. Everyone was encouraged to get in touch with Séamus if they need to check the status of their subscription.

Acceptance of the Hon. Membership Secretary's report was proposed by Doug Herdson and seconded by Teresa Darbyshire and carried with no votes against.

The Hon. Editor's Report was presented by Vicki Howe.

We are producing 2 colour Bulletins per year, all the layout and design is done by Teresa Darbyshire. All conference speakers were encouraged to submit articles for the next Bulletin.

If members do not want a paper copy, we can supply a pdf instead, this would help with the issues about printing costs, please contact Vicki Howe or Séamus Whyte.

As well as generally needing articles for the Bulletin, we particularly need people to offer book reviews, website reviews and app reviews.

There were several comments and suggestions from the floor: firstly that we need leaflets to give out to allow people to promote membership. These could be given out by academics within universities. Also, that we should integrate our Facebook page with other institutions' pages to help get the word out. A further suggestion was that the leaflet or flyer should be a downloadable file on our website which people could print out. The idea of having student representatives to help promote membership in universities with marine departments was discussed and it was agreed that this would help.

Acceptance of the Hon. Editor's report was proposed by Anne Bunker and seconded by Ken Collins and carried with no votes against.

The Hon. Web-site Officer's Report was presented by Tammy Horton.

The website is very easy to update and almost runs itself. We use it to advertise the conference and other meetings, all the documents are held there and we see a surge in 'hits' prior to meetings. Most daily activities and news are now on our Facebook page, the website is more static. There is the whole back catalogue of all the newsletters on the website now apart from the most recent editions. Anyone can send messages to go as news items on the website. We are open to suggestions for how to improve the website.

Acceptance of the Hon. Web-site Officer's Report was proposed by Paul Brazier and seconded by Vicki Howe and carried with no votes against.

The Hon. Records Convenor's Report

There was no report from the Hon. Records Convenor.

The Hon. Chairman's Report was presented by Andy Mackie.

Last year's conference was in Galway and was organised by Louise Firth and her team with 49 attendees. Field work followed at places in Galway Bay to look at a boulder shore and Dogs Bay foraminiferan beach.

The Hon. Chairman thanked Gordon Watson and the team at Portsmouth University for hosting this year's conference. It had so far been a very diverse and enjoyable conference and all seemed to enjoy the conference dinner.

Last year we ran a successful field meeting in the Isle of Man organised by Angie Gall with the Manx Wildlife Trust. We were grateful for sponsorship received from Sea Changers. Despite bad weather at some points, the 12 attendees (all divers) managed to collect a lot of data. There is an account of the field meeting in the latest Bulletin.

The Hon. Chairman recorded with sadness the passing of Roger Bamber in February this year. Roger first attended Porcupine meetings as a student and was always a driving force behind the society.

Acceptance of the Hon. Chairman's report was proposed by Tammy Horton and seconded by Ken Collins.

4. Porcupine Grants Scheme and Newsletter student prize

The grants scheme is now on hold until finances improve. The student prize is on offer for student articles in the Bulletin, the prize is £50 plus free membership for a year.

5. Election of Officers and Council

Roni Robbins stepped down as Honorary Records Convenor to become an Ordinary Member of Council.

Julia Nunn was elected as Honorary Records Convenor.

Angie Gall is acting Honorary Secretary but wishes to step down from the role.

Frances Dipper was elected as Honorary Secretary.

All other office bearers were re-elected for another year. Ordinary members Sue Chambers and Fiona Crouch stood down from Council and were re-elected.

The motion was proposed by Doug Herdson and seconded by Tammy Horton and carried with no votes against.

The council for 2015-16 is as follows:

Office Bearers:

Hon. Chairman – Andy Mackie

Hon. Secretary – Frances Dipper

Hon. Treasurer – Jon Moore

Hon. Editor – Vicki Howe

Hon. Membership Secretary – Séamus Whyte

Hon. Records Convenor – Julia Nunn

Hon. Web-site Officer – Tammy Horton

Bulletin Layout & Design – Teresa Darbyshire

Ordinary Members of Council:

Peter Barfield

Paul Brazier

Anne Bunker

Sue Chambers

Fiona Crouch

Angie Gall

Dawn Powell

Roni Robbins

The council is looking to co-opt a student

representative. Four people put their name forward – Ben Robinson, Southampton Uni, MSci; Joanne Younger, Portsmouth Uni, first year MPhil; Kesella Scott-Somme, Portsmouth Uni, 3rd year BSc. and Isabelle Cooper, IOW College/Southampton Uni from October 2015. It was thought best to engage all four in some way and for them to discuss amongst themselves who would attend council meetings. More thought is needed about how a 'student sub-committee' might work and which council member will be their lead contact.

6. Future meetings

The next conference is tentatively suggested to be at Millport, however this will be organised by Fiona Crouch who was not at the AGM to confirm plans.

There is a planned field meeting to Staffa Archipelago in the week of 26th September 2015. This is being organised by Rayner Piper

and Seamus Whyte after the owners of these 4 privately owned islands approached Rayner at the Zoological Society of London, looking for a marine survey of their area. We need to provide a list of species and habitats as we would from any field meeting. There will be funding of transportation to the islands, food and basic accommodation. There is also at least one boat available for diving and transporting the shore party around the island. There are still some logistics to be worked on and we are looking for experienced divers to come. Anyone interested should contact Séamus Whyte.

7. A.O.B

A Porcupine jumper worn by Paul Brazier has been admired and there is interest among the members for having new sweatshirts printed. Member Kathryn Birch has offered to look into costings for sweatshirts.

The following QR codes relate to Roger Bamber, whose obituary follows this section:



Porcupine invite you to watch a presentation by Roger which was recorded at Joel Hedgepeth's memorial meeting in 2008.

We hope that by watching this video you will get a flavour of Roger's character, his wonderful pedantry, his particular sense of humour, and his immense knowledge.

<https://youtube/bDf3xwPI348>

A collection of taxonomic studies commemorating Roger N. Bamber (1949–2015)

Special Volume Zootaxa 3995

<http://www.mapress.com/zootaxa/list/2015/3995%281%29.html>



Deep sea news: posted on April 2, 2015 by Dr. M

Roger Norman Bamber (1949-2015)

<http://www.deepseanews.com/2015/04/roger-norman-bamber-1949-2015/>

New species of flesh eating prawns discovered off the coast of Ireland

By Stuart Winter

*PUBLISHED: 00:00, Fri, Aug 7, 2015
| UPDATED: 16:49, Fri, Aug 7, 2015*

<http://www.express.co.uk/news/nature/596847/Prawn-flesh-eating-Ireland>



**PORCUPINE MNHS
RECEIPTS AND PAYMENTS ACCOUNT**

YEAR TO 31 DECEMBER 2014

Year to 31.12.13			Year to 31.12.14
£	£		£
		RECEIPTS	
52		Subscriptions	0
2946		2012 & earlier	26
144		2013	2049
0		2014	46
		2015 onwards	
	3142		2121
	5	Bank Interest	0
	3142	Total Receipts	2121
		PAYMENTS	
(4037)		Newsletter-	Printing (3142)
(306)			Postage & other expenses (0)
(4343)		Total Newsletter Costs	(3142)
(144)		Web site expenses	(10)
(44)		Council meeting expenses (travel/catering)	(0)
	(4531)		(3152)
	(1389)	DEFICIT BEFORE MEETINGS & GRANTS	(1031)
1031		Annual Conferences – Swansea (2013)	0
0		– Galway (2014)	344
(500)		Field meetings – Isle of Man (2014)	777
(2193)		Porcupine grants	0
(50)		Newsletter prize	(50)
	(1712)		1071
	(3101)	SURPLUS FOR THE YEAR	40
5070		BANK BALANCE BROUGHT FORWARD	1969
<u>1969</u>		BANK BALANCE CARRIED FORWARD	<u>2009</u>

Jon Moore, Hon Treasurer
10 March 2015

J. J. Moore

Nick Light, Hon Examiner
25 March 2015

N. Light

OBITUARY
Roger Norman Bamber
1949 – 2015

by Tammy Horton

"Fortis et egregious"



It is with great sadness that I report here on the loss of one of our treasured members, Roger Norman Bamber. Roger passed away peacefully in his sleep on February 16th 2015, just over a year after a diagnosis with Motor Neurone Disease, in January 2014.

Roger was an integral member of the Porcupine Marine Natural History Society, working as the Hon. Editor of the *Porcupine Newsletter*, between August 1985 and April 1994, and as a member of the Editorial sub-committee since May 1998. It is very likely that Roger has attended every meeting of the Porcupine Marine Natural History Society since its inception in 1976. He will be greatly missed by the UK community of 'Porcupines'.

His passion has always been for an understanding of the natural history of marine organisms, with a particular focus on morphological taxonomy. He has studied many different taxa over the years, specialising in Pycnogonida and Tanaidacea but he retained strong interests in other taxa and in both community ecology and autecology additionally.

Roger was born on the 1st September 1949 in Lewisham, to Frank and Ethel Bamber. He was brother to Les and Anice and grew up

in Catford, South London. He was educated at Haberdashers' Aske's Boys' School, where his interest in the natural world was sparked and encouraged. He always remembered a particularly good botany teacher who inspired him to achieve high marks, yet his overwhelming interest was zoology.

Roger studied Zoology at the University of Newcastle-upon-Tyne where he achieved a 1st Class Honours degree in 1974. It was during his first year at university that he was encouraged to work at the Dove Marine Laboratory where he found his vocation and developed his passion. Roger stayed at Newcastle to undertake his doctoral studies on "The effects of dumped pulverised fuel ash on the benthic fauna of the Northumberland coast" under the tutelage of Frank Evans. He completed his PhD in 1978, publishing his first scientific paper in 1977. So began a lifelong interest in the marine environment and an eclectic career followed, throughout which Roger has more than dabbled his toes in a number of scientific fields, on which he has left his unmistakable mark.

Throughout his working life he has developed and maintained an interest in the following diverse fields: benthic marine and estuarine community ecology; marine invertebrate biology and life history; marine zoogeography; South China Sea cave fauna; marine meiofauna; population parasitology; atherinid biology; coastal saline lagoons; environmental impact assessment; ecophysiology and ecotoxicology; marine pollution; commercial fouling; all of which have resulted in peer reviewed scientific publications as can be seen from his extensive publication list (see Horton, Błażewicz-Paszkowycz, Staples & Bird 2015). He published a total of 214 scientific papers in his lifetime. Roger also published many hundreds of reports and non- peer reviewed papers and articles.

Roger is probably best known in taxonomic circles for his work on both pycnogonids and tanaidaceans and it is in these fields and by the researchers who study these taxa in particular that his loss will be profoundly felt. Roger's first paper on the Pycnogonida (or Pycnobeasts as he always referred to them) was published in 1979 and described a new species of *Endeis* from West Africa. It is perhaps his love of

the Pycnogonida that is most enduring and he followed this first paper with a further forty-six papers on them. He established an Order, a family, a subfamily, a genus and 42 species new to science. He was also instrumental in the creation, with Aliya El Nager, of 'PycnoBase'. PycnoBase is an enduring legacy to his contribution to pycnogonid systematics and today it represents the foundation for all future work in the field.

He was particularly proud (and rightly so) of his 2010 book *Sea-spiders (Pycnogonida) of the Northeast Atlantic. Keys and notes to the identification of species*, to which he would point anyone with a query on the group as it was likely covered somewhere within. A colleague, Judith C. Price, tells us that Roger had a most dismissive attitude to the ecological importance of his beloved pycnobeasts; often saying that "if all the pycnogonids on Earth were to vanish tomorrow, he would be one of the three organisms left who gave a damn." Judith says she will be one of the very many who will give a damn that he has vanished.

His second love was perhaps the Tanaidacea, to which he became fully acquainted fairly late in his career. He published his first paper on tanaidacea in 1986 which detailed the tanaid fauna of the Cullercoats district, but his first taxonomic work was not published until 1990 and described a new species of *Zeuxo* from the French Atlantic Coast. His 'second love' could be argued to have somewhat overtaken his first, as he has since that time authored (or co-authored) a total of two families, three subfamilies, 42 genera, one subgenus and 229 tanaid species!

His extraordinary track record for species descriptions does not stop at these favoured taxa as Roger has also authored or co-authored seven isopod species, two amphipod species, one leptostracan, six mysids, one Bocheacean, two copepod taxa (including a new genus) and three polychaete taxa (including a new genus). Roger described species from shallow and intertidal waters to the deep sea, and in total he established 346 taxa.

When Roger passed away there were already eight taxa named in his honour, including genera of Pycnogonida and Tanaidacea:

***Bamberene* Staples, 2014 (Pycnogonida)**

***Austrodecus bamberi* Wang, Huang, Lin & Zheng, 2013 (Pycnogonida)**

***Bamberus* Stępień & Błazewicz-Paszkowycz, 2013 (Tanaidacea)**

***Kalliapseudes bamberi* Drumm & Heard, 2011 (Tanaidacea)**

***Leptognathia bamberi* Larsen & Shimomura, 2007 (Tanaidacea)**

***Makassaritanaia bamberi* Gutu, 2012 (Tanaidacea)**

***Chaulioleona bamberi* Bird, 2015 (Tanaidacea)**

***Cypridopsis bamberi* Henderson, 1986 (Ostracoda)**

There is now also a special issue of *Zootaxa* that has named 27 new taxa in his honour and two for Roni Robbins, his partner at ART00 Marine Biology Consultants. This issue, attracted a total of 20 papers from 44 authors, and is testimony to Roger's influence and popularity both as a scientist and the personal friendships he made throughout his distinguished career (Horton, Błazewicz-Paszkowycz, Staples & Bird 2015).

Roger was a well-known member of a number of editorial boards (*Zootaxa* Editor, for Pycnogonida, Tanaidacea, Cumacea; Editor of *Zookeys*, Pycnogonida; Editorial Advisory Board for *Polish Polar Research*; Guest Editor for *Journal of Natural History*) and his input to these was invaluable. Roger also served as a Taxonomic Editor for the World Register of Marine Species (WoRMS) where he edited Tanaiids and Pycnobase, and has also provided valuable input to the World Register of Deep-Sea Species (WoRDSS).

One of the many tasks of a modern taxonomist is to provide guidance and advice to fledgling taxonomists as they prepare their first papers and learn the 'tools of the trade' and this is something Roger was particularly adept at. He would gladly accept manuscripts to edit and comment on, and had the required patience and ability to conduct this task with ease. His talents as an eloquent writer of prose must not be overlooked. He was a celebrated pedant, always ready to correct a grammatical injustice and known to carry a red pen in his top pocket for such occasions as might arise.

Roger appreciated a scientific name with a bit of thought put into it, as he so often put into his species names. This was part of the taxonomic process that he thoroughly enjoyed and which is exemplified by the many unusual names he bestowed upon his new taxa.

He was particularly proud of the name *Tanystylum sinoabductus* Bamber, 1992 a species of pycnogonid which came from the South China Sea and was thus a 'Chinese takeaway' although the etymology in this case modestly reads: "The name for this species, unique in being the first to be described from Hong Kong, is from the Latin, meaning that which is taken from China."

Macrolabrum impedimenta Bamber, 2005 starred in a collection of species in which "The novel nomenclature derives from the names of characters or places from the 'Discworld' series of novels by Terry Pratchett, particularly Pratchett (1999) which refers to the "Last Continent", a place which "just happens to be a bit ... Australian". All the taxa were from Western Australia and *Macrolabrum impedimenta* is a tanaid species with characteristic spination on each of the legs that give it the appearance of having lots of smaller legs hence the Etymology reads "from the Latin *impedimenta* – luggage, the Luggage being a notable and fearsome entity from the Counterweight Continent, Discworld, with a lot of small legs".

Keska sei Błazewicz-Paszkowycz, Bamber & Józwiak, 2012, is one of my favourites for which the Etymology reads: "Phonetically from the name apparently given to this species by a French colleague on first seeing the drawings (in combination with the specific epithet)". Enough said.

Roger was always great company, interesting, engaging, controversial, but always good fun. He certainly stood out from the crowd with his unmistakable and timeless unique style. He was unusual, amongst academics, in successfully carrying off a mixture of a great intellect and no-nonsense approach to science, with an infectious amiability and ability to enjoy life to the fullest. He was always happy to have a beer with you (and definitely two or three!). He smoked more than he should, and really

appreciated good food. Therefore, it was in the pub, restaurant, or outside smoking that Roger could be relied upon to be found and it was always in these places that the best discussions, friendships and memories were made.

The special issue dedicated to Roger published in the journal *Zootaxa* contains Roger's full list of peer-reviewed publications (Horton, Błazewicz-Paszkowycz, Staples & Bird 2015). Here we provide a list of his non-peer reviewed publications (excluding his many hundreds of environmental survey reports) many of which were prepared for the *Porcupine Newsletter*:

Bamber R.N. 1977. On mobile littoral environments. *Porcupine Newsletter* 1 (4): 62–63

Bamber R.N. 1978. Some recent records of *Okenia pulchella* (Alder & Hancock) from Northumberland. *Porcupine Newsletter* 1 (5): 79.

Bamber R.N. 1979. A short note on marine macrofaunal invertebrates newly recorded for the Medway Estuary. *Porcupine Newsletter* 1 (8): 148–149.

Bamber R.N. 1981. Observations on the benthic fauna of the River Blackwater Estuary, Spring 1979. *Porcupine Newsletter* 2: 16–24.

Bamber R.N. 1981. Benthic offshore invertebrates from Sizewell, Suffolk, June 1976. *Porcupine Newsletter* 2: 34–38.

Bamber R.N. 1982. A taxonomic key to the British marine mites of the Halacaridae. *Porcupine Newsletter* 2: 92–98.

Bamber R.N. & Henderson P.A. 1983. Epifaunal arthropods from the tide pools at Rhosneigr. *Porcupine Newsletter* 2: 196.

Bamber R.N. & Henderson P.A. 1983. Meristic and biological variation in British atherinids. *Porcupine Newsletter* 2: 244–245.

Bamber R.N. 1983. Halacarid mites at Cullercoats, 9th October 1983. *Porcupine Newsletter* 2: 244–245.

Bamber R.N. 1983. Why don't fish show a Poisson distribution? *Porcupine Newsletter* 2: 254–258.

Bamber R.N. 1985. Why do pycnogonids prefer inaccessible anemones? *Porcupine Newsletter* 3: 67–71.

Bamber R.N. & Shearer M. 1985. Arthropods associated with *Corallina officinalis* from Crackington Haven, Cornwall. *Porcupine Newsletter* 3: 128–129.

Bamber R.N. 1985. A re-examination of some of Brady's microscope slides. *Porcupine Newsletter* 3: 131.

Bamber R.N. Coughlan J. & Turnpenny A.W.H. 1985. Environmental aspects of the thermal discharges from Castle Peak Power Stations. Report to British Hydromechanical Research Association, Castle Peak Power Stations Heat Dispersal Study. Part V of Vol. 3, October 1985: 32pp.

Bamber R.N. & Henderson P.A. 1986. Sand smelt in the Fleet. *Porcupine Newsletter* 3: 149–151.

Bamber R.N. 1987. Epifaunal collections from the Channel Islands, September 1986. *Porcupine Newsletter* 3: 235–239.

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In Roger's own words....

Honorary Secretary of the Porcupine Marine Natural History Society:

Dr Roger Bamber is a Senior Partner with ART00 Marine Biology Consultants, having had a career in applied and commercial science, particularly coastal and deep-sea environmental impact assessment, non-chemical pollution, expert witnessing and saline-lagoon conservation. He is a marine biologist specializing in benthic invertebrate communities, with a peculiar obsession with pycnogonids and tanaidaceans (and a few other obscure taxa) but also indulging in other crustaceans, polychaetes, molluscs, echinoderms and the occasional fish, is responsible for the World Pycnogonid Webpage (PycnoBase) as well as for describing a ridiculous number of new species world-wide, and has recently produced the updated version of the Synopsis of the British Fauna on sea-spiders (Pycnogonida). He seems to have been on the Council of Porcupine since 1980.



February 17th 2015: "It is with great sadness that I am writing to you to tell you that our dear friend, colleague and longstanding member of the Porcupine Marine Natural History Society, Roger, died peacefully in his sleep last night. Whilst not completely unexpected, we are still shocked and saddened at his loss."

Following news of Roger's death, many kind, often humorous, comments, reminiscences and photos were posted. Here a few of those from the Porcupine Facebook group pages that we particularly liked:

We will all miss him so much. x



Very sad news

A great guy, fun - supportive and immensely knowledgeable.



Sad sad news. Roger was a fantastic guy, so helpful to anyone, and he gave me lots of help over the years with specimens for my taxonomic studies. He was always fantastic company and was so knowledgeable. Porcupine meetings and the International polychaete conference will not be the same. I don't really have the words but he will be greatly missed.

This is shocking and very, very sad news for me. He was a great man, friend, scientist, colleague always a lot of fun with him and a lot to learn from him ... R.I.P. dear Roger !

This is a sad day. A great friend in every way: Sociable, knowledgeable, brilliant, intelligent, prolific, enthusiastic, inspiring, generous, witty ... the list is endless. A magnificent man with a wonderful sense of humour. We will miss Roger immensely

Such sad news. We'll miss you Roger and the friendly, always knowledgeable, banter.





I have such happy memories of times shared at Porcupine meetings. I loved his banter, he was so witty and a very clever man.

Roger was a fantastic guy, always had time to help friends & enjoy a pint or 2. I'll miss him lots xx

Very sad news, an extremely intelligent and charismatic man.



I hope he knew how much he enlivened the Porcupine meeting experience. Memories return.....the night at Millport a group of us drank each other under the table on Shelagh Smith's malt and I laughed so much it hurt!

I admired his pycnogonid clothing.

That is terrible news. What a loss.



Great photos. This is a sad day, a great loss. But it is impossible to think about Roger and not to end up smiling, even laughing; He was a great man and his energy inspiring



This evening I sat for ages looking at all these great pictures of Roger laughing and smiling. Thank you for posting the pictures. I feel privileged to have known him



It's a very sad day. I spent a long time with Roger over the years in bars, restaurants and even labs and lecture halls. I was one of his many chauffeurs ferrying him back from the field or pub. I'll miss the discussions, arguments, correction of my use of English and perhaps even his singing from the back seat. Roger was great fun but he always challenged you to think.

Great photos of a lovely man. Sad

What a legend. Irreplaceable. He will be missed. X



Likewise - he was a joy to be around - long may his smile inspire us all - with memories of his irreverence, intelligence, challenge and best of all staunch support and friendship through all. Much loved.

CONFERENCE 2015

Report on the Annual Conference (27th-29th March 2015) Species: home and away

Gordon Watson (conference organiser)

Over 90 people attended the annual conference held in late March at the Institute of Marine Sciences of the University of Portsmouth. The event was a great success with Professor Graham Galbraith, Vice Chancellor of the University, opening the proceedings and welcoming the delegates. Keynote talks on the 'Amphipod Island' and underwater photography were followed by a diverse set of presentations and posters from undergraduates, postgraduates, academics and specialists. Topics included non-native species in the Solent, ballast water, MCZ management, origins of deep sea fauna and keystone starfish from Chile to name but a few. The talks and posters reflected the diversity of research areas of the independent delegates and 25 institutions (Universities, research centres, environmental consultancy companies and government agencies) attending and ensured that there was plenty for the delegates to talk about during the coffee breaks!

Aside from the talks, over 60 delegates enjoyed the conference meal on the Friday at the Spice Island Inn, Old Portsmouth; appreciating the views of the Spinnaker Tower and the

new Ben Ainslie Racing America's Cup team headquarters. On the Sunday a brave set of souls visited Southsea Marina to look for non-native species and investigate the fouling community covering the floating pontoons. In the afternoon we were blown around the local nature reserve of Farlington Marshes observing the birds and discussing the management issues that affect such an exposed coastal site. Although the weather was a little wild, many species of invertebrate, wading and wildfowl birds were recorded and the sun did finally come out as we returned to the minibuses.

The feedback via social media channels has told me that the event was a great success and so I hope I have continued the tradition of the previous conferences. From a personal point of view the conference reminded me why I do marine biology; re-energising me to get my family and I back out into the marine environment, and to go exploring!



Porcupine Conference delegates, March 2015



Delegate affiliations

BU Bournemouth University

ABP mer
marine environmental research



THE ISLE OF WIGHT
college



CARDIFF UNIVERSITY
PRIFYSGOL CAERDYD



UNIVERSITY OF LIVERPOOL

University of Portsmouth



PLYMOUTH UNIVERSITY



UNIVERSITY OF CAMBRIDGE



SEA nature studies



CANFORD

UNIVERSITY OF Southampton



Porcupine field trip to Southsea marina

Paul Brazier

After an interesting 2 days of conference, 22 Porcupiners ventured into the high winds of Ferry Road to Southsea marina, Langstone Harbour on 29th March 2015. Although the tide did not drop below 1.85 m above chart datum, this was not constraining due to the floating nature of the marina pontoons. Small areas of mudflat and the piles were also observed, but recording was largely from walkways, finger pontoons, ropes and buoys associated with the structures. The party scattered across the marina, but primarily split into east (outer) and west (inner) groups. The visit was ably organised and assisted by Gordon Watson and Marc Martin of the Institute of Marine Sciences, University of Portsmouth.

The field visit was seen as an excellent opportunity to familiarise ourselves with the non-natives that are often associated with harbour, ports and marinas, particularly on the south coast of England where the boating traffic is high and with other European sea ports. The marina remains wet throughout the tidal cycle due to a sill gate, is sheltered from wave action and has no freshwater flow, other than the immediate vicinity.



Fig. 1: Intrepid Porcupines heading for the marina!



Fig. 2: Low power microscopic image of Pterothamnion plumula.

Whilst there were the expected fouling species (those known to be rapid colonisers) such as plumose anemones *Metridium senile*, solitary seasquirt *Ciona intestinalis*, sponges, amphipods and green algae *Cladophora* spp., many other species were also recorded that are associated with rocky habitats such as *Sabella pavonina*, bryozoans and brown algae. A specimen of possible *Watersipora subtorquata* (invasive non-native bryozoan crust) was later identified by Camila Robins as *Cryptosula pallasiana*. An unusual find was a specimen of the sea spider *Ammothea hilgendorfi*, confirmed by Grant Rowe, an introduced north Pacific species, only recorded from the coasts of Hampshire and Dorset (details are in Roger Bamber's 2010 Linnean Society *Synopsis of British Fauna*). Specimens of foliose red algae, were originally thought to be the non-native red alga *Grateloupia turuturu*, but further microscopic observation by Kath Slade suggests that some maybe *Schizymenia dubyi* (Chauvin ex Duby) J. Agardh, 1851. The full species list from the inner and outer areas of the marina are listed in Table 1. Most of the species were common to both areas and the list tends to reflect the interest areas and expertise of those at each location.

Taxon Name	Authority	Inner marina	Outer marina
PORIFERA			
<i>Sycon ciliatum</i>	(Fabricius, 1780)	P	P
<i>Halichondria (Halichondria) panicea</i>	(Pallas, 1766)	P	P
CNIDARIA			
<i>Anemonia sulcata</i>	(Forskål, 1775)	P	
<i>Metridium senile</i>	(Linnaeus, 1761)	C	
POLYCHAETA			
<i>Platynereis dumerilii</i>	(Audouin & Milne Edwards, 1834)		P
<i>Sabella pavonina</i>	Savigny, 1822	P	P
CHELICERATA			
<i>Ammonothea hilgendorfi</i>	(Böhm, 1879)		P
ARTHROPODA			
Mysidae	Haworth, 1825	P	
<i>Austrominius modestus</i>	(Darwin, 1854)	F	
Amphipoda	Latreille, 1816	P	P
<i>Gammarus locusta</i>	(Linnaeus, 1758)	P	
<i>Macropodia rostrata</i>	Leach, 1814	P	
BRYOZOA			
<i>Vesicularia</i> sp	Thompson, 1830		P
<i>Cryptosula pallasiana</i>	(Moll, 1803)	P	
<i>Bugula neritina</i>	(Linnaeus, 1758)	P	
TUNICATA			
Polyclinidae	Milne Edwards, 1841	P	
<i>Diplosoma</i> sp?	Macdonald, 1859	P	O
<i>Ciona intestinalis</i>	(Linnaeus, 1767)	C	C
<i>Corella eumyota</i>	Traustedt, 1882	F	P
<i>Ascidella aspersa</i>	(Müller, 1776)	P	
<i>Botryllus schlosseri</i>	(Pallas, 1766)	P	
<i>Botrylloides</i> sp?	Milne Edwards, 1841	P	
RHODOPHYTA			
<i>Porphyra</i> sp	C.Agardh, 1824		R
<i>Dumontia contorta</i>	(S.G.Gmelin) Ruprecht, 1850	P	
<i>Grateloupia turuturu</i>	Yamada, 1941	C	C
<i>Grateloupia subpectinata</i>	Holmes, 1912	P	
<i>Grateloupia filicina</i>	(J.V.Lamouroux) C.Agardh, 1822		P
<i>Phyllophora pseudoceranoidea</i>	(S.G.Gmelin) Newroth & A.R.A.Taylor, 1971	P	F
<i>Ceramium secundatum</i>	Lyngbye, 1819	C	F
<i>Halurus equisetifolius</i>	(Lightfoot) Kützting, 1843	P	
<i>Neosiphonia harveyi</i>	(J.W.Bailey) M.-S.Kim, H.-G.Choi, Guiry & G.W.Saunders, 2001	C	C
<i>Pterothamnion plumula</i>	(J.Ellis) Nägeli, 1855	P	O
OCHROPHYTA			
<i>Pylaiella</i> sp.	Bory de Saint-Vincent, 1823	F	
<i>Cladostephus spongiosus</i>	(Hudson) C.Agardh, 1817	C	P
<i>Dictyota spiralis</i>	Montagne, 1846	P	
<i>Desmarestia aculeata</i>	(Linnaeus) J.V.Lamouroux, 1813	C	C
<i>Colpomenia peregrina</i>	Sauvageau, 1927	P	
<i>Fucus</i> sp (on flats)	Linnaeus, 1753	P	P
<i>Sargassum muticum</i>	(Yendo) Fensholt, 1955		P
CHLOROPHYTA			
<i>Ulva</i> spp.	Linnaeus, 1753	P	R
<i>Blidingia minima</i>	(Nägeli ex Kützting) Kylin, 1947	P	
<i>Chaetomorpha linum</i>	(O.F.Müller) Kützting, 1845	P	
<i>Cladophora albida</i>	(Nees) Kützting, 1843	P	
<i>Cladophora battersii</i>	Hoek, 1963	P	
<i>Cladophora pellucida</i>	(Hudson) Kützting, 1843	P	
<i>Bryopsis plumosa</i>	(Hudson) C.Agardh, 1823	P	

Table 1: Species from Southsea marina, Langstone Harbour, 29th March 2015. Abundance categories: P=Present, R=Rare, O=Occasional, F=Frequent, C=Common.

Porcupine visit to Langstone Harbour and Farlington Marshes, 29th March 2015

Douglas Herdson

On Sunday afternoon a brave (foolish) group of Porcupines emerged from the lab and went off to investigate the wildlife of the Farlington Marshes to the east of Portsmouth, led by Tim Ferrero of the Hampshire and Isle of Wight Wildlife Trust. This nature reserve, owned by Portsmouth Council and managed by the Wildlife Trust, consists of rough grazing, scrub, a large shallow pool with a reedbed, other ponds and lagoons.

During WWII it was a "Starfish Site"; that is an area that was lit up to resemble a bombed Portsmouth and mislead the approaching bombers. Hence the numerous depressions that are now the scattering of ponds. It is enclosed by a sea-wall which can be topped by exceptional waves. Beyond this are the extensive mudflats of Langstone Harbour with patches of *Spartina* dominated saltmarsh.

Most of the Langstone Harbour area, including Farlington Marshes, is an SSSI and SPA, while the lagoon is an SAC. [see below for list of main designations]

After a very unpromising start to our visit in gale conditions, the weather became bright and warm, provided you ignored the Force 8 wind. Sue and Chris Chambers made use of the partial shelter of the sea-wall to investigate a small lagoon. Unfortunately it proved to be rather disappointing; producing just the small brackish water snail *Semisalsa stagnorum* and an as yet unidentified crustacean.

However, despite the conditions 24 species of birds were seen on the marsh and surrounding area of Langstone Harbour.

Farlington Marshes (including Lagoon)

Farlington Marshes Local Nature Reserve

Langstone Harbour SSSI

Chichester & Langstone Harbours SPA (+ Ramsar)

Lagoon

Solent and Isle of Wight Lagoons SAC

Langstone Harbour

Langstone Harbour SSSI

Solent Maritime SAC

Chichester & Langstone Harbours SPA

Name	Common Name
Aves	
<i>Egretta garzetta</i> (Linnaeus, 1766)	Little Egret
<i>Cygnus olor</i> (Gmelin, JF, 1789)	Mute Swan
<i>Branta bernicla bernicla</i> (Linnaeus, 1758)	Dark-bellied Brent Goose
<i>Branta canadensis</i> (Linnaeus, 1758)	Canada Goose
<i>Tadorna tadorna</i> (Linnaeus, 1758)	Shelduck
<i>Anas platyrhynchos</i> Linnaeus, 1758	Mallard
<i>Anas clypeata</i> Linnaeus, 1758	Northern Shoveler
<i>Anas penelope</i> Linnaeus, 1758	Eurasian Wigeon
<i>Anas crecca</i> Linnaeus, 1758	Common Teal
<i>Mergus serrator</i> Linnaeus, 1758	Red-breasted Merganser
<i>Falco peregrinus</i> Tunstall, 1771	Peregrine Falcon
<i>Gallinula chloropus</i> (Linnaeus, 1758)	Common Moorhen
<i>Fulica atra</i> Linnaeus, 1758	Eurasian Coot
<i>Haematopus ostralegus</i> Linnaeus, 1758	Oystercatcher
<i>Vanellus vanellus</i> (Linnaeus, 1758)	Northern Lapwing
<i>Calidris alpina</i> (Linnaeus, 1758)	Dunlin
<i>Tringa totanus</i> (Linnaeus, 1758)	Common Redshank
<i>Limosa lapponica</i> (Linnaeus, 1758)	Black-tailed Godwit
<i>Numenius arquata</i> (Linnaeus, 1758)	Eurasian Curlew
<i>Larus ridibundus</i> (Linnaeus, 1766)	Black-headed Gull
<i>Larus argentatus</i> Pontoppidan, 1763	European Herring Gull
<i>Pica pica</i> (Linnaeus, 1758)	Common Magpie
<i>Corvus corone corone</i> Linnaeus, 1758	Carrion Crow
<i>Sturnus vulgaris</i> Linnaeus, 1758	Common Starling
Mammalia	
<i>Oryctolagus cuniculus</i> Linnaeus, 1758	Rabbit

Chordates of Langstone Harbour and Farlington Marsh – 29th March 2015

The Influence of Acute Hyposaline Exposure on the Biofouling Assemblages of Millbay Marina (Plymouth)

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Abstract

Globalisation and the recent expansion of international shipping has resulted in the problem of biofouling carrying greater industrial and ecological penalties than ever before. With environmental implications associated with traditional antifouling practises and legislation banning their use, demand for the development of non-toxic techniques is high. In this study, the influence of acute hyposaline stress on the survivability of macrofouling assemblages is investigated with reference to antifouling applications. The different tolerances of native and non-native biota to hyposaline exposure are also assessed. Three replicate groups of 15 PVC (12 x 12 cm), colonised in Millbay Marina Plymouth (UK) and then exposed to salinities of 35, 24, and 12 ‰ for 3 days. Analysis of count and percentage cover data testing revealed that exposure to 12 ‰ induced a significant reduction in the percentage cover of all fouling species. 24 ‰ exposure had an intermediate effect and 35 ‰ exposure had no effect. The species composition of assemblages was found to change significantly, with native species exhibiting a greater adverse response than non-native species. A 15-day recovery period allowed the growth of spreading and robust species on panels exposed to 24 and 12 ‰. It is concluded that low salinity exposure has potential application as an antifouling technique when used in conjunction with existing coatings to mitigate fouling of niche

hull regions, particularly among ascidian dominated assemblages.

Introduction

Background

Biofouling is the growth of marine life upon submerged substrata. This affects both industry and the environment in a multitude of ways. Bio-erosion, hydrodynamic impediment, and the bio-degradation of components are major penalties biofouling presents to maritime industry (Braithwaite & McEvoy 2004; Shultz *et al.* 2007; Schultz *et al.* 2011). In addition, elevated fuel consumption incurred by the drag of a fouled hull extends the issue to a global scale through increased greenhouse gas emissions and atmospheric pollution (Corbett & Köhler 2003; Eyring *et al.* 2005; Shultz *et al.* 2007).

Shipping is widely recognised as a vector for the dispersal and introduction of biofouling organisms throughout the globe (Minchin & Gollasch 2003). Transport of a species out of its native range can, when conditions are favourable, facilitate the introduction of non-native species to coastal systems (Carlton 1989; Gollasch 2002). A 'non-native' species is defined as being one that is able to survive and reproduce outside of its natural historical range (Falk-Peterson *et al.* 2006). Once introduced, non-natives have the propensity to spread, outcompeting native counterparts and becoming ecologically disrupting. In these circumstances, species are defined as 'invasive' (Kolar & Lodge 2001). Historically, the attachment and transportation via slow moving wooden sailing vessels has played a significant and largely undocumented part in transfer of non-native species to coastal systems (Carlton & Hodder 1995). Today, the omnipresence of maritime traffic acts as a driver for the spread of organisms, contributing to the homogenisation of the World's oceans via the breakdown of ecosystem barriers (Peters 2001; Godwin 2003; Ashton *et al.* 2006; Davidson *et al.* 2009). This often results in the disruption of marine community dynamics, food web structure, and ecosystem services due to an increased tolerance to prevailing environmental stressors (Chapin *et al.* 2000; Galil *et al.* 2009; Molnar *et al.* 2008).

Antifouling Technologies

Issues associated with biofouling have created significant demand for the production of antifouling technologies, and in particular antifouling coatings. 'Traditional' antifoulants containing toxic organotin biocides are ecologically damaging to the marine environment (Laughlin *et al.* 1983; Salazar *et al.* 1987). The widespread use of Tributyltin (TBT) has been shown to cause a range of detrimental ecotoxicological effects linked to its endocrine disrupting properties. These include: imposex in the marine gastropod *Nucella lapillus* (Oehlmann *et al.* 1991), the deformation of oyster valves (Alzieu 2000), and risk to human health via bio-accumulative processes (Antizar-Ladislao 2008). Consequently, the development of non-toxic antifoulants is at the forefront of research in the industry (Yebra *et al.* 2004). Recent guidelines devised by the International Maritime Organisation (IMO), banning the use of TBT based coatings worldwide has pushed the focus further towards the adoption of non-toxic alternatives (IMO 2001; Champ 2003; Chambers *et al.* 2006).

Of emerging interest both within the literature and the antifouling industry is the occurrence of biofouling within niche ship areas such as sea chests, (recessed in-hull regions serving as seawater intakes for engine cooling and ship services). The sheltered nature of these areas fosters the survivability of a greater diversity of biota compared to that recruited on the hull surface (Minchin & Gollasch 2003). In addition, the low water flow within them results in insufficient shear stress for many antifouling coatings to be effective, making them high risk for non-native species transfer (Frey *et al.* 2014). Alternative non-toxic and shear independent techniques have the potential to control fouling in niche regions. Therefore, the potential application of hyposaline stress as a biofouling control method, and the reduction in survivability of assemblage members, is the primary focus of this study.

Assemblage Characterisation and Physiology

The macrofouling assemblages characteristic of Millbay Marina (Plymouth), during the summer months are dominated by the tunicate *Ciona*

intestinalis (Linnaeus, 1767), coinciding with lesser abundant tunicates *Ascidella aspersa* (Müller, 1776), and *Clavelina lepadiformis* (Müller, 1776). Assemblages typically reside upon an encrusting bryozoan basal surface composed of *Membranipora membranacea* (Linnaeus, 1767) and *Watersipora subtorquata* (d'Orbigny, 1852). Interwoven appearances of erect bryozoans (*Bugulina* spp. and *Tricellaria inopinata* d'Hondt & Occhipinti Ambrogi, 1985), barnacles (*Balanus crenatus* Bruguière, 1789) and localised spreading of colonial ascidians such as *Diplosoma listerianum* (Milne Edwards, 1841) complete the generalised assemblage.

Low salinity exposure, particularly over a sharp gradient is likely to adversely affect macrofouling organisms to differing extents via direct or indirect osmotic damage caused by cellular lysis and enzymatic destruction respectively (Dybern 1967; Davenport 1984; Vázquez & Young 2000). Such osmotic damage is documented to be the cause of the mass mortality of such sessile marine invertebrates around the globe, and considered a natural controller of survivability (Beaven 1947; Goodbody 1961).

Tunicates and their allies are considered to express sensitivity to salinity reduction due to their sessile and osmoconforming life history strategy, responding to hyposaline shock by valve closure or burrowing responses to prevent short term osmotic damage (Davenport 1984; Reinhardt & Hudson 2012). As a group the Bryozoa are considered better able to withstand brackish and euryhaline conditions (Winston 1977). However, reduced salinity is linked to a decrease in their diversity (Ryland 1970).

The ability of certain assemblage members to exhibit a greater tolerance to low salinity exposure and environmental stress may be correlated to their non-native phenotype; expressing increased osmoregulatory capacities compared to their native counterparts due to inherent ecological resilience and plasticity (Oglesby 1981; Pierce 1982; Lenz *et al.* 2011; Zerebecki & Sorte 2011). The interaction between native and non-native macrofouling species in response to hyposaline stress is

largely unknown and supplementary focus of this study. It is hypothesised that non-native species will have an increased tolerance to acute salinity stress when compared to native species.

This study aims to provide an indication of the effectiveness and potential application of a simple, non-toxic, and cost-effective solution to the issue of biofouling whilst also assessing the relative tolerances of non-native and native biota. The hypotheses that acute low hyposaline exposure will significantly influence the percentage cover of fouling organisms, will reveal a higher tolerance among non-native compared to native species, and will induce a difference in assemblage composition during recovery are tested.

Materials and Methods

Site overview

The experiment was conducted from August to September, 2014 in Millbay Marina, Plymouth (050° 21' 48.36" N, 004° 09' 08.47" W) (Figure 1). Millbay is a semi enclosed, tidal marina situated in Plymouth Sound. This location was selected primarily due to an extensive maritime history, which has resulted in the presence of a diverse range of native and non-native fouling species. A site with good connectivity to Plymouth Sound was selected, thus reducing the environmental variability associated with the marina environment (Rivero *et al.* 2013).

Panel Deployment

50 PVC panels (12 x 12 cm) were used as the settlement surface and systematically roughened for 10 seconds using FEPA P60



Fig. 1: Map indicating the location of Millbay Marina and proximity to surrounding freshwater point sources via the Plym and Tamar Estuaries. (Google Earth 2015).

sandpaper, creating a standardised surface texture to which assemblages could suitably colonise (Crisp & Ryland 1960; Thomason *et al.* 2002). Panels were fixed to a 50 x 50 cm settlement array in groups of 9. All panels were deployed in a horizontal orientation, allowing the standardisation of recruitment pressure (Connell 1999). Settlement arrays were deployed at a depth of 2 metres for a period of 6 weeks. Weekly monitoring of salinity and temperature values at the deployment site was conducted using a YSI 556 Multiparameter meter. Prior to panel recovery, the most recent and representative water temperature (17°C) and salinity conditions (35 ‰) recorded in the marina at a depth of 2 metres were replicated within a 110 x 60 x 30 cm tank in a temperature controlled laboratory.

Pre-Exposure Analysis

Panels were recovered from the marina and transported to the laboratory within plastic boxes (71 x 36 x 46 cm) for a transit time of 30 minutes. Each panel was dipped in seawater (35 ‰, 17°C) to remove excess sedimentation, and suspended horizontally fouled side down within the 110 x 60 x 30 cm tank. Throughout a period of 3.5 days the percentage cover of species contributing to assemblages of each panel was determined. To score for percentage cover, panels were transferred to a 12 x 12 cm Perspex gridded scoring platform within a glass dish containing tank water, (monitored and kept within a range of $\pm 2^{\circ}\text{C}$), and placed under a light microscope (SDZ - P Kywo Optical). A mounted needle was dropped vertically from the surface to base of the assemblage on the bottom right hand corner of each 1 cm² grid square leaving a 1 cm perimeter not sampled to eliminate edge effects. On each occasion an individual was encountered it was identified to species level (Hayward & Ryland 1995; Ryland *et al.* 2011; Anna Yunnies pers. comm.), and counted. For colonial species such as *D. listerianum*, counts represented each occasion the colony was encountered as opposed to number of individuals hit. This provided a pre-exposure analysis of species abundance. Throughout the scoring period, assemblages were fed with 6 ml of Instant Algae Shellfish diet 1800TM temperature and salinity values were recorded, controlled, and monitored

once daily. Nitrate concentrations were also monitored daily using a TetraTest™ liquid indicator kit. Tank aeration was achieved using 4 Interpet™ aeration stones (14 x 25 cm) supplied with 2 TetraTec™ APS air pumps and plastic sheeting covered the tank to minimise evaporation.

Hyposaline Exposure and Analytical Procedure

One day prior to exposure, water salinity values of 35, 24, and 12 ‰ were prepared in 3 plastic barrels (120 x 70 x 70 cm) using seawater sourced from the Plymouth Marine Laboratories offshore monitoring site L4 (50.25°N, 4.22°W), passed through a two stage 0.5 and 0.2 µm filter (approx. 36 ‰, 8°C). Deionised water was added and thoroughly mixed until the respective salinity values were reached. Once the ambient temperature of 17°C (laboratory controlled) was achieved ($\pm 1.10^\circ\text{C}$), the water from each barrel was transferred into 3, 32 L plastic tanks (59.5 x 39.5 x 18.0 cm). This resulted in 3 repeat tanks of 35, 24, and 12 ‰ (9 in total). 45 panels were randomly distributed among the tanks with 5 suspended horizontally fouled-side down in each. Tanks were distributed randomly at the same height throughout the laboratory. 5 panels were returned to the marina to be used as procedural controls, testing for any affects associated with the transport process. Panels were exposed to respective salinities for a period of 3 days.

Assemblages were fed once daily with 2 ml of Instant Algae Shellfish diet 1800™ per tank. Salinity and temperature values were recorded monitored and controlled within ± 0.3 ‰ and 0.9°C respectively. The occurrence of false results due to decay of organic matter following death induced by low salinity exposure could potentially lead to the biased die-off of individuals. This was minimised by keeping panels in the same tanks and implementation of frequent (once daily) quarter water changes.

Following exposure, salinity was returned to 35 ‰ within all tanks and panels were re-scored for percentage cover, adopting the same procedure as previously described. This provided a quantification of abundance post-exposure. Mortality was assessed under the

microscope or by no observable response for 3 seconds after agitation. If mortality was suspected the individual was not counted.

Post-Exposure Recovery and Analysis

All panels were transported back to the marina and deployed in the same horizontal orientation (fixed in groups of 9 to 50 x 50 cm settlement arrays) for a recovery period of 15 days in accordance to the work of Sugden *et al.* (2007). Following this, panels (including procedural controls), were transferred back to the laboratory and randomly allocated in groups of 5 within the 9 59.5 x 39.5 x 18.0 cm tanks at 35 ‰ (± 0.2 ‰) and 17°C ($\pm 1.1^\circ\text{C}$), (representative of *in situ* conditions of the marina) and analysed providing a post-recovery score for percentage cover. Temperature, salinity, and nitrate conditions were recorded, monitored and controlled.

Throughout the entire experimental period, weekly *in situ* salinity and temperature conditions were monitored and recorded. This enabled the validity results during the recovery period and redeployment of procedural controls to be verified.

A site specific quantification of the natural salinity fluctuations experienced within Millbay Marina and their relationship with heavy rainfall events was compiled for the month of October. *In situ* salinity data was continuously logged at the panel deployment site for a period of 12 days using a YSI 556 Multiparameter meter deployed at a depth of 2 metres. This was then correlated with rainfall data obtained from Plymouth Live Weather Station, 2014 (50.3654° N, 4.1423° W) using a Davis Vantage Pro2+ weather instrumentation.

Data Analysis

The data collected were analysed using PRIMER ver. 6.1 Software (Primer-E, Ivybridge) with PERMANOVA add in (Anderson *et al.* 2008). Prior to all statistical testing, abundance data were 4th root transformed (down-weighting the influence of highly abundant species), and tests were performed on Bray-Curtis similarity matrices (Clarke & Warwick 2001).

Permutational multivariate ANOVA (PERMANOVA) was utilised to assess the effect

	35 ‰		24 ‰		12 ‰	
Time Points	T-value	P-value	T-value	P-value	T-value	P-value
Before - After Exposure	0.496	0.915	1.900	0.003	5.673	<0.001
Before - After Recovery	1.275	0.170	2.629	<0.001	7.595	<0.001
After Exposure - After Recovery	1.189	0.239	2.524	<0.001	5.045	<0.001

Table 1: Pair-wise PERMANOVA comparing the difference in the percentage cover of panels before-after exposure, before-after recovery and after exposure-after recovery across salinity treatments.

of low salinity exposure on percentage cover and assemblage composition of fouling species over time and between salinity exposures. PERMANOVA was also used to measure the differential responses of non-native and native species to low salinity exposure and differences in panels prior to experimentation. This allowed inherent differences in panel composition to be taken into account in the final analysis. Time (before exposure, after exposure, and after recovery) and salinity (35 ‰, 24 ‰, and 12 ‰) were allocated as fixed factors. Type III sums of squares (SS) and 9999 permutations were used in the PERMANOVA models.

Multidimensional scaling ordination (MDS) plots, (based on Bray-Curtis similarities), were used to compare the differences between macrofouling assemblages on settlement panels exposed to the three salinity treatments and compositional changes following exposure recovery period (Figure 2). Higher resolution of this was achieved using Similarity Percentage Analysis (SIMPER), determining which species contributed most to the differences and similarities observed within each salinity exposure over time.

Photographs of one panel from each salinity

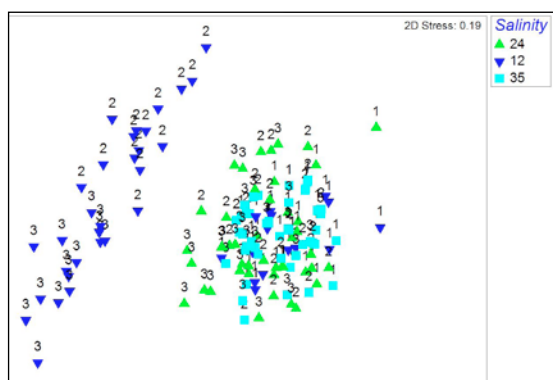


Fig. 2: Multidimensional scaling ordination (MDS) plot showing the differences between panels exposed to 12, 24 and 35 ‰ before exposure (1), after exposure (2), and after recovery (3).

treatment and time point were taken and arranged to provide a side by side visual comparison of change in percentage cover and assemblage composition as a result of each salinity exposure (Figure 3).

Results

Acute hyposaline exposure was found to induce a highly significant difference in percentage cover between panels throughout the course of the experiment. Exposure to 35 ‰ had no statistically significant effect on the percentage cover of fouling organisms, with 12 and 24 ‰ exhibiting greatest and intermediate responses respectively (Table 1; Figure 3). A multidimensional scaling plot (Figure 2) shows that panels exposed to 12 ‰ are most different from those exposed to 35 ‰, with 24 ‰ treatments exhibiting an intermediate difference in percentage cover.

No significant difference in the percentage cover of fouling organisms was detected among panels prior to experimentation ($p = 0.134$).

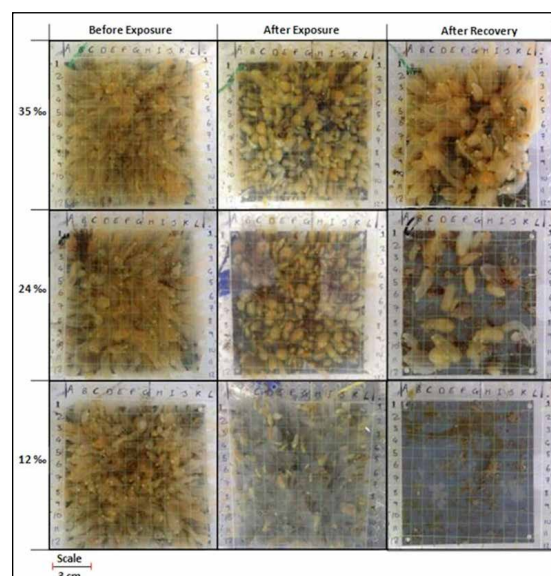


Fig. 3: Photographic comparison tracking one panel per exposure (12, 24 and 35 ‰) throughout the course of the experiment.

DF	Pseudo - F statistic	P-value
3	1.370	0.134

Table 2: Overall PERMANOVA analysis comparing the difference in the percentage panels before exposures.

However, pair-wise PERMANOVA analysis revealed a significant difference in percentage cover between panels undergoing 24 and 12 ‰ exposure before the experiment began (Table 3; $p = 0.007$). Pair-wise PERMANOVA analysis revealed no significant difference in percentage cover of fouling organisms between procedural controls and panels prior to exposure (Table 3).

Community composition changed significantly in response to low salinity exposure over time (Figure 4). Non-native species were statistically more tolerant than native species to hyposaline stress (Table 4, Figure 5). However, the native species *D. listerianum* and *M. membranacea* exhibited a significant increase in abundance following the recovery period, accounting for over 12% of the dissimilarity across all panels post exposure to post recovery (Figure 6). *Ciona intestinalis* was the most abundant organism across all panels prior to experimentation (Figures 3 & 4) and showed the greatest sensitivity when exposed to 12 ‰ but resilience when exposed to 24 ‰ (Figures 4 & 5). *Ascidella aspersa* and *C. lepadiformis* expressed a high sensitivity to 24 ‰ exposure (Figure 4).

A high proportion of the dissimilarity among panels was accounted for by *C. intestinalis*, *C. lepadiformis* and *A. aspersa* when compared before and after exposure. Although severely affected by exposure to 12 ‰, *C. intestinalis* was found to exhibit a partial tolerance to 24 ‰ exposure expressing an intermediate response (Fig. 7).

For the majority of species (*A. aspersa*, *C. lepadiformis*, *D. listerianum*, *W. subtorquata*, *Molgula* spp., *Ascidella scabra* (Müller, 1776), *Bugula neritina* (Linnaeus 1758), *T. inopinata*, *Botrylloides* spp.), the biggest difference was observed due to a decrease in percentage cover between 35 -24 ‰ exposure (Fig. 7). *Bugulina fulva* (Ryland 1960), *Balanus crenatus* and the invasive species *Bugulina stolonifera* (Ryland,

Designated Exposures	T-value	P-value
24, 12	1.611	0.006
24, 35	0.661	0.869
24, procedural controls	1.424	0.059
12, 35	0.938	0.547
12, procedural controls	1.188	0.203
35, procedural controls	0.961	0.482

Table 3: Pair-wise PERMANOVA analysis comparing the difference in the percentage cover among panels prior to experimentation.

1960) exhibited the greatest difference in percentage cover between 24 and 12 ‰ exposures (Figure 7).

Bugula neritina was also found to be negatively affected by low salinity exposure but exhibited an ability to recover quickly after disturbance, regaining near original abundance after the 15 day recovery period (Figure 7). *Bugulina stolonifera*, *T. inopinata* and *B. neritina* showed resilience to low salinity treatment with less than 50% decrease in abundance after exposure. *Bugulina fulva* appeared to be most negatively affected post exposure during the recovery period (Fig. 5).

Membranipora membranacea, *D. listerianum* and *B. crenatus* were found to increase in abundance dramatically after the recovery period following exposure to 12 ‰, accounting for the majority of difference in panels after treatment and after exposure (Figure 6). *Diplosoma listerianum* was adversely affected by low salinity exposure but spread rapidly during the recovery period. No effect of low salinity exposure was observed among *B. crenatus* (Figure 6).

Discussion

Acute hyposaline stress was found to significantly decrease the percentage cover of fouling species studied. Intermediate and most extreme responses were exhibited by 24 and 12 ‰ exposures respectively (Table 1, Figures 3, 4 & 5). The statistically significant difference in percentage cover between 24 and 12 ‰ panels prior to exposure (Table 3) is likely to have been carried forward, accounting for the large difference between these groups following experimentation. Therefore, caution must be applied when interpreting the potency of the salinity

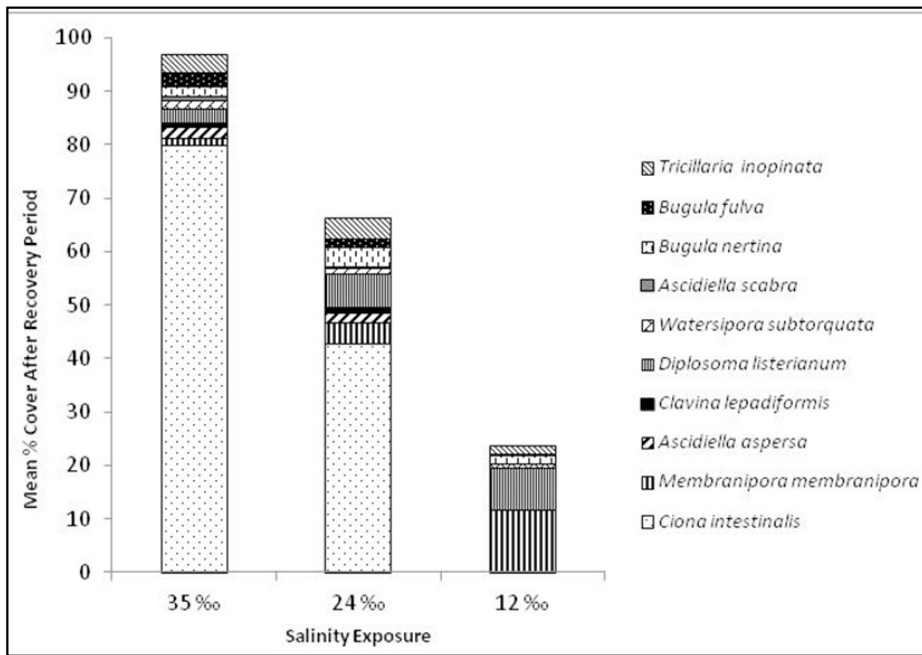


Figure 4: Mean percentage cover of species exhibiting the highest 15 dissimilarity values before experimentation and after the recovery period (based on SIMPER analysis).

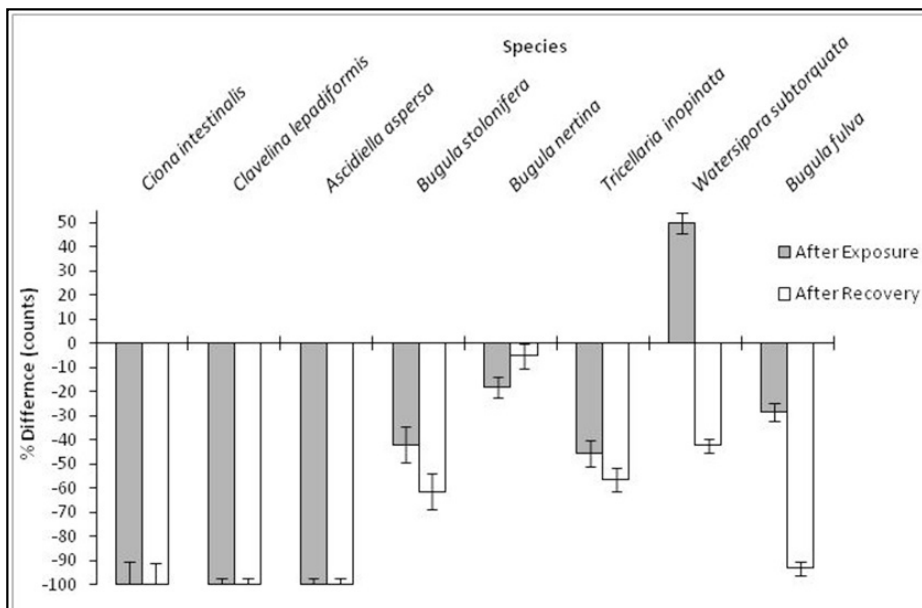


Figure 5: The percentage change in counts of individuals following exposure to 12 ‰ and after the recovery period (error bars from standard deviation).

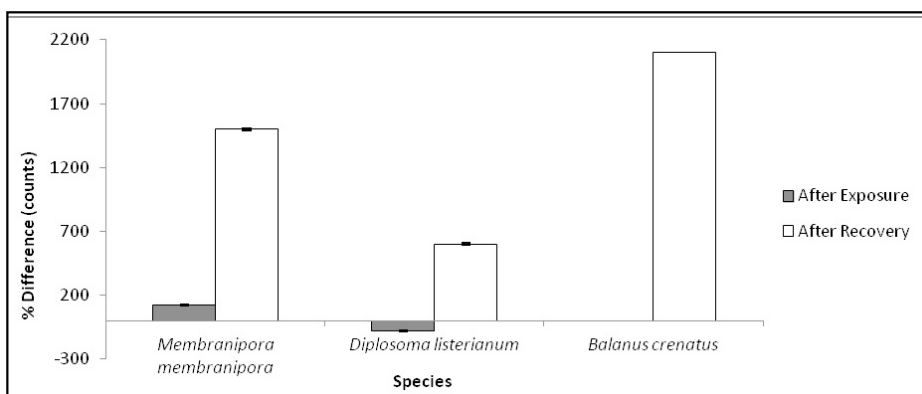


Figure 6: The percentage change in counts of individuals that increased dramatically after the recovery period following exposure to 12 ‰ (error bars are derived from standard deviation).

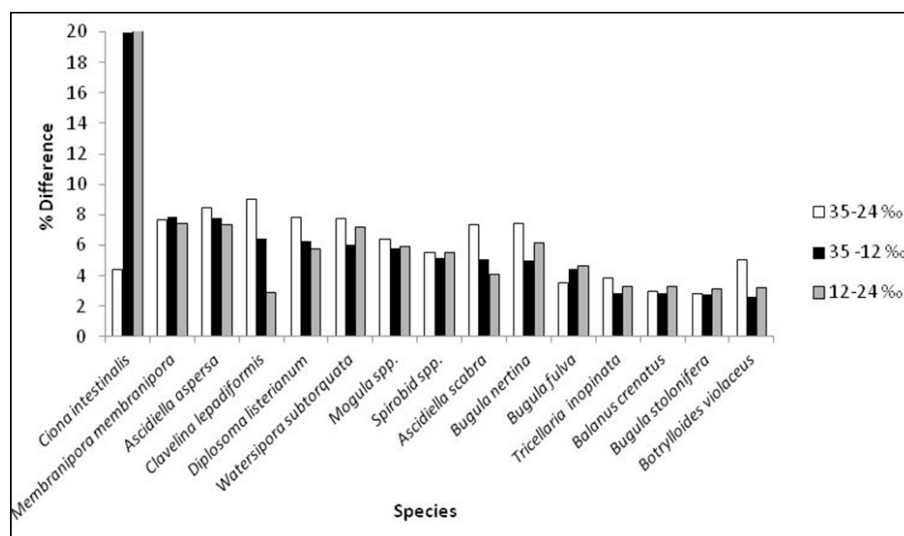


Fig. 7: The pair-wise comparison of the dissimilarity of species between the exposures of 35-24, 35-12, and 12-24 ‰.

treatments tested. This initial difference may have been induced by any number of factors including: different orientations of panels, localised attack from fish, or inter-assemblage competition. Despite this, differences were isolated to the two groups with no significant difference in overall percentage cover detected prior to experimentation (Table 2). As the conditions in the laboratory were sufficiently controlled, the observed difference in percentage cover following exposure can be attributed to low salinity exposure. Therefore, the osmoregulatory capacity of the majority of individuals contributing to the fouling assemblage was not sufficient to promote survivability during exposure to an acute decrease in salinity, (as inferred by Davenport 1984).

A significant change in species composition was shown across salinity treatments (Figure 4) due to the different tolerances of fouling species in response to low salinity exposure. The high sensitivity of the ascidians *C. lepadiformis*, *A. aspersa*, and *C. intestinalis* is supported by the work of Lambert (2005) where the optimal metabolic performance is suggested to be above 25 ‰. *Clavelina lepadiformis* has been documented to tolerate salinities of 14 ‰ (Reinhardt & Hudson 2012) and *C. intestinalis* as low as 9 ‰ (Dybern 1967), however it is suggested here that such plasticity does not extend to acute salinity decreases. This is supported by Shumway (1978), who showed that the oxygen consumption and heart rate of *C. intestinalis*

are significantly negatively affected by acute decrease in salinity. Removal of *C. intestinalis* is likely to greatly influence the heterospecific interactions and ecological functioning displayed by the assemblage. Mortality of this species was shown to facilitate the community shift to the dominance of spreading and more resilient species such as *D. listerianum* and *M. membranacea*. In addition, the high filtration rate exhibited by *C. intestinalis* infers that removal from natural systems may induce benthic-pelagic coupling alterations via the decreased transfer of planktonic material to the benthos (Riisgård *et al.* 1996). This may lead to regime shifts in higher trophic levels with consequent alterations in ecosystem function and fisheries dynamics.

Non-native species were found to be less negatively affected by low salinity exposure compared to native species. However, most non-native biota encountered are of bryozoan origin and little comparative evidence can be obtained for ascidian assemblage members. It is suggested that the increased tolerance of non-native species (particularly *B. stolonifera* and *T. inopinata*) over native species such as *B. fulva* is a reflection of their ecological resilience. Since the introduction of *T. inopinata* from the Pacific to Venice (Italy) in 1982 (D'Hondt & Ambrogi 1985) this species is widely considered as an out-competitor of erect bryozoans such as *Bugulina stolonifera* (Occhipinti & Ambrogi 1991). The ecological dominance of *T. inopinata* may be accelerated in regions of lowered salinity due to regional

climatic change.

Interestingly, the non-native species *B. neritina* and *W. subtorquata* for which temperature is considered to be the predominant driver for their introduction to the North Atlantic within the 20th century (Ryland *et al.* 2009; Ryland *et al.* 2011), expressed sensitivity to intermediate low salinity exposure of 35-24 ‰ (Figure 7). The observed sensitivity to acute low salinity exposure expressed by *W. subtorquata* may have particular pertinence within the antifouling industry. The high resistance of this species to many biocides result in it being particularly problematic, with extensive crusts creating non-toxic refugia. This then facilitates the attachment of additional (often non-native) macrofoulers, thus hindering the effectiveness of many antifouling coatings (Ryland 1967; Floerl *et al.* 2004). Hyposaline treatments applied in conjunction with existing antifouling coatings may offer a complementary control in the proliferation of *W. subtorquata* and the attachment of additional fouling species adhered to its surface. The sensitivity of *B. neritina* to low salinity exposure may prove useful in predicting the potential habitable range of this non-native species throughout UK shores (Ryland 2011).

The reduction in the percentage cover of fouling organisms across treatments was maintained after the recovery period (Figure 4). However, this was not the case for all species. The proliferation of *M. membranipora*, *D. listerianum*, and *B. crenatus* post recovery illustrates their ability to rapidly extend into available space following a disturbance event when competition is suppressed. The increased counts observed following exposure particularly among *W. subtorquata* (Figure 5) and *M. membranipora* (Figure 6) and are to be interpreted with caution as encrusting organisms such as these may have been miscounted during the initial scoring process due to obscurement by larger members of the assemblage. The increase in abundance of *M. membranipora* within the marine environment as a consequence of climatically induced salinity disturbance may facilitate the establishment of non-native species particularly among kelp dominated habitats

(Levin *et al.* 2002).

It is reported here that acute hyposaline stress significantly affects the survivability and recoverability of macrofouling organisms found at Millbay, showing a negative impact on overall species diversity and abundance. The particular sensitivity expressed by ascidian species suggests potential for hyposalinity to act as an effective non-toxic antifouling treatment when the biomass of these organisms is high. Tolerances exhibited by non-native species highlight the requirement for additional, complementary techniques to mitigate their survivability and transportation. With the continuing development of natural antifoulants and improved harbour design (Floerl & Inglis 2003; Qian *et al.* 2015), a combination of low salinity treatments may offer an additional environmentally friendly solution to biofouling control. However, further testing is required to determine an effective salinity range and time period of exposure to assess feasibility in a commercial context.

In addition to the mitigation of ship fouling, applications may arise in the aquaculture industry where problem species are more susceptible to low salinity than commercially targeted species. For example, *C. intestinalis* is invasive to West Atlantic shores and has presented many problems to the cultivation of the blue mussel (*Mytilus edulis* Linnaeus, 1758) due to its rapid growth rate (Howes *et al.* 2007, Ramsey *et al.* 2009). As *M. edulis* exhibits a much higher tolerance to low salinity exposure than *C. intestinalis*, hyposaline stress could aid in controlling its proliferation.

It may be argued that owing to the extensive scale of shipping traffic across the globe that the introduction of new invasive species will eventually stabilise with the marine environment becoming optimally homogenised. This however is not likely to be the case. Changing environmental conditions such as lowered salinity create favourable conditions for introduced species to colonise. Whilst strain on the marine environment has never been as great as it is today, neither has our understanding of life contained within it. Adoption of processes,

controlling the survivability of biota far back throughout evolutionary time, is the best option of sustaining an environment we are all a stakeholder of.

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Recent observations of the non-indigenous species *Caprella mutica* Schurin, 1935 (Crustacea, Amphipoda) in Langstone Harbour confirms a new eastward limit in the English Channel

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Key words: Invasive species, range expansion, *Caprella mutica*, Japanese Skeleton shrimp, Langstone Harbour.

Introduction

Little is known of the ecology of native and invasive species of caprellids (Crustacea, Amphipoda) in the Solent European Marine Site (Figure 1). Langstone Harbour is one of 3 tidal basins, situated between Chichester and Portsmouth Harbours, in this internationally important marine site. Langstone Harbour has

a 90% mean tidal water exchange, exposing large areas of extensive mudflats at low water. The University of Portsmouth inshore testing platform is permanently moored in the centre of Langstone Channel (approx. 50°48'22.57"N, 1°1'20.38"W) and provides an island of continuously submerged artificial substrate. The platform is therefore ideally situated for native and non-native biofouling species, and is likely to be representative of the biofouling community of the wider harbour. The presence of *Caprella mutica* in Langstone Harbour is confirmed by identification based on morphological characters. This is also the first overview of the native caprellid species diversity in Langstone harbour.

Background

The genus *Caprella* belongs to Caprellidea, one of four suborders of Amphipoda. Caprellids possess a highly distinctive morphology among the Amphipoda (Figure 2). They lack a carapace and generally possess laterally flattened bodies with a highly reduced/absent abdomen. Caprellids exhibit low substrate specificity and can be found attached to a

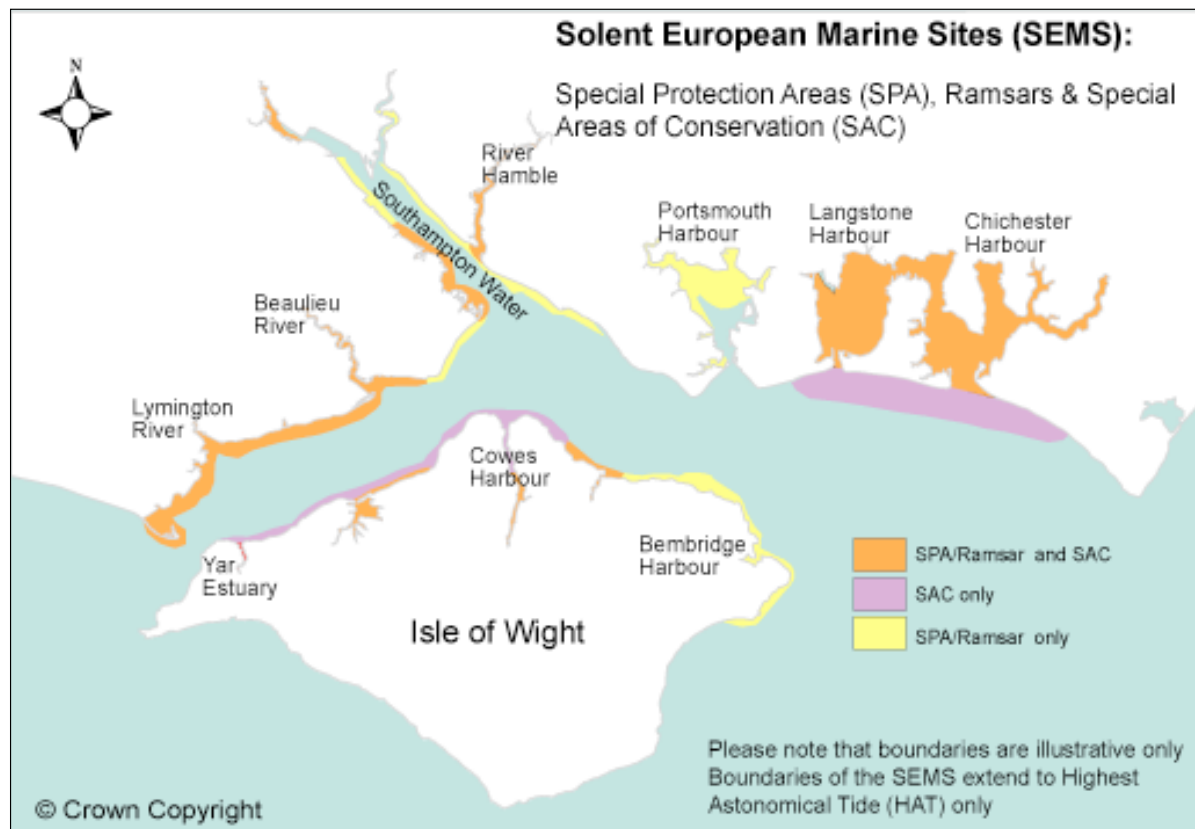


Fig. 1. Solent European Marine Sites boundaries and designations. © Crown.

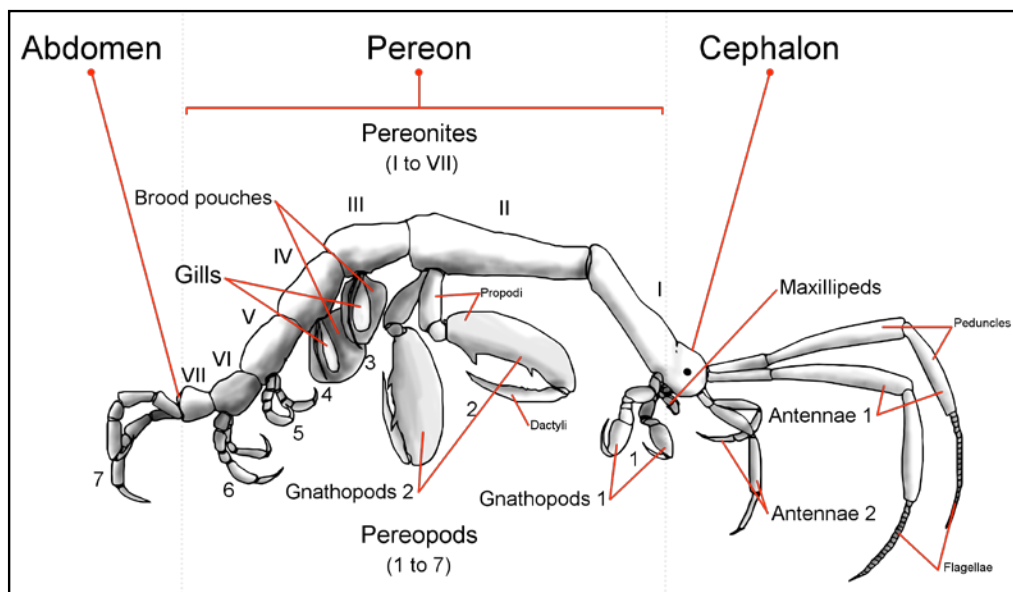


Figure 2: Lateral view of generalised caprellid (*Pseudoprotella phasma*) Guerra-Garcia *et al* (2012). [http://commons.wikimedia.org/wiki/File%3AGeneralized_caprellid_\(skeleton_shrimp\)_body_plan_anatomy.png](http://commons.wikimedia.org/wiki/File%3AGeneralized_caprellid_(skeleton_shrimp)_body_plan_anatomy.png)

variety of branching or filamentous substrata, including algae, hydrozoans and bryozoans (Guera Garcia 2012). This lifestyle is reflected in the adaptation of the last three pereopods for clinging to the substrates on which they settle. The appendages used for swimming in other amphipods are greatly reduced in caprellids, and consequently they are inefficient swimmers (Lolas & Vafidis 2013).

Many species exhibit intraspecific variation in body pigmentation and it is well noted that caprellids are often a similar colour to their host substrate (Harrison 1944), as observed in this study (Figure 3). Whether this is due to substrate selection during settlement,



Figure 3. Dense aggregations of red-brown *Caprella penantis* attached to *Sargassum muticum*. Collected from Langstone Harbour on 16/10/14.

selection pressure, or an ability to adapt pigment expression is not clear. However, combined with their slender body structure, this confers excellent camouflage to avoid predation (Manton 1977).

Caprellid populations are an important trophic component of coastal ecosystems and can reach extremely high densities of 200,000 individuals m^{-2} (Boos *et al.* 2011). This biomass is significant to the local and regional ecosystems, providing important prey items in shallow water habitats. Some species of fish have been found to rely on seasonal changes in caprellid abundance to provide food through the breeding time (Caine 1991a). Several animals rely on caprellids as a food source throughout the year, as a small (Wakabara *et al.* 1982; Russell 1983) or main component of overall diet (Woods 2002, Woods 2009). As detritus provides the majority of the caprellid diet, they provide a trophic link between primary producers and higher predators (Ohji *et al.* 2002).

Caprellids also reach high densities in the biofouling community (Edwards *et al.* 2014) occurring on artificial substrates such as ship hulls, aquaculture netting, pontoons, submerged buoys and other man-made substrates (Ros *et al.* 2013). Caprellids can spend their entire life-cycle within bio-fouling communities as the young are produced by

Family	Genus	Species
Caprellidae Leach, 1814	<i>Aeginina</i> Norman, 1905	<i>Aeginina longicornis</i> (Kroyer, 1843)
	<i>Caprella</i> Lamarck, 1801	<i>Caprella acanthifera</i> Leach, 1814
		<i>Caprella andreae</i> Mayer, 1890
		<i>Caprella equilibra</i> say, 1918
		<i>Caprella erethizon</i> Mayer, 1801
		<i>Caprella fretensis</i> Stebbing, 1878
		<i>Caprella linearis</i> (Linnaeus, 1767)
		<i>Caprella mutica</i> Schurin, 1935
		<i>Caprella penantis</i> Leach, 1814
		<i>Caprella septentrionalis</i> Kröyer, 1838
		<i>Caprella tuberculata</i> Bate & Westwood, 1866.
	<i>Pariambus</i> Stebbing, 1888	<i>Pariambus typicus</i> (Kröyer, 1845) Synonym
	<i>Parvipalpus</i> Mayer, 1890	<i>Parvipalpus capillaceus</i> (Chevreux, 1888)
	<i>Pseudoprotella</i> Mayer, 1890	<i>Pseudoprotella phasma</i> (Montagu, 1804)
Phtisicidae Vassilenko, 1968	<i>Phitistica</i> Slabber, 1769	<i>Phitistica marina</i> Slabber, 1769

Table 1: Caprellid species identified from British coastal waters (families Caprellidae and Phtisicidae) excluding the 9 parasitic species belonging to Cyamidae Rafinesdque, 1815 (Guerra-Garcia, 2014).

direct development. They are frequently transported within biofouling communities attached to floating objects such as ships hulls and oceanic debris (Ramalhosa & Canning-Clode 2015) and relocated over long distances (Lolas & Vafidis 2013). This is thought to play a large part in the cosmopolitan distribution of caprellids and the rapid spread of non-indigenous caprellid species (NIS) (Ros *et*

al. 2013). Typically, NIS caprellid species are associated with fouling communities outside of their native habitats (Turcotte & Sainte-Marie 2009).

Currently, there are 15 recognised species of caprellids identified from British waters; fourteen of which belong to the family Caprellidae, including the non-native species *C. mutica*, Table 1.

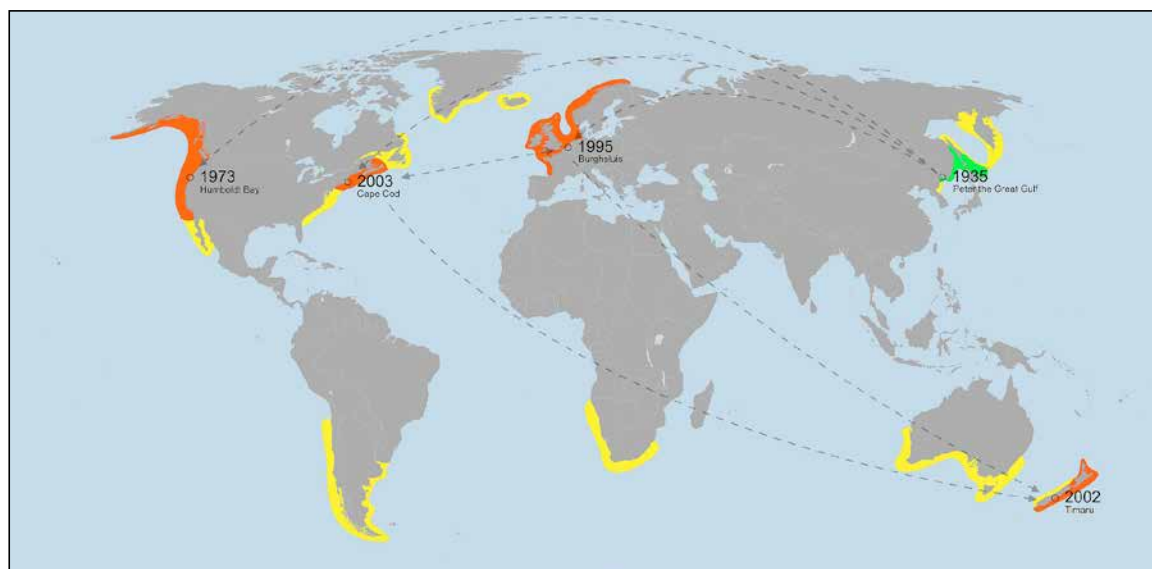


Fig. 4: Global distribution of *Caprella mutica*: ■ Native distribution, ■ Potential ecological range, ■ Introduced population location and date of first records in each area are also shown, along with likely introduction pathways indicated by arrows. Data from: (Ashton 2006). [http://commons.wikimedia.org/wiki/File%3ACaprella mutica map of introduction pathways and global invasive distribution.jpg](http://commons.wikimedia.org/wiki/File%3ACaprella_mutica_map_of_introduction_pathways_and_global_invasive_distribution.jpg).

The Japanese Skeleton Shrimp *Caprella mutica* Schurin, 1935.

The Japanese Skeleton Shrimp *Caprella mutica* is native to sub-boreal northeast Asia in the shallow coastal waters of the Sea of Japan. The rapid, circum-global range expansion of this species over the last 40 years is a consequence of its ability to cling to rafting and/or artificial substrates over long distances (Ashton *et al.* 2008, Frey 2009, Inglis *et al.* 2006), combined with increased maritime traffic (Endresen *et al.* 2003) and a greater occurrence of artificial substrata in the oceans (Eriksen *et al.* 2014), Figure 4. In 1995, *C. mutica* reached the Netherlands (Platvoet *et al.* 1995) and the first record of *C. mutica* in the UK was in 2000 from a salmon farm in the Lynne of Lorne (56°27.090' N 05°27.733' W) on the west coast of Scotland (Willis *et al.* 2004). Specimens collected from Roseneath Patch (Clyde Sea, 55° 58.50' N, 4° 47.50' W) in 1999 incorrectly identified as *C. tuberculata*, have been re-identified as *C. mutica* (O'Reilly 2007). By 2003, low numbers of *C. mutica* were present in Southampton Harbour (Cook *et al.* 2007), and a rapid assessment survey confirmed the presence of *C. mutica* at the National Oceanography Centre (NOC) pontoon in Southampton, and Poole Quay Boat Haven during September 2004. No specimens were found in Gosport, Southsea or Brighton marinas at this time (Arenas *et al.* 2006). For several ecological and conservation reasons, it is important to determine the impact of this aggressive invasive on native species, habitats and ecosystems.

Methods and Materials

Caprellids were collected from 3 localities within Langstone Harbour on 16/10/2014. Site 1: University of Portsmouth (UoP) research platform [50°48' 22.57" N, 1° 1' 20.38" W], Site 2: Hayling Island Ferry pontoon [50°47' 46.68" N, 1° 1' 49.01" W] and site 3: Southsea Marina [50°47' 30.39" N, 1°2' 1.75" W]. Caprellids were sampled during a 1hr timed search of a 10m length of pontoon or research platform by 2-3 people. Caprellids were removed from a range of substrates submerged between 5-100cm using paint brushes and tweezers. Specimens

Species	Number
<i>Caprella penantis</i>	237
<i>Caprella equilibra</i>	145
<i>Caprella andreae</i>	34
<i>Caprella septentrionalis</i>	20
<i>Caprella fretensis</i>	3
<i>Caprella mutica</i>	2
<i>Caprella linearis</i>	1
Unknown	2
Total	444

Table 2: Caprellid species collected fromn Langstone Harbour on 16/10/14.

were fixed in either 10% formalin for identification or 98% ethanol for molecular analysis. Substrate of origin was recorded for all specimens. Formalin fixed samples were transferred to 70% ethanol for preservation after 3 days. Densely populated substratum was scraped off with a scalpel and preserved with attached caprellids in situ. Caprellids were removed from the host substrate shortly after collection. Caprellids were identified to species level where possible using the Guerra-Garcia guide to British Caprellids, 2014. Species, gender, life stage and body length was recorded for each specimen and representative specimens photographed using a Leica compound microscope with mounted camera.

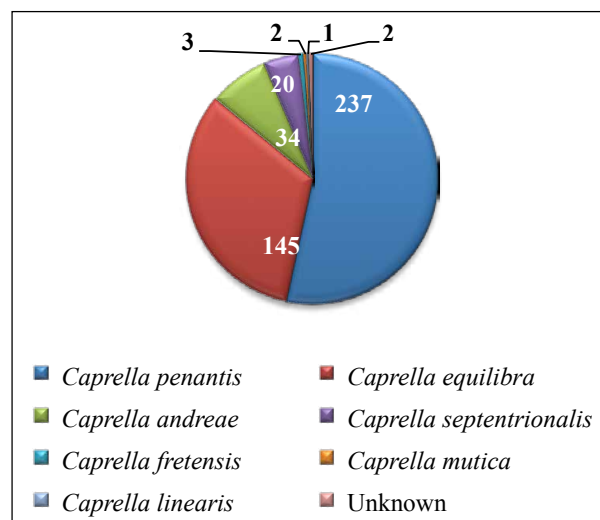


Fig. 5: Pie chart of Caprellid species diversity in Langstone Harbour.

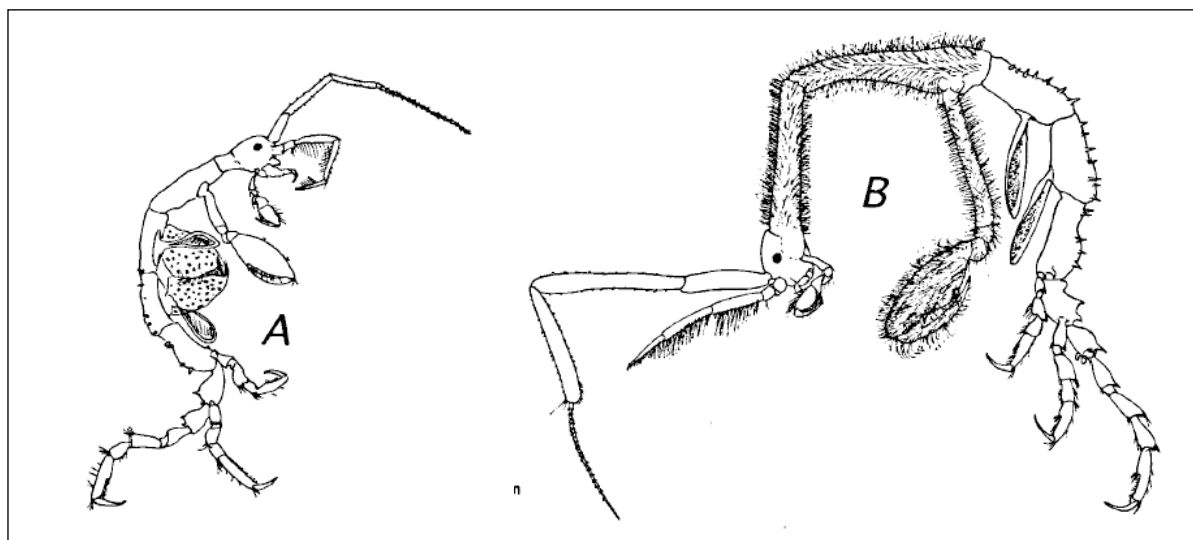


Fig. 6: Sexual dimorphism in *Caprella mutica*. Recreated from Platvoet et al. (1995).

Results

A total of 444 Caprellidae individuals were collected on 16/10/14, Table 2. Provisionally, based on morphological features, 7 species were identified (Figure 5). Large numbers of caprellids were observed attached to the algae *Halurus flosculosus* and *Sargassum muticum* in particular. Other host substrata included encrusting sponges, hydrozoans and tunicates. Overall, *C. penantis* was the dominant species (n=237) followed by *C. equilibra* (n=145).

Of the 444 caprellids, two small male *Caprella mutica* specimens were identified. Both were attached to a green algal mat encrusting a steel frame submerged from the UoP research platform at a depth of 0.7m. A small number of female *C. mutica* samples were provisionally identified (Preston, J. unpublished data), and are awaiting confirmation by DNA barcoding. The *C. mutica* specimens collected from the research platform were immature males of total body length 8.9 mm and 11.6 mm.

Mature male *C. mutica* are more readily identified *in situ* due to their large size (approximately 24 mm), distinctive red colour and a suite of morphological characters that distinguish them from British native species. The cephalon lacks projections and the first pereonite is distinctively elongate. Pereonites 1 and 2 are often densely covered in setae (hair like structures), as is the 2nd antenna and 2nd gnathopod. The third to seventh pereonites possess distinctive spines,

or dorsal projections, but no setae in both the male and female. Female *C. mutica* have a pale white brood pouch with red spots and are considerably smaller than their male counterparts (Figure 6). For further discussion on the taxonomic features of *C. mutica* see Turcotte & Sainte-Marie (2009).

Discussion

The global distribution of the non-indigenous species *C. mutica* is probably due to its broad physiological tolerances, opportunistic feeding strategies, high fecundity, growth rate and short generation times (Ashton 2006). The presence of *C. mutica* in Langstone Harbour is not unexpected, the west to east stepping-stone colonisation route along the south coast of Britain, and its occurrence in nearby harbours Southampton and Poole. Interestingly, no *C. mutica* individuals were observed on the Hayling ferry pontoon or Southsea marina during this survey. However, only 2 small male individuals were confirmed in this study, mirroring the low numbers sampled in Poole Harbour during other studies (Ashton 2008). In its native habitat, *C. mutica* can reach densities of up to 2,600 individuals per m² (Boos et al. 2011). Non-native populations of *C. mutica* have been recorded in Northwest Europe at even greater densities of 3000 and 200,000 individuals per m² (Baushbaun & Gutow 2005 and Boos et al. 2011 respectively). Bates et al. (2014) describes stages of range expansion due to

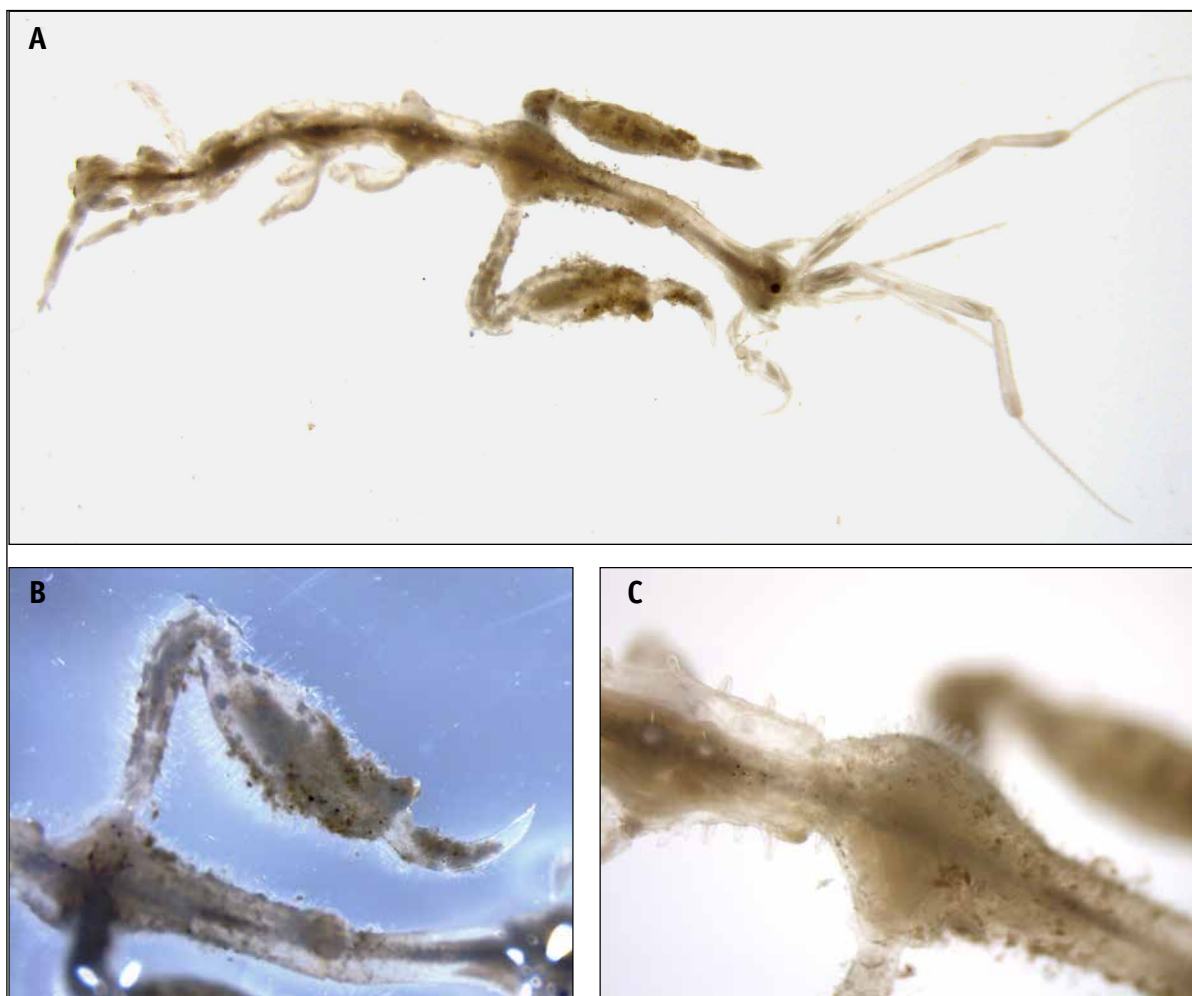


Fig. 7: *Caprella mutica* male juvenile, length 8.9mm. Collected from University of Portsmouth research testing platform, Langstone Harbour 16/10/2014. A, Lateral view, whole animal. B, Setae on 2nd peronite and spines on 3rd peronite. C, Setae of 2nd gnathopod.

climate change, a theory that can be applied to non-native species such as *C. mutica* extending their range within the area of their introduction. Bates describes three stages: (1) arrival, (2) population increase and (3) species persistence. From this short study, initially it may seem that *C. mutica* is currently at stage 1 in Langstone harbour, with evidence of a small founder population. However, the sampling was conducted during October when the second generation of juveniles hibernate until the spring reproductive period of the following year (Fedotov 1992). Long-term monitoring of Langstone Harbour and the surrounding Solent European Marine Site is required to determine the eastward limit *C. mutica*, and confirm the presence of an established population in Langstone Harbour.

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Ballast Water Management and Compliance

Alice Bowles

Introduction

Water is used as ballast to stabilise vessels at sea. Ballast water is pumped into ballast tanks to maintain safe operating conditions throughout a voyage. This practice reduces stress on the hull, provides transverse stability, improves propulsion and manoeuvrability, and compensates for weight changes in various cargo load levels due to fuel and water consumption (IMO 2015). Usually ballast water is pumped into ballast tanks when a ship has delivered cargo to a port and is departing with less or no cargo. It is then discharged when cargo is reloaded at the next port of call.

While ballast water is essential for safe and efficient modern shipping operations, it may pose serious ecological, economic and health problems because of the multitude of marine species carried within it. These include bacteria,

microbes, small invertebrates, eggs, cysts and larvae of various species. The transferred species may survive to establish a reproductive population in the host environment where they do not naturally occur. These introduced species may grow very quickly in the absence of natural predators, becoming invasive, out-competing native species and multiplying into pest proportions. Only few species are successful invaders as most are unable to survive in their new surroundings, because of the temperature, food and salinity differences encountered. However, the species that do survive can very quickly establish a population of very hardy species that have the potential to cause major harm.

The problem of invasive species in ships' ballast water is largely due to the expanded trade and traffic volume in relation to shipping over the last few decades. The spread of invasive species is now recognised as one of the greatest threats to the ecological and the economic wellbeing of the planet (IMO 2015).

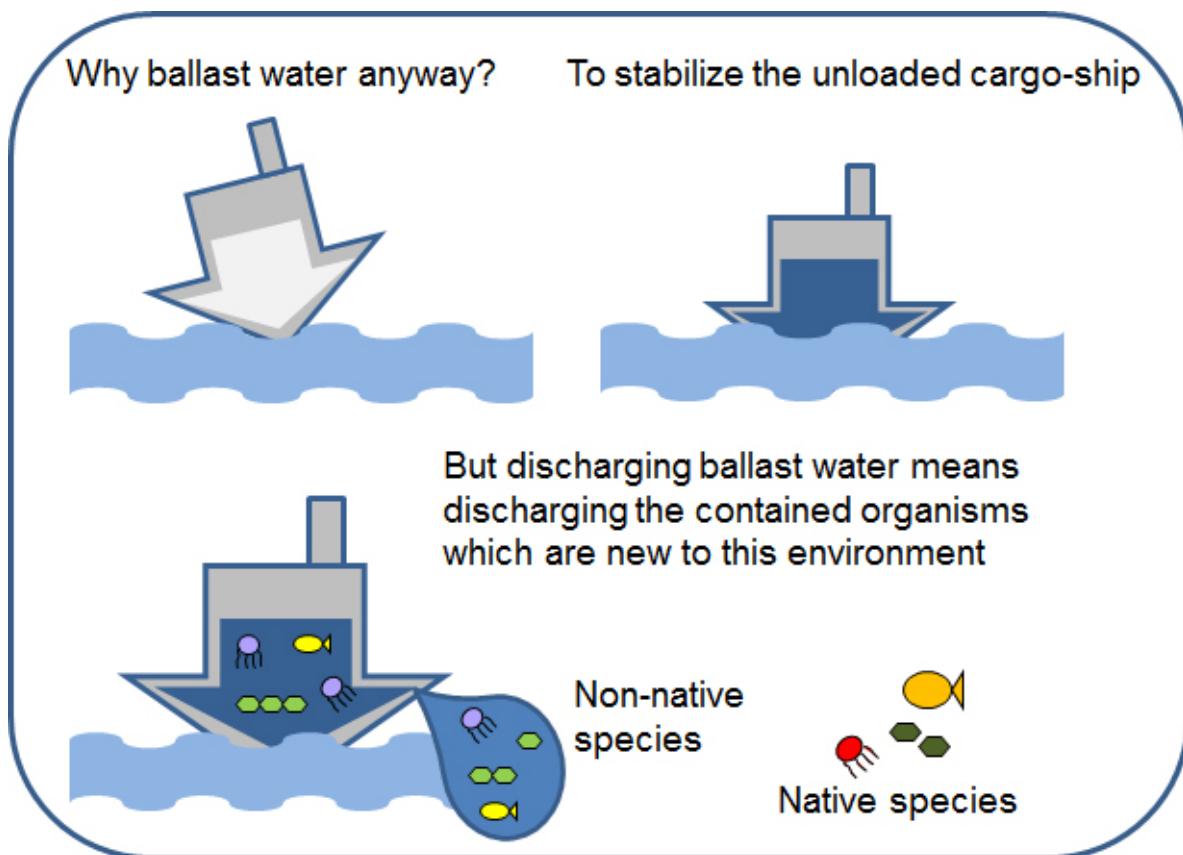


Fig. 1: The threat of ballast water. Source: <http://www.northseaballast.eu/northseaballast/2145/5/0/82>

Examples of Invasive Species in Europe

Chinese mitten crabs *Eriocheir sinensis* burrow into river banks and dykes contributing to erosion and siltation. Mitten crabs prey on fish and invertebrate species, which may cause local extinction of these prey species. They may also interfere with fishing activities, for example, by cutting nets.



Fig. 2: Chinese mitten crab *Eriocheir sinensis*. Source: <http://www.nhm.ac.uk/nature-online/life/other-invertebrates/chinese-mitten-crabs/>

American comb jellies *Mnemiopsis leidyi* feed excessively on zooplankton; depleting zooplankton stocks; altering food web and ecosystem function. The depletion of zooplankton stocks are thought to have contributed significantly to the collapse of the Black and Asov Sea anchovy and sprat fisheries in the 1990s, with massive economic and social impact.

European zebra mussels *Dreissena polymorpha* can foul all available hard surfaces in massive numbers and thus displace and outcompete the native organisms. Mass colonisation, excessive feeding and excretion can alter habitats, ecosystems and food webs. Zebra mussels cause



Fig. 3: European zebra mussels *Dreissena polymorpha*. Source: <http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/indiana/journeywithnature/the-nature-conservancy-in-indiana-zebra-mussels.xml>



Fig. 4: Ship discharging ballast water. Source: <http://www.safety4sea.com/updated-alternate-management-systems-for-ballast-water-treatment-16609>

severe fouling problems on infrastructure and vessels, for instance by blocking water intake pipes and economic costs can be extensive.

Toxic algae may form harmful blooms (red/brown/green tides) and can cause massive loss of marine life. Some species may contaminate shellfish and cause fisheries to be closed. Consumption of these contaminated shellfish by humans may cause severe illness and even death (North Sea Ballast Water 2015).

History of Ballast Water Management

Invasive species can be managed in two ways: prevent them from invading in the first place, or eliminate the exotic species that have invaded. Getting rid of established invasive species is practically impossible and very expensive. Preventing invasions occurring in the first place is considered to be a more practical and economic solution. Ballast water discharge is just one of the pathways by which invasive species can be introduced and a brief history of the management of ballast water is provided in Table 1.

In 2004, the International Maritime Organization (IMO) adopted the International Convention for the Control and Management of Ships' Ballast Water and Sediments (Ballast Water Management Convention (BWMC)). However, over a decade after it was first adopted by the IMO, the BWMC has not yet met the requirements for full ratification.

The BWMC will enter into force one year after ratification by 30 states representing 35%

Year	Management Measure
1991	The International Maritime Organization (IMO) Marine Environment Protection Committee (MEPC) adopted Guidelines for preventing the introduction of unwanted organisms and pathogens from ships' ballast water and sediment discharges (MEPC resolution 50(31)).
1992	The United Nations Conference on Environment and Development, held in Rio de Janeiro in 1992, recognised the issue as a major international concern.
1993	The IMO Assembly adopted resolution A.774(18) based on the 1991 Guidelines requesting the MEPC and the Marine Stewardship Council (MSC) to keep the Guidelines under review with a view to developing internationally applicable, legally-binding provisions.
1997	The IMO adopted resolution A.868(20) - Guidelines for the control and management of ships' ballast water to minimise the transfer of harmful aquatic organisms and pathogens.
2004	The International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention) was adopted by consensus by IMO Member States.
2005-2008	MEPC adopted 14 sets of Guidelines, to assist member states to ratify the Convention.
Present	Eleven years since the adoption of the Convention, it has still not met the minimum requirements for ratification.

Table 1: History of Ballast Water Management

of world tonnage. Currently, 44 countries have signed up to the BWMC but these countries only represent 32.86% tonnage. Full ratification requires only one more large flag state, or a few small flag states, to sign up to the Convention and this is expected to occur within the next year.

Requirements under the BWMC

Regulation D-1 Ballast Water Exchange Standard

For an interim period, vessels will be permitted to exchange ballast water taken on board in port or near the coast with water from the open ocean. The exchange needs to be at least 200 nm from the nearest land and 200 m in depth. In theory, this reduces the risk of transferring species as deep ocean water tends to contain fewer organisms and these generally

have more difficulty surviving in coastal and port environments when discharged, and vice-versa. However, ballast water exchange at sea is not considered an ideal ballast water management method and ultimately most vessels will be required to fit ballast water treatment systems.

Regulation D-2 Ballast Water Performance Standard

Ballast water treatment systems will be required to treat water to a specific performance standard before it is discharged. These standards are based on agreed numbers of organisms per unit of volume. Current treatment system technologies rely on either mechanical treatment (filtrations, separation or destruction); physical treatment (ultraviolet light, electric currents, heat treatment,



Fig. 5: Ballast Water Treatment System.
Source: <http://www.oceansaver.com/news.html>



Fig. 6: UK Ferry Routes. Source: <http://www.ferrysavers.com>

deoxygenation); chemical treatment (active substances); or combinations of the above. Ships will also be required to implement a ballast water management plan and maintain a ballast water record book.

Resistance to Ratification

There are a number of perceived problems with the BWMC which have, to date, prevented many countries from becoming signatories to the Convention. These include a lack of approved treatment systems, costs of equipment and implementation, installation capacity, sampling and analysis, guideline robustness and political will. In particular, it has been estimated that approximately 60,000 vessels will need to meet the requirements of the BWMC performance standard. This equates to approximately 30 ships that will need to be retrofitted with treatment systems per day, which in itself is a huge challenge.

Alternatives under the BWMC

A number of alternatives to installing treatment systems do exist and these include:

- holding ballast water;
- using municipal water supplies as ballast; and

- using land based systems to discharge ballast water into.

However, these alternatives are not yet considered advanced enough to be considered economically, environmentally or socially viable at this stage.

Exemptions under the BWMC

The BWMC does state that exemptions from needing to meet the discharge standards of the Convention can be granted under specific conditions which include ships travelling between specific ports e.g. ferry operators. This exemption process is not yet finalised in the UK but will be based on robust risk assessments which will compare the two ports physical and environmental conditions. Guidelines for exemptions are currently being finalised by HELCOM/OSPAR and will be reviewed by the UK Government. Ultimately the ports being considered under an exemption will need to be surveyed for a wide number of parameters, including the presence of target (non-native) species. The risk assessment will compare the two ports under consideration and determine whether an exemption can be granted based on the risk of introducing or transferring species.

Notes about Author:

Alice Bowles is a marine consultant at ABPmer specialising in non-native species and their spread and introduction in ballast water. Alice has worked on a number of projects reviewing the implications of the BWMC for ports and has completed an internship at IMarEST drafting a Ballast Water Guidance Manual.

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Recognizing Undulate Rays *Raja undulata*

Martin & Sheilah Openshaw

Abstract

Undulate rays *Raja undulata* are on the IUCN Red List of Threatened Species, however they are distributed in patches along the English Channel with sites of local abundance (Ellis, McCully & Brown 2012). The identification of one particular site in Dorset where *Raja undulata* are commonly seen provides an opportunity to repeatedly observe them in their natural habitat. Photographic techniques have been used to record the pattern on the upper surface of numerous fish. Using widely available image processing packages, individual rays can be identified with confidence and in several cases their size estimated by use of photographic scales. Repeated diving on the site provides an opportunity to build a body of observations and data. Using the photographic techniques and analysis, it is possible to identify individual undulate rays that return to the site over prolonged periods, including fish that have been present in successive years.



Introduction

Undulate rays *Raja undulata* are generally considered rare and a threatened species but are reported as abundant in patches distributed along the English Channel including Sussex, Poole, around the Isle of Wight, Lyme Bay and the Channel Islands (Ellis, McCully & Brown 2012). They are important for fisheries management because their low fecundity, late maturing and slow growth rate makes them susceptible to over fishing (Cuelho & Erzini 2006). Data

on their distribution, size and development is generally developed from fishing, trawl records and limited tagging programs.

As recreational divers, diving along the Dorset coast for 20 years we have come across undulate and other species of rays on numerous occasions. These have been isolated occasions without any particular pattern and would appear to match the experience of other divers who occasional report seeing rays along this coastline. In 2012 during a series of dives in one specific area, one or more rays were seen on almost every occasion, sufficiently unusual to merit further investigation.

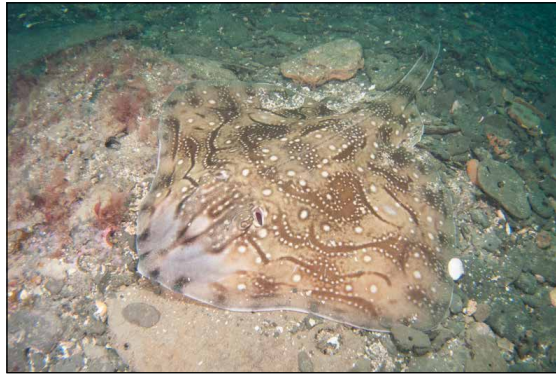
The Site

The site forms part of Kimmeridge Ledges, a series of shallow ledges reaching out to sea for up to a mile that have caught many sailors unaware and been the cause of numerous shipwrecks. With each ledge the seabed rises towards the surface, creating a series of wide shallow valleys between each pair and a variety of habitats for sea life. The area observed is approximately 50 metres wide and over 200 metres north to south, an extremely small area on the south coastline but being roughly the size of two football fields is an extensive area to cover by a diving activity. Numerous dives in the summer periods from 2012 to 2014 have provided the opportunity to observe undulate rays in their natural environment and we are not aware of records existing of similar congregations of undulate rays in a particular place.

The Rays

The rays are found resting on the seabed and although some can be quite skittish and will dart or, more likely, gracefully swim away as a diver approaches, others are comparatively placid and can be approached with care. In most cases where an undulate ray is seen, it is possible to get very close, photograph the fish and in many cases, place a photographic scale close by to give an indication of size.

The undulate rays vary in colour from predominantly brown through greyish-brown to predominantly grey. They are patterned with wavy, undulating dark bands and varying amounts and sizes of white spots. In 1926,



Robert Selby Clark reported that “In the examination of thousands of Rays, I have never met with examples which have been perfectly symmetrical.” (Clark 1926). This comment was relating to the size and shape of undulate rays, however the pattern of bands and spots is also asymmetrical and seen to be unique to the individual fish. By comparison of photographs showing the pattern and marking, single individual fish can be identified with confidence and matched to previous sightings of the same ray.

Obtaining a good quality image of a ray underwater in UK conditions is however

not necessarily easy. Visibility can vary dramatically from 15+ metres (easy) to 2 or less metres (not easy). The diver needs to be mid water, 1 or 2 metres above the fish and there will generally be some tide movement pushing the diver along; attempts to stay stable in one position are likely to disturb the ray causing it to swim away, along with any chance of obtaining a photograph.

To get the full width of the ray in the frame of the photograph requires the camera to be some distance above the fish. At this distance in UK waters, there is inevitably a considerable amount of material in suspension between the camera and the fish, any use of the built in flash therefore causes a large amount of backscatter, obscuring the subject of the photograph. Trying to overcome this with more elaborate equipment means that more care must be taken not to disturb the fish.

Under these conditions, we have had most success getting overall images of the fish by using a small, relatively low-cost compact camera, with natural light. Often this produces dark, greenish images of little photographic merit like

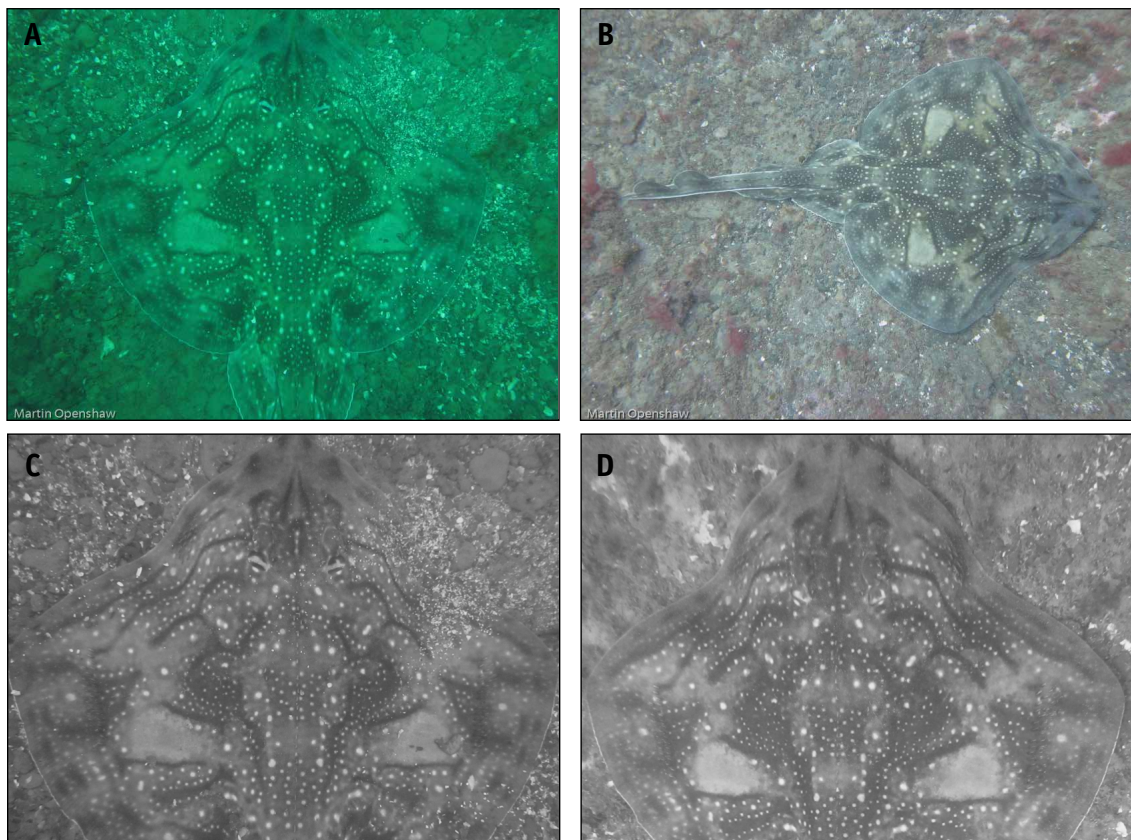


Fig. 3: A. Garay sighting A as taken; B. Garay sighting B as taken; C. Garay sighting A processed; D. Garay sighting B processed

the example “Garay sighting A as taken” (Figure 3) but these can easily be processed by readily available software to highlight the pattern and marking. Once processed in this way, the photographic merit of the original photograph is mostly lost as shown by comparing the “as taken” and “processed” examples of the two sightings A and B. By detailed comparison of the pattern with particular attention to the asymmetry of individual markings on the fish it is possible to identify individual undulate rays with confidence. The example shown is male undulate, 0.85 metres in length and the photographs were taken about 1-week apart in 2013. He was subsequently named “Garay”. More information is available on the image processing and identification technique on the website http://www.stardis.co.uk/ray_id.html.

One hundred and eighteen encounters have been recorded, the majority of these (97) being with undulate rays *Raja undulata*.

Sightings of Rays = 118
97 undulate rays (<i>Raja undulata</i>)
14 spotted rays (<i>Raja montagui</i>)
4 thornback rays (<i>Raja clavata</i>)
3 not identified (sp?)

Table 1: Sightings of all rays between 2012 and 2014

From the ninety seven undulate rays, ten individuals have been seen and subsequently identified, several days or weeks later. This brings the total to seventy three individual undulate rays that have been recorded and photographed on this site between 2012 and 2014. Four of the ten individuals have been seen in separate years.

One individual, named “Billy” has been recorded on at least one occasion each year during the three year period and 3 times in 2013. “Billy” was first identified as an individual in 2013 when he was seen and

Individual Undulate Rays = 73
66% females, 27% males, 7% females
10 individuals seen on more than one day
4 of these seen on more than one year
3 not identified (sp?)

Table 2: Sightings of undulate rays

photographed on 3 successive occasions across a 2-month period from the end of June to the end of August. He was named after Billy Bones from Robert Louis Stevenson’s Treasure Island because of a distinctive black spot on his left wing. Billy is a mature male with a wingspan (disc diameter) of almost 50 cm and an overall length of approximately 90 cm. He was photographed on the same site in July 2012 and was subsequently photographed in August 2014. Hence he has been in the vicinity or visited the same site over 3 consecutive years.



Fig. 5: ‘Billy’

Summary

Although the data remain insufficient to draw firm conclusions, the following observations would appear relevant. Given the few occasions that divers visit the site over the three year period, the occurrence of repeat sightings at approximately 1 in 7 suggests the rays represent a relatively small population that visit the same area/site on a regular basis. They appear to be resting during the day, often remaining in the same position for several hours but why they are in the area remains unknown.

We know the rays are not always there but we have no knowledge of where they go, how frequently they may visit the site, how far they may travel, whether they remain close by between sightings or whether they visit on occasional days as part of a much wider travelling pattern. Hopefully more information gathered from this site, the possible identification of similar sites will compliment other research studies and provide answers to some of these unknowns.

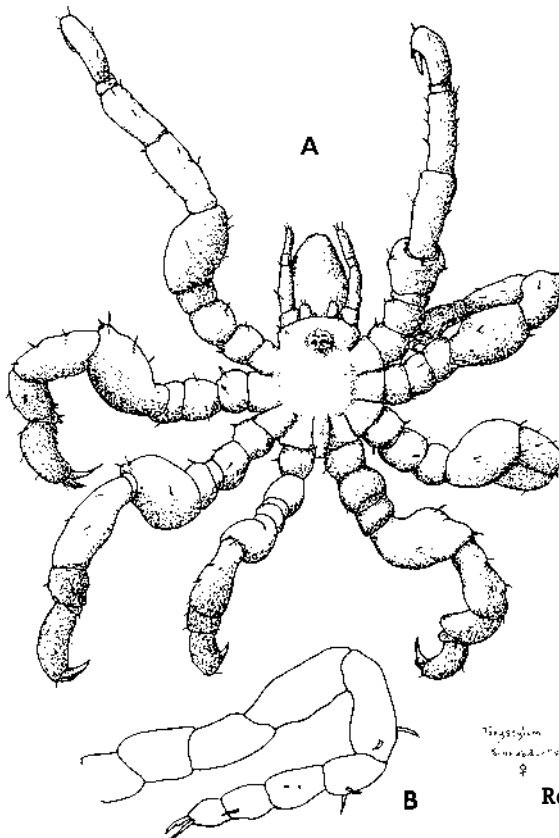
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Tanystylum sinoabductus Bamber, 1992

Pycnogonida: Ammotheidae

Described from exposed shore mussel beds at Cape d'Aguilar, Hong Kong.

A: whole specimen, dorsal

B: oviger

Roger Bamber

“Think I’ll go eat worms.....”: Does Nutrient Pollution Transform Upper Trophic Levels of Estuarine Food Webs?

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Introduction

Nutrient pollution of estuarine environments is a global conservation concern. Increases in nitrates and phosphates, resulting from land run-off (both agricultural and urban) together with sewage input, leads to eutrophic conditions within the intertidal mudflats associated with estuarine ecosystems (McLusky & Elliott 2004).

It is widely acknowledged that a functioning estuarine ecosystem requires a minimum amount of macro-algal coverage for primary production within the food-web (Raffaelli *et al.* 1999; Fox *et al.* 2009) and, in undisturbed systems, nitrogen levels are a significant factor limiting primary production (Fox *et al.* 2009). A consequence of excessive nutrient input within a system is the development of macro-algal blooms (Nedwell *et al.* 2002), an increasingly common sight within temperate estuarine systems (Jones & Pinn 2006). In the UK these include extensive mats of opportunistic chlorophytic algae such as *Ulva lactuca*, *Ulva (Enteromorpha) intestinalis*, *Cladophora rupestris* and *Chaetomorpha linum* (WFD-UKTAG 2009). Blooms develop quickly as nutrient uptake by certain green algal species (e.g. *Ulva*) can be 4-6 times faster than slower growing Phaeophyta or Rhodophyta species (Pedersen & Borum 1997). In southern England, mat growth usually commences in the spring with greatest coverage during July and August (Jones & Pinn 2006). As the algae develop, lower fronds become starved of light and unable to successfully photosynthesise (Flindt *et al.* 1999). Decomposing layers release nutrients back into the sediment

thereby becoming available for uptake by growing algae and benthic organisms (Raffaelli *et al.* 1998).

There is agreement that certain types of estuaries are more susceptible to the effects of eutrophication; particularly those with ‘restricted tidal inundation’ (Cloern 2001). These estuaries have a tidal range of <2m, reduced flushing and are less able to dilute effluents (McLusky & Elliott 2004). A number of estuaries within the UK fall into this category including the Ythan Estuary in Scotland (Raffaelli *et al.* 1999), and Langstone, Chichester and Poole Harbours along the south coast of England (Soulsby *et al.* 1982; Humphreys & May 2005).

High levels of nutrient enrichment can significantly affect sediment chemistry leading to the development of hypoxic/anoxic conditions and the production of hydrogen sulphide (Bolam *et al.* 2000; McLusky & Elliott 2004; Morand & Merceron 2005; Flindt *et al.* 1999). The alteration of sediment chemistry affects the benthic macro-invertebrate community (Wildsmith *et al.* 2009). As the anoxic layer (visually identified as black mud) develops and moves closer to the surface, invertebrates struggle in increasingly oxygen-poor conditions (Pearson & Rosenberg 1978). Some species are able to adapt either by extending siphons, (e.g. the bivalve *Macoma balthica*) or by moving within the sediment column (e.g. the annelid *Capitella capitata*) (Rosenberg *et al.* 2001). However, such behaviour can increase vulnerability to predation from the surface (Grall & Chauvaud 2002; Jones & Pinn 2006). As the algal mat increases in extent, thereby creating a greater area of hypoxic/anoxic sediment, refuges for invertebrates become fewer (Pearson & Rosenberg 1978).

Poole Harbour

With an area of 3600 ha at High Water Spring Tide (Humphreys & May 2005) Poole Harbour is the UK’s largest natural harbour. The area provides an ideal opportunity to study the pressures associated with a shallow estuarine system with restricted tidal flow and a low (<2m) tidal range (Humphreys & May 2005). The harbour carries a number of national,

European and international conservation designations; these include recognition as a wetland of international importance under the Ramsar Convention; a European Special Protection Area; a Special Area of Conservation; a European Marine Site; and a Site of Special Scientific Interest. To the north, the urban conurbation of Bournemouth and Poole supports a commercial port and ferry terminal located at Poole Quay. To the south of the harbour lies the Isle of Purbeck with its diversity of important habitats including heathland (Natural England 2013).

Aims

The overarching aim of this research is to determine whether the development of macro-algal mats affects the overwintering estuarine bird population.

Methods

The research focuses upon the impact on upper trophic levels of estuarine food-webs. For the purposes of this project, these are coastal bird species (waders and wildfowl). Methods have been developed which use these trophic levels

as a framework. Fieldwork has been conducted across two years (March 2013 – March 2015) covering growth and development cycles of the algal mat (Figure 1) and incorporating the overwintering period for migratory coastal birds.

Primary production (macroalgal mats)

The development and extent of the algal mats has been measured and mapped at five key survey sites around Poole Harbour (Holes Bay NE, Holes Bay NW, Ower Bay, Newton Bay, Brands Bay (Figure 2)). These sites were selected as representing a diversity of surrounding land-use and aspect. Algal samples were removed from 5 quadrats at the upper shore. Prior to weighing the algae, any invertebrates were removed and the sample was rinsed thoroughly over a 0.5 mm sieve. Wet weight biomass was obtained and the samples frozen for storage.

In addition, at each of the sampling sites, percentage cover of algae was recorded across the bay. This will be compared with aerial images taken during August 2013 to determine whether terrestrial mapping is an effective measure of algal mat extent.

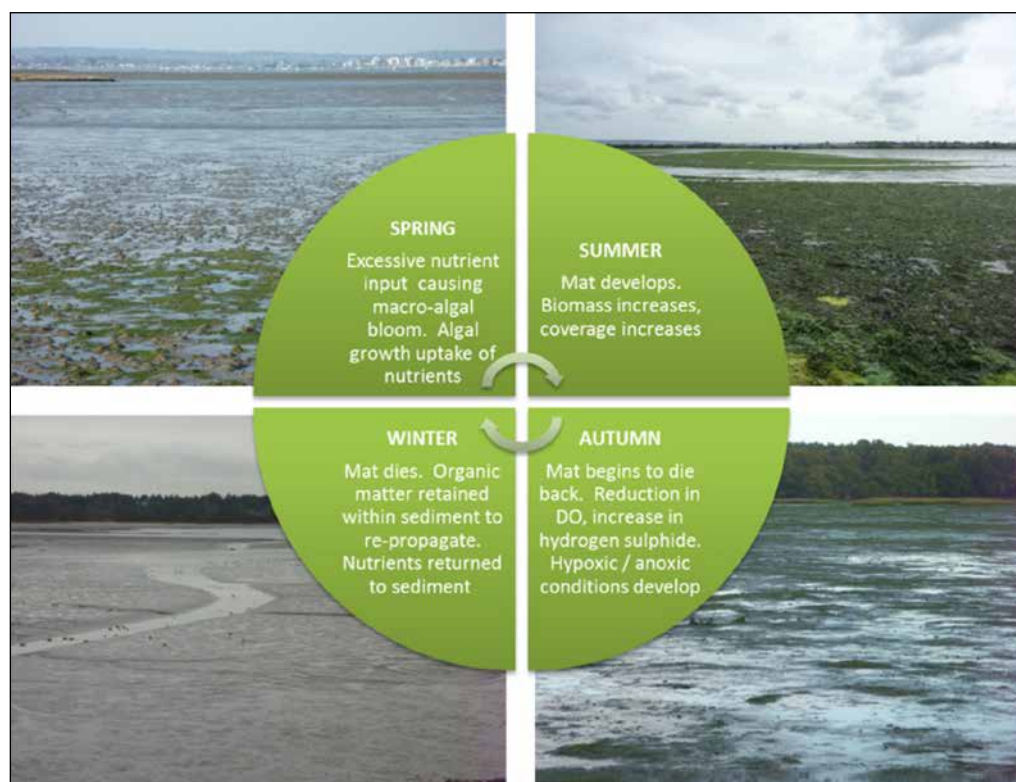


Fig. 1: Ecological cycle for macro-algal mat development in Poole Harbour. Clockwise from top left: Ower Bay (April 2014), Holes Bay (August 2014), Newton Bay (October 2014), Brands Bay (February 2015). Images © A Thornton.

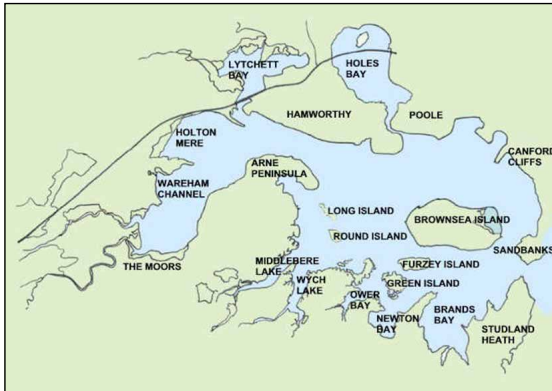


Fig. 2: Map of Poole Harbour. Image © Poole Harbour Study Group.

Primary/Secondary consumption (benthic macro-invertebrates)

Three key sites were selected for the next level of sampling; Holes Bay, Ower Bay, Brands Bay. These were considered to have the necessary heterogeneity of algal-mat coverage together with a suitable vantage point from which to conduct bird observations. The aim is to link invertebrate availability in these bays with bird feeding behaviour.

Core samples were taken using a bespoke suction corer from a boat. Samples were taken from three shore levels (upper, mid and

lower) in September 2013, December 2013 and September 2014. These periods coincide with the arrival and mid-point of the overwintering bird population.

Samples were sieved over a 0.5 mm mesh and any algae removed, weighed and retained. Invertebrates were removed, identified and measured (where appropriate).

A total of 42 invertebrate species were recorded during the study – 18 annelids, 10 molluscs, 10 crustaceans, 2 insect larvae, 1 nemertean and 1 anemone. These included common benthic invertebrates such as *Corophium volutator*, *Tubificoides* spp., *Hediste diversicolor* and *Peringia (Hydrobia) ulvae*, together with some non-native species (*Desdemona ornata*, *Ruditapes philippinarum*). Table 1 provides a list of the invertebrate species recorded.

Tertiary consumption (Coastal birds)

Coastal birds (waders and wildfowl) provide the upper trophic level studied for this project. Poole Harbour supports nationally and internationally important populations of overwintering wading birds. These birds arrive in September to feed on the species-rich intertidal mudflats prior to returning to

Annelida	<i>Scoloplos armiger</i>	Mollusca
<i>Ampharete acutifrons</i>	<i>Streblospio shrubsolii</i>	<i>Abra tenuis</i>
<i>Aphelochoeta marioni</i>	<i>Tubificoides</i> spp.	<i>Cerastoderma edule</i>
<i>Arenicola marina</i>		<i>Dynamene bidentata</i>
Capitellidae	Crustacea	<i>Gibbula umbilicalis</i>
<i>Chaetozone</i> sp.	<i>Carcinus maenas</i>	<i>Lepidochitona cinerea</i>
<i>Desdemona ornata</i>	<i>Corophium volutator</i>	<i>Littorina</i> spp.
<i>Eteone longa</i>	<i>Cyathura carinata</i>	<i>Macoma balthica</i>
<i>Glycera tridactyla</i>	<i>Gammarus</i> spp.	<i>Mya arenaria</i>
<i>Hediste diversicolor</i>	<i>Idotea balthica</i>	<i>Peringia (Hydrobia) ulvae</i>
<i>Melinna palmata</i>	<i>Melita palmata</i>	<i>Retusa obtusa</i>
<i>Nephtys hombergii</i>	<i>Microdeutopus gryllotalpa</i>	<i>Ruditapes philippinarum</i>
<i>Phyllodoce mucosa</i>	<i>Microprotopus maculatus</i>	
<i>Polydora</i> sp.	<i>Sphaeroma</i> sp.	Other
<i>Pygospio elegans</i>		<i>Actinaria</i> sp.
<i>Scolecopsis</i> spp.		Chironomidae spp.
		Dolichopodidae sp.
		Nemertea sp.

Table 1: Species recorded during invertebrate sampling in Poole Harbour in September and December 2013 and September 2014.

their breeding sites the following spring. Six species (Curlew (*Numenius arquata*), Black-tailed godwit (*Limosa limosa*), Oystercatcher (*Haematopus ostralegus*), Redshank (*Tringa totanus*), Dunlin (*Calidris alpina*), and Shelduck (*Tadorna tadorna*)), were selected for more detailed study.

Behaviour of these six species was observed throughout their overwintering period during two seasons (September 2013-March 2014, September 2014 – March 2015). Each site was visited monthly on a neap and spring tide with behaviour noted at 1/2hr intervals commencing 1 hour before low water until 1 hour after. In addition, video recordings were made of individual species feeding on areas with algal mat coverage and areas of bare mud.

Observations made during this time suggest that some species (e.g. Curlew) are adapting to the presence of macro-algal mats and even actively foraging and feeding within the algae.

MORPH-ing the future?

The use of individual-based models (IBMs – also known as agent-based models) is becoming increasingly relevant to ecological research (Grimm & Railsback 2005). Using coastal birds as subjects provides an ideal opportunity to model the impact of varying environmental conditions on the distribution of algal mats and any corresponding impact on upper trophic levels of the estuarine food-web. A study by Durrell *et al.* (2006) used the MORPH IBM to predict the effect on wader survival in Poole Harbour of increases in sea levels that are likely to result from on-going climate change. The model incorporated Dunlin, Redshank, Black-tailed godwit, Oystercatcher and Curlew.

The existing MORPH IBM for Poole Harbour will be developed to provide a conservation tool for use in predicting the effects of macro-algal mats under varying environmental conditions. The functional responses recorded during the bird observation phase of the project will provide the basis upon which to build the IBM. Additional data will be provided for the model from the invertebrate sampling and algal biomass and extent surveys. Climate projections will also be incorporated (IPCC 2013) with particular reference made to

potential sea level rise reducing available intertidal areas for birds, and temperature rise leading to greater biomass and persistence of algal mats throughout the bird overwintering period.

Summary

The presence of macro-algal mats forms part of the assessment criteria for SSSI units. Bird numbers also provide a measure of estuarine SPA quality (Durrell *et al.* 2006). A reduction in biodiversity resulting from eutrophication would, therefore, have implications for the UK's binding agreements under the Birds and Habitats Directives and overall coherence of NATURA 2000 sites. Any decline in the condition status of EU designated bird populations may result in financial penalties being imposed on the UK under current legislation (JNCC 2014)

Outputs from this research will contribute to an overall understanding of the possible effects on the intertidal mudflats, and those species that rely on them, from the development of macro-algal mats. Data will also be used to predict likely impacts from environmental conditions associated with climate change and inform future estuarine conservation management practices and mitigation strategies.

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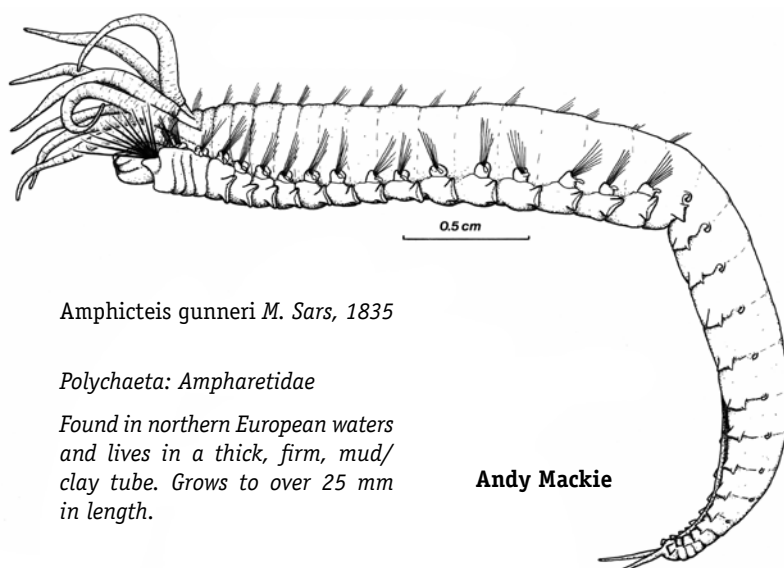
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Amphicteis gunneri M. Sars, 1835

Polychaeta: Ampharetidae

Found in northern European waters and lives in a thick, firm, mud/clay tube. Grows to over 25 mm in length.

Andy Mackie

The Pacific Oyster: Making itself at home in the UK

Stephanie Deane

The Pacific oyster, *Crassostrea gigas*, is a species of oyster native to Japan and Korea which now has global distribution largely due to its popularity within the aquaculture industry. The Pacific oyster is farmed in at least 25 countries including England and Wales, and has become an established non-native species in 14 of those countries (Ruesink *et al.* 2005). Globally it is ranked number one in terms of aquaculture production by volume and value, and in 2006 it is estimated that over 4.6 million tonnes were produced worldwide (FAO 2008). The popularity and success of the Pacific oyster in aquaculture is largely the result of their fast growth rates without the requirement for additional food beyond the natural supply, and their ability to adapt to a wide range of environments through high tolerances to temperature, salinity and turbidity (Mann *et al.* 1994). Furthermore they have shown a resistance to diseases such as Bonamiosis (caused by a protozoan, *Bonamia ostrea*), which is a disease that has resulted in economic losses of native oyster stocks in Europe since 1982 (Culloty *et al.* 1999).

Until recently it has been widely accepted that Pacific oysters were first introduced into the UK in 1965 via the hatchery and quarantine facilities at the Fisheries Laboratory, Conwy, where a broodstock imported from British Columbia were spawned and the resultant oysters were supplied to British hatcheries for breeding purposes (Utting & Spencer 1991). The species distinction between Pacific (*Crassostrea gigas*) and Portuguese oysters (*Crassostrea angulata*) have also been in question as they easily hybridise producing indistinguishable larvae and adults that are both anatomically and morphometrically similar (Menzel 1974; Huvet *et al.* 2002). Recent molecular comparison and DNA base sequencing have confirmed the species to be synonymous (Buroker *et al.* 1979; Reece *et al.* 2008) and this has been recognised by the UK National Biodiversity Network (*Crassostrea gigas* (Thunberg 1793), NBN ID code NBNSYS0000174740). Consequently a

revision of the history of Pacific oysters in Britain by Humphreys *et al.* (2014) has placed the first introduction of oysters to be from Arcachon, France, into Poole Harbour by the Poole Oyster Company as early as 1890. During this time juvenile Pacific oysters, known as spat, were shipped into the UK and grown-on in estuaries. Oyster spat continued to be imported to boost the industry until more stringent legislative regimes were introduced in 1965. It had become apparent that shellfish imports were a notable source of inadvertent introductions of pests and diseases into local ecosystems, and that some of these hitchhiking species had become invasive. It was also necessary to ensure that the Pacific oysters themselves did not have the capability to become invasive. Trials were successful in producing oysters that remained disease free and grew to a marketable size whilst the ambient water temperature remained low enough to inhibit reproduction and hence uncontrolled population expansion (Spencer *et al.* 1994). Alongside these field trials, hatchery techniques were being developed that allowed larvae to be cultivated under controlled conditions to produce spat that could be sold on to aquaculture. This meant that the full farming process of Pacific oysters could now be contained within the UK and that oysters laid out in estuaries to grow-on came from a managed source. The production of Pacific oysters in the UK has increased as aquaculture sites have proliferated and expanded. This coupled with multiple years of failing recruitment of the native oyster and continued closure of native oyster fishery grounds has seen a shift in the industry such that farmed Pacific oysters now contribute to approximately 90% of UK oyster landings (FAO 2012).

Water temperatures are currently rising due to global warming, and as a consequence reproduction of the Pacific oyster is no longer inhibited in UK waters. Sporadic natural spatfalls of Pacific oysters were reported coinciding with aquaculture production along the southwest coast in 1994 (Spencer *et al.* 1994), and more recently regular settlement in the southeast has been sufficient to provide growers with a source of seed (Syvret *et al.*



Fig. 1: Pacific oysters fouling the hull of a yacht moored in the Hamble River that had been repainted with antifouling paint just 9 months prior. Photographer: James Lucey

2008). Establishing wild aggregations are becoming further disassociated from areas of aquaculture in the southeast and south of England and there is concern that as a result, naturalised aggregations may establish and disrupt local coastal ecosystems, alter habitats and exclude native biota. The Pacific oyster initiates gametogenesis and spawns at different temperatures in different regions of the world. In their native range spawning occurs at water temperatures of 23-26°C (Kobayashi *et al.* 1997), however Pacific oysters found in Europe spawn in lower water temperatures of 17-20°C (Li & Hedgecock 1998). This species is a sequential hermaphrodite, reaching sexual maturity as a male one winter after settlement before potentially switching to become female. Simultaneous hermaphrodites are rare and fecundity is high with females able to release up to 50 million eggs into the water column (Helm *et al.* 2004).

Following a planktonic dispersal phase, larvae respond to chemical cues released by mature oysters already established in the intertidal zone. As a result many generations of oysters can form aggregations of high densities and Pacific oysters are a species of oyster known to form reefs. As densities increase the orientation of oysters are forced from lying flat to standing upright and the shells of neighbouring oysters

become cemented together. Over many years a consolidated and hard substrate or reef is formed and will persist after the oysters themselves die. It is of great concern in areas of protected habitat that if reefs were allowed to form that they would compromise the conservation status of that area (Syvret *et al.* 2008; Herbert *et al.* 2012). Larvae are able to settle and metamorphose on an array of hard substrate incurring both biological and economic losses. On the Kent coast biological reefs of Ross worm, *Sabellaria spinulosa*, and the sand mason worm, *Lanice conchilega*, are being displaced by colonising Pacific oysters, and blue mussel beds are becoming heavily fouled (McKnight 2012). Boat hulls of all sizes become fouled and industrial water cooling and effluent piping becomes clogged resulting in decreased efficiencies and increased energy wastage. Furthermore Pacific oysters appear to be more resilient than many biofouling organisms to common antifouling treatments (Rajagopal 2005) (Pers. obs. Figure 1). Additional examples can be taken from European countries where Pacific oysters are already present in large numbers, such as France and the Netherlands, where there has been reduced production on shellfish farms fouled by Pacific oysters (Cognia *et al.* 2006; Diederich 2006), and a loss of tourism to beaches as sharp shells pose a threat to the

safety of humans and animals alike (e.g. dog walking) (Nehls *et al.* 2006).

There have also been positive impacts associated with colonisation of Pacific oysters and it appears to depend largely on the habitat type being colonised. In some instances, such as the colonisation of rocky shores and mudflats an increase of species abundance, biomass and diversity has been recorded (Van Broekhoven 2005; Markert *et al.* 2010; Lejart & Hily 2011) as a result of the complex shell structure adding heterogeneity to the substrate and providing a multitude of exploitable niches. In areas where reefs have formed, they serve as a protective nursery ground and stabilize the shoreline to the benefit of a wide range of other marine algae, plants and animals (Beaumont *et al.* 2007).

In the UK wild Pacific oyster settlement has been recorded with increasing frequency and over a wider area (Couzens 2006; Herbert *et al.* 2012; McKnight 2012), (pers. obs. current study). The distribution pattern of establishing oysters largely mirrors the locations of aquaculture plots indicating farmed stocks as a dominant source of larvae for wild aggregations. There are however some anomalies such as the estuaries being studied for my PhD; Southampton Water and Poole Harbour are approximately 50 km apart on the south coast of England. Southampton Water has no aquaculture, yet multiple and abundant recruitment events have occurred, resulting in a relatively uniform distribution of 2-10 oysters per m² in the intertidal zone of the eastern shore. By contrast Poole Harbour contains the largest producer of Pacific oysters on the UK mainland (Othneil Oysters Ltd.) but wild recruitment is sparse and intermittent with only one notable 100 m stretch in an excess of 1 km of shoreline where recruitment has been successful.

Transects and quadrats were used during beach surveys in order to estimate the density of oysters on the beach, whilst handheld GPS units were used to map their exact location, and Vernier calipers were used to measure the shell length (umbone to the furthest peripheral of the cupped shell). Surveys were carried out during 2013 and 2014 and each site

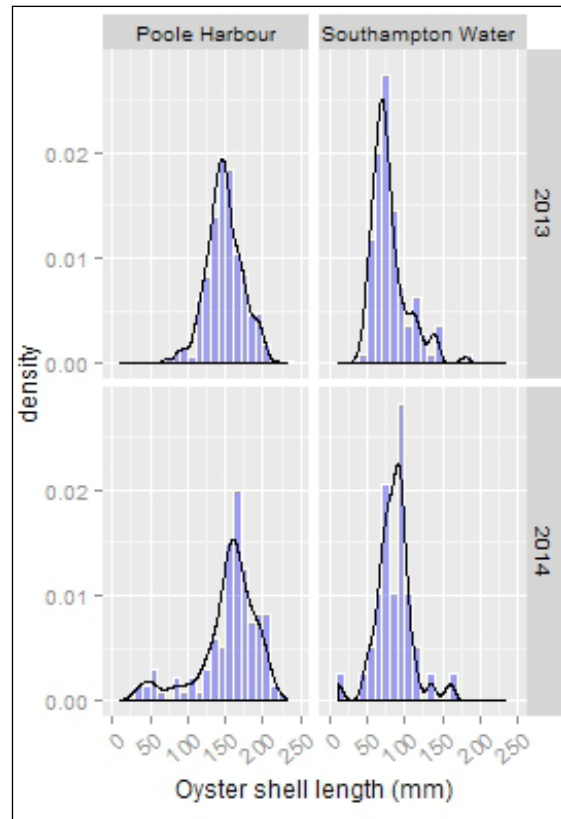


Fig. 2: Size frequency distribution of wild Pacific oysters surveyed in Southampton Water and Poole Harbour during 2013 and 2014.

was revisited at least once per year to monitor the growth of existing oysters and check for recruitment. Size frequency distributions were used to estimate the number of recruitment events, how abundant they were and the approximate age of the oysters present. The size frequency of wild Pacific oysters surveyed in Poole Harbour during 2013 was unimodal and normally distributed which is indicative of a single year of recruitment (Figure 2). Water temperatures 1 m below the surface of Poole Harbour have been logged by the University of Southampton since 2005 and the particularly long and warm summer of 2006 surpassed the spawning threshold for Pacific oysters. The water temperature data combined with the large average size of the oysters (150 mm) suggests 2006 was the year that wild oysters first colonised in Poole Harbour. It is evident from the survey in 2014 that recruitment occurred again in 2013 however the abundance is relatively low in comparison to the event in 2006. In Southampton Water shell lengths ranged from 40 to 180 mm in 2013 with 4 size cohorts indicating as many years of

recruitment (Figure 2). The oysters found inhabiting Southampton Water were generally smaller than those in Poole Harbour suggesting a more recent introduction. However this may be the result of human intervention as hand pickers are commonly seen in Southampton Water harvesting an array of shellfish including Pacific oysters (pers. obs.), furthermore the largest oysters surveyed in 2013 (170-180 mm), although considerably less abundant, were of a similar size to those in Poole Harbour implying that they too could be the result of the warm summer of 2006. Similarly it is evident that recruitment occurred in Southampton Water in 2013 as can be seen by the 10 - 20 mm oysters surveyed in 2014.

Since the introduction of the non-native Pacific oyster into UK waters for aquaculture, global warming has caused ambient water temperatures to rise. As a result Pacific oysters are now reproducing in waters around the UK and it would seem what was a well-managed aquaculture practice could now represent a significant uncontrollable source of a potentially invasive species. Evidence from mainland Europe demonstrates the potential severity of the negative impacts arising from large naturalised aggregations, but also highlights positive consequences and suggests that the receiving habitat type is an important element to consider when predicting the effect colonising oysters may have locally. To date the abundance of wild Pacific oysters on UK shores has remained at a comparatively low abundance and the effects have varied from negatively impacting biological reefs to the economic benefit a source of wild spat provides for local oyster farmers. However the success of wild spatfall has been unpredictable and diverse, emphasising the variation in controlling factors on recruitment between estuaries. The case studies on recruitment occurring in Southampton Water and Poole Harbour confirm Pacific oysters on the south coast are colonising a range of estuarine habitats. The recorded spread and frequency of colonisation in Southampton Water suggests that the larval source of recruitment in recent years has been the established wild oysters in the estuary, and consequently an increase in both spread and density of colonisation

should be expected within Southampton Water (and the adjacent Solent). The presence of aquaculture in Poole Harbour coupled with the intermittent and sparse recruitment accentuates the variability of controlling factors on recruitment between estuaries, and identifying what is hampering recruitment may prove a useful tool in future management of their spread. In conclusion, Pacific oysters are making themselves at home in the UK and their adaptable nature complicates predicting the consequential impacts. The concern for fragile and protected habitat is justified, however the potential to utilise this species for enhancing local habitat and providing a source of spat for aquaculture should not be overlooked.

I am currently studying for a PhD at the University of Southampton. I began in 2012 and have focused my work on the intertidal Osteroidea bivalve Crassostrea gigas commonly known as the Pacific oyster. The aims are to investigate evidence that aggregating Pacific oysters on the south coast of England are self-sustaining and the current distribution does not represent maximum possible settlement. Furthermore I will undertake an assessment of the biotic interactions, such as predation of oysters, and environmental parameters, such as water temperature, that influence the success of recruitment. Understanding the recruitment success of Pacific oysters and the varying effects elicited by differing ecosystems facilitates robust and specific risk assessments of future proposals to farm Pacific oysters.

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Request for Specimens of Specialist Species of Saline Lagoons in the British Isles

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Saline lagoons are characterised as 'areas of typically (but not exclusively) shallow, coastal saline water, wholly or partially separated from the sea by sandbanks, shingle or, less frequently, rocks or other hard substrata. They retain a proportion of their water at low tide and may develop as brackish, fully saline or hyper-saline water bodies' (Bamber *et al.* 2001a). There are numerous sub-types of saline lagoons determined by the nature of the barrier, the size and shape of individual lagoons. Sizes can range from less than 1 hectare, (Keyhaven, Hampshire) to 800

hectares (Loch Stenness, Orkney). Large, narrow or convoluted lagoons support the most diverse biological communities (Covey 1999).

The level of water exchange from the open sea has been described by a water confinement index (Guelorget & Perthuisot 1992). The index ranges from 'freshwater with freshwater biota' to 'estuarine and beyond' to 'hypersaline with cyanobacterial mats'. All water bodies in the range have a free connection to the open sea with marine biota. In their paralic ecosystem the zones of Guelorget & Pethuisot are similar to the biological suite of species groups described by Bamber, 1992:

- Freshwater and low salinity species
- Lagoonal species
- Euryhaline specialist lagoonal species
- Stenohaline species
- Estuarine species pre-adapted to lagoonal conditions



Fig. 1: Map of British Lagoon sites, Ireland (Oliver 2005), Scotland (Covey 1999) and England and Wales (Bamber *et al.* 2001b).



Fig. 2: *Idotea chelipes*, dorsal view, Uists, NMSZ. 2013.034
(Image Bill Crichton NMS/SNH)



Fig. 3: *Idotea chelipes aesthetasc*. Uist, NMSZ.2013.034.
(Image Bill Crichton NMS/SNH)

- Estuarine species incidental to lagoons.

Lagoons became important for policy development after the Council of European Communities (CEC 1992) EU designation, as a priority habitat, largely based on geomorphology (Habitats Directive, Annex 1). Many policy documents and surveys followed on from the work on coastal lagoons by Barnes in the 1980s, who described coastal lagoons as a neglected habitat (Barnes 1980, 1988, 1989 a&b). Some sub-types of lagoon found in the British Isles are rare elsewhere on European NE Atlantic coasts. The recognition of rarity led to a large proportion designated as Special Areas of Conservation (SACs) or Special Sites of Scientific Interest (SSSI). In the UK there are about 330 lagoon sites (JNCC 1995) and in Ireland 89 lagoon sites (Oliver 2005) but some sites may have more than one lagoon (Figure 1). In the UK a high proportion of the lagoon sites have been selected as SACs (Smith & Laffoley 1992; Bamber 1997; Brown *et al.* 1997). There are 25 SACs in the UK and 25 in Republic of Ireland (see Appendix 1).

Specialist Lagoon Fauna and Flora

Definitions of lagoons are complex as the data are inconsistent or poor, e.g., salinity rarely accounts for temporal variability. Consequently, an attempt to use biological communities as part of the definition has been attempted several times. This is also problematic as comprehensive verified data are not available. There are several lists of lagoon indicator or specialist species most

of which are based on an original British list produced by Barnes (1989a) although this largely ignored Scottish and Irish Lagoons. Over the next 25 years lists were compiled by Bamber *et al.* (1992, 2001a, b), Davidson *et al.* (1991), Healy *et al.* (1982) and Healy (1994), Oliver (2005) and Angus (in press). The lists had a different basis for inclusion of taxa which included indicator species and insects. Only published lists of euryhaline specialist lagoonal species have been included as described in the suite of zones (Bamber *et al.* 1992). The list re-produced in Table 1 does not include insects.

There is recognised taxonomic confusion within a number of phyla which has led to doubts about existing records or absence of records largely due to mis-identification, e.g., *Cerastoderma glaucum* (Bruguère, 1789). The specialist taxa are mostly very small, 2-3 mm, and the identification guides are not always helpful. For example, *Idotea chelipes* (Pallas, 1772) (Figure 2) is separated from other taxa on the presence of a single distal aesthetasc (Figure 3) and coxal plates whereas the identification guide is based on the shape of the telson. Another constraint is seasonality. For example, the Tasselweed *Ruppia cirrhosa* can only be identified with confidence in late summer when it is in flower. Consequently, most records of Tasselweed are recorded as *Ruppia* sp?.

Although there have been many surveys that included biological sampling, specimens have not been retained for comparison (BMT Cordah

Species	Notes
Plants	
<i>Chaetomorpha linum</i> (Müller) Kützing, 1845	A distinct form found in sheltered sites Bamber <i>et al.</i> (2001a)
<i>Cladophora battersii</i> Hoek, 1963	Only listed in Roden (1999)
<i>Chara baltica</i> Bruzelius, 1824	
<i>Chara canescens</i> Loiseleur-Deslongchamps, 1810*	
<i>Chara ?connivens</i> Salzmann ex Braun, 1835	Only listed in Oliver (2005)
<i>Lamprothamnium papulosum</i> (Wallroth) Groves, 1916*	
<i>Tolypella nidifica</i> (Müller) Leonhardi, 1864	
<i>Ruppia maritima</i> Linnaeus, 1753	
<i>Ruppia cirrhosa</i> (Petagna) Grande, 1918	
Cnidaria	
<i>Pachycordyle navis</i> (Millard, 1959)*	
<i>Gonothyraea loveni</i> (Allman, 1859)	Unlikely specialist as it is also found sub-tidally to 200m
<i>Edwardsia ivelli</i> Manuel, 1975*	Probably extinct.
<i>Nematostella vectensis</i> Stephenson, 1935*	
<i>Cordylophora caspia</i> (Pallas, 1771)	
Annelida	
<i>Armandia cirrhosa</i> Filippi, 1861*	
<i>Alkmaria romijni</i> Horst, 1919 *	
<i>Ficopomatus enigmatus</i> (Fauvel, 1923)	Also common in estuaries/low salinity.
<i>Hediste diversicolor</i> (O.F. Müller, 1776)	Also common in estuaries/low salinity.
Crustacea	
<i>Cyprideis torosa</i> (Jones, 1850)	Only listed in Bamber (2001a)
<i>Gammarus chevreuxi</i> Sexton, 1913	
<i>Gammarus insensibilis</i> Stock, 1966*	
<i>Allomelita pellucida</i> (Sars, 1882)	Only listed in Oliver & Healy (1998)
<i>Leptocheirus hirsutimanus</i> (Bate, 1862)	Tentative record, Healy (1994)
<i>Monocorophium insidiosum</i> (Crawford, 1937)	
<i>Cyathura carinata</i> (Kroyer, 1847)	Tentative record, Healy (1994)
<i>Lekanesphaera hookeri</i> (Leach, 1814)	
<i>Jaera nordmandi</i> (Rathke, 1837)	Oliver & Healy (1998)
<i>Idotea chelipes</i> (Pallas, 1766)	
Mollusca	
<i>Rissoa membranaea</i> (Adams, 1800)	Lagoonal variety, Oliver and Healy (1998)
<i>Littorina saxatilis</i> (Olivi, 1792)	Brackish ecotype, previously <i>Littorina tenebrosa</i>
<i>Onoba aculeus</i> (Gould, 1841)	
<i>Hydrobia acuta neglecta</i> Muus, 1963	
<i>Ecrobia ventrosa</i> (Montagu, 1803)	
<i>Caecum armoricum</i> de Folin, 1869	
<i>Haminoea navicula</i> (da Costa, 1778)	
<i>Tenellia adspersa</i> Nordmann, 1845*	
<i>Cerastoderma glaucum</i> (Bruguière, 1789)	
Bryozoa	
<i>Conopeum seurati</i> (Canu, 1928)	
<i>Victorella pavidia</i> Saville-Kent, 1870*	
* plants and animals currently protected under schedules 8 and 5 (respectively) of the Wildlife & Countryside Act, 1981	

Table 1: Specialist Lagoon Species after Barnes (1989a), Davidson *et al.* (1991), Oliver & Healy (1998), Healy (1982, 1994), Bamber *et al.* (1992, 2001a). All taxonomic names follow the World register of marine species (WoRMS).



Fig. 4: *Hydrobia acuta neglecta*, one of NMS.Z.2012.70 Anne's Point, Strangford Lough, coll. R Anderson 17th June 2012 (Image Bill Crighton, NMS)

2004; Thorpe *et al.* 1998). Without access to survey samples it is impossible to verify the records and confirm presence at particular localities. An example of this dilemma is hydrobiids, a group of mud snails, which have

been studied extensively by Barnes and others. (Barnes 1991, 1993, 1996, 1999, 2005; Barnes & Gandolfi, 1998; Bishop 1976; Fish & Fish 1981; McArthur 1998).

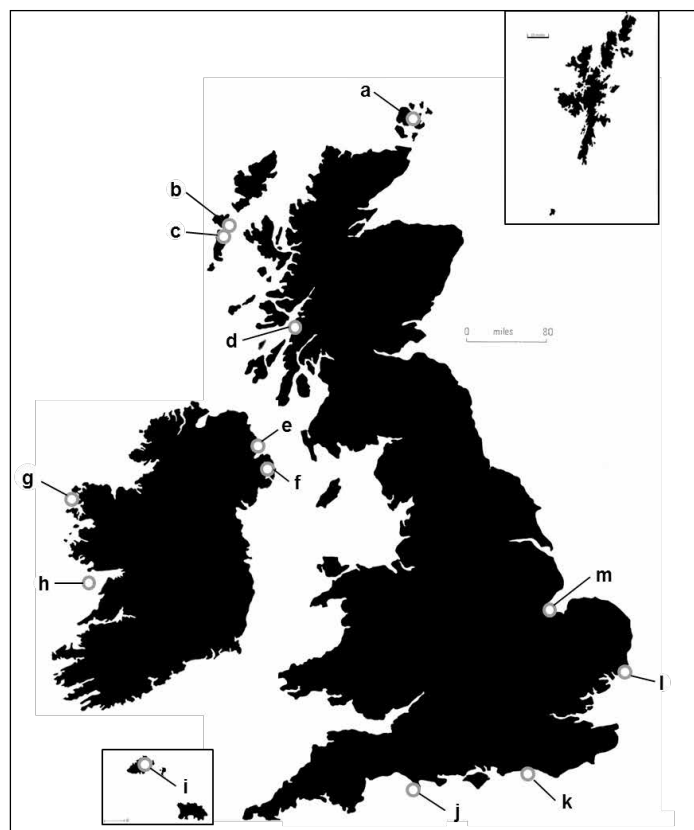


Fig. 5: Map of known *Hydrobia acuta neglecta* specimens in museum and personal collections. (see Table 2 for key)

Fig. 5 Ref.	Location		Accession Number	Preservative	Collector
Scotland					
a	Oyce of Isbister	Orkney	NHM	Dry shells	
b & c	Loch an Dùin Loch an t-Sruith Mhoir Oban a’ Chlachain	North Uist	NMS.Z.2011.71	99% ethanol	SNH/NMS
	Loch nam Madadh lagoons Oban a’ Chlachain	Uists	NMS.Z.2013.34	75% denatured alcohol & 99% ethanol	SNH/NMS
	Loch Euphort lagoons Loch Bì				
	West Loch Bì	South Uist	NMS.Z.1970.26.11101	Dry shells	R Waterston
	Pool NW of Gashernish	South Uist	NMS.Z.1998.26.14	75% denatured alcohol	? R Covey
d	Seil Island	Argyll	NMS.Z.1999.9.105	75% denatured alcohol	? R Covey
Ireland					
e	Islandmagee	Antrim	MN806		
f	Ann’s Point, Strangford Lough	Down	NMS.Z.2012.70	99% ethanol	R Anderson
g	Leam Lough	Mayo			J Nunn
h	Inishmore	Galway			J Nunn
Channel Islands					
i	Baie de Pulias	Guernsey	NHM	75% denatured alcohol	
	Pulias Pond, St. Sampson	Guernsey	LEEDM.C.1993.1.1	Dry shells	
England					
j	Fleet Lagoon	Dorset	NMS.Z.2001.111.1	75% denatured alcohol - poor condition	
k	Littlehampton	W Sussex	NHM	75% denatured alcohol	R Bamber
l	Aldeburgh Marshes	Suffolk	UMZC I 67192 NHM 2258	75% denatured alcohol	Bishop
m	Wyberton Marsh	Lincs	UMZC I 67192	75% denatured alcohol	
	Shingle Street	Suffolk	Genbank AF 278817.1		Wilke

Table 2: *Hydrobia acuta/neglecta* specimens held in museums or other institutes. NMS=National Museums Scotland, Edinburgh; NHM=Natural History Museum, London; LeedM=Leeds; UMZC=University Museum Zoology Cambridge; MN = Ulster Museum, Belfast.

There are 5 British Hydrobiids (Anderson 2008), all usually smaller than 5 mm and difficult to identify on shell shape alone. The 4 species frequently mis-identified are *Potamopyrgus antipodarum* Grey, 1843; *Ecrobia ventrosa* (Montagu, 1803), *Hydrobia acuta neglecta* Muus, 1963 and *Peringia ulvae* (Pennant, 1777). The distribution of specialist lagoon species *H. acuta neglecta* (Figure 4) is of particular interest for taxonomic research.

Identification guides are based on the shell characters, tentacle patterns and more recently penis shape. The tentacle patterns and penes are best observed in living specimens. Hydrobiid records have been published in the *Atlas of the Land and Freshwater Molluscs of Britain and Ireland* (Kerney, 1999), but specimens associated with Kerney's Humber and Ayrshire records have yet to be located. The National Biodiversity Network (www.nbn.org.uk).

org.uk) records are based mostly on sightings and may not have an associated specimen available for examination. There are only 17 locations from which specimens have been verified (Table 2, Figure 5).

Apart from the recent samples collected from North Uist and Ireland, most identifications are based on preserved dead specimens or dry shell characters. Many records need to be re-examined as shell characters alone are inadequate for identification, and often the soft tissues are not completely preserved and of little value. Identification is greatly enhanced if specimens are examined alive when the tentacles and head characters are easily visible. For subsequent examination of preserved specimens the shell needs to be cracked pre-preservation to allow penetration of formalin for complete fixation of tissue. The absence of well preserved, verified specimens available for examination means the distribution of *Hydrobia acuta neglecta* in the British Isles is largely unknown.

In 2011 and 2012 SNH commissioned two surveys to North Uist lagoons to collect specimens of *H. acuta/neglecta* and other lagoon specialist taxa (Chevalier *et al.* 2014; Howson *et al.* 2014) to provide well-preserved and documented specimens with georeferenced data. The specimens have been deposited at the National Museums Scotland. The presence of *H. acuta/neglecta* in the Outer Hebrides was confirmed.

Comments

As well as the type of barrier and their ephemeral nature, the physical and biological characters of lagoons are variable; temperature, salinity, acidity and species composition vary over time and location. Consequently, lagoons are not uniform but individual physiographic habitats which host rare species of significant conservation value (Bamber 1997). However, lagoons do not fit neatly into categories for the Water Framework Directive as a water body for monitoring as they are naturally variable and may even disappear due to natural causes or human impact (Bamber 2010). Government country agencies are responsible for biota surveillance and policy development. Planning

to monitor changes becomes futile without verifiable baseline information and knowledge of uniqueness.

Next steps

Specimens of all lagoon specialist taxa are required to obtain accurate data on their current distribution this would include all Crustacea, Polychaetes, *Cerastoderma* and *Ruppia* spp. If you collect any specimens, after obtaining relevant permissions, please keep them cool and damp and send to the above address.

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Appendix 1: List of UK lagoon sites designated as Special Areas of Conservation

Country	SAC Site Name	Local Authority
England	Benacre to Easton Bavents Lagoons	Suffolk
	Chesil and the Fleet	Dorset
	Dungeness	East Sussex; Kent
	Humber Estuary	City of Kingston upon Hull; East Riding of Yorkshire; Lincolnshire; North East Lincolnshire; North Lincolnshire
	Minsmere to Walberswick Heaths and Marshes	Suffolk
	Morecambe Bay	Cumbria; Lancashire
	North Norfolk Coast	Norfolk
	Orfordness - Shingle Street	Suffolk
	Solent and Isle of Wight Lagoons	City of Portsmouth; Hampshire; Isle of Wight
	Solent Maritime	City of Portsmouth; City of Southampton; Hampshire; Isle of Wight; West Sussex
	The Wash and North Norfolk Coast	Lincolnshire; Norfolk
England & Wales	Dee Estuary/ Aber Dyfrdwy	Cheshire; Sir y Fflint/ Flintshire; Wirral
Northern Ireland	Strangford Lough	Down
Republic of Ireland	Durnesh Lough	
	Ballyteige Burrow	
	Carrowmore Point to Spanish Point and Islands	
	Clew Bay Complex	
	Connemara Bog Complex	
	Drongawn Lough	
	Farranamanagh Lough	
	Galway Bay Complex	
	Gweedore Bay and Islands	
	Inishbofin and Inishshark	
	Inisheer Island	
	Inishmore Island	
	Kilkeran Lake and Castlefreke Dunes	
	Kilkieran Bay and Islands	
	Lady's Island Lake	
	Lough Cahasy, Lough Baun and Roonah Lough	
	Lough Swilly	
	Lower River Shannon	
	Mweelrea/Sheeffry/Erriff Complex	
	Rutland Island and Sound	
	Slyne Head Peninsula	
	Tacumshin Lake	
	Termon Strand	
	Tory Island Coast	
	Tralee Bay and Magharees Peninsula, West to Cloghane	
Scotland	Loch nam Madadh	Western Isles / Na h-Eileanan an Iar
	Loch of Stenness	Orkney Islands
	Loch Roag Lagoons	Western Isles / Na h-Eileanan an Iar
	Obain Loch Euphoirt	Western Isles / Na h-Eileanan an Iar
	South Uist Machair	Western Isles / Na h-Eileanan an Iar
	Sullom Voe	Shetland Islands
	The Vadills	Shetland Islands
	Yell Sound Coast	Shetland Islands
Wales	Bae Cemlyn/ Cemlyn Bay	Ynys Môn/ Isle of Anglesey
	Cardmarthen Bay and Estuaries/ Bae Caerfyrddin ac Aberoedd	Abertawe/ Swansea; Caerfyrddin/ Carmarthenshire; Penfro/ Pembrokeshire
	Pembrokeshire Marine/ Sir Benfro Forol	Penfro/ Pembrokeshire
	Pen Llyn a'r Sarnau/ Llyn Peninsula and the Sarnau	Ceredigion; Gwynedd; Powys

Metabarcoding has come to town: Will we lose sight of our marine invertebrate fauna?

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Barcoding

Over the last decade DNA barcoding has fast become an important identification tool for the invertebrate taxonomist and ecologist. A quick search on the internet will reveal a plethora of sites and publications explaining how barcoding works and where it has been applied. In short, for animals, this most commonly involves sequencing a portion of the mitochondrial genome (mostly the cytochrome c oxidase subunit 1 gene, also known as COI or Cox1). COI (which represents about 7% of the mitochondrial genome) is presumed to vary between species but has limited within-species variability and so can be used as a species-specific marker (Hebert *et al.* 2003). Sequences for individual specimens are uploaded to a public database (e.g. GenBank, BOLD) and the specimen (from which the barcode has been produced) is archived as a 'voucher'. Future workers can then match sequences from their own specimen to those on the database and so determine its identity. Although the COI gene was first proposed for the barcode, alternative regions of the genome are also used in environmental studies.

The advantages of using genetic material like this for identification are that methods are standardized and results are objective. The problems posed by morphological variability and observer subjectivity, which sometimes frustrate species identification by microscopy, are eliminated. Barcoding technology means that non-specialists, sometimes working in remote areas, can quickly and accurately identify a species (Hayden 2015) and so speed up the process of building inventories and recording biodiversity before it disappears. Moreover, genomic analysis can account for damaged or partial specimens, polymorphic species, different life stages

and sexual dimorphism, all of which can be problematic or impossible to deal with using 'traditional' methods. It can also play a part in distinguishing cryptic species (Nygren & Pleijel 2010) which would be missed by most people and even perhaps by professional taxonomists.

Metabarcoding

As with computing, technological advances in genomics have been extremely rapid. Whole genomes (let alone portions of mitochondrial genes) can now be determined in hours rather than days. With this advance has come the advent of metabarcoding (alternatively referred to as ultrasequencing, metagenetics, next-generation sequencing, high-throughput sequencing, massively parallel sequencing or pyrosequencing). Here, instead of just one specimen, whole samples containing DNA from many species can be analysed to create a list of gene sequences. These can then be matched up with previously determined sequences from the databases to produce a species list, or at least a partial list, with any remaining unassigned sequences presented as operational taxonomic units (OTUs). OTUs can be thought of as labels for undescribed taxa. The ultimate goal is to have all species individually barcoded, so that any sample taken in the field can be objectively deconstructed into its component species in a standardized way. However, at the moment, only a small proportion of sequences can be matched up in this way, making its application problematic in poorly known habitats or regions. For more detailed reviews see Cristescu (2014) for an introduction to applications, Bourlat *et al.* (2013) for a marine monitoring perspective and Shokralla *et al.* (2012) for a review of the various gene sequencing platforms.

Needless to say, metabarcoding has advantages which encompass those already mentioned above for single specimen barcoding, but it also vastly increases the taxonomic scope and power of biological investigations. Environmental samples are not restricted to one component of the biota (e.g. macroinvertebrates or meiofauna), but can be 'scanned' for a wide

range of eukaryote (and prokaryote) sequences to give a much more extensive coverage (Coward *et al.* 2015; Lallias *et al.* 2014). The technology can also be harnessed to analyse animal diets, to search for targeted rare, endangered or invasive species by detecting DNA released into the environment (Bohmann *et al.* 2014), or to investigate food safety or forensic samples.

Although metabarcoding protocols are complex, highly technical and computationally demanding, the degree of automation and the availability of suitable algorithms, means that any well trained laboratory assistant will be able to analyse any sample from anywhere in the world and produce a list of OTUs (Yinqiu Ji *et al.* 2013). This is potentially cheaper and quicker than a traditional analysis and so highly attractive to financial executives of companies that are required to conduct environmental surveys. Even if OTUs have not been assigned to any known species they could still be used as some form of baseline in an environmental assessment, as any follow-up survey, analysed in the same way, will show changes in the presence or absence of the OTUs and hence changes in species richness. The OTUs are amenable to some of the standard statistical tools that are currently used in describing and analysing animal communities.

Not all is sweetness and light. For instance, there are potential taxonomic problems when a sequence in the online database is not associated with any voucher specimen, if the voucher itself has been misidentified or if the sequence is of poor quality. Erroneous 'COI-like' sequences may be present in the databases (Buhay 2009). Also, the commonest marker used for animals (the mitochondrial COI gene) is not universally applicable across the whole animal kingdom (for example, nematodes are best analysed using part of their nuclear DNA - Bhadury & Austen 2010), and so multiple sequencing protocols may have to be applied to the same sample for the analysis to be comprehensive. The chosen markers are amplified via primers in a PCR (polymerase chain reaction), but the selection of primers

can result in amplification biases and problems of interpretation (Deagle *et al.* 2014). Platforms that do not use PCR are being developed (for example Pacific Biosciences SMRT technology and the Oxford Nanopore Technologies reported in Hayden 2015) but will these newly produced sequences be exactly analogous to the ones produced by earlier technology?

There are also unresolved complications underlying the theory (Rubinoff, Cameron & Will 2006) such as the increasing discovery of heteroplasmy and the nuances of species delimitation. Heteroplasmy occurs where one individual has more than one type of mitochondrial DNA. This occurs through various mechanisms such as doubly uniparental inheritance seen in bivalves (Plazzi, Cassano & Passamonti 2015), introgression (Nydam & Harrison 2011), recombination (Tsaousis *et al.* 2005), or pseudogenes (Schizas 2012). The extent and effect of these phenomena are not known for the majority of marine taxa.

Exactly how species are delimited using metabarcoding sequence data is still under discussion. Defining species on the basis of one particular small part of the genome from only one or two individuals is unlikely to be sufficient for taxonomic purposes, but is, in effect, standard practice for barcoding. When distance measures are used (common practice), where is the dividing line between interspecific and intraspecific variation (DeSalle, Egan & Siddall 2005) and how does this vary across taxa? Delimiting species on barcode data (Blaxter *et al.* 2005) could rapidly create a confusing disconnection between OTUs and formally described species, as new OTUs outpace the rate of species description.

Environmental assessments and genomics

Despite all this, there is no doubt that single specimen barcoding and "whole" sample metabarcoding have been important in reforming the way in which biological communities can be analysed and quantified, and genomic methods will continue to develop. But, there is a sense in which we might be dazzled by the bright lights of technology

and become blind to other aspects of ecology. In what follows, I have in mind the surveys undertaken by commercial organizations as baseline or follow-up surveys for marine developments, license applications etc. on the continental shelf, but the comments may very well apply in other areas of ecology. These surveys have been conducted for many years in the traditional way where seabed samples are analysed by teams of expert technicians producing data that feed into an interpretive report of the benthic ecology in the study area. Although it can be time consuming and labour intensive to produce, the dataset enables some kind of assessment of recent past events and a prediction of the effects of going ahead with the planned development. Metabarcoding is essentially a listing and searching tool and so can lose some of the subtleties that are often required for sensible interpretation. At the moment it cannot provide abundances (population data) or biomass data, nor can it distinguish between different life-stages, all of which can be very helpful, if not essential, for investigating the processes on the seafloor. For example, were there a few larvae, a large spatfall or some to many adult bivalves in the survey area? Does the presence of a *Sabellaria* sequence indicate a reef that was not seen on sonar or camera? A list of mitochondrial gene sequences cannot answer these kinds of questions and has, in effect, lost sight of ecological processes.

These examples show how ecological insights may be lost, but the extreme sensitivity of sequencing will invariably result in many information gains. These appear in the form of taxa that are not usually taken into account, are unidentifiable or are sometimes missed by traditional methods. Most of these will be unassigned OTUs (at least until the libraries of sequenced species become more comprehensive). For instance, in a study of *Zostera* bed fauna, Cowart *et al.* (2015) uncovered many more frequencies of arthropods, molluscs and annelids (using two genetic markers) than were found in previous morphology-based surveys. However, the

nature of these additional OTUs surely needs further investigation. What exactly do they represent? Are they parasites, eggs, gut contents, faeces or barcoding artefacts?

Furthermore, how old is the DNA? The seabed is a dynamic environment and the sediment, boundary layer and overlying water are presumably awash with DNA. If this 'zombie' DNA is relatively stable in post mortem remains the sample could contain information from places and times not relevant to the area under study. The original, carefully targeted sample has then lost its spatial and temporal focus.

Only relatively small volumes of homogenised sample can be sequenced. The animals from, a Hamon grab sample, for example, must therefore be sieved, picked from the sediment (or otherwise separated) and scraped off the cobbles before being homogenized, all without sample cross-contamination (Leray & Knowlton 2015). Large animals may have to have parts removed in order to add to the mix. This could be quite a time consuming operation and is perhaps one of the unspoken reasons why marine metabarcoding studies have focused recently on meiofauna (e.g., Creer *et al.* 2010, Fonseca *et al.* 2014, Lallias *et al.* 2014).

Meiobenthologists have long advocated the use of this taxonomic subset in environmental monitoring but have had little success, despite its theoretical advantages, because of the perceived difficulties in the taxonomy. The small volume meiofauna samples are more amenable to standardized extraction techniques and provide a more convenient input for sequencing machines. However, although meiofaunal sampling is relatively straightforward in fine sediments it is not so easy to obtain a good sample from gravel and cobble substrata. From a barcoding point of view it is more difficult to produce a species barcode of a meiofaunal voucher specimen because of the technical difficulties of first identifying it, and then removing part of the animal for sequencing without diminishing its value as a voucher. Sequencing the whole animal and lodging digital images has been proposed for nematodes but is unlikely to be

sufficient for all meiofaunal taxa. “Paratypes” could be lodged in support of the sequence data but these are not always available (see below). The task of populating a database of named sequences therefore becomes more difficult and comes up against the problem of a meiofaunal ‘taxonomic impediment’ (a term used to show that there are insufficient taxonomic resources to swiftly discover, describe and name all remaining unknown species (Mora *et al.* 2011). Meiofaunal metabarcoding studies are less likely to be able to identify described species and, because of the small mesh sizes used, will also be more likely to include other environmental DNA from miscellaneous sources leading to the loss of focus mentioned above.

This brings me to the title of this piece. As metabarcoding is destructive, any undescribed species will be rendered only as a sequence, making it impossible to know what it looked like other than by reference to a higher or related taxon. In deeper waters, away from the continental shelf, much of the benthos is small or meiofaunal and mostly undescribed. In surveys many species are often only represented by single specimens. If these singletons have been homogenized they will be lost to science, save for a sequence of a small fraction of their genome giving a rough idea of what they were.

It is possible to imagine a scenario in the near future where all non-academic surveys are analysed by gene sequencing laboratory technicians and bioinformaticians who never see the animals on the seabed or have much idea of the ecology. Developers are unlikely to pay for individual barcoding, which means that only ‘biodiversity soup’ will be analysed. The taxonomic technicians, who would usually sort, identify and curate the specimens (and wherever possible work in conjunction with museum taxonomists), would no longer be required and an important part of the taxonomic community would have disappeared. And, as metal prospecting and oil companies venture into unknown areas of Arctic shelves, mid-ocean ridges and abyssal plains, a metabarcoding approach will mean

that we could literally lose sight of this “new” fauna. The traditional sampling and analysis would at least mean that specimens are kept for future study, even though they might remain, and be treated as, unofficial, provisional taxa in environmental reports (Schindel & Miller 2010). Metabarcoding is a powerful tool for species identification where comprehensive, good library sequences exist, but it is not always the right approach for investigating ecological interactions.

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Lost Islands: Hy Brasil and the Porcupine Bank

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There are many islands in the North Atlantic including, for instance, the Bahamas, the Cape Verde Islands, the Canaries, Madeira and the Azores as well as the less prominent Rockall and the even more obscure St. Paul's Rocks, a shipping hazard situated almost exactly at the equator in the mid-Atlantic, consisting of a few pinnacles rising to only eighteen metres above sea level and famously visited by Charles Darwin aboard the *Beagle*.

Phantom islands are equally common. Most prominent is Atlantis, described by Pliny and others; there is Ultima Thule, which is possibly Iceland; and the often recorded Island of St. Brendan, generally placed off the North African coast and discovered during the saint's seven year voyaging. But there are many more. They mostly derive from the unverifiable reports of ancient mariners who,

sailing only by latitude and the stars, could not pinpoint precisely where they had been. Early cartographers filled their maps with the satanic beasts and horrific or idyllic landscapes the sailors fancifully described.

Some spectral islands carried sufficient conviction to make their way onto Admiralty charts even up to the nineteenth century (Stommel 1984). Five of the six islands of the North Atlantic charted by the British Hydrographic Office may be listed as Fonseca Island, False Bermudas, Green Island, Mayda Island, and Jaquet Island, the last of which was an island believed to exist even into the 1850s, when cartographers discussed it as a possible midway point for the transatlantic telegraph cable. Finally and particularly, Hy Brasil was said by some sources to be found at around 51°N and at several declared distances off the west coast of Ireland. As we shall see, the shallowest part of the Porcupine Bank off the Irish coast is at 53° 22'N.

The mythical island of Hy Brasil, named well before the country of Brazil, has a long and distinguished history. It was mentioned in

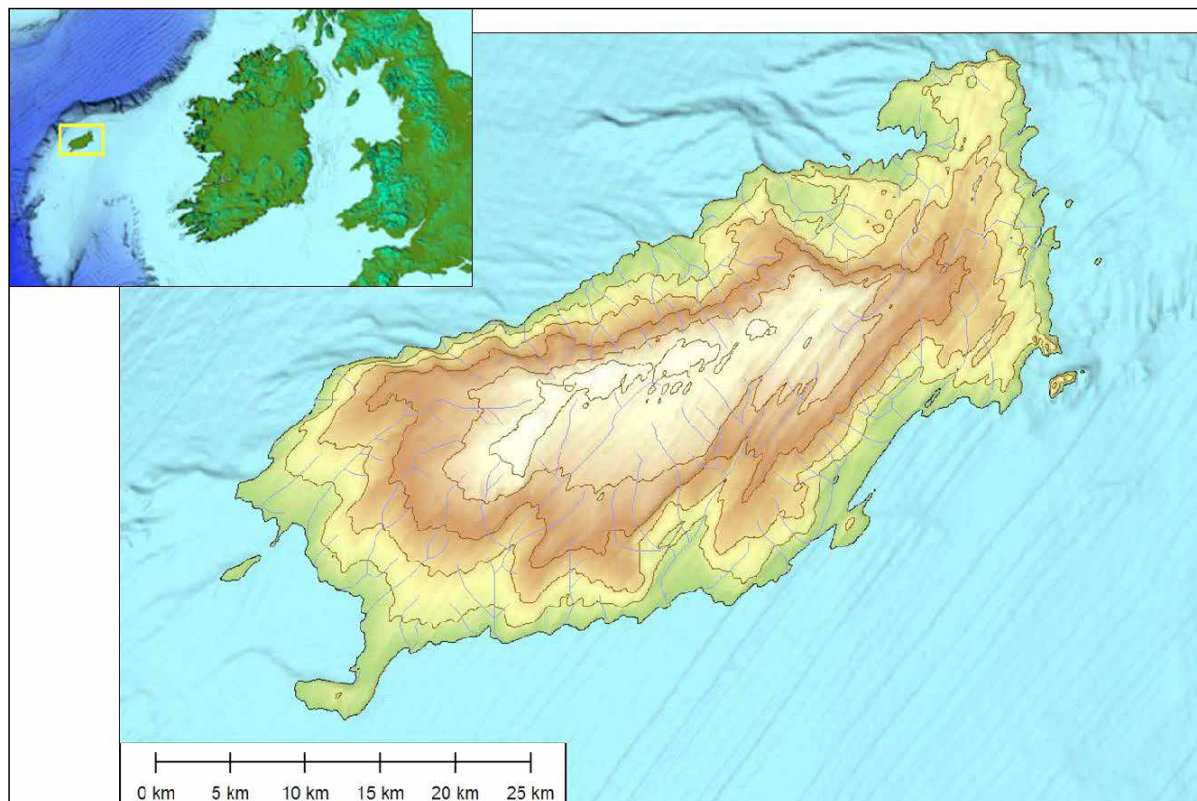


Fig. 1: Hy Brasil realised by dropping sea level 180 m over the crest of the Porcupine Bank (NE-SW stripes in the topography are bathymetric acquisition artefacts)

writing in around 1100 and has appeared on many maps since its first portrayal on a portolan chart of 1325. Men claimed to have landed on it and to have met its inhabitants. It was variously reported as appearing only once every seven years; that it was shrouded in mist; and, that it was visible from time to time from the Irish mainland. A reasonably accurate map of the coasts and seas of north Europe published in 1634 by Le Sieur Tassin, Royal Geographer to King Louis XIII, showed Hy Brasil about the same distance offshore as Rockall, which later he plotted correctly (Frazer 1879). There is a book in the library of the Royal Irish Academy called the Book of O'Brasil that is supposed to have been brought in 1668 from the legendary island. But as the years passed and the island's existence became more nebulous its charted outline, as is the way with phantom islands, gradually grew smaller, reducing from a substantial circular figure with a central rift or river crossing it, until by 1865 it had dwindled to a spot labelled merely Brasil Rock. Its last appearance in an Admiralty publication was in a chart of 1850.

Islands are of course dependent on sea level, which varies over the long term. Columbus attempted to take a sounding of the ocean during his first transatlantic voyage but, failing to find bottom, concluded he had reached the deepest part of the Atlantic, unsurprisingly without finding an island. The first real sounding in the deep ocean was taken in 1840 at 27°N in the Atlantic by Sir James Clark Ross, aboard Her Majesty's ships *Erebus* and *Terror* on their way to the Antarctic continent. The depth they found of over four thousand metres is typical of the abyssal plain, occupying most of the floor of the three great oceans of the world, where islands are rare but not unknown.

In the shallower waters of the continental shelf we find, twenty years later, the little naval survey ship, HMS *Porcupine* working off the south west coast of Ireland, searching for a new and less precipitous route for the latest transatlantic cable. *Porcupine* was a naval surveying ship that had spent much of her life in the North Sea. She was a remarkably undistinguished vessel, a wooden two masted brigantine-rigged paddle gun-ship, a hundred

and forty feet long and built in Debtford in 1844 (Rice 1986). Her primitive engine had served in two previous vessels. But she was a good sea boat and well equipped for her surveying work. In fact she had been sent to the Baltic during the Crimean War to prepare charts for the arrival of our war fleet there. It was in 1862 while surveying for the transatlantic cable under the captaincy of Commander Richard Hoskyn (Fisher 1956) that she discovered the shallow bank which is named after her, the Porcupine Bank. She made a landing on Rockall in the same year and she was later to be the first ship, under the command of Captain Edward Calver, to bring up living creatures from the abyssal plain (Davis 1982).

Myth and fact combined together on the Porcupine Bank with the suggestion that its shallowest point represented a recently submerged Hy Brasil. As early as 1870, a paper was read to the Geological Society of Ireland by Mr. W. Frazer proposing a connection between the two (cited by Winsor (1889)). The idea has since reappeared more than once, e.g. in an 1883 edition of *Notes and Queries* when "shells of the common periwinkle", an intertidal mollusc, were dredged up from the Bank (Frazer 1883) and in various more recent considerations, e.g. Johnson (1994), Hancock (2002), Freitag (2013) and see Wikipedia. However, it was not fully understood that the minimum depth of a hundred and fifty metres and the seismic inactivity of the Bank make unlikely the claim that it could have been exposed above sea level in historical times. It is, however, the type locality of the little sea porcupine, *Thalassiohystrix scuba*, the mascot of the Porcupine Marine Natural History Society. (Thalassa = sea (Greek); hystrix = porcupine (Greek); scuba = self-contained underwater breathing apparatus (English)).

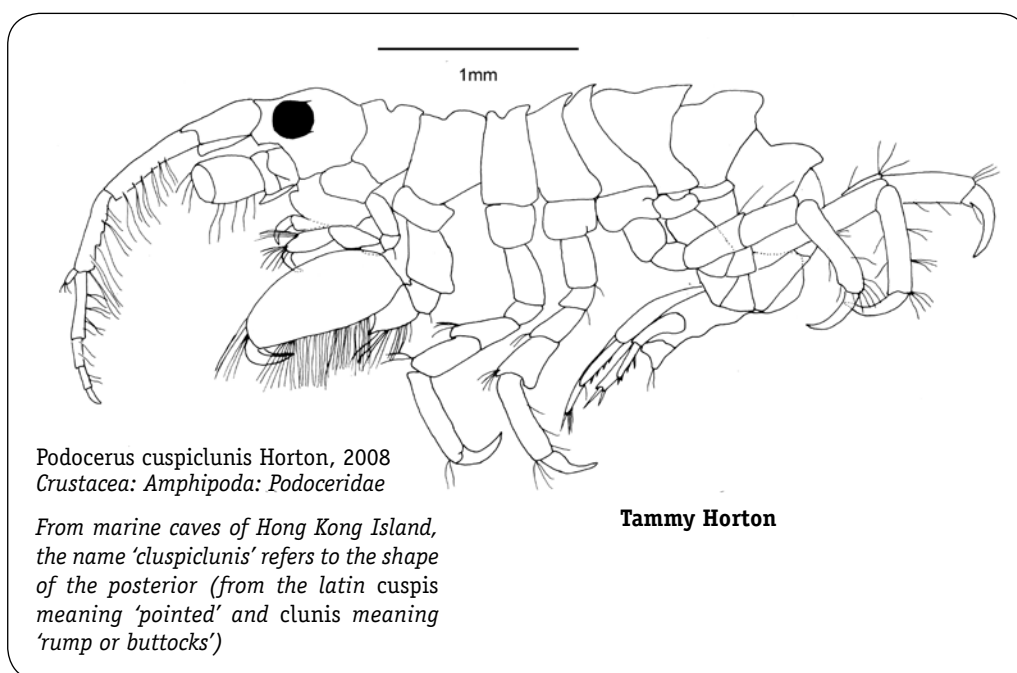
Finally, it is interesting to speculate what Hy Brasil might have looked like if the legends were true and based on a remembered exposure of the Porcupine Bank during a sea level minimum. A realisation of such a Hy Brasil can be created by taking detailed digital bathymetric data and artificially lowering sea level using appropriate mapping software. The bathymetric data set used is one released

into the public domain by the Geological Survey of Ireland (Geological Survey of Ireland Interactive Web Data Delivery System <https://jetstream.gsi.ie/iwdds/map.jsp>). This is very high resolution with depth values posted every 0.001° in both east-west and north-south directions. At the latitude of the Porcupine Bank, this equates to bathymetry values roughly every 68m east-west and 111m north-south. The source of the data is not explicit, but clearly derives from a towed side-scan sonar device. Acquisition “stripes” are discernible on the images derived from the data.

Tests were run to see what would happen at different sea level states. Artificially dropping sea level by 180 m gave a good result and created a land mass roughly 62km long and 23km wide located over the crest of the bank, centred at approximately 53° 22'N, 13° 48'W, 235km west of the Irish mainland. The created island has a NE-SW orientation and rises to an elevation of 29m above the notional sea level. If terrestrial map shading, contours, and streams following the valleys are added, a very plausible-looking island is created (Figure 1). Welcome to Hy Brasil.

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C. T. Canon writes:

Roger Bamber and I have been closely related, indeed hard to tell apart, for many years. At his passing I was pleased to discover that I was able to retain communication with him through a "Stipe" telephone programme, which uses the ethereal algorithm "*Laminaria*". He tells me that while crossing the Styx in the surly care of the ferryman Charon he was surprised to note that at the point of the crossing the river was tidal. He resolved on landing on the far shore to make an immediate search for pycnogonids. However, his plan was frustrated when he encountered a large and unwelcoming dog, which gave its name as Cerberus.

Fearing attack, Roger threw the dog a sop by offering to classify the brute. Something in the proposal must have softened the dog and won its favour for it grumpily allowed Roger to approach more closely. It probably knew that Roger had set himself an impossible task. Cerberus's family tree resembles a jungle; its mother was Echidne and its sister was Hydra. Moreover its back bore clusters of serpent heads. If ever there was a case for the postulation that genetic material is occasionally transferred between animals that are not closely related this was it.

But the way being clear Roger was able to make his way into Hades which he found to be a more agreeable place than he had been led to believe. There were several pubs that looked possible, bearing such names as "Ye Olde Fag Packet", "Blue Haze" and similar welcoming signs. He was pleased to notice in the distance the massive walls of a nuclear power station. My kind of electricity, he told himself.

On several occasions since his arrival I have been able to contact him and each time I have found him sitting cheerfully surrounded by about twenty hearty companions in one or other of the aforementioned hostelrys, all of which serve proper brown ale and all showing notices announcing "Newcastle Brown Ale not served here" with such additions as "Don't ask" and "Newky Brown, no thank you".

I enquired of him whether there was a monetary system in Hades and he assured me there was and that he had taken advantage

of it by starting a consultancy for the decommissioning of several nuclear power stations. It was a lucrative and highly skilled task, he assured me, although his solution was always one he had suggested to me many years ago, namely to close the station down internally, walk out and lock the door, job done.*

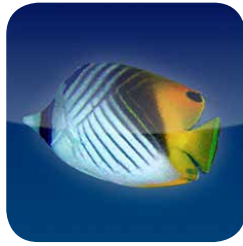
He has now befriended Cerberus and throws pycnogonids for him to catch. Roger has not reached a taxonomic conclusion for Cerberus but has provisionally placed him in the family Canidae with the proposed generic name *Cannotnine*.

I have temporarily lost contact with Roger. The Stipe programme is currently not working, I understand because the *Laminaria* algorithm is under revision, the growing season having come to an end.

*This is the only shaky fact in an otherwise truthful account. Or else the other way round.

FischFinder APP.

Reviewed by Frances Dipper



I have never reviewed an 'app'. In fact I had never used one before downloading this one onto an iPad. Perhaps not surprising since my mobile phone can only phone people. Perhaps, though, it's time to change all that. I think I'm hooked – not on this particular app but on new technology. I even have a twitter account now (@FrancesDipper). So back to the FischFinder – the spelling is intentional (I think). It was originally produced in German and one of the six sections (Knowledge) has yet to be translated but will be soon.

The instructions (found in the Information section) are easy to follow and the first sentence says: "FischFinder offers the possibility of identifying marine animals by appearance, taxonomy, name or via the search for word parts". Actually it's mainly fish, hence my interest. So I tried it out to see if this was the case. Firstly there is indeed a TAXONOMY button. Press it and you get a list of the animals covered, using the English group names. There are 26 taxonomic groups, including invertebrates such as flatworms as well as mammals and of course fish. However, most of these have just a very few species (sensibly) whereas 'Bony fishes' has 620 and 'Cartilaginous Fishes' has 44. Click on 'Bony Fishes' and you get 12 groups (orders). 'Cads and Hakes' amused me, meant of course to be 'Cods and Hakes'. 'Perch-like Fishes' or Perciformes naturally contains the majority of species (I knew that but perhaps beginners might wonder). Within that is a further list of 41 families, arranged as with the other lists, alphabetically using the English names – Angelfish come first and Wrasses last. So going in this way you need to know already what SORT of fish you are trying to identify

e.g. Butterflyfishes. So far so good. Click on butterflyfishes for a list of 55 species. There are over 120 species but the common ones (and some rarities) are shown. It should be fairly easy to identify which butterfly species you saw or photographed after your tropical dive. Finding out more about the animal would be more difficult as the information given is basic and this applies for all species in the app.

So let's try the other route in through SEARCH. Type in 'wrasse' and you get a list of 21 species (there are over 450 species worldwide). In 'Search' you can also filter for 9 different regions. So I tried this and blocked out all regions except the North Sea. It gave me all 21 species but only two in the list are found there. So that function is clearly not yet working fully. Searching for 'butterflyfishes' gave no results, for 'butterfly fishes' the same, 'butterfly fish', still nothing. What it wanted was 'butterflyfish'. Again the filter (I tried Red Sea) didn't work. I also tried 'codfish', 'cod fish', Gadidae and 'codfishes' and only 'cod' produced anything – that was rather confusingly a juvenile cod which looks nothing like the adult of course. This is odd since under 'Cads and Hakes' (!) there are two



groups, 'codfishes' and 'cod-like fish'. Even 'Cads' produced nothing. So there are some glitches to be rectified.

The app is also supposed to allow us to identify marine animals by appearance, presumably through the 'Search' option. So I tried 'red fish', 'red fishes' to no avail and finally just 'red' which produced a short list of animals with 'red' in the name e.g. Red Sea Goatfish and Red mesh starfish.

So what do I think? On the plus side the photographs are almost all top quality and I was happy just flicking through and enjoying a lot of these. It only costs £2.99 and for the groups of fish that are covered well, it could be a useful supplementary identification guide especially if the region filter worked (perhaps it's just me doing it wrong). It would not be easy to identify a fish totally unknown to the user, so might not be so good for beginners. I suspect that the species included reflect the availability to the authors of good photographs, which is fair enough. Sadly the information given for species is not always totally accurate though I only checked a few of my favourite species such as Ballan and Cuckoo Wrasse. The Bibliography listed in the Information section and which the authors presumably referred to, has some excellent books in it but has nothing after the year 2000 and it's now 2015.

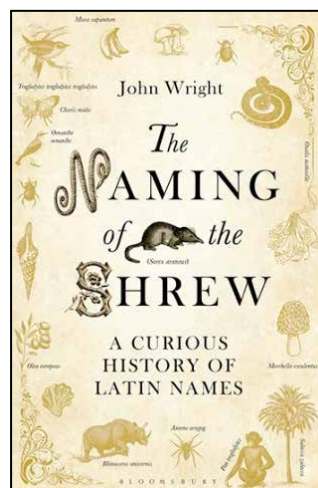
Happy Fisch Hunting!



The Naming of the Shrew: A Curious History of Latin Names

John Wright

Book review by Paula Lightfoot



What's in a name?

Come on, admit it – who hasn't giggled at the name *Pelvetia canaliculata*¹ while on a rocky shore ramble, or enjoyed explaining the meaning of *Crepidula fornicata* to bemused students or Seasearch trainees? Did you share Roger Bamber's delight in the 12-legged pycnogonid named *Sexanymphon mirabilis*? Were you as disappointed as I was when the name *Spongiforma squarepantsii*, surely destined for a marine creature, was given to a new species of terrestrial fungus in 2011? And what on earth were Natural England thinking when they chose *Phallusia mamillata* for their 'name the species' competition?!

As anyone involved in studying or recording marine wildlife knows, using Latin names avoids the confusion which can arise from common names, such as 'sea oak' which has been given to both a red and a brown seaweed, or 'monkfish' which is used for a species of angler fish and a shark. Most marine invertebrates don't even have common names, so we have no choice but to attempt to learn these confusing and sometimes unpronounceable names. However, with a little understanding of etymology, Latin names often give us a useful insight into the species'

appearance, behaviour, habitat preference or country of origin. And of course, the more absurd or suggestive names, together with anecdotes about the naturalists who named them, can be a great source of amusement and a useful tool for teaching and public engagement.

John Wright's book, *The Naming of the Shrew*, published by Bloomsbury in November 2014, is a well-researched, informative and entertaining account of Latin names. Why do we use them, how are they created, why do they keep changing, and what happens when taxonomists get it wrong?

The author makes the difficult subject of nomenclature and taxonomy accessible and interesting, but although it is written with clarity and often presented in a witty way, it is not 'dumbed down'. This is far more than just a collection of amusing Latin names, although there are some wonderful examples of names inspired by popular culture, puns and anagrams, plus a jolly assortment of double entendres, showing that taxonomists do have a sense of humour!

The first half of the book focuses in some detail on the language, conventions and rules of biological nomenclature, shedding light on this often complicated subject. The author explains the concept of the holotype, the specimen used in the formal description of a new species, by describing a trip to the Natural History Museum where Professor Juliet Brodie showed him "a tattered manila folder in which was an ancient, dried specimen of the laver species *Porphyra umbilicalis*...the *P. umbilicalis* on which all others must depend." The 'principle of priority', which states that a formally published name cannot subsequently be given to another taxon, is illustrated by a contest between sharks and moths. Aristotle named hammerhead sharks *Zygaena*, from the Greek word for 'yoke' which perfectly describes the shape of the shark's head. However, when a taxonomic split took place creating the need for a new smooth hammerhead genus name, *Zygaena* could not be used as it had already been formally published as the genus name of burnet moths.

The second half of the book is the history promised by the title, taking the author on a journey from "the comfortable world of frock-coated naturalists, collecting baskets and quill pens" to "the modern domain of computers and DNA analysis." We gain an insight into the lives and contributions of key players from Aristotle to Darwin, with a full chapter dedicated to Linnaeus, the 'Father of Taxonomy'. The book's final two chapters cover modern developments in taxonomy, including a discussion of problems with the definition of the term "species", which is not as straightforward as some might think, and concluding with a very useful explanation of cladistics.

Many examples throughout the book are drawn from the world of fungi, as this is the author's own specialism, but there is something in this book for everyone with an interest in the natural world. I highly recommend it to marine naturalists, with the caveat that scientific names can be misleading – thanks to this book, I now know that *Gelae fish* is actually a fungus beetle!

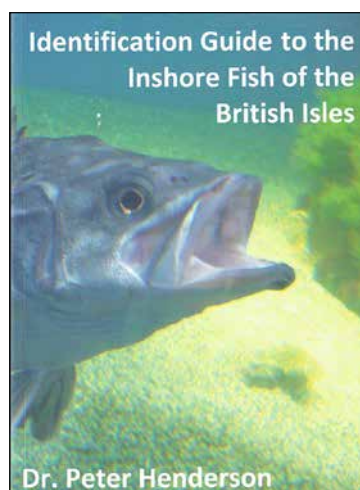
¹ *Canaliculata* means 'channelled' so is an excellent description of this brown seaweed's morphology, but is often pronounced 'can I lick you later?' *Fornicata* comes from the Latin *fornix*, meaning archway, describing the shape made by a stack of mating slipper limpets – but this is doubly apt as a name for this prolific mollusc because the English word *fornicate* derives from prostitutes plying their trade in the archways of Roman towns. *Sexanymphon* sounds kinky but is merely a reference to the sea spider's six legs (on each side). The Malaysian rainforest fungus *Spongiforma squarepantsii* was named for its resemblance to the cartoon character *SpongeBob SquarePants*. And well...if you need an explanation of *Phallusia mamillata*, see me after class!



Identification Guide to the Inshore Fish of the British Isles

Identification Guide to the Inshore Fish of the British Isles - Peter Henderson
Pisces Conservation Ltd, Pennington, U.K., 2014.
321 pp.
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Available from Pisces Conservation Ltd (IRC House, The Square, Pennington, Hampshire, SO41 8GN, U.K.) and online at www.piscesconservation.com, & www.nhbs.com £25.00.

Book review by Douglas Herdson



A comprehensive photographic guide to the coastal fish of the British Isles, this book is aimed at anglers, commercial fishermen, fish merchants, students, naturalists, as well as professional marine biologists. It claims to be the definitive guide to British marine fish, but is it?

Certainly, if anyone could write such a book it is Peter Henderson. He is a Director of Pisces Conservation, with 35 years of experience of regular monthly sampling around the British Isles, runs fish identification courses and is supported by an expert team, and this really shows.

There is an on-going argument as to whether field guides are best illustrated by photographs or artists' drawings. While line drawings can direct attention more readily to important characteristics (Wheeler 1978), photographs can be closer to what is actually seen. The

format of a two-page spread for most species allows both to be used; with 2 or more photos of most fish and a variety of illustrations, some historical. [Unfortunately no-one in Britain, or Europe, has adopted Jack Randall's onerous but effective method of fish photography for taxonomic purposes (Randall 1961).] Most photos are of fish after capture, often dead, with few of live fish in their natural habitats; and many readers, especially divers, will find it useful to also refer to *A Field Guide to the Marine Fishes of Wales* (Kay & Dipper 2009) or Paul Naylor's *Great British Marine Animals* (Naylor 2011). The book is also backed-up by a website www.britishseafish.com run by Robin Somes.

Each spread carries large clear photos, including some comparing similar species, and sometimes annotated to show characteristics used for identification. There is a standardized lay-out to aid quick reference. The common names given include those used in up to eleven countries (though not Welsh). The format provides space for more information on the biology, fisheries and life histories, as well as identification, colouration and distribution. It is illustrated with clear maps giving an indication of relative abundance, and the seasonal abundance of selected species are given in charts for the Bristol Channel, Suffolk and a few other vicinities.

One unusual feature in a book of this kind is the inclusion of photographs of the otoliths of the majority of the fish. This will be especially useful to those working on the stomach contents of predatory species, or on archaeological remains.

The species accounts also include angling records and lots of helpful references.

A further unusual feature is the use of dichotomous keys. Strangely, these are seldom found in European fish books, despite the names of some. This does however leave itself open to discussion and quibbles. Personally, I do not like the emphasis on maximum size of the giant goby (*Gobius cobitis*), especially when three other species can reach 14 cm in length, and in Wynn Wheeler's study most of the specimens he found were between 8 and 12 cm (Wheeler,



Variable blenny, *Parablennius pilicornis*, Plymouth Sound, June 2015 (Image: Paul Naylor)

1993). Similarly, having spent almost ten years telling children to look at seahorses and see that they are not S-shaped, it is annoying to see them in the key as “Body S-shaped...”

The arrangement of families into chapters seems rather idiosyncratic; e.g. Angel Shark (Squatinaidae) in the ray chapter. And in the same way the selection of species to include is questionable; it states that the coverage is “from the upper shore to depths of about 500 m.” but appears to exclude most fish found below 100 m. It seems strange to only mention in passing blackfish (Centrolophidae) and ignore the argentines (Argentinidae) whilst including rarely seen species such as the Piper (*Trigla lyra*) and the short-beaked garfish (*Belone svetovidovi*).

Obviously there are always points which can be picked on. I consider it misleading not

to mention that a small proportion of grey gurnards (*Eutrigla gurnardus*) can be red. The photograph of a skate (*Dipturus batis*) (p.39) appears to show the shape of a skate but with the markings of a small-eyed ray (*Raja microocellata*). The authors also state that “there are no commercial fisheries” for boarfish (*Capros aper*), when in 2010 Irish vessels landed over 137,000 tonnes (O'Donnell *et al.* 2012).

The section on sandeels (Ammodytidae) is the most useful I have seen and that on gobies is very good. It is particularly useful on the *Pomatoschistus* gobies, especially when used in conjunction with Lin Baldock and Paul Kay's *Porcupine* article (Baldock & Kay 2012).

However this book's claim to be the definitive guide must be questioned when some regular coastal species are dismissed in passing and



Couch's Sea Bream, *Pagrus pagrus*, Newquay, 01 January 2002 (Image: Douglas Herdson)

others not mentioned at all. In most books this claim could be dismissed as 'publisher's blurb' but in this case Pisces Conservation is the publisher.

Torsk (*Brosme brosme*), Greater Forkbeard (*Phycis blennoides*) and the pufferfish (Tetraodontidae) are missing. Porcupines will be surprised to read that "the variable blenny, *Parablennius pilicornis*, and the red tompot blenny, *Parablennius ruber*, which occur in French waters to the south of Britain, but have yet to be reported in British coastal waters....", when in fact *P. ruber* has been recorded in the north west of Scotland and Ireland since the early part of this century (Goodwin & Picton 2007) and is now known from Cornwall as well. *Parablennius pilicornis* was first photographed near Plymouth in 2007 (Maitland & Herdson, 2009) and is now regularly found in Plymouth Sound and photographed by Paul Naylor among others.

The sea breams (Sparidae) and Mackerel family (Scombridae) are particularly poorly covered. The semi-pelagic bogue (*Boops boops*) is listed as a rare migrant, when shoals regularly occur in sheltered bays of Devon and Cornwall in winter. Couch's sea bream (*Pagrus pagrus*) has been breeding in the south west since 1999 and is now regular in anglers' catches in Cornwall and south Devon (Maitland & Herdson, 2009). On Plymouth fish market it is referred to as red sea bream as it is more frequent than *Pagellus bogaraveo*, and yet it is totally neglected in this book.

Similarly with the scombrids only mackerel (*Scomber scombrus*) is given any coverage, while several other species are now turning up in anglers catches and on the fish markets. Most perplexing is the complete absence of the Atlantic chub mackerel (*Scomber colias*), formerly known as Spanish mackerel (*Scomber japonicus*); which in some years is caught in significant numbers.

These omissions are a shame in a book aimed at anglers as they are often needing this kind of detail in order to separate a Couch's bream from a pandora or a chub mackerel from a common one in order to claim a club, district or even national rod-caught record. Perhaps the Angling Trust's British Record (Rod Caught)

Fish Committee list would have been a good guide to which species warranted inclusion.

This is a well-produced and outstanding book in general and certainly one to be recommended; but unfortunately definitely not the definitive guide to British marine fish.

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How I became a marine biologist

Séamus Whyte



Budding ecologist on the rocks at White Strand

Growing up in Dublin in the 70s, there was surprisingly little chance to explore the coastal environment, mainly due to there being many miles to the nearest 'beach', insurmountable to a young child. I was more of a mountain boy. However, my father was a Clare man and I, along with the rest of the family, spent what felt like half my life down in Miltown Malbay, County Clare, well known for its annual traditional music festival, the Willie Clancy week. More importantly to my development as a budding naturalist was that the town was one mile from the sea. Set in amongst the wild west coast of Ireland is a nice safe bay harbouring the aptly named White Strand. Though I paid little attention to the mid to low shore sand set beneath a cobble and boulder upper shore, apart from picking a path to get to the water, the bay is surrounded by slate rocky shore and cliff. I would spend ages staring at limpets and coaxing shrimp from their hiding places with the promise of food, namely limpets somehow upturned in their rock pools (don't know how that always seemed to happen). Later, I started snorkelling where the ledges dropped into the sea and first impressions of the subtidal with my cheap all-magnifying glasses were in all honesty, big and freaky, though I quickly grew to love it.

In school, I can't say I ever loved a subject but I can say that I liked biology...a lot, a feeling helped by my favourite teacher, Mr Kelly. My experience with nature as well as my liking of biology made me decide at an early age that I wanted to be a biologist, though looking back, I don't think that I really

knew what that meant. Thus, I went on to study, surprise surprise, biology at University College Dublin, the bigger, and of course, better of the two universities in Dublin. Education being what it is in Ireland, we don't believe in specialising too early, which means I ended up with a BSc in Zoology and Botany, having studied Biology, Maths, Chemistry and Physics in my first year! In amongst the broad range of topics, two stood out, aquatic zoology, including a little marine biology, and parasitology. Commonality between the two? I probably didn't think about it then, but both had small beasties that piqued my interest, especially worms, which wriggled their way into my psyche in my early career.

A day after finishing my final exams for my BSc, I was on a plane to New York, the plan being to make some money to facilitate a post-grad, because I thought that I didn't want to work in academia, but to get a job in this, whatever this may be, I needed a second degree. Of course, for that reason I became a bellman at a top hotel on Central Park West, and long story short, I applied for a few places in the US but being completely ignorant of where to go, none of the degrees sparked my attention. As an afterthought, I applied to a couple of places in the UK; parasitology in Bangor and Marine Biology at Liverpool University. Two things made me go for Liverpool; it wasn't Bangor, and I remembered the fun I had growing up by the sea in Clare, Ireland.

Being a bit naïve/stupid, I left Manhattan and ended up in....the Isle of Man. As things worked out, I was immensely lucky ending up where I did, undertaking the final year of Liverpool's then Honours Marine Biology course to shore up my knowledge. I was also very lucky to be supervised by Dr Richard Hartnoll and meet the late great Dr Norman Jones, whose sites I revisited to study the soft bottom subtidal habitats off the west coast of the Isle of Man. This was amongst the areas studied by Dr Jones in the 50s and formulated his ideas of classifying benthic habitats using sediment type.

I had to be pretty self-sufficient in learning

to identify infaunal beasties and got fairly good at it, which held me in good stead to get a job straight away at the National Rivers Authority, later to become the Environment Agency. With the help of Dr Brian Barnett and Dr Helgi Guðmundsson I honed my skills as a marine invertebrate identifier and marine ecologist. Adding to my skills, I later got quite involved in fisheries and I am still learning and developing new skills with recent forays into the world of underwater sound. With over 20 years now working in marine ecology, I've even done some work identifying marine mammals in the field, which finally allows me to say yes to people asking me whether I study whales and dolphins when I tell them that I'm a marine biologist. Trying to explain the difference between a marine biologist and ecologist always proved difficult and though I've left my marine invertebrate identification somewhat behind me, I never quite got the same reaction explaining that I identify worms rather than big and/or cute marine mammals.



Not quite fishing: large cod caught in 6ft Agassiz trawl

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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).
- The main reference styles are as follows:

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