

# Exploring the consequences of ocean acidification caused by carbon dioxide increases on coral reef fish behaviour

**Michael D. Jarrold reports on the outcome of work done with the aid of an FSBI Research Grant. Michael is at the ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia and is also a member of the College of Science and Engineering, at the same university.**



Sensory performance and behavioural responses of coral reef fishes are impaired by CO<sub>2</sub> levels associated with ocean acidification projected to occur by the end of the century. However, all studies to date have used stable CO<sub>2</sub> treatments, not taking into account the substantial diel CO<sub>2</sub> variation that occur in shallow reef habitats.

The aim of our study was to determine how natural CO<sub>2</sub> fluctuations will interact with rising mean CO<sub>2</sub> levels to affect the behavioural performance of coral reef fishes under ocean acidification. To do this we reared juvenile damselfish,

*Acanthochromis polyacanthus*, and clownfish, *Amphiprion percula*, under a series of stable (400, 750, 1000  $\mu$ atm) and diel fluctuating CO<sub>2</sub> treatments (400  $\pm$  300, 750  $\pm$  300 and 1000  $\pm$  300  $\mu$ atm) before assessing their behavioural performance.

As expected, lateralization of *A. polyacanthus* and response to predator cue of *Am. percula* were

significantly negatively affected by ocean acidification in fish reared under stable, elevated CO<sub>2</sub>. However, diel CO<sub>2</sub> fluctuations alleviated the negative effects of ocean acidification on behaviour, although, the extent of alleviation was dependent on the magnitude of mean CO<sub>2</sub> level experienced. Importantly, behavioural abnormalities that were present ➤



A damselfish, *Acanthochromis polyacanthus*. Photo JE Randall with permission (from FishBase)



Clownfish, *Amphiprion percula*. Photo by JE Randall with permission (from FishBase)

◀ in fish reared at 750  $\mu\text{atm}$   $\text{CO}_2$  were completely absent in fish reared at 750  $\pm$  300  $\mu\text{atm}$   $\text{CO}_2$ .

Overall we show that diel  $\text{CO}_2$  cycles can substantially reduce the severity of behavioural abnormalities caused by elevated  $\text{CO}_2$ . Thus, past studies may have over-estimated the impacts of ocean acidification on the behavioural performance of coral reef fishes. Furthermore, our results suggest that diel  $\text{CO}_2$  cycles will delay the onset of behavioural abnormalities in natural populations.

### Project Outputs

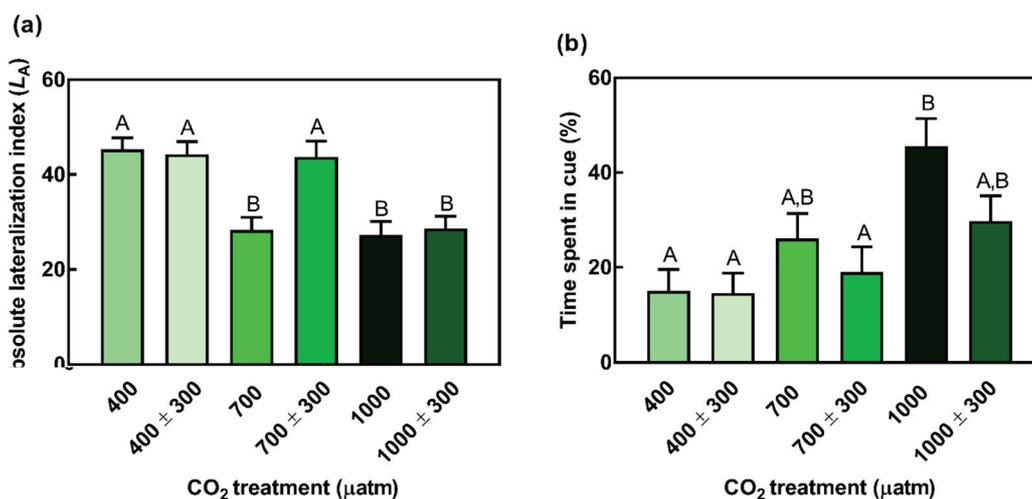
#### Papers submitted

Jarrold MD, Humphrey C, McCormick MI and Munday PL. Diel  $\text{CO}_2$  cycles alleviate behavioural abnormalities in coral reef fish under ocean acidification. *Global Change Biology*.

#### Papers in preparation

Schunter C, Jarrold MD, Humphrey C, Ravasi T and Munday PL. Molecular processes underlying behavioural responses of coral reef fishes to diel  $\text{CO}_2$  cycles under ocean acidification.

### A figure taken from the full report



The effect of  $p\text{CO}_2$  treatment on (a) absolute lateralization of juvenile *Acanthochromis polyacanthus* ( $n = 60$  per treatment) and (b) response to predator cue of juvenile *Amphiprion percula* ( $n = 24$  per treatment).

Different letters represent significant differences between treatments (Tukey,  $P < 0.05$ ). Bars are mean values  $\pm$  SE

# Editorial

Producing this Newsletter is made easier by the resources available on the World Wide Web. In general accessing information on the Web has become almost too easy but it does mean that it is no effort to find pictures of people mentioned in the Newsletter or of fish that are the topic of a report. The accessibility of this information and the ease with which we can now contact each other using Skype or FaceTime can only be a benefit to the majority and we are all fooled into thinking only of the positive aspects of the Web. The darker side tends to be either ignored or forgotten most of the time although we are made aware of the negatives in the press and on TV. There is no doubt that through the Web, Twitter, Facebook and all the other connectivity apps it is now easier to keep in touch with colleagues and the deluge of information which is published each week. This Newsletter is to some degree anachronistic in that it is sent to you by post and is on paper although a pdf is always available on line and I send a Tweet to say it's on the Society's website.

There seem to be two disadvantages to the apparent transparency and inclusiveness of the Web; the ability of those with suspect intentions to obtain information for undesirable activities about people and places and the flood of information that we are all faced with from moment to moment.

An example of the two edged nature of the resources available on the Web is Google Earth. I have been using it recently to obtain information about seamounts along the Emperor-Hawaiian chain. Using Google Earth it is possible to determine the locations of the seamounts and their depths beneath the sea surface, information which would have taken much labour to get before the existence of Google Earth. For the terrestrial parts of the world it is possible to visit places on street view and almost be in New York or London. To most of us Google Earth is a valuable resources that can be used for good. On the down side it can also be used by terrorists and criminals to plan their unwanted activities.

The availability of information,

made so easy and in such quantities by the Web is a boon but also a curse. At times one can feel swamped by all the new papers appearing, the flood of Tweets and the constant reminder from ResearchGate that the system has found a new reference to your work. What time is left to do original thinking and research?

This Newsletter just adds to your reading material but I hope that its old-fashioned format gives you a moments break from that constant online flood and gives you ten minutes of reading that keeps you up to date with one of your professional societies (as I am sure you belong to more than one!).

Paul Hart  
Leicester, May 2017

Next deadline: 1st August

*(Note added in proof: This editorial was written before Friday 12th May's worldwide cyber attack! I rest my case. Ed)*

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The ***Fishing into the Future*** programme recognises that the major issues facing fisheries can be solved using a bottom-up approach – one that improves the buy-in and collective actions of fishers. If their resourcefulness, passion, experience and commitment can be effectively harnessed then sustainable and prosperous fisheries will be achieved. Fishermen must be part of this journey, however, which is why they are involved at the heart of all we do.



<http://www.fishingintothefuture.co.uk/who-are-we/>

# President's Piece

As you know, 2017 is something of a 'red letter' year for the Society, as we celebrate our 50th Anniversary. Plans for the 50th Anniversary Symposium are now at an advanced stage, with all keynote speakers lined up. We also had a really impressive number of abstracts for submitted talks and posters, and have managed to accommodate most of these into the schedule. Details of the conference, including registration information, details of invited speakers and sessions, are available on the conference website <http://www.exeter.ac.uk/fsbi17/>. Registration options start at £390 for student members (£500 for full members) and this includes all events and accommodation. Non-member rates are a little higher, but include a full year's membership of the Society. Compared to some of the conferences I have been sending PhD students to recently this is very good value, and I hope that many of you will come along to share what I am sure will be a fantastic experience, and an important event in the Society's development.

Another initiative celebrating the Society's Anniversary is the

FSBI history project, which is now well and truly up and running, with a number of the interviews complete and other planned for the near future. We look forward to hearing about the findings of the project, which will be presented at the Exeter conference. Please can I ask any members with any interesting Society memorabilia (photos, conference schedules, meeting minutes, publicity leaflets etc. especially from the early days of the Society) to contact the project lead Dr Sally Horrocks ([smh4@le.ac.uk](mailto:smh4@le.ac.uk)) as we are trying to piece together an archive of Society documents. As well as the conference presentation, a paper will also be written for the Symposium volume and a series of short 'oral history' recordings will be made available via the website.

Speaking of the website, we have now appointed a professional web development company (BoldLight: <http://boldlight.co.uk/>) who are in the process of completely redesigning and rebuilding our website. We will be rolling out the new website later on in the year, and as part of the design we would like to include a greater range of member-contributed images, ideally

focusing on people engaged in fish biology and fisheries science research, as well as the fish themselves. If you feel that you may have images that you would be happy to share with the Society (they must be copyright free and high resolution) then please contact myself ([iain.barber@ntu.ac.uk](mailto:iain.barber@ntu.ac.uk)) or Alan Pike ([apike@lucidusconsultancy.com](mailto:apike@lucidusconsultancy.com)) and we would be very happy to speak to you about this. Having a more visually appealing, more easily navigated and more functional website will benefit the Society in many ways. Any offers of high quality photographs will be greatly appreciated!

Finally, as some of you may know, John Craig will be vacating the post of Editor in Chief of the Journal of Fish Biology at the end of this calendar year. John has done an outstanding job of developing the Journal and under his stewardship the performance of the Journal has flourished. As a Society we are completely dependent on income from the Journal to support our many initiatives, so finding and recruiting someone with the gravitas, leadership and experience to replace



◀ John has been a crucially important challenge for Council. I am therefore delighted to be able to end my piece to announce the excellent news that **Anthony (Tony) P. Farrell** (pictured) will be the new Editor in Chief of the *Journal*, and will be taking over from John Craig from 1st January 2018, following a period of job-shadowing that will commence 1st September 2017. Many of you will know, or know of, Tony, who has been a long standing member of the JFB Editorial team, as well as a

prominent member of the research community. Even if you have not met Tony, you will be very familiar with his outstanding contributions to the fields of fish biology and fisheries science, and I can suggest his website <http://tonyfarrell.landfood.ubc.ca> as a great place to get an overview of the work he does. We are very fortunate to have such a high profile and high caliber replacement to take on the role and to continue the fine work that John Craig has done with the *Journal*. I would like to

personally thank all members of the publications committee, and the appointment panel – and especially Gary Carvalho – for their considerable input into this process. We are confident that Tony will provide excellent stewardship of the *Journal*, and that his appointment will help to secure the success of the *Journal*, and hence the Society.

I look forward to seeing you at the meeting in Exeter!

Iain Barber

## Representation of the American Fisheries Society at the Exeter symposium in July

As most members know the Society has a long standing link with the American Fisheries Society which is most visibly expressed by each President attending the annual conference of the other society. The relationship is also expressed through the exchange of a younger representative from each Society and this year the AFS is to be represented by Jane Sullivan whose background is described in what follows (Ed). Jane is keen to make contacts with like-minded fish biologists so please welcome her.

Jane Sullivan is an Alaska Sea Grant Fellow and fishery analyst at the NOAA Fisheries Alaska Regional Office in Juneau, Alaska. She currently collaborates on projects with the North Pacific Observer Program, including developing the annual observer deployment review into a reproducible research product and building an optimization algorithm for incorporating electronic monitoring tools into the observer program. Jane holds a Master's of Science in Fisheries from the University of Alaska Fairbanks, where she researched environmental and



fishery effects on growth and size-at-age of Pacific halibut. Jane's primary interests lie in the field of applied marine fisheries research, and consequently, she gravitates towards projects that use population dynamics and estimation methods to inform policy and management.

Jane has benefited immensely through her involvement with the American Fisheries Society. She served as Vice President of the University of Montana subunit

during her undergraduate program, President of the University of Alaska Fairbanks subunit, and the Student Representative to the Western Division of AFS during graduate school. She is honored to serve as the 2017 International Fisheries Section Fellow and represent IFS at the 50th Anniversary Symposium of the Fisheries Society of the British Isles. She loves living in Alaska, fishing, and meeting people who love fish as much as she does.

# Further reports from Society PhD students



**GRAHAM MONKMAN** is based in the School of Ocean Sciences at Bnagor University. He is supervised by Michel Kaiser, Kieran Hyder and Franck Vidal and his project is '*Integration of sea angling associated catch and mortality for stock assessment*'. He started in 2014

The first half of the year focused on the consolidation of results derived from Year 1, in particular distilling, refining and reworking previous analyses on the utility of social media and marine recreational fisher acquired knowledge (MRF, FAQ) in quantifying spatial and temporal effort. Time was invested on developing a novel approach to validating the statistically problematic sparse effort data which inevitably results from such sources. Permutative Monte Carlo resampling was coded to derive spatial correlation estimates against directed survey results and the problem of spatial correlation analysis where areas have to be precisely match spatially and on the dependent variable was overcome by combining the permutative Monte Carlo approach in combination with sliding window mean convolutions on  $n$  by  $n$  kernels.

Although the gathering of MRF and directed survey data continued during the year, the major focus during quarter 3 of 2016 was on single lens photogrammetry in obtaining estimates of fish

length in the absence of specialist photogrammetry equipment (essential in large scale MRF surveys and citizen science like projects). Low tech approaches were evaluated and the causes of error identified and minimised to demonstrate they were viable to deploy and would be amenable to automatic metric extraction using machine vision. In particular, image processing in Python with the OpenCV library was coded in preparation for the automated correction of captured images. This empirical assessment of the accuracy and precision of length (and other morphometric measures) is crucial preliminary work prior to embarking on object recognition, which will transition to my core work thread for 2017.



**NATASHA PHILLIPS** is at the Queen's University Belfast and is supervised by Jon Houghton & Chris Harrod. The title of her study is '*The extent and drivers for cryptic benthivory in the ocean sunfish*'. She started in 2014

## Aim

Strong conservation management of vulnerable species requires detailed knowledge of their distribution patterns spatially and temporally. The *Mola* genus (ocean sunfishes) is comprised of two species listed as vulnerable

and data deficient yet are currently subjected to extremely high levels of by catch globally. Within this study, we aim to provide a primary description of *Mola* spatio-temporal distribution as a baseline for future management practice. Specifically, we aim to consider *Mola* distribution patterns, identify the best predictive variables and assess if the *Mola* can be classed as seasonal migrants.

## Methods

Global records of *Mola* collected between 2000 and 2015 were used to build environmental niche models to provide an initial description of seasonal distribution patterns. These models also provided a quantitative assessment of seasonal changes in the total area and latitudinal position of suitable habitat available to *Mola*.

## Results

The *Mola* are a widely distributed genus; however the population is subject to significant clustering in specific locations, particularly in coastal regions. Species distribution modelling suggests that prediction of *Mola* presence is strongly dependant on sea surface oxygen concentration. The models identified significant seasonal variation in the sea surface area available to *Mola* seasonally and significant population shifts latitudinally, although some locations contain suitable year-round habitat.

## Main conclusions

This study provides an initial description of *Mola* distribution on a global scale, with evidence of significant clustering across a wide range. By assessing the results of the environmental niche models alongside evidence from satellite tagging studies in the literature, we suggest that the *Mola* genus is highly mobile, acting as facultative seasonal migrants. By identifying key suitable habitat alongside potential population movements,

this study provides a baseline that could be used in active conservation management for this genus.

A short video of a *Mola ramsayi* in the open sea can be watched at <https://www.youtube.com/watch?v=K4DuOcFqZwA>

**Papers submitted, in press or published in 2015/16.**

Phillips, N. D., Harrod, C., Gates, A. R., Thys, T. M. and Houghton, J. D. R. (2015), Seeking the sun in deep, dark places: mesopelagic sightings of ocean sunfishes (Molidae). *J Fish Biol*, 87: 1118–1126.  
Second manuscript submitted

to *Journal of Biogeography* and currently in review: Phillips, N. D., Reid, N., Thys, T. M., Harrod, C., Payne, N., Morgan, C., White, H.J., Porter, S. and Houghton, J. D. R., Applying species distribution modelling to a data poor, pelagic fish complex: the ocean sunfishes.

## The summer symposium



**Steve Simpson** reported to the recent Council meeting on the progress made in organising the summer symposium **Understanding Fish Populations**. The following are the major points about what is going to be a landmark meeting for the Society.

The lecture named after the founding President, Jack Jones will be given by **Charles Tyler** (University of Exeter) who will talk about *Feminisation of fish and fish populations – An unnatural history*. There will be six Plenary Speakers who between them through the week will reflect the themes of the symposium. They are:

**Iain Couzin** (Max Planck Institute for Ornithology and University of Konstanz, Germany) on *Collective sensing and decision-making in animal groups: From fish schools to primate societies*. Ex-Council member **Isabelle Côté** (Simon Fraser University, Canada) on *Invasions from the top: The multi-faceted repercussions of marine predator introductions*. Another speaker from Vancouver, **William Cheung** (University of British Columbia, Canada) who has done much work on the effects of climate change will talk on *The*

*future of fishes and fisheries in the changing oceans: interactions between human stressors*. **Joanna Alfaro-Shigueto** (ProDelphinus & Universidad Científica del Sur, Peru) will give a new perspective on fisheries and conservation when she talks about *Small scale, large potential: Using artisanal fisheries to promote marine conservation research in South America*. **Peter Mumby** (University of Queensland, Australia) who at one time was also at Exeter will speak on *The connectivity, ecosystem overfishing, and*

*rebuilding of coral reef fisherie*. Finally, one of the leading modellers of fisheries ecosystems **Beth Fulton** (CSIRO, Australia) will talk about *Fisheries induced ecosystem restructuring – what is acceptable?*

There was no shortage of abstracts submitted with a total of 202 from 25 countries, including 47 from students. The Science Committee selected papers as orals, speed talks and posters leading to 184 presentations.

The current breakdown of presentations is:

Theme	15 min Orals	3 min Speed talks (+ optional poster)	Poster only	Total
Biology of Fish	35	16	18	<b>69</b>
Changing World	22	16	6	<b>44</b>
Valuing & Managing	11	4	9	<b>24</b>
Tools	15	11	9	<b>35</b>
FSBI Celebration	10		2	<b>12</b>
<b>Total</b>	<b>93</b>	<b>47</b>	<b>44 (+32 from speed talks)</b>	<b>184</b>

**Additional Activities**

There will be an optional Genomics workshop on the Monday morning. Monday evening will have a Pub Quiz hosted by the PhD students. If you are feeling extra energetic there will be optional pre-breakfast campus runs each morning. (A good thing they are optional! – Ed). Tuesday and Thursday lunches will have Meet the Mentor and Themed Discussion picnics (the weather better be good). Tuesday evening will have a West Country Garden Party: BBQ/hog roast, cider/ale & live band.

On Wednesday afternoon the Society’s AGM will take place and **we hope as many members as possible will attend**.

On the Thursday there will be a two and a half hour FSBI Celebration session (including history talk, and orals from FSBI and AFS students), all organised by Iain Barber. Thursday night will be the symposium banquet, with a Guest Lecture from Charles Clover (*End of the Line*) followed by music/dancing. There is the option for Friday afternoon workshops/meetings (suggestions welcome).

# Notices

## Are you keen to run an Annual Symposium?

The Society is always keen to hear from members who are prepared to volunteer to host the Annual Symposium. Anyone interested should contact either Iain Barber or John Pinnegar, preferably with a conference theme in mind.

## Would you be willing to be a Council member?

Any member can put her or himself forward for election to the Council. If you would like to put yourself forward please contact John Pinnegar for information as to what you need to do. As a Council member you will be on one of the subcommittees dealing with grant applications, travel grants, studentships or

publications. There are just two Council meetings a year and the rest of the work is done by email or other electronic means. Elections to Council take place at the Annual General Meeting held during the summer symposium.

## New PhD students.

Two students will be starting their doctorates at the beginning of the next academic year. They are:

Kirthana Pilly studying at Bangor University with Simon Creer, Nigel Milner, Nathalie Fenner and Michael Parsons. The project will be *'Investigating the mangrove productivity paradigm in relation to socio-economically important fisheries'*.

## And



George Balchin, working at the University of Sussex under the supervision of William Hughes. George's project will be *'Exploring behavioural cascades: community-level effects of generalist predators'*.

# Information Desk

For all membership enquires (except subscription payments), including grant application submissions, please contact the FSBI office at:

FSBI, c/o Charity & Social Enterprise Department, Brabners, Horton House, Exchange Flags, Liverpool L2 3YL, UK

Contact: Shirley Robinson

Phone: +44 (0) 151 600 3362

Email Enquiries: [grants@fsbi.org.uk](mailto:grants@fsbi.org.uk)

In the UK and Europe subscription enquiries should be addressed to:

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See <http://www.fsbi.org.uk/membership/joining-the-fsbi/> for further information.

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