e-ISSN: 1948-6596 https://escholarship.org/uc/fb doi:10.21425/F59235175

BOOK REVIEW

Desk-based deep sea exploration

Biological Sampling in the Deep Sea, by Malcolm R. Clark, Mireille Consalvey, and Ashley A. Rowden (editors), 2016

Wiley-Blackwell, 466 pp., ISBN: 9780470656747

> "Well if you go one-on-one with a limpet you can learn an enormous amount. You can do that. How do you do that with a great white shark or blue whale? There's this barrier to what I would call natural history." Bob Paine, interviewed in 2013 [1]

As a macroecologist, I don't get out much. Growing fat on Other People's Data, the temptation is simply to sit and process and analyse and publish on whatever system provides the best API (Application Programming Interface). However, I have always shared Paine's view that it is important to have a feel for the natural history of your subject too. Starting out, I worked -- as was more or less obligatory at the time, for a macroecologist -- on birds. I'm no twitcher, but I do get birds. I enjoy watching them, and have a sense of their lives and of their interactions with the environment. There is no barrier to natural history there, especially working with a nice colour field guide at hand to remind me of the feathered reality of my rows of data.

Shifting my focus to the macroecology of marine ecosystems, I maintained a similar routine: greedily hoovering up data, keeping a stock of glossy pictures and natural history monographs close by. This was all well and good when working on the shelf seas. I had never been out for more than a few hours of boat based sampling, but the general process -- whether sampling by trawl, box core, or scuba -- was at least familiar enough that the idea of going 'one-on-one' with the organisms did not feel outlandish. But then I started to venture off the shelf, into the world's biggest ecosystems in the deep sea (e.g. Webb et al. 2010). In this alien setting, even something as apparently straightforward as casting and hauling in a net starts to seem unfeasible as you realise that the cables involved must be passing 3, 4, 5 km in length…

I approached Clark et al.'s book, then, probably not as a member of its main target audience. I had no intention of putting any of the detailed protocols for different sampling gears into practice[2], but read it rather as someone hoping to get a feel for the labour that has gone into the data I analyse, and thus of its potential and limitations for macroecological research. Even viewed from this somewhat oblique angle, the book stands up very well. The first chapters present a broad overview of the 'deep sea', and in so doing reveal its complexities and heterogeneities. Tyler et al. (Chapter 1) provide an excellent primer on the habitats of the deep sea floor, as well as a very readable history of key points in its discovery, from the early 'heroic' age through the first quantitative studies and on to the finer scale, more systematic approaches now possible using new imaging and geolocation technologies. For instance, they show how recent, high resolution exploration of the abyssal plain -- previously thought to be flat and boring -- has revealed interesting biogenic and abiotic structuring down to sub-metre scales.

In the next chapter, Schiaparelli et al. move from habitats to organisms, with an overview of key deep sea taxa as well as of broad patterns in their distribution. This covers several topics likely to be of interest to macroecologists, including the widespread occurrence of both miniaturisation and of gigantism in the deep sea, driven largely by energetics. They also describe the feature that has really drawn me to deep sea macroecology:

1 http://www.biodiverseperspectives.com/2013/09/10/diverse-introspectives-a-conversation-with-bob-paine/

2 Or so I thought: by a strange twist of fate I write this on board the RV Pelican in the Gulf of Mexico, a mile and more of cable stretching below us. But that's another story.

the lack of primary productivity that leads to the decoupling of chemical and thermal energy, providing a means to tease apart different drivers of large-scale gradients in diversity (e.g. Tittensor et al. 2011, Webb 2012, McClain & Schlacher 2015, Woolley et al. 2016). Most food in the deep sea comes from the rain of Particulate Organic Matter (POM), but there are rich oases of biomass too, around chemosynthetic vents and seeps and from biogenic sources like whale and wood falls. Research into these kinds of systems is moving on from the initial discovery phase into more synthetic analyses and even experimental macroecological studies (e.g. McClain et al. 2016, Webb et al. 2017).

Chapters on sampling design are most interesting to me for the insight they give into the basic logistics of studying the deep sea. For instance, Clark et al. (Chapter 3) reckon on allowing 24 h to deploy one CTD cast (Conductivity, Temperature, Depth) and one ROV (Remotely Operated underwater Vehicle) transect at a single 4000 m depth site, while Christiansen (Chapter 6) discusses the challenges of sampling mesozooplankton which occur at a total abundance across all species in the deep pelagic of only 0.1--1 individuals per cubic metre. Sampling sufficient volumes of water is thus critical, and to do so to a depth of 2500 m will require over 4 km of wire, sampling 900 m^3 every 500 m on a 4 h oblique haul. Hauling up a single 100–1000 kg benthic grab (Narayanaswamy et al., Chapter 10) in sometimes heavy seas is also a delicate operation.

The more technical chapters on specific survey methods set useful standards for the field, but are perhaps of less immediate interest to the lay reader. However, most include a section on some aspect of data interpretation which idle analysts would do well to study. For example, Clark et al. (Chapter 7) cover trawl surveys, and include a valuable discussion of trawl efficiency and selectivity: how effectively do deep sea trawls actually sample the communities we want to study? Are individuals of different shapes, sizes, and life histories equally likely to be represented?

These kinds of issues are nicely summarised in O'Hara et al.'s Chapter 17 on data exploration and analysis, both with examples in the text and with a very useful flowchart of steps leading from initial research questions, through data checks and quality, design of the analysis, and interpretation and contextualisation. The authors have clearly (and successfully) aimed to make this text general, and while the analyst in me would have liked some actual worked examples with code, in the end maybe that's my job. I really like the fact that there is a whole chapter on information management strategies (Stocks et al., Chapter 16). As already stated, I benefit hugely from other people's data; but I suffer for it too, and following the clear guidance in this chapter will result in data that are much easier to integrate into biogeographic databases such as OBIS (Ocean Bioegeographic Information System; iobis.org), as well as into a range of analytical work flows.

The other thing that has drawn me into deep sea work is the simple fact that it is thrilling, and this book does a good job of capturing the past and likely future technological advances that have enabled us to move from a situation as recently as the 1950s when popular texts used imaginative paintings as no good photos existed of deep sea species (Shciaparelli et al., Chapter 2) through the revolutionary effect that cameras have already had on deep sea research - including conducting transects with towed cameras (Bowden & Jones, Chapter 12) and taking *in situ* measurements of individuals from baited camera traps (Jamieson, Chapter 11); to the first developments of deep ocean observatories (Matabos et al., Chapter 14), where linked, autonomous systems of instruments are connected via cables or moored buoys into a network, an inspiring vision of large scale international cooperation and collaboration wholly fitting for the study of systems that largely lie outside of national jurisdiction. As Tyler et al. put it, such autonomous systems give us "…access from desktop to the deep sea without the need to board a ship!" This book provides the means for us desk bound explorers to better understand what it is we're seeing.

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Submitted: 21 June 2017
Accepted: 26 June 2017
Edited by Markus Eichhorn

