Taxonomy in trouble?

An ocean science perspective

Nick Higgs

A debate that has been simmering within the biological sciences has erupted onto the pages of leading scientific journals in the last few years, and it shows no signs of abating. If you want a taste of the discourse here is Prof Quentin Wheeler: *'I find this claim preposterous, dangerous and complacent*.' What is it that provokes such scathing and strident remarks? The short answer is 'taxonomy', but more specifically, the perceived state of taxonomy and systematic biology in today's scientific landscape. Taxonomy is the science of identifying and describing new species, and falls within the biological discipline of systematics, which is concerned with classifying organisms according to their evolutionary history.

I know what you're thinking. This might seem like an irrelevant and esoteric topic, but I hope to persuade you that one way or another this is something that the whole ocean science community should be paying attention to, not just marine biologists. I also want to make it clear that I am not a taxonomist – simply an interested party, a user of the products of taxonomy, as we all are in some way.

Who needs taxonomy?

Governments, and the funding for ocean science that comes from them, are supremely concerned with the productivity of the oceans. In other words, what we humans get from the seas. Not only biological resources like fisheries species, but hydrocarbons and minerals too. All of this is dependent, directly or indirectly, on taxonomic science. If you were in Jennifer Skinner's talk at the last Challenger Society meeting, you may recall that knowledge of tiny rows of teeth on copepods is essential for understanding large-scale ecosystem shifts in the North Atlantic Ocean and subsequent effects on important fish stocks. Likewise, taxonomic research on fossil plankton is an integral part of oil and gas exploration.

The latest marine resource to pique the interest of government is the prospect of obtaining mineral resources from the deep sea bed. Yes, even mining needs taxonomy – perhaps especially mining. When Prime Minister David Cameron launched the UK's bid to mine metallic nodules from the Pacific sea bed in 2013, the Online Biogeographic Information System (OBIS) had zero records of the most abundant deep-sea animals within the entire UK claim area. Before mining could even be contemplated it was essential to know what was living in this environment and how it might be affected. To do this, UK Seabed Resources hired an international team of taxonomists and ecologists to gather the necessary baseline ecological information. Taxonomic expertise is critical to this whole endeavour.

Determining baseline ecological information is not simply a case of providing run-of-the-mill identifications of specimens. Taxonomy is more than just diagnostics. Besides, you can't assign an ID to something that has never been described before. Previous surveys of this region of the deep sea bed have found that a staggering ~90% of species brought up are new to science! With this level of novelty you need systematic experts to make sense of the picture. At the last Challenger Society conference, Adrian Glover from the Natural History Museum gave an insight into the new approach that the team has been using to document life 4000 m below the surface of the Pacific Ocean. This so called 'end-to-end' taxonomy combines traditional morphological descriptions with DNA barcoding and state-of-the-art bio-informatics to ensure that all data are freely shared online.

In this context, taxonomic expertise becomes an issue of national capability, which is why concerns about the state of taxonomy have been rumbling on since the early 1990s. Over the last 25 years there have been three inquiries by the House of Lords Science and Technology Committee into the issue (1992, 2002, 2008), the last of which deemed UK capacity to be unsatisfactory 'to the point of crisis' in some areas. In response, in 2010 the Natural Environment Research Council (NERC) commissioned a UK Taxonomy and Systematics Review on behalf of all funders in this area to dig deeper and come up with some hard data.

Fragile funding

Although the NERC study found 1100 active taxonomists at work in the UK, most of these were only engaged in diagnostics work (identifying things); only 400 were carrying out descriptive and revisionary systematics. A key finding was that taxonomy in universities had declined markedly, both in terms of teaching and in terms of academic staff numbers. A worrying finding for national capability was that the implementation of government environmental policy is heavily reliant on volunteer taxonomists. A number of recommendations were put forth to address the issues raised and a follow-up paper in 2011 outlined a National Strategy in Taxonomy and Systematics to be monitored by a UK Taxonomy Coordination Committee.

So, what has happened since the 2011 paper on *Developing a National Strategy in Taxonomy and Systematics*? A meeting held at the Linnean Society in 2014, 'Who Needs Taxonomists?', shed some light on the situation, but the short answer seems to be 'not much' (at least to an outsider like me). The meeting report highlights the fact that 'there is no ring-fenced funding for taxonomy nor is there any one body taking a strategic overview of funding in taxonomy'. Funders have little appetite for taxonomy-only initiatives or strategic programmes. Instead, taxonomy must be embedded as part of wider collaborative projects if it is to receive funding. For example, the Natural History Museum combines core capabilities in taxonomy and collections (actually funded through the Department for Culture, Media and Sport) with external research grants to integrate taxonomy into broader scientific collaborations on disease, natural resources, biodiversity discovery and planetary change.

A search of Research Council UK-funded projects since 2011 shows that a total of £1.75 million has been spent on projects that have systematics research as a major element, equivalent to £347 000 per year. And that is just for projects that merely mention taxonomy. The actual amount of money that went to taxonomic work is difficult to calculate but unlikely to be more than half that amount. Only one project actually had 'taxonomy' in the title. Of course, there are other sources of funding but research councils are one of the largest and most directly controlled by government, the other being the Darwin Initiative.

To be fair, NERC's Advanced Training Short Courses do fund the provision of taxonomic training for early career researchers that ensures skills are passed onto the next generation (£314 000 since 2014). They also provide a source of income and status to taxonomic researchers and their institutions. In addition to funding taxonomic training, the research councils run an Individual Merit Promotion scheme that allows senior researchers at NERC institutions and some museums to gain promotions, which

has supported a number of excellent taxonomic researchers. NERC have set up the Strategic Programme Advisory Group, allowing the science community to provide input on where it thinks science funding should be targeted. So, the door is at least open to direct funding towards taxonomic research.

It is easy to complain about funding allocations, but it is clear that at least part of the blame for the state of taxonomic science in the UK falls at the feet of the research community itself. There is a perceived lack of regard or esteem for this type of science that some have linked to changes in the way that research output has been assessed, especially in the UK. The problem is that prestige is increasingly bestowed (even by scientists) according to the level of income generated and so taxonomy is hit by the lack of direct funding available. Even more worrying is the lack of consideration for taxonomy in larger grant proposals that just assume taxonomic work will be done for free.

The 'death of taxonomy' mantra is not universal in academia though, and there are some who would argue that the picture is not as bleak as it seems. This is the gist of a 2013 paper published by Mark Costello and colleagues in *Science* enitled 'Can we name Earth's species before they go extinct?' In a series of papers Costello and colleagues have argued that there has in fact been an increase in the number of authors describing new species over time. Secondly, they are having to put more and more effort into finding new species, suggesting that most species have already been discovered. It is these claims that have generated so much controversy, and what seems to be a statistical arms race in the literature about the most appropriate way to analyse the data that we have.

An emerging theme from all sides of the debate is the need to think wider than national interest when assessing taxonomic capability. We work in a global scientific community and it is surely unnecessary for each country to have taxonomic expertise on every possible group of organisms. Should we not be assessing taxonomic capacity at the level of state cooperation; the EU for example, rather than the UK? Nevertheless, at a global level there are still gaps and shortages in knowledge, especially for taxa that are prevalent in the deep sea. Craig McClain cites the example of a whole class of aplacophoran molluscs for which you can count on your fingers all the experts in the whole world, many of which are close to retirement. Such shortages in expertise and knowledge can lead to real problems in science.

As an undergraduate, I worked on a project dealing with the seasonality of reproduction of deep-sea molluscs that were collected in the early 1990s using manned deep-sea submersibles. Over a decade later that experiment had not been written up because no-one could tell whether the animals collected were a single species or multiple species. This was not simply a case of needing the animals identified, but was a taxonomic problem that needed a specialist. Unfortunately, the world expert on the group had died before the samples could be analysed, leaving the data unintelligible. A lot of time and financial resources down the drain. Fortunately, a posthumous monograph was published some time later, which allowed confirmation of a single species and the eventual publication of the data. Many such stories do not end so fortuitously, but rather with samples sitting on a shelf, or worse, in the bin.

Answering big questions

Until recently, it was thought that for some common elements of marine flora and fauna, such as diatoms and copepods, most species have already been described and the taxonomic groups well established. However, both diatoms and copepods are actually among the least well known taxonomic groups in the marine realm, and are thought to contain more than 50 000 and 3000–50 000 undiscovered species, respectively. This is because, due to their small size and apparent lack of distinct morphotaxonomical characteristics, speciating plankton taxa requires highly skilled taxonomists. Additionally, fewer taxonomists focus on less charismatic and small-sized marine invertebrates, such as plankton, than on megafauna such as fish and mammals.

When it comes to the unexplored deep-ocean habitats, the number of undescribed species must be even higher. How many and what types of animals are left to be discovered in the deep ocean is one of the biggest unknowns in marine science. Rates of discovery of new species during deep-sea expeditions vary between 30 and 90% of species collected. The extent to which they really are 'new' needs taxonomic expertise though. Are we simply encountering the same undescribed species over and over again?

Until we can answer such questions, we are limited in our ability to answer the big ones, such as 'How many species are there in the ocean?' Some have tried to come up with estimates but they are widely divergent (ranging from 0.75 to 5 million species). In a recent paper I showed that our records of marine biodiversity are a non-random collection of species and we have picked the low-hanging fruit in terms of species discovery. Because of this we can't even say whether the total biodiversity of the deep oceans is greater or less than that of the shallow seas, and so we can't yet predict how much biodiversity remains undiscovered. As humanity pushes ahead with ever greater exploitation of the deep ocean, it is critical that we can understand what is down there. To do that we must preserve the knowledge and expertise of taxonomists and ensure that it is passed on. Perhaps crucially, there must be career pathways for systematic scientists and that will involve increasing the perceived value and credit bestowed upon taxonomists by the wider scientific community.

I am an unashamed advocate for the work of taxonomists because my own work relies on it heavily. But the aim of this piece has not been to elevate taxonomy above other areas of basic science. What I hope to have shown is that taxonomy is a vital element of an increasingly multidisciplinary scientific landscape. Working with taxonomists will be a part of the new era of big projects aimed at solving the grand challenges in ocean science. So the next time that you start a grant application, ask yourself 'How many taxonomists do I know?'

Further reading

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