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A research diver collects data in a coral reef.

MARINE BIOLOGY

Charting sea life

You want a career in marine biology but your maths is weak. Relax, the basic skills can be mastered.

BY CHRIS WOOLSTON

Biology attracts all sorts, from number crunchers to big-picture dreamers. These days in science, there's no escape from maths in any scientific discipline, even in one like marine biology, historically lighter on sums than, say, molecular biology or quantitative genetics. But nobody should let maths jitters deter them if their call is to study ocean life.

Although marine biology is built on a foundation of numbers — from the concentration of pores on a shark's snout to the survival rates of seal pups or worm distribution in sea-floor sediments — not every successful marine biologist is a whiz with numbers. Milton Love at the Marine Science Institute at the University of California (UC), Santa Barbara, readily acknowledges that maths is his biggest weakness. "I failed eighth-grade algebra," he says. "And I failed calculus as an undergraduate at UC San Diego. There was a point where I thought I'd have to take calculus 800 times to finally pass." He ended up squeaking through a lower-level calculus course, and went on to build a fulfilling career in research without ever feeling comfortable with the numerical side of his work. "I always managed to finesse the whole thing," he says.

Like many other scientists who struggle with a particular aspect of their research, he simply refused to let a deficiency derail his ambition — an ambition that he had harboured from childhood. "Nobody ever told me that I couldn't be a scientist because I was bad at math," he says. "I just bullied ahead. I was driven." In Love's — and other researchers' — opinion, almost anyone who is truly committed to science can find a niche, even if maths feels like a foreign language. Marine scientists for whom maths is not a strong point need a mix of determination and collaboration to go with their calculations — and the willingness to read a few books, download a video or two and maybe take an online maths and statistics course.

RUBBISH AT MATHS

Tammy Horton, a marine biologist at the National Oceanography Centre in Southampton, UK, often shares a not-so-secret confession with her students. "I'm very honest," she says. "I say I'm rubbish at maths. A lot of them breathe a sigh of relief." As it happens, Horton's speciality, the taxonomy of small deep-sea crustaceans, does not require ▶

much quantitative skill. To sort out one species from another, she often measures limb lengths or counts hairs, but that is a long way from differential calculus. It is also a long way from the types of multivariate analyses that ecologists, for example, face routinely. "I'm very lucky that I don't have to use much maths," she says. "A lot of marine biologists use a huge amount of maths, and it's getting more mathematical all the time."

Horton stresses that she did not get into taxonomy because she was trying to avoid hard-core statistics. Instead, she ended up diving into the tiniest details of already tiny creatures because that was what she really wanted to do — study the diversity and adaptations of deep-sea denizens at a very fundamental level. Career paths, she says, should be based on strengths, not on weaknesses. "You shouldn't choose a career because you have anxiety about statistics," she says. In her experience, determination can overcome most deficiencies. "The best thing to do is to recognize that maths doesn't come easily for you," she says. Armed with that self-awareness, she says, it's possible to learn skills, erase deficits and find a place in science.

"I would blame math anxiety more on educational history and less on innate abilities."

PACKAGE DEALS

Kathy Conlan, who researches marine life in the Arctic and Antarctic at the Canadian Museum of Nature in Ottawa, also feels disadvantaged when it comes to maths. "It doesn't come easy for me," she says. She is not above asking other people for help with statistics or programming, but she often just ploughs ahead on her own. That is partly because she works at a small institution with fewer options for collaboration, but also because she thinks it is better to "face the hurdles head on". Before using the statistical package PERMANOVA for analysis of multiple variables in a recent paper, she took a university course on the programme. Even then, she says, analysing the data was somewhat of a struggle. "I was reading and rereading the manual," she says. "I had to go back and look at university statistics books."

Conlan's maths issues go back to her master's degree, when she had to use punch cards to program the university's computer (it was the 1970s). She says that young researchers today probably face greater expectations when it comes to mathematical ability. But they do have more resources, including online maths and statistics courses to make up the gaps (see 'Resources for mathophobes'). "There are so many more ways now to help yourself," she says.

Statistics programs such as PERMANOVA, and the increasingly popular R, have levelled the playing field, says Steve Haddock, a marine biologist at the Monterey Bay Aquarium Research Institute in Moss Landing, California, and co-author on a book on computing for biologists. "You don't have to type in all of the equations, and you don't have to do the math yourself," he says. But he warns that canned programs also open the door for big mistakes if users are not thinking carefully about their data — detritus in, detritus out. Scientists who do not feel comfortable with numbers need at least to develop an intuitive sense of the problem that they are trying to address, he says, so that they know which part of the program to use. And, he adds, they need to have at least a general feeling for the data so that they can sort out the plausible results from the outlandish. "If you can't do all of the calculations, you should at least be able to make a ballpark estimate," he says.

MISGUIDED FEAR

Haddock, who used to program his own simple adventure games when he was a kid, says that his proficiency with computers has been a big asset in his career. But he knows that many early-career researchers are not so well prepared. In his view, anxiety about maths and computing should not keep anyone from pursuing science. "It's easy to think, 'Other people are better at this than I am'," he says, "but these things can be overcome." Besides, he says, fears about maths are often misguided. "It makes me sad to think about people who tell themselves that they're not good at math," he says. He believes that many junior scientists who feel that they have a maths deficiency could become fluent with the right encouragement and practical instruction.

From his own experience and conversations with other scientists, Haddock believes that many biologists get counterproductive instruction that erodes their confidence with numbers. "I would blame math anxiety more on their educational history and less on their innate abilities," he says. He recalls, for example, a poorly run biology statistics class in his graduate programme. Instead of introducing the students to the stats that they might need to describe their data, the instructor started by mathematically deriving the rationale for the *t*-test — the classic statistical method for determining whether two sets of data differ significantly from one another — which they were unlikely to understand and even less likely to use in the future. Similarly, he believes that many programming classes for scientists dwell on esoteric computing topics instead of on skills that researchers need, such as writing and debugging code to sort through large data sets.

Love says that many of the required or core maths courses for both undergraduate and graduate students seem designed more to weed out degree candidates or to complete a rite of passage than to prepare students for scientific careers. "The first couple of years as a biology major has nothing to do with a career in biology," he says. "If you can survive the first couple of years, you can find out what biology is all about. It's not about calculus and physics." When students come to him with concerns about maths or other parts of their education, he encourages them to look at the big picture. "If they say they like algae, I tell them to hang in there long enough to take an actual algae class," he says.

STRENGTH IN NUMBERS

Many researchers have found that a little outside assistance can go a long way when facing mathematical obstacles. Horton says that she sought advice from members of the statistics department when she was getting her PhD, and she still depends on collaboration today. There is a particular statistics-minded

LINDA SNOOK

Marine biologist Milton Love researches fish from a manned submersible.

HELPING HAND
Resources for mathophobes

Junior researchers who feel intimidated by maths and computing have options for sharpening their skills and building their confidence, says Steve Haddock, a marine biologist at the Monterey Bay Aquarium Research Institute in Moss Landing, California. His book *Practical Computing for Biologists* (Sinauer, 2011) was written to cut through the confusing clutter of many computing classes and focuses on the 10% of programming techniques that scientists use 90% of the time.

Unfortunately, Haddock says, few books take a similar approach to statistics. But researchers can get a better grasp of their data, including the ability to spot patterns and outliers, with the help of books on data visualization, such as William Cleveland's classic, *The Elements of Graphing Data* (Hobart, 1994), and Stephen Few's *Now You See It* (Analytics, 2009).

Haddock notes that the website Stack Exchange (stackexchange.com) can be a good place to get answers to specific maths and computing questions, although the online maths community might feel intimidating to someone who is already anxious about the topic. Help is also available on YouTube, including a channel by mathematician Vi Hart (see go.nature.com/mcqcr3) that uses art to demonstrate mathematical concepts. The videos help viewers to feel more familiar and comfortable with the numbers around them.

As part of its Elementary Maths for Biologists course, the University of Cambridge, UK, offers free online audio-visual tutorials on a wide range of mathematical topics including scientific notation, logarithms and exponential equations (see go.nature.com/nx8xga).

For sheer inspiration, scientists who feel inadequate with numbers could read 'Great scientist ≠ good at math', a 2013 *Wall Street Journal* essay by the eminent entomologist E. O. Wilson (see go.nature.com/573cmo). One of his observations: "Many of the most successful scientists in the world today are mathematically no more than semiliterate." **C.W.**

person in her department who is always glad to answer a question or give her much-needed feedback. "People are going to be willing to help you, and they'll do it for free," she says.

Like Horton, Love counts on outside support for his maths. Most of his recent grants have included earmarks — typically about US$10,000 at a time — specifically for statistical help. As he explains, his main areas of research, such as measuring fish productivity around oil platforms, require a level of analysis that is beyond his reach. He uses that grant money to rent the brainpower of people such as his colleague Mary Nishimoto at the UC Santa Barbara Marine Science Institute or Jeremy Claisse, a biologist at Occidental College in Los Angeles, California. "If I could actually do the statistics myself, which I can't, it would be more efficient," Love says. "But because I'm not doing it, I can do other stuff."

Still, as the importance of maths continues to grow — especially in big-data areas such as ecology, genomics and molecular biology — a little self-sufficiency can go a long way, says Elena Sarropoulou, a marine biologist at the Hellenic Centre for Marine Research in Crete, Greece. "I tell all undergrads and grad students to take a statistics class and to learn the programming language Python," she says. "Just the basics, in order not to be addicted to your bioinformatician in your lab." She maintains that marine biologists do not have to aspire to mathematical greatness. But they do need to know enough to be able to design an experiment with the appropriate sample size and other parameters to address the problem that they are trying to solve. In her own speciality of molecular biology, she says that researchers too often fail to consider statistical analysis when designing an experiment. She adds that relying solely on a maths expert to interpret results can be risky, because maths-minded people do not always see "the biology behind the data". A biologist with sufficient maths skills will be in the best position to see experiments through from beginning to end, she says.

Until the perfect scientist is invented, every researcher will have some gap in their skill set. The key, Love says, is to find ways to compensate, collaborate and, ultimately, to persevere. Not every researcher can, or even should, hire someone else to do their statistical analyses, he says, but they can find a way to match their aptitudes to their careers and vice versa. "Unless you're just not cut out for the academic life, keep going," he says. "Almost anyone can become a researcher. It's not magic." ■

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TRADE TALK
Venture capitalist


MVM LIFE SCIENCE PARTNERS LLP

Bali Muralidhar is an investment manager at London-based MVM Life Science Partners, an international life-sciences growth-capital fund. He describes his move from medicine into business.

Did you always want to work in investment?
No. Initially I wanted to go into academic medicine. I did preclinical training and worked as a junior doctor for a few years before I earned a PhD in translational cancer research from the University of Cambridge, UK. After that, I took a job as a health-care consultant at a small consulting firm and then moved into venture capital.

How did your scientific background prepare you for working in venture capital?
Medicine teaches you how to handle pressure. I learned how to deal with different types of people across the spectrum of wealth and personality. Equally, it puts a lot of the decisions I make in business into perspective: although everything is important, they are not life-or-death decisions. My PhD taught me to apply analytical rigour when I am collecting data, planning experiments and thinking things through.

What does your role entail?
We look for and invest in early-stage health-care and bioscience companies that we think have the best chance of success in drug or medical-device development and in their potential to help patients. Assessing the science is critical, but of equal importance is assessing whether a product will be clinically and commercially successful.

How do you determine if an idea will work?
You have to ask yourself where this product or treatment would fit in to a real-life medical setting. Is it viable in terms of time and resources in the treatment area? Is it going to make the company profitable? These are all things you wouldn't think about when you are doing in-depth research on a particular molecule, say. Just because you find something novel and get onto the front cover of *Nature* does not actually mean that this is going to change people's lives. ■

INTERVIEW BY JULIE GOULD

This interview has been edited for length and clarity; see go.nature.com/nvh18c for more.