

# Carry a Big Net—Cast It Far and Wide

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## Key Points

To have a rewarding and varied career with a positive effect on natural resource conservation, we recommend that you

- Dedicate yourself to developing new collaborations,
- Develop an eye for large-scale questions that necessitate large-scale collaborations and large-scale data sets, and
- Make the effort to learn a second language.

## Introduction

This is a vignette of events that led three fisheries scientists from very different places to collaborate on transcontinental and intercontinental research projects involving large data sets that none of us could have collected or synthesized alone. How did this happen and what results have come of it?

## Three Sinuous but Separate Paths

Robert Hughes (Bob): I grew up near a Michigan lake, where fishing was an important form of recreation and fish were a key component of the family diet. In this time, I began to understand the consequences that rapid population and economic growth can have on aquatic ecosystems. This catalyzed my decision to study biology and to earn an M.S. in resource planning and conservation from the University of Michigan, with the hope of protecting the natural resources I had come to value. I subsequently completed a Ph.D. in fisheries at Oregon State University and was hired as a contract research scientist at the U.S. Environmental Protection Agency (USEPA) lab in Corvallis, Oregon, where I worked for 30 years.

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Daniel McGarvey (Dan): I also grew up in the Midwest, where I spent much of my free time fishing in local streams and reservoirs or watching Sunday morning fishing shows. Studying biology and ecology as an undergraduate was therefore an easy decision for me. So was the decision to pursue an M.S. in fisheries at Pennsylvania State University. After completing my M.S., I moved to the Pacific Northwest and spent the next several years working as an industry consultant (aquatic bioassessment), traveling around the country to survey streams and rivers in a range of very different environments. These years were a wonderful opportunity to travel and learn, but I eventually decided that my career aspirations could only be met with a Ph.D. I felt this way for multiple reasons, but the truly decisive factor was simple curiosity: I wanted to know why the fish and invertebrates that I had spent the past several years collecting were so different in, say, the Willamette (Oregon), Susquehanna (Pennsylvania), and Pascagoula (Mississippi) River basins.

Bianca de Freitas Terra (Bianca): I am from Brazil, home to some of the planet's most biologically diverse biomes (e.g., the Amazon rainforest, the Cerrado, and the Atlantic Forest), its largest river (the Amazon), and its richest fish fauna. Although Brazil is a biologically and culturally rich nation, it is faced with ongoing conflicts between conservation and economic development. As a child, I witnessed the rapid degradation of the Atlantic Forest and decided to pursue a career in natural resource conservation and rehabilitation. I attended the Universidade Federal Rural do Rio de Janeiro (UFRRJ), where I entered the fish ecology program and began work on my first research project. As part of a team of undergraduate and graduate students, I surveyed streams and rivers throughout the Paraíba do Sul River basin. In this time, I came to know and appreciate the entire river system, including its many native fishes and the diverse people living along the river.

## The Paths Converge

### *Bob and Dan*

Bob: Our professional relationship began with a serendipitous encounter at the 2002 Annual Meeting of the North American Benthological Society (now the Society for Freshwater Science). Dan was presenting some of his previous bioassessment work and preparing to begin his Ph.D. studies in the Freshwater Interdisciplinary Sciences program at the University of Alabama. His recent exposure to rivers and streams throughout the United States had caused him to wonder why fish assemblages were so distinct in different parts of the country, and he was beginning to lay the groundwork for a dissertation on the ecology and biogeography of North American freshwater fishes.

Dan: Learning about my interests, Bob saw an opportunity for collaboration and told me about a large fish data set that was being compiled through the USEPA Environmental Monitoring and Assessment Program (EMAP). He suggested that the EMAP data might be ideally suited for the kinds of macroscale analyses I wanted to perform. Shortly thereafter, Bob agreed to serve as a member of my Ph.D. committee and I began a dissertation project that split my time between the Southeast and Pacific Northwest. Years later, Bob and I remain friends and his intuition regarding the usefulness of the EMAP fish data (and subsequent national-scale surveys) has proven to be correct; my research regularly incorporates a Southeast versus Pacific Northwest contrast (this is natural because the Southeast has the most diverse fish fauna in the United States, whereas the Northwest fauna is relatively depauperate), and the paper that I coauthored with Bob remains my most highly cited.

*Bob and Bianca*

Bob: I first met Bianca when she was an undergraduate at UFRRJ. Several years previous to this, I was approached by her (to-be) major professor after a talk I gave at a conference in Brazil. Her major professor invited me to come observe his work on the Paraíba do Sul River the next time I was in the country, and two years later I took him up on his offer. At that time, Bianca was part of a student crew working on the project and I enjoyed spending some time in the field with her and her classmates.

Bianca: I was initially hesitant to approach Bob because my English language skills were not as strong as I would have liked. I was also a bit intimidated by his reputation; his expertise in aquatic bioassessment was considerable and my major professor clearly respected him. But Bob's dedication and personality motivated me to work even harder, particularly in my English studies, and I eventually overcame my fear of not being able to communicate with him. Looking back, I am glad that I did because he has become a wonderful friend and mentor. He even helped me secure a five-month residency in Corvallis, Oregon while I completed my Ph.D. studies. And I am now proud to say that we have successfully published multiple papers together, including a cover story in *Fisheries*!

*Dan and Bianca*

Dan: Bianca first came to my attention during an email exchange with Bob. I was filling him in on the latest developments in my new role as an assistant professor in the Center for Environmental Studies at Virginia Commonwealth University when he asked if I would be interested in working with a postdoc from Brazil. (Side note: you know you have found a great mentor when years later he or she still checks in periodically to see how you are doing.)

Bianca: Bob mentioned that he might know of a suitable postdoc mentor for me and put me in touch with Dan. After a couple of emails, Dan and I agreed that the kinds of biogeographical questions he was working on would be a good way for me to apply and expand my research skills, which also pertained to field-based biological assessment projects. For instance, we discussed the possibility of using hydrologic time-series data to build macroecological models of the richness of tropical, subtropical, and temperate fish assemblages. We quickly drafted a research proposal and submitted it to the Conselho Nacional de Desenvolvimento Científico e Tecnológico of Brazil (CNPq) Science without Borders program. Several months later, I learned that I had been awarded a postdoctoral fellowship and I began making preparations to move to Richmond, Virginia.

**Our Proverbial Glue: Large-Scale Collaboration and Large-Scale Data**

Bob: Working at the Corvallis USEPA lab, I was fortunate to have the opportunity to help design and conduct national-scale research on river and stream ecosystems. EMAP and its successor, the USEPA National Streams and Rivers Assessment, required close collaboration with a large number of agency and academic geographers, computer programmers, ecologists, chemists, hydrologists, statisticians, and aquatic biologists. Becoming an expert in all of these diverse but interrelated fields is not something that any one person can hope to accomplish, and so it was quickly evident to me that large-scale collaboration would be the key to success in large-scale surveys. Efforts to develop biological, sediment, and nutrient criteria for U.S. streams and rivers, which will (hopefully) lead to more sustainable regional and national land and water management practices, have gone mostly according to plan. But, the really fun part of this large, complex process—the part that I could not have antici-

pated in advance—has been the increased opportunities to work with talented collaborators, many of whom are from places that I had never been and might otherwise never visit. I now have ongoing projects in South America, Europe, and Asia, where collaborators are eager to apply the regional surveying and bioassessment lessons that I have learned here in the United States. And to top it all off, I get to work with and mentor some really bright, up-and-coming young scientists!

Dan: Let me start by pointing out that it is we “young scientists” who are lucky to be working with Bob. Since completing my Ph.D., I have often struggled to find data sets that are as useful for multifaceted, large-scale research projects as the EMAP family of biological surveys. Most of the time, large-scale questions must be tackled by compiling data from several independent sources and then devising a way to standardize those data. This approach requires collaboration, too, and it sometimes works okay, but rarely so well as having access to a single large-scale data set that was generated using standard field methods. Now that I am responsible for leading, managing, and funding my own field surveys, I have begun to appreciate how difficult it is to build something like EMAP. I can also attest to the incredible value of the process and endpoint. Having access to EMAP data has allowed me to answer many of the questions that I explicitly set out to address. But it has also provided a means of generating peripheral publications to help maintain my productivity during transitional periods—and continuous productivity is essential for anyone considering an academic research career. I am now teaching this philosophy and some of the necessary skills to Bianca as we try to answer some new questions regarding the factors that maintain such exceptional fish diversity in tropical rivers and how these factors may change in the future. And I am still pursuing opportunities to work with Bob; next up is a major grant proposal to build fish interaction network models from some of the data that he has worked so hard to collect.

Bianca: Teamwork and collaboration have been essential components of all my research projects. Both as an undergraduate and a graduate student, it was necessary to work as a coordinated group because research funding is more limited in Brazil than in the United States, and large, tropical rivers require many hands to adequately sample. All of the students in my major professor’s lab (and in most Brazilian universities) worked together, regardless of individual thesis topic or level of experience. But this worked well because the more experienced students took it upon themselves to teach and mentor the newer students, and within this mix, new ideas were always evolving. For me, the more significant hurdle to large-scale collaboration, particularly with international collaborators, has been the need to master English. English is now the international language of science and it can be difficult for nonnative English speakers to integrate with the larger scientific community. Fortunately, the Brazilian government has created the Science without Borders program to immerse young scientists (me, for example) in English-speaking research environments. The program’s goal is to send 101,000 Brazilian undergraduate, graduate, and postdoctoral researchers abroad by 2015. It is because of this program that I have been able to work with international researchers like Bob and Dan, focusing on large-scale questions that require new and exciting skills in geographic information systems, statistical analysis, and ecological theory. These skills are particularly important to me because tropical rivers are inherently large-scale systems! When I complete my postdoctoral research, I am excited about returning to Brazil to share what I have learned, to begin building new collaborative networks of my own, and to expand on those developed with Bob and Dan.

## Reflections and Some Nonintuitive Advice for Those Starting on a Similar Path

Bob, Dan, and Bianca: Through independent experiences, we each came to understand that some of the most interesting and pressing research questions are, by nature, large-scale. And we learned that answering these questions requires large data sets that are beyond the capacity of any one of us to collect alone. Progress has therefore meant learning to work in teams and to manage and analyze large data sets. This last point is not trivial. Anyone working with very large, complex data sets will quickly learn that data management is an essential yet difficult skill. Basic spreadsheets will only take you so far before they corrupt the referential integrity of your data. (Just think about the last time you put the kibosh on your meticulously prepared data by accidentally sorting a spreadsheet without selecting all rows.) Eventually, you will need to invest some time in mastering a relational database system, such as Microsoft Access.

Finding creative ways to apply your past experiences and skills can also help to open new, collaborative doors. For instance, Bob has followed a uniquely nonlinear career path, transitioning among academic, agency, and consulting roles; working on four continents; and ultimately becoming president of the American Fisheries Society. At some level, this flexibility has been a product of his formal training and studies in psychology, environmental policy, and economics, which were all motivated by his personal interest in the human side of natural resource management. As an alternative example, Dan is now developing some precautionary decision-making tools for endangered species science. His past interest in environmental law and policy, which led to formal law school training (while working on his Ph.D.) and a law review article, helped him network with several leading scholars in environmental law. Together, they are searching for ways to better integrate the proactive intent of the Endangered Species Act with the evidence-based norms of scientific research. Some of your most productive and exciting collaborations will develop in ways that you did not originally intend, so be creative, remain open to new ideas, and remember that successful, large-scale collaborations begin with solid, small-scale collaborations.

Finally, we strongly recommend studying a second language. If you are a nonnative English speaker, this goes without saying. Becoming part of the international science network was and continues to be a significant challenge for Bianca. Basic English classes within the Brazilian school system did not fully prepare her to communicate at professional meetings or in English language science journals, and the opportunity to perfect her English is a big part of the reason she is now a postdoc in the United States. But even if you are “lucky” enough to have English as your first language, you should remain cognizant of the fact that other scientists, many of whom are brilliant and potentially fantastic collaborators, may not fully understand your work. Clearly, Bob’s international research would be easier to conduct if he had mastered a second language. And in our anecdotal experience, others are more prone to like and respect you if you at least make a minimal effort to communicate in their native language.

In summary, we suggest the following points to young and aspiring professionals in fisheries science and management:

- Actively seek collaboration with other disciplines and interest groups, including nonscientists;
- Present your work at large scientific meetings, where you are likely to meet new professionals and future collaborators;

- Develop some large-scale research interests that can serve as a substrate for large-scale collaboration;
- Learn to manage and analyze large data sets collected over large spatial extents;
- Be creative in leveraging and applying skills that are not immediately relevant to your primary research;
- Study and use a second language to facilitate cross-cultural communication; and
- Seek out a capable and caring mentor, and when you find one, do everything you can to make sure he or she knows how much you appreciate him or her.

Our shared penchant for large-scale research has become a signature of both Bob's and Dan's research portfolios, and it is quickly becoming an asset that Bianca will be able to leverage in her own career. Of course none of us can say with certainty where this path will take us. But, we each trust that by walking it together, we will have more opportunities, have more fun, and go further than any of us would alone.

## **Biographies**

Bob Hughes, the 2013–2014 president of the American Fisheries Society, is a courtesy associate professor at Oregon State University and senior scientist at the Amnis Opes Institute. He received his A.B. and M.S. from the University of Michigan and Ph.D. from Oregon State University. Prior to joining Amnis Opes, Bob worked as an on-site contractor for the U.S. Environmental Protection Agency. He is a member of Oregon's Independent Multidisciplinary Science Team and has been a guest professor at the Universität für Bodenkultur, Vienna, Austria; Universidade Federal de Lavras, Brazil; and Universidade Federal de Minas Gerais, Brazil.

Dan McGarvey is an assistant professor at Virginia Commonwealth University. He received his B.A. from Wittenberg University, M.S. from Pennsylvania State University, and Ph.D. from the University of Alabama. Dan conducted postdoctoral research with the U.S. Environmental Protection Agency. He has served as an adjunct professor at the University of Georgia, a research assistant for Oregon's Independent Multidisciplinary Science Team, and a consultant for the National Council for Air and Stream Improvement.

Bianca Terra is a postdoctoral research fellow at Virginia Commonwealth University through Brazil's Science without Borders Program. She received her B.S., M.S., and Ph.D. from the Universidade Federal Rural do Rio de Janeiro. She previously served as a research intern at Oregon State University.