Verifying the Validity of Volunteer Monitoring

by David Delaney

Currently I am a Ph.D. student at McGill University in Montreal. One problem I have with academia is that the findings made by academics mainly stay within academia. This is frustrating since it decreases the utility of the work. In order to rapidly disseminate my research results to the widest audience possible, I have written articles for newsletters, helped prepare newspaper articles, produced a free educational video, given presentations at conferences and workshops, and had many impromptu interactions with the public while sampling.

The lack of communication between scientists and the public is a two-way problem. Just as scientific information often doesn't reach a broad audience, a lot of the data collected by volunteer environmental monitors isn't getting to scientists. So I also strive to publish data by citizen scientists in peer-reviewed science journals. Recently a paper that I coauthored, reporting on a project in which citizen volunteers collected data on invasive crab species, was published by the journal *Biological Invasions* (see reference at end of article).

I believe that the validity testing we conducted on the volunteers' data was critical to the acceptance of our results in a peer-reviewed scientific journal. One of the two anonymous reviewers wrote that the "approach taken to validating the data is excellent and answers many of the concerns that many scientists have about using such data." Our *Biological Invasions* paper includes an extensive discussion of this validity testing. Only after presenting the results of the validity testing does the paper present and discuss the volunteers' data on invasive crab abundance and distribution.

Our success doesn't mean that validity testing is a guarantee that volunteer monitoring data will be published in science journals. However, in my view, a validation study is a prerequisite for publishing volunteer-collected data in a peer-reviewed journal.

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Volunteers search for crabs inside a randomly selected quadrat, then measure the carapace width of a specimen.

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One factor that helped in getting our paper published is that the field of invasion ecology is particularly receptive to, and appreciative of, volunteer data. Many important invasive species discoveries have been made by laypeople. For example, one of the species my research focuses on is the Asian shore crab, whose first sighting in North America was by an undergraduate student. The first time this species was reported in Massachusetts was at Woods Hole — but, oddly enough, it was not found by the great researchers who work in that town, but by a group of young campers.

The invasive crab study

The study was designed to collect data on the abundance and distribution of native and invasive species of crabs, with a particular focus on two invasives—the Asian shore crab (*Hemigrapsus sanguineus*) and the European green crab (*Carcinus maenas*)—that are the dominant species on the coast of the northeastern United States. The study also examined how accurately volunteers collected this data, as this was an important starting step for the establishment and authentication of a new regional volunteer network called the Citizen Science Initiative: Marine Invasive Species Monitoring Organization (CSI MISMO).

During the summer of 2005, my field assistant and I led free workshops at over 50 sites in seven states from New Jersey to Maine. Approximately 1,000 people of various ages, education levels, and professions participated.

After an hour-long training session on methodology, volunteers collected and recorded data during the hour before and the hour after the extreme low tide. During this period, volunteers randomly placed quadrats in the study area and searched the rocks and seaweed within the quadrat for all the crabs they could find. For each specimen, they

continued on next page

identified the species and gender and measured the width of the carapace (hard exoskeleton). The carapace width of the Asian shore crab ranges in size from 1 to 50 millimeters (mm), and that of the European green crab from 2 to 100 mm.

Gender and species can be determined fairly easily by examining external features on the carapace. For example, the European green crab has five anterolateral teeth (commonly known as notches or spines) on each side of its eyes, while the Asian shore crab has three. Surprisingly, color is useless for determining species. The European green crab can even be red! To learn how to properly measure the size of a crab or determine its gender, please see www.salemsound.org/mis/miskids.htm.

Asian shore crab (*Hemigrapsus sanguineus*)

European green crab (*Carcinus maenas*)

BOTH PHOTOS: DAVID DELANEY

The validation study

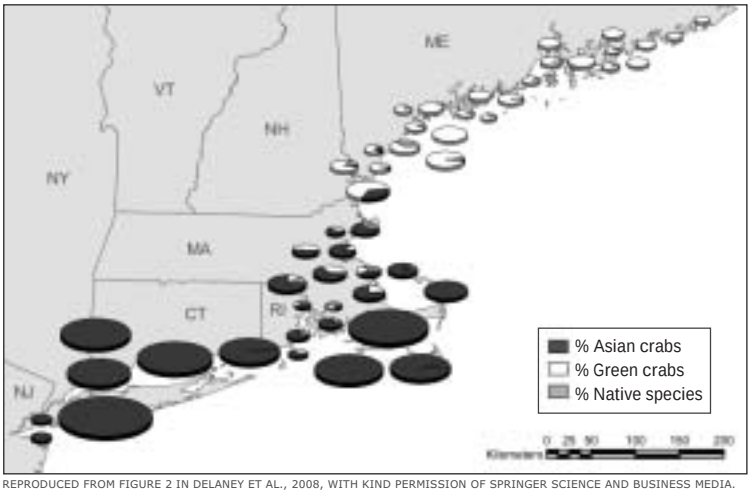
To have scientists accept and use the data collected by volunteers, I had to conduct a validation study to determine how accurately volunteers would determine crab species, gender, and size. The factors affecting the quality of data fall into two categories: factors related to the people conducting the sampling, and attributes of the thing being sampled. For my study, the people-related factors we evaluated were age, education, and the size of the group volunteers were working in. The volunteers' education level ranged from pre-kindergarten to doctorate degrees, and group size ranged from 1 to 10. For factors relating to the thing being sampled, we thought the size of the crabs would matter—larger crabs would probably be easier to correctly count and identify.

To gather the validation data, we checked every crab found by all 1,000 volunteers. Although this sounds excessive, and maybe it was (since we could have just checked a random subsample of the crabs collected by each volunteer), I feel it is always better to have too much data than not enough. It may mean the difference between a statistically significant result and an experiment that lacks sufficient statistical power to find a relationship that may actually be present.

We found that the size of the crab and the size of the volunteer group did not matter, but the education and age of the volunteers were highly significant. The great news was that even young volunteers could collect species data with high levels of accuracy. Volunteers in the third grade and above were 80 percent accurate in identifying species, and those in seventh grade and above were 95 percent accurate. Determination of the crab's gender was more challenging, requiring at least seventh grade for 80 percent accuracy and at least two years of university education for 95 percent accuracy.

We can maintain data quality assurance by enforcing eligibility criteria as a guideline for whose data can be used in peer-reviewed publications. For example, the data used in the figure at left below are data from people with a seventh grade education or greater, which ensures at least a 95% level of accuracy. Although we only used data from volunteers that met a certain level of education, everyone was allowed to participate in data collection. I feel it is important that young kids be involved in the monitoring since it raises awareness of the topic and of science as a whole.

The invasive crab species we studied are relatively easy to identify. Monitoring a different set of crab species in another region would require further validation. When in doubt, it is always best to hedge on the side of caution and do a validation study!



Graphic depiction of the volunteers' crab monitoring data. Pie chart size is proportional to average crab density at the site; the largest pie represents an average density of 43.83 crabs/square meter.

REPRODUCED FROM FIGURE 2 IN DELANEY ET AL., 2008, WITH KIND PERMISSION OF SPRINGER SCIENCE AND BUSINESS MEDIA.

Science literacy

Validation of volunteer-collected data is one important goal that can be achieved by collaboration between volunteer monitoring programs and the scientific community. Another important outcome of such collaborations is increasing the science literacy of the public. In our training workshops, we talk about scientific concepts like hypothesis testing, randomization (i.e., why quadrats must be randomly placed), and replication. Most important, participating together in monitoring allows the volunteers and trained scientists to exchange perspectives, information, and

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questions. This direct interaction rarely occurs, which I feel is a great shame.

The volunteers' findings

After discussing the validation study, our *Biological Invasions* paper presents and analyzes the volunteers' data. The figure on page 22, reproduced from the paper, shows how the volunteer data were used to map the distribution and abundance of the two introduced species as well as native crab species. This dataset is one of the largest standardized datasets that currently exists for native and invasive crabs in New England and New York. It clearly shows two southward-to-northward patterns — a decrease in crab density, and a species shift from the Asian shore crab to the European green crab. The most novel piece of information from our study was the finding of an Asian shore crab at a location 60 km northeast of the previous most northeastern observation.

Is publishing worth the effort?

Should volunteer monitoring groups work to have their data published in peer-reviewed journals? My answer is yes, for multiple reasons. If volunteer data is not contained within scientific journals, it may never be seen or used by scientists and managers. Publication greatly increases the data's accessibility and utility. By publishing in peer-reviewed journals, volunteer programs will receive feedback in the form of reviewers' comments as well as responses from others in the scientific community.

If you have data, it is worth contacting an academic to form a collaboration that could end in publication — a positive result for both the monitoring group and the scientist. Some scientists, such as ecological modellers, are limited mainly by a lack of data and may welcome the opportunity to work with volunteer-collected information.

David Delaney is a marine biology Ph.D. candidate at McGill University and the Director of CSI MISMO. He may be contacted at david.delaney@mail.mcgill.ca.

For more information:

Delaney, D.G., C.D. Sperling, C. Adams, and B. Leung. 2008. Marine invasive species: Validation of citizen science and implications for national monitoring networks. *Biological Invasions* 10:117-128.

CSI MISMO website: www.InvasiveTracers.com

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David Delaney trains a group of students.