Serendipity in My Life

Kathleen J. Vigness-Raposa

Serendipity is that wily combination of being in the right place at the right time and creatively connecting that experience with disparate events that have occurred in one's background to chart a new path of exploration, sometimes considered an "ah ha" moment. This has occurred at several points in my life, fueling my passion for ocean acoustics outreach (earning the nickname "Kathy DOSITS") and crucial conversations about best practices for evaluating the risks of anthropogenic activities in ocean acoustic environments.

Both of my parents were teachers and several summers were spent camping and exploring the western United States. These experiences exposed me to extraordinary natural beauty and diverse cultures. One summer day while tide pooling along the California coast, we encountered a sperm whale that had stranded and died. Being from Wisconsin, this creature absolutely fascinated me, and I became passionate about studying marine mammals.

As many lovers of large megafauna can attest, it is a difficult journey to develop that expertise, and my parents were convinced I would never get someone to pay me to do something so wonderful. My undergraduate degree was in secondary science education from Miami University, Oxford, Ohio, which provided me with an incredibly diverse foundation in biology, chemistry, physics, geology, and mathematics along with educational psychology, teaching principles, and communication skills. This extensive background has provided me with an incredible foundation that has helped me make connections across a variety of disciplines.

I was fortunate to earn a spot in the master's program at the Graduate School of Oceanography at the University of Rhode Island (URI), Kingston, working with Howard Winn on analyzing acoustic recordings of minke whale vocalizations. One of the courses I took was on marine mammal population dynamics, taught by Tim Smith from the United States National Oceanic and Atmospheric Administration (NOAA) Northeast Fisheries Science Center. This was a serendipitous encounter because it was the one time that Tim taught at URI, and it made me think about the possibilities of integrating passive acoustics into population dynamics. At that time (mid-1990s), population dynamic surveys for marine mammals consisted of visual surveys, typically from a vessel or airplane, and analyzed with distance sampling statistics.

Distance sampling has several underlying assumptions. One of the foundational assumptions is that all animals are equally available for detection at any given time, that is, that the probability of detecting an individual, by whatever means being used, is 100% within a known area. This assumption is obviously not met with visual surveys for diving marine mammals. Statistics have been developed to deal with diving marine mammals, which led me to wonder if similar statistics could be developed for detecting vocalizing marine mammals during a passive acoustics survey. Spoiler alert! They could (Thomas and Marques, 2012); however, that work would come much later by statisticians; my focus was on the foundational knowledge needed to inform those statistics.

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To use passive acoustics in population dynamics requires a fundamental understanding of each species' vocalizing behaviors and how those behaviors will affect the probability of detecting individuals. For example, do all individuals produce the same types of vocalizations (frequency, source level, signal length, repetition rate)? Do they vocalize with the same temporal patterns (diel variation, seasonality)? Do they vocalize in the same locations at the same water depths? My master's thesis was a simulation study of the diving, movement, and vocalizing behaviors of minke whales during a passive acoustics survey and a visual survey. By running many thousands of iterations of animals diving and vocalizing during simulated surveys, I looked at how each surfacing and vocalizing behavioral parameter influenced the detectability of individual animals. The ultimate question was: How well do we need to know the diving, movement, and vocalizing behaviors of a species to conduct surveys that would result in accurate population dynamics estimates?

Unfortunately, Howard Winn died of a heart attack after my first year at URI, but as serendipity would have it, that was just when James H. Miller came to URI's Department of Ocean Engineering (see bit.ly/3WQqHtw), which started a long-term collaboration that continues today (e.g., Amaral et al., 2020; Potty et al., 2023). Jim connected me with one of his colleagues from their time together as students at MIT, Cambridge, Massachusetts, William T. Ellison, founder of Marine Acoustics, Inc. (MAI; see bit.ly/46UtNkJ), where I started to work during my time as a master's student. This was also a serendipitous connection because my bioacoustics work complemented the mechanical/electrical engineering background of almost everyone else at MAI at a time when the potential effects of underwater acoustic exposure on marine animals was just beginning to be understood.

The simulation work I was doing to understand the importance of various behavioral parameters for visual and passive acoustic surveys informed parameters needed in the animal movement component of MAI's Acoustic Integration Model (AIM). AIM was built first in the computer programming language Fortran by Bill, then converted to Java to simulate the four-dimensional (threedimensional [3D] space plus time) interaction of diving and moving marine animals ("animats") within an acoustic field created by a sound source. The animats record their acoustic exposure at each time step; the recorded sound pressure level or particle velocity at each time step can be used to calculate each individual's overall exposure over a simulated activity (Frankel et al., 2002).

This development moved risk assessment analyses from simplistic zones of influence (ZOIs), where potential effects are estimated to occur out to a distance from an activity and animals are distributed in two-dimensional (2D) space based on their density (number of individuals per area). In that type of analysis, an animal within the ZOI range is affected and an animal outside the range is not affected. There is no consideration of water depth with acoustic propagation nor animal movement during the activity.

With models such as AIM, the animals and the anthropogenic activity are simulated in real-world scenarios, and at specified timesteps, the animals sample the environment, including the acoustic field. The output of each simulation is a time-stamped movement and exposure profile for each individual animal from which potential effects may be estimated. Animals can be programmed to respond to environmental features, and their densities and distributions can be predicted using geospatial statistics and landscape ecology principles, another serendipitous exploration during my PhD work at URI (Vigness-Raposa et al., 2010).

Another part of my master's career led to a long-term collaboration in developing the Discovery of Sound in the Sea (DOSITS) project (Vigness-Raposa et al., 2021), which has been a series of serendipitous events that have blended outreach education and underwater acoustics to develop world-class resources. As a student, I had an educational outreach assistantship with Gail Scowcroft (2023), working with educators, media professionals, and graduate students to incorporate marine science topics and processes into their daily work as well as developing educational outreach material on a variety of marine science concepts.

In later years at MAI, I was conducting risk analyses for underwater acoustics experiments funded by the Office of Naval Research (ONR). One of the research cruises coincided with an operational United States Navy military training exercise in the Providence Channels of the Bahamas, which resulted in a multispecies mass stranding of 17 cetaceans (Evans and England, 2001). In trying to field questions from legal teams, public affair officers, program managers, and the general public, it became clear that there were no resources readily available to explain the fundamental scientific principles of underwater acoustics.

I started collaborating with Peter F. Worcester at Scripps Institution of Oceanography, La Jolla, California, to develop an educational website on underwater sound, but thankfully, serendipity stepped in and reminded me of my foundational roots with Gail Scowcroft. Peter, and I soon realized that as much as we loved the science of underwater sound, we needed to expand our team to include educational outreach and communication professionals, which was unique in marine sciences at the time and really only occurring with large NASA projects. The DOSITS project was launched in 2001, with the DOSITS website (see dosits.org) coming online in November 2002. Gail and I have been co-Principal Investigators ever since, with Peter, Jim, and me as the original subject matter experts for DOSITS, and Gail and colleagues at URI as the educational expertise, translating our "science-ese" for the general public.

DOSITS has continued to be supported primarily by the ONR, for which we are incredibly grateful. The website has grown from tens of pages of content to over 500 pages (Vigness-Raposa et al., 2021). Content is divided into three main sections: Science of Sound, People and Sound, and Animals and Sound. The difficulty level begins with basic content describing sound and its properties and how and why people and animals make and use sound. Content progresses through difficulty, reaching university level in some advanced topics where physics and mathematics are introduced. Galleries provide information inviting to all ages, with audio files of underwater sound sources (Audio Gallery), equipment descriptions (Technology Gallery), representative scientists (Scientist Gallery), and careers that use acoustic skills (Career Gallery).

Moreover, DOSITS resources have expanded to include webinars, structured tutorials, and professional development opportunities. Webinars have been ongoing since 2015, offering opportunities for participants to connect virtually with acoustic professionals. There were more than 3,134 registrations and 1,385 individual live connections from over 79 countries for the 2023 webinar series (several people participate in the DOSITS webinars in groups). As of fall 2024, there have been 38 webinars, which are recorded and openly available for nonconcurrent viewing (see bit.ly/47CRVbu).

I have continued to dedicate my life to helping build resources for scientists to communicate with the public. As scientists, we rarely receive training on how to have crucial conversations with the public or media personnel. It is difficult for nonscientists to understand the scientific process and the importance of peer review, particularly now in our immediate gratification culture. But I know we can continue to be creative and support multidisciplinary thinking to encourage serendipity in others.

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