ARTICLES

Field Research Studying Whales in an Undergraduate Animal Behavior Laboratory

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Abstract: This work describes a new field research laboratory in an undergraduate animal behavior course involving the study of whale behavior, ecology and conservation in partnership with a non-profit research organization – the Blue Ocean Society for Marine Conservation (BOS). The project involves two weeks of training and five weekend trips on whale watch vessels to the Jeffreys Ledge region of the Gulf of Maine to collect behavioral data, and to track and individually identify humpback and fin whales as well as document the presence and behavior of other marine mammals and seabirds. Students learn to use an ethogram of whale behaviors as well as methodology related to individual identification in the field. Students work with BOS scientists, using the BOS field research protocol described herein. In conjunction with the project, students keep a journal, pass data collection and ethogram proficiency tests, and complete data sheets associated with each trip. The project has been very successful, providing students with exposure to multiple scientific skills, and emphasizing competencies over content. We hope it may serve to inspire the development of similar partnerships and/or quantitative field studies in other more practical species.

Key words: behavior, marine biology, field research, whales, conservation, community outreach

INTRODUCTION

A key goal of undergraduate coursework in animal behavior involves providing students opportunities to engage in descriptive and quantitative data collection and analysis in the form of controlled laboratory studies and field data collection. The latter can be difficult to incorporate into a traditional undergraduate course given the logistics associated with planning field experiences and the oftentimes poor quality and quantity of data collected. This article describes a laboratory studying whale behavior, ecology and conservation in the Gulf of Maine (GOM) as part of an undergraduate advanced animal behavior course offered within the Department of Biology at Merrimack College in North Andover, MA.

The laboratory involves collaborating with a non-profit organization, the Blue Ocean Society for Marine Conservation (BOS), in marine mammal research and education. Established in Portsmouth, NH, in 2001, BOS's mission is to conserve the marine environment through education and research in New England. From May through October, BOS naturalists work aboard four commercial whale watch vessels collecting behavioral and physical data on whale, dolphin, and seabird populations in the GOM while educating passengers about marine mammal ecology and conservation.

The BOS/Merrimack relationship began with a regional scan of internships available for college biology majors conducted by Merrimack Associate Professor Dr. R. David MacLaren in November, 2008. MacLaren met with BOS cofounders Dianna Schulte and Jennifer Kennedy soon thereafter, leading to the establishment of a partnership in research and education in January 2009. As part of the collaboration, BOS provides competitive internship opportunities to qualified Merrimack students. BOS's 14 years of research offer a wealth of opportunities for students to engage in the analysis of complex behavioral and environmental datasets, while the field work provides opportunities to engage in unique and exciting research experiences. At the tail end of a successful summer collaborating with BOS in whale research and public education in 2009, Dr. MacLaren began developing the animal behavior course with a lab component inspired largely by the BOS partnership. BOS was very receptive to the idea, seeing it as an opportunity to further their educational mission, draw more interest to their internship program, and acquire additional resources in the form of undergraduate assistants as well as technology for data collection and analysis (e.g. access to greater computational power, geographic information systems and statistical software, digital SLR cameras, and handheld GPS units provided by the College).

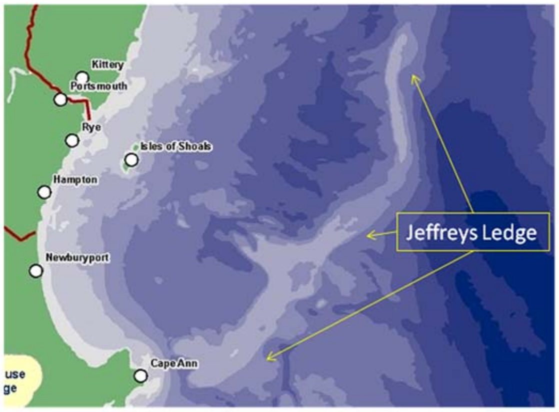

Fig. 1. Jeffreys Ledge, a seasonal feeding area for numerous species of endangered marine mammals and the region where Blue Ocean Society naturalists travel most frequently to study whales given its proximity to the ports of Rye Harbor, NH, Hampton Beach, NH, and Newburyport, MA. Jeffreys, a productive fishing ground, is a rocky underwater ledge approximately 30 miles long and 5-6 mi wide. The water above the ledge is 150-200 ft. deep, whereas the surrounding water can be as much as 400-600 ft.

Jeffreys Ledge (a biodiverse and productive fishing ground in the GOM) is BOS's principal study area, given its proximity to the ports of Rye Harbor, NH, Hampton Beach, NH, and Newburyport, MA. Jeffreys is a rocky ledge, similar to an underwater mountain range, approximately 30 miles long and 5-6 miles wide (Figure 1). Due to its unique topography, the ledge is a productive marine ecosystem and major seasonal feeding area for numerous endangered marine mammals including fin whales(*Balaenoptera physalus*), humpback whales (*Megaptera novaeangliae*), North Atlantic right whales (*Eubalaena glacialis*), and Atlantic white-sided dolphin (*Lagenorhynchus acutus*) among several other species.

Incorporating field research into coursework in animal behavior

The animal behavior course met at Merrimack College for three 50-min lectures and one 2.5-hr lab per week for 15 weeks. The lab was divided into two half-semester projects designed to introduce students to careful observation in nature and controlled laboratory experimentation. The laboratory addressing the former is the focus of this paper, introducing students to marine mammal behavior, life history, ecology, and conservation in the region. Students learned to use an ethogram of whale behaviors, methodology related to individual identification and the BOS field research protocol. Upon completion of data collection and ethogram proficiency tests, students collected behavioral data, tracked, and individually identified humpback and fin whales among other marine species in collaboration with BOS scientists on five trips aboard local whale watch vessels. Additionally, they kept journals, completed data sheets for each trip, and were actively engaged in public education as described below.

Although all students entering the course were junior/senior biology majors having taken a common core sequence of Biology I & II, Ecology, and Genetics, they had virtually no exposure to the study of animal behavior – a required course for Merrimack's concentration in "Ecology and Environment" and an open elective for all Biology majors. Moreover, despite Merrimack's geographic location, several students had never been on a whale watch before, or even spent time on the ocean.

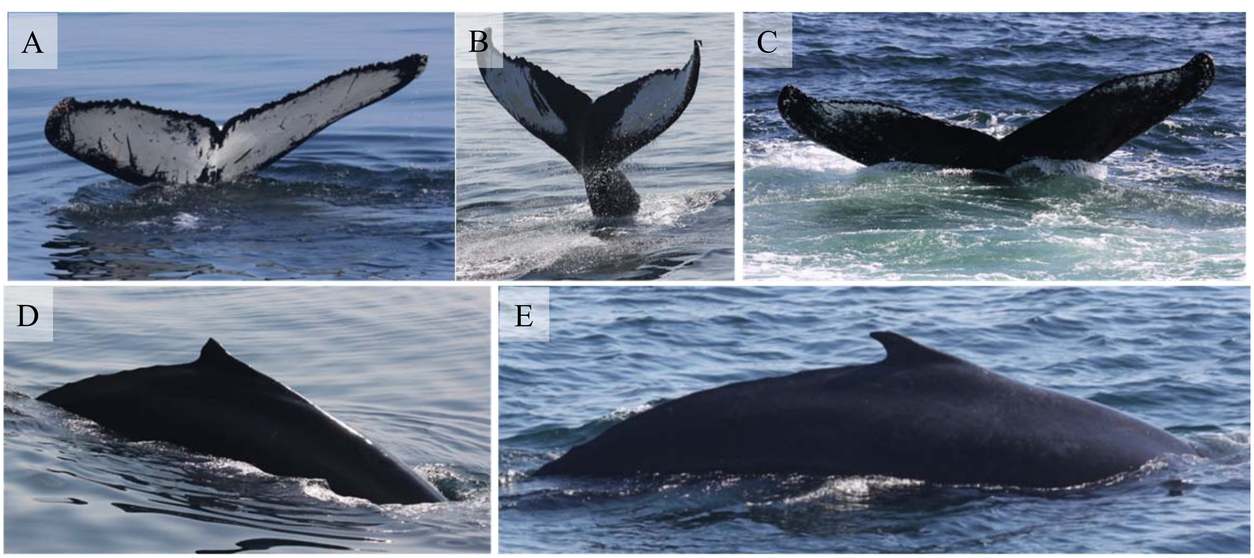

Fig. 2. Humpback whales (*M. novaeangliae*) possess markings on the ventral surface of their tail flukes used to identify individuals. Flukes vary from all white (T1) to all black (T5) and change little over the course of an individual's lifetime, serving as whale "fingerprints." All identified humpbacks are given permanent names used by all research organizations studying them world-wide. A) Filament's T1 fluke; B) Chromosome's T3 fluke; C) Ivee's T5 fluke; D) Filament's dorsal fin; and E) Flicker's dorsal fin.

The goals of this paper are to describe the whale project, provide student feedback about the course, and reflect on how this laboratory may be used as a model for the development of similar field-based experiences.

Whale research: A brief history

Marine mammals serve as keystone species in fragile marine ecosystems, inspiring greater environmental appreciation and awareness. With many species near extinction in the mid-1900s, early cetologists launched field studies, finding it was possible to repeatedly locate and recognize individual whales (e.g. Katona *et al.*, 1979; Whitehead and Payne, 1981; reviewed in Hammond *et al.* 1990; Figures 2 and 3). Photo identification and data on resightings of individuals provided valuable information on population parameters, among other life history traits (Hammond *et al.*, 1990). Individual identification thus paved the way for modern whale behavioral studies (Payne *et al.*, 1983) and is now common practice in studies of animal behavior.

Although the threats have changed over time (reviewed by Whitehead *et al.*, 2000), conservation persists as the principal thrust of whale research. As some risks to whales have diminished since the worldwide ban on commercial whaling in 1986, new threats have emerged including entanglement in fishing gear, disturbance by and/or collision with boats, pollution, and climate change. Conservation concerns and the ability to recognize individual animals have ushered in a new era of field research that includes an increasing number of studies emphasizing long-term monitoring of known individuals to assess cetacean sociality and the selective forces that shape patterns of whale communication, life history, behavior, and ecology. Moreover, cetacean behavioral research compares favorably in quantity and sophistication with those of terrestrial mammals such as ungulates and primates (Whitehead and Dufault, 1999), revealing a number of parallels between whale societies and those of terrestrial mammals (Conner *et al.*, 1992; Smolker *et al.*, 1992; Weilgart *et al.*, 1996).

PROCEDURE

Two laboratory manuals were developed by Dr. R. David MacLaren in collaboration with BOS cofounders Dianna Schulte and Jennifer Kennedy. The first is a 43 page document, "Whale Behavior and Ecology Lab Handbook," which includes BOS background information; policies, procedures, meetings and deadlines for course field trips; a project overview; description of a typical whale watch; and information regarding the ecology and species typically observed on Jeffreys Ledge. The second manual, "Guide to Whale Data Recording and Sequencing," describes the research protocol used for data collection including the ethogram used for behavioral sequencing.

Week 1a. On-campus lab meeting--whale project introduction: The first laboratory involved reviewing whale behaviors, data collection, educational approaches, schedules, and general policies described in the lab handbook. Students viewed videos of whales exhibiting the behaviors to be learned in the ethogram and practiced behavioral sequencing. Students also learned techniques used to distinguish among different whale species in the field and how to identify individuals.

The Ethogram

Forty years of whale behavioral studies in the GOM have provided a greater understanding of the function of over eighty discrete behaviors exhibited by our study species, leading to the development of an ethogram–a comprehensive list of well-defined behaviors that whales exhibit at the water's surface. In mastering the ethogram, students learned to distinguish between short-duration behavioral displays (e.g. breaches or breaths) and long-duration behaviors (e.g. "logging" and associations between individuals) (Altmann, 1974). The behaviors described in our ethogram represent humpback

Fig. 3. Sample fin whale (*B. physalus*) dorsal fin and chevron photos used for individual identification: A) dorsal fin of whale #9820; B) dorsal fin of whale #0613; C) Chevron of whale #0720; and D) Chevron pattern of whale #0613.

whales, but some are also seen in other species. To record behaviors quickly and efficiently, behavior codes are used to describe specific activities. Table 1 contains sample behaviors and codes found in the whale ethogram. Students were asked to memorize the codes for the most common behaviors observed in the field.

Individual Identification

Individual identification is another important aspect of long-term field studies. It is therefore critical that students learn techniques used for identifying individuals *within* species—specifically humpback and fin whales. Humpbacks can be individually identified using distinctive color patterns on the ventral surfaces of their flukes, marks on the fluke's trailing edge, dorsal fin shape, and scars (Katona *et al.*, 1979; Figure 2). Fin whales are identified using back pigmentation patterns (the chevron), dorsal fin shape, and scars (Figure 3). The best photographs of identifiable individuals from each encounter are compared with a catalog of existing photo-identification records to determine the identity of all whales observed. Students were asked to identify individuals encountered in the field using a catalog provided by BOS.

Week 1b. First weekend on the water: Week 1 culminated in the first of five 5-hr weekend whale watch trips departing from an affiliated whale watch company on the New Hampshire coastline. The College paid a fee of $15-20 per student per trip to the whale watch companies. No fees were paid to BOS scientists as they were compensated by the whale watch companies for serving as naturalists hosting the trips. Students did not collect data on their first trip, using it as an opportunity to familiarize themselves with the boat, see whales for the first time, and observe others collecting data.

Week 2a. On-campus lab meeting #2: Students took a proficiency exam in week two, assessing their grasp of the material in the handbook, competency in behavioral sequencing using the ethogram, and ability to identify individuals using an abbreviated photo catalog of named whales. The meeting also provided time to address student questions and concerns before collecting data the following weekend.

Week 2b. Second weekend on the water: At the end of week 2, students began the first of four weeks of data collection in collaboration with BOS scientists aboard commercial whale watch vessels. The following protocol was typically used:

1. Passengers boarded 15-25 minutes before departure and received safety announcements from the captain and an introduction of the crew.
2. The naturalist invited passengers to check out the posters and displays and to look for marine life on the way to Jeffreys Ledge. Students used this time to look for whales and marine debris or to talk with passengers about whales and marine ecology etc.
3. Once we got within 5-10 miles from potential sightings, the naturalist gave an introduction speech on the Gulf of Maine, whales in general, and the species we might see that day.

Table 1. Sample codes and descriptions of behaviors exhibited by humpback and other large whale species included in the ethogram used for behavioral sequencing (see methods for further explanation).

Code	Description
FLU (fluke)	Bringing the tail flukes into the air at the beginning of a dive so that the ventral pigmented surface (humpbacks) would be visible from behind the animal.
LTA (lob tail)	Slapping the tail ventral surface down on the water after an even arc of the tail stock (as opposed to the sporadic uneven motion of a tail breach).
BUSLP (belly up flipper slap)	Pectoral flipper is brought into the air and dorsal side is slapped onto the surface. BUSLP's may take place from both flippers simultaneously if the whale is on its back. If both flippers are slapped down at exactly the same time, it is recorded as a DBLBUSLP (double belly up flipper slap).
S (spout)	Animal exhales, followed by inhaling. Blowholes are above the surface and a misty column is formed.
BRSH (spinning head breach)	The highest and most spectacular of all breaches; animal comes 2/3 to all of the way out of the water, while spinning up to 360 degrees. Generally, one flipper is held close to the side, while the other is outstretched. Animal usually falls on its side or back.
SND (sounding dive)	Animal arches its back tightly and appears to be taking a deep dive, but does not bring flukes into air. Animal may or may not actually be diving.
VBRL (vertical lunge)	Animal's body is perpendicular as it breaks the water (often up to the eyes). Evidence of feeding is seen. Whale usually sinks vertically as well.
BLC (feeding bubble could)	Large circular patch (10-13m diameter) of fine bubbles appears. Animal surfaces after 5-20 seconds of bubbles appearing, with mouth open, or with mouth closed but filtering.
***LOG** (logging)	Animal is stationary at the surface, breathing at regular intervals, and appears to be in a resting state.
***CTB** (close to boat)	A social behavior. Animal is directly orienting its behavior to the vessel, usually in a curious manner.
***NURSE**	Calf makes one or more shallow dives directly in the vicinity of its mother's tailstock area as the mother continues moving along at the surface.

* continuous behaviors and should be recorded with a *start and end time*.

4. We spotted marine species and the naturalist gave a commentary on the species' natural history and its identification, and its life history (if it was a whale that was recognized from past whale watches). Students collected detailed data and helped the naturalist with photo identification.
5. During the return trip, the naturalist and interns again brought around displays (whale bone, baleen, plankton sample, whale sounds) and answered passenger questions.
6. As we docked, the naturalist gave a wrap-up summary of what happened on the trip.

Students were responsible for collecting detailed data pertaining to the animals observed and answering passenger questions about whales and the local marine environment. The amount of detail in the data collected depended on the species observed. At minimum, a trip summary sheet was completed recording physical data such as weather conditions and tides (Figure 4). A behavioral sequencing sheet was also completed for all humpback, fin and right whale sightings. The field protocol was taught to students as described below.

Student materials required for data collection included a handheld GPS, pen, digital watch, trip summary sheet, and sequencing sheets all attached to a clipboard. Of particular importance was that students be able to hold the clipboard, write and note the time all at once. As soon as the boat left the harbor, students began logging the time and position (latitude and longitude) every 10 minutes to record the boat's track line throughout the trip. Students logged animal sightings onto the trip summary sheet as described in Table 2.

Behavioral Sequencing

Behavioral sequencing, a method of data collection used in animal field studies, provides a chronological record of behaviors along with notes on individual identification, position, and other significant activities in the area. Sequencing allows analysis of many subtle aspects of animal behavior and provides a general record of activity patterns for studying population dynamics. Students assign one column of the behavioral sequencing sheet to each whale in the immediate vicinity. The whale's name or dorsal fin description is written at the top of the column. The whale's behavior is documented in sequence using the behavioral codes in the ethogram along with the time, to the second, it occurred. It is important for students to quickly distinguish the dorsal fin of each whale in the group (Figures 2 and 3) before attempting to record the whales' behavior to ensure proper identification of individuals sequenced simultaneously in separate columns. Each line on the sequence sheet represents one point in time. Thus, each successive behavior gets recorded on a new line. Only behaviors that occur simultaneously are written on the same line. The goal is to recreate the exact sequence of behaviors from the information recorded on the data sheet.

Students occasionally encountered continuous behaviors as well (e.g. LOG, NURSE, Table 1). A whale might do other things during the course of the continuous behavior. For example, a whale can be "logging" for 10 minutes, but take a breath every minute. When a continuous behavior began, students wrote "Start LOG" (or whatever behavior it was doing) and the time followed by "End LOG" and the time when the behavior ended. If/when students became confused or missed behaviors, they were instructed to write "MISS" in the column at the time where there was a lapse in data collection. Otherwise someone looking at the data later on would mistakenly assume nothing had happened during that time interval.

Documenting Associations

We emphasized to students the importance of recognizing and recording "who is with whom" (i.e.

Table 2. Students logged animal sightings into the trip summary sheet (MacLaren *et al.*, 2012) as described below.

Animal Sightings: The largest section of the trip summary data sheet is the area to record all mammal and fish sightings. Refer to the sample sheet sheet (MacLaren *et al.*, 2012).
Time: Write the hour and minutes of the first time we see a whale (or seal, shark, tuna, etc.). Below that, in the same box, write the time when we leave that animal.
Location: Write the Latitude and Longitude, in decimal degrees, which correspond with the first sighting time. Below that write the latitude and longitude that correspond to the time when we leave the animal.
Sp. /#/A: Species/number/Association. Write the species code (e.g. humpback = Mn for *Megaptera novaeangliae*) and how many are in the area or traveling together. If there is more than 1 animal, note if they are associated or not (A=associated, N=not associated). (e.g. Mn/3/A = 3 humpbacks associated; Mn/3/N= 3 humpbacks not associated)
ID: Write the name of the humpback or finback, if known. If it is unknown, identification will be determined after the trip using the catalog back in the lab.
Behavior: Summarize the major and minor behaviors of each sighting by using behavior codes from the ethogram.
Photos: Write the digital image numbers of all shots taken so that each photo can be associated with the correct behavioral data taken on each whale.
Buoys: Record the number buoys of each type seen within a 1-mile radius of sighting.
Birds: Circle codes for the major bird species in the area.
WW Vessels: Circle the vessels that are at the same sighting. If one of the boats is arriving or leaving, please indicate by noting "POW-leaving 12:32" or "POW-arriving 11:45". This helps BOS link sightings of the same whales, and gives them a better idea how many non-identifiable whales are really out there.

associations/changes in group structure) in the field as a critical aspect of the study of social behavior. Association is defined as the state of being within 1.5 body lengths of each other and coordinating behaviors (e.g. diving, surfacing together). Students were instructed to document associations as follows:

JOIN (MacLaren *et al.*, 2012): When two or more whales associate, a horizontal line is drawn connecting the columns in which those whales are listed. The time they joined is recorded in the left margin next to that line. If the whales are associated upon initial approach, a horizontal line connecting their names is drawn immediately.

SPLIT (MacLaren *et al.*, 2012): If a whale leaves a group, a horizontal line with a diagonal slash is drawn between that whale's column and the column(s) of the other whale(s) in the group, noting the time in the left margin.

OFF (MacLaren *et al.*, 2012): When an animal leaves the vicinity, the boat leaves the animal, or the student is no longer recording the animal's behavior, "OFF" is written directly below the last behavior recorded for that animal followed by the time and location (lat/long).

Documenting Other Activity in the Area

Often, when sequencing whales, we see other activity that is too far away to sequence effectively. When this happened, students were instructed to record the species, number of animals, position, time, behaviors (if known) and photos taken on the trip summary sheet. Lastly, students were asked to record any information that may be significant to the whales' behavior in the left margin of the sequencing sheet including birds and their concentration, bait patches, tuna, sharks, sunfish, nets/buoys, and boat activity.

<u>On-campus lab meetings, weeks 3-5</u>: Beginning in week 3, students were assigned relevant primary literature to improve their general knowledge and presentation of information to passengers. The purposes of these weekly meetings were to provide students opportunities to ask questions, discuss the trip(s), and address the weekly readings, requiring no more than 30-60 min of lab time. Students also kept journals to log their hours at sea, summarize each trip, record their ideas for improvements in data collection, and reflect on their experience. Journals were reviewed weekly, beginning week 3.

<u>Weekends 3-5 on the water</u>: Students continued field data collection and public education as described above.

Assessment of student learning

Learning assessment was conducted by the course designer and instructor and included a whale data collection, behavioral sequencing and ethogram proficiency test; species identification and humpback whale fluke matching quiz; accurate and organized completion of four trip summary and behavioral sequencing sheets; five whale journal entries; several short essay questions pertaining to the whale project built into the first lecture exam; and attendance and participation in laboratory meetings and whale watches.

ASSESSMENT

Student evaluations of the Animal Behavior laboratory were positive, rating it highly overall (3.86 out of 4). Specifically, they found the labs to be well-organized/prepared (4.0), and the instructor's teaching effective (4.0). They also indicated the course challenged them to think critically (3.43), lab assessment techniques accurately reflected course material (3.71), and grading practices were fair (3.57). Student comments regarding the lab included the following:

"[The instructor] is so enthusiastic about the subject and took time on weekends to take us whale watching...really got us involved with animal behavior"

"One of the best labs I have taken at Merrimack"

"This was by far one of, if not the best lab experience I've had at Merrimack"

At the end of the semester, students were required to write a "credo statement"—a 3-4 page document in which students explain, in their own words and from their own perspective, what they perceive to be the value of being knowledgeable about animal behavior and its interdisciplinary significance. We asked that they be introspective and address the skills and experiences that were of greatest value to them as a biology student. Lastly, we asked them to provide their opinion of whether they felt Animal Behavior is a course all undergraduate Biology majors should take and why they felt that way. We attached the learning goals for the course (Table 3) to the credo to be used as a guide for the type of understanding we were attempting to achieve. Like the standard course evaluations, the credo statements were positive. Student reflection on the whale laboratory included the following:

"I found the lab especially beneficial in that it taught me how to conduct research, design an experiment and sharpen my scientific writing skills."

"Despite being wary and almost opposed to the thought of going on whale watches every weekend, I found in the end that it allowed me to gain very important research and communication skills. Although I may never record data on a whale watching trip again, the skills I acquired can transfer over to any aspect of data collecting."

"The lab made me appreciate how much effort actually goes into behavioral data collection. If I was simply told how to collect data on whales, I would never have appreciated how complicated it gets."

"I am an environmental science major and this course has helped me see the potential I could pursue in the field. It has given me practical knowledge about how the study of behavior is undertaken."

Table 3. Expected learning outcomes for the Animal Behavior course.

After completion of the course students will:
1. Have a broad knowledge and understanding of animal behavior.
2. See the information presented and discussed in this course not as a collection of facts, but as an ongoing research effort.
3. Be able to read and understand primary literature articles in the field of animal behavior.
4. Learn and appreciate many of the analytical and technical skills used in the collection of data presented in this course.
5. Gain experience conducting behavioral field studies and laboratory studies (experimental design).
6. Identify proximate and ultimate questions and hypotheses to explain observed behaviors.
7. Be able to discuss the evolution of different reproductive strategies (male and female) and mating strategies (e.g., monogamy, polygyny)
8. Understand the evolution of animal signals, why they evolve, and how they are used to communicate.
9. Learn and/or sharpen your critical thinking skills.
10. Become a better science writer/critic.

"It is because of the whale lab that I realize that I belong in the field. Office work, sitting behind a desk or working in a chemistry lab do not suit me. It was being out there that made the greatest impact".

"Animal Behavior provided me with an understanding of how experimental design is so critical in the field of ethology."

"Gaining field experience whale watching has already played a significant role in obtaining an internship at the end of the semester."

DISCUSSION

In our efforts to analyze BOS data for publication and raise awareness of marine environmental issues, we recognize the valuable contribution Animal Behavior students made in support of BOS's mission. Additionally, two students continued their research after the course was over and presented at regional and national conferences. Furthermore, Animal Behavior has served as an excellent intern recruitment tool for BOS. Word spread quickly through the Department of Biology at Merrimack beginning in fall 2009 when the course was first offered, producing eight Merrimack student BOS internship applicants in the past two summer research seasons (2010 and 2011).

BOS's mission, in addition to research, is to increase awareness of marine conservation issues through education/public outreach; to help the public understand and appreciate the diversity of life in the oceans and to realize the need to protect these creatures and their habitat. To this end, BOS strives to make the whale watches as informative as possible by addressing passenger questions and incorporating hands-on activities, exhibits, and visual aids. Animal Behavior students assumed the majority of this responsibility, benefiting from ample opportunities to share their newly-acquired knowledge and practice oral communication skills through passenger education. BOS's mission of environmental awareness and appreciation of nature clearly resonated with students. The whale project thus went beyond the study of animal behavior as students experienced a clear shift in their attitudes towards marine conservation while recognizing the naiveté of the general public regarding such issues—perhaps the most important and unique objectives the course has to offer. Moreover, the experience gave them an appreciation for the rigor, complexity, and level of detail involved in field research.

Offered on a two-year cycle, Fall 2011 enrollment in Animal Behavior was over three times that of the initial offering (from 8 to 28 students). Improvements for 2011 included providing students with the option of expanding the project from a six-week field experience to a full semester project involving significant data entry and analysis. All of the data collected are added to the BOS database, which students can "mine" for noteworthy, statistically testable relationships/trends. Engaging students in an examination of complex behavioral and environmental data culminating in a written report of their findings provided a more comprehensive laboratory experience, involving them in the process of science from field observation and hypothesis generation to data analysis and conclusions. Several students in the 2011 class chose this option (over an alternative fish behavior project) leading to the completion of a pair of quality lab reports that may evolve into senior theses.

For geographically constrained educators interested in developing a similar lab experience, the individual identification and behavioral sequencing work may be done on a smaller scale using videos of whales in the wild, especially in dry labs where several computers are available. Alternatively, this kind of study may be applied to numerous more 'practical' species where an ethogram of discrete behaviors can be constructed (e.g. squirrels). To understand behavior, students must first spend time familiarizing themselves with the species to identify the range of behaviors typically observed, thus generating a species-typical catalog of behaviors (or becoming familiar with an existing ethogram). Constructing a useful ethogram requires observing animals, taking careful notes, and making sense of the observed behaviors. Students end up with an annotated catalogue of behavioral patterns grouped in a coherent fashion that describe what a given species does in a given environment. Project objectives may include becoming more aware of biases present in making observations and collecting data; practicing formal methods of behavioral observation; practicing the skill of defining and categorizing observations in an objective manner; considering different strategies for collecting data; practicing the conversion of observations into objective, quantitative information; and developing and comparing ethograms. Exercises like the whale project or a campus squirrel study make it clear to students that in order for behavior (or any observation for that matter) to be scientifically analyzed, it must first be objectively quantified, but it cannot be quantified without first being explicitly defined. Such projects thus instruct students to practice turning casual subjective observations of animal behavior (be it whales on Jeffreys Ledge or squirrels on campus) into objective, quantitative data. Methods such as developing a time budget may then be applied to express patterns in behaviors observed through the observational techniques. In the case of squirrels for example, the time budget may reflect the amount or proportion of time an individual spends engaged in different behaviors (e.g., feeding, resting), performing different classes of behavior (e.g., resting versus movement) and/or located in specific parts of the environment (e.g., canopy, ground, nest cavity).

In conclusion, the whale laboratory or similar quantitative field study of animal behavior is a good model for how to provide students with exposure to multiple scientific skills (e.g. experience handling complex datasets, oral communication/public education, observational and data recording skills, practice in following a research protocol, working as a research team, multitasking in data collection etc.) that emphasize competencies over content. The whale project in particular is all the more valuable given its community service component along with student recognition of the importance of *accurate* data collection given their direct contribution to BOS's research efforts. The whale project exemplifies how partnering with an area non-profit research organization may enrich/enhance field laboratory experiences. We hope that the partnership described herein may inspire the development of similar college laboratory and non-profit field research collaborations in the future.

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