DIVING RESEARCH METHODS: A SCIENTIFIC DIVER TRAINING COURSE AT NORTHEASTERN UNIVERSITY

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ABSTRACT

There has been much discussion among AAUS member organizations on the training of scientific divers. At Northeastern University, we have developed a course to train scientific divers which fulfills the AAUS requirement of 100 hours training with 12 dives. This course is designed to introduce students to techniques used in the study of biology, ecology and physiology of subtidal organisms. Current underwater research methods are learned and implemented in underwater exercises. Topics include: diving physiology, diving accident management, sampling design, underwater video and photography, population censusing methods, shipboard diving operations, and the use of submersibles in research. The laboratory component demonstrates quantitative analysis of field data including statistical analysis using microcomputers, and computer image analysis. Students enter the course as Divers-in-Training and upon completion are certified Scientific Divers depth certified to 60 feet.
INTRODUCTION

The AAUS Standards For Scientific Diving Certification And Operation Of Scientific Diving Program, Scientific Diving Training Standards have often been criticized for being too vague. AAUS Section 4.22 Scientific Diver Training states the following:

The diver must complete additional theoretical aspects and practical training beyond the diver-in-training permit level for a minimum cumulative time of 100 hours.

1. Theoretical aspects should include principles and activities appropriate to the intended area of scientific study. Suggested topics include, but are not limited to data gathering techniques, collecting, common biota, behavior, installation of scientific apparatus, use of chemicals, site selection, site location and relocation, animal and plant identification, ecology, tagging, photography, scientific dive planning, coordination with other agencies, appropriate governmental regulations, and small boat operation.

2. Practical training shall include additional dives to ensure a cumulative total of at least 12 supervised ocean or open water dives in a variety of dive sites and diving conditions, for a cumulative bottom time of 4 hours. No more than 3 of these dives shall be made in one day.

This paper presents a course developed at Northeastern University which fulfills the AAUS Scientific Diver training requirements and can be used as an advanced diver course for those not requiring scientific diver certification. It is designed to run as full day sessions but could be adapted to a regular university course schedule with hour long lectures and dive sessions during a three hour lab period. This course is offered twice a year at Northeastern University. The summer session is taught at the Marine Science Center in Nahant, Massachusetts and is open to scientific divers in training as well as non-scientific divers in training with basic Scuba certification. A second course is run in the fall at the University of Washington Friday Harbor Labs as part of Northeastern University's East/West Marine Biology Program. In this course, 20 upper level undergraduates and beginning graduate students from around the world are trained as scientific divers so they may dive in the East/West Program.

COURSE PREREQUISITES

Medical approval.
For divers wishing Scientific Diver certification, the complete AAUS medical is required. For non-scientific divers, Northeastern University medical clearance for athletics is required.

Proof of diver-in-training permit level or its equivalent.
Basic Scuba certification is required. Additionally all divers in the East/West Program are required to log 10 dives beyond basic certification six months prior to the start of the program.
CPR certification.

**BASIC SCUBA REVIEW, ADVANCED DIVING PRINCIPLES, CHECKOUTS**

**Diving Lectures**
Topics covered in these lectures include; cold water diving, introduction to dry suits, review of dive tables, Nitrox, Saturation, and Submersibles. The DAN Oxygen First Aid in Diving Accidents Course is given. This provides a good review of diving physiology and decompression illness as well as training in oxygen first aid administration.

**Checkout Dives**
This begins with an equipment examination. Students supply their own equipment and must show proof of equipment service within the past 12 months. The checkout dive begins with a water entry with full equipment followed by a surface swim while breathing from a snorkel only. Once under water the following skills are performed; mask removal, replacement, and clearing, buddy breathing as a donor and recipient sharing a single regulator, tank removal and replacement, simulated emergency swimming ascent, rescue techniques, buoyancy control. If students are dry suit diving, they must right themselves from a feet up inversion situation and demonstrate removal and replacement of inflator hose at depth.

**Written Exam on Basic Scuba**
A thorough written exam is given covering all the topics required by AAUS section 3.22. This exam is given after the second day of the course following the Scuba lectures and checkout dives.

**Advanced Diving Principles**
Students in the course are introduced to diving from small boats, shipboard scientific diving, deep diving, and night diving.

**DIVING RESEARCH METHODS**

**Kelp Growth Lab**
In this lab, students are introduced to a diving field technique for estimating and comparing growth rates of macroalgae. This simple method involves finding, marking and punching holes in individual kelp 10 cm from the base of the blade (Mann 1972, Chapman and Craigie, 1977). The same specimens are re-located some time later and the punched holes are re-measured to determine growth rate over time. This exercise is a good introduction to diving research techniques in that it utilizes the following skills; site selection, species identification, data recording, measuring, marking and tagging.

**Underwater still photography and E-6 Film processing**
Underwater still photography is a widely used research tool. A thorough introduction to
underwater photography is contained in Sommers (1990). Students are introduced to basic photographic concepts and the effects of light and water in underwater photography. A detailed description of the Nikonos V camera system is followed by hands-on familiarization of the system. Camera systems are set up with various photographic modes and taken underwater for shooting. After the dive, the students are shown how to develop E-6 color slides.

**Underwater video**

The use of video underwater has greatly expanded the abilities of the underwater scientist to collect data. Traditionally the only means of recording events underwater was by using still photography. A compact video camera can be placed in a housing and used underwater, recording for up to 120 minutes. These cameras have high resolution and work under low light conditions. Video cameras can be mounted on ROVs and used in areas not accessible to divers. Many quantitative research techniques used with still photography can be adapted for video use including; mapping and quadrat photography, transects and surveys, measuring water flow near surfaces, time-lapse photography, and monitoring predation (Maney et al. 1990). Advantages to video over still photography are; instant results, longer recording time, and continuous recording.

Students are introduced to using video cameras in underwater housings with hands-on familiarization of the systems followed by an underwater shooting session.

**Quantitative video and photographic techniques**

Underwater video and still photography provides an ideal way of collecting large amounts of data in a short period of time. In addition, a permanent record of the data is obtained and this can be analyzed at the researchers leisure. Uses of this technique include; percent cover analysis of community structure and competition of encrusting organisms on hard substrates, direct counts of organisms in randomly placed quadrats (Dayton, 1971 and 1975; Connell, 1966a and b), and photographs of organisms in permanent quadrats (Connell, 1972). One of the biggest problems of this research method is that large quantities of data are obtained and this can require many hours of tedious data analysis. In this lab different methods of data analysis for determining community structure of a rock wall are compared. The data is collected using a photo and video quadrupod of the same area. Comparisons of still versus video are made as well as comparisons of different methods for analysis for percent cover.

Percent cover analysis can be performed by projecting a slide or freezing a video frame and digitizing (Buss, 1980) or random dot patterns (Connell, 1970; Dayton, 1971, Menge, 1976; Lubchenco and Menge, 1978). A single video frame or slide image can be grabbed with a computer and areas can be computed using the program Image (Maney et al. 1990).

**Analysis of mobile fauna**

The aim of this lab is to demonstrate the problems of surveying mobile fauna. A technique comparison between fixed area vs fixed time time surveys is used to compare mobile fauna abundance during the day and at night.

For the fixed area survey, a 25 meter tape is played out along the area to be surveyed.
Divers swim along the tape and record any mobile fauna seen in an area 1 meter from the tape for a distance of 5 meters. The diver’s buddy is surveying the same area on the other side of the tape. Each diver will have 5 samples of a 5 square meter area.

In the fixed time survey or rapid visual technique (Jones and Thompson 1978), each diver swims along the bottom surveying a 1 meter wide area for 1 minute intervals. Every species encountered in the first minute is recorded. In the next and successive minutes, only newly encountered species are recorded. The species are then ranked with the species seen in the first minute getting the highest rank. This technique assumes that the species encountered in the first minute are the most abundant.

Measurements of diversity and evenness are calculated for the two methods. The surveys are repeated at night in the same area to determine if there are night/day differences in mobile fauna abundance.

**Sampling Methodology**

The purpose of this lab is to determine the population size of a known distribution of animals and to demonstrate the effects of using different sized quadrats to estimate the population size.

One of the most common problems of marine biology is to determine population densities of sessile or sedentary marine organisms. The answer will invariably involve some application of a quadrat survey method to determine the abundance in a sample size followed by extrapolation to the whole area. These factors can have a pronounced effect on the results obtained. Ideally the whole area should be surveyed. This is rarely possible and, therefore, smaller areas must be sampled. There is a need to get statistically reliable data with a minimum amount of effort.

For this exercise, 300 painted rocks are randomly placed in a fixed area. The students randomly sample the rocks in the area using different sized quadrats. The data is pooled to determine which quadrat size best approximates the real density of the rocks.

**Juvenile lobster distribution off Canoe Beach**

The goal of this lab is to determine the density of a population of subtidal lobsters (*Homarus americanus*) and their potential competitors, the rock crab (*Cancer irroratus*) and the Jonah crab (*Cancer borealis*). Two different sampling methods are used to conduct the survey. First a 0.25m² quadrat is randomly placed on the bottom. Next all crabs and lobsters are collected from within the quadrat and placed in sample bags for later measurements. The quadrat area is then suction sampled to collect smaller juvenile crabs and lobsters that are in the gravel using an air lift suction device explained in Coyer and Witman (1990).

In the lab, all crabs and lobsters are measured. The suction samples are sorted to get counts and measurements of smaller juvenile crabs and lobsters. The data is analyzed to give density values for the population of crabs and lobsters in the area sampled.
Measuring *in situ* water movement

The purpose of this lab is to introduce some of the techniques available for measuring *in situ* water movement. The choice of methods depends on factors such as: money and facilities available, magnitude of water currents, water conditions adjacent to the study site (depth, temperature, etc.) and, the degree of resolution required (large scale water flow or microflow around individual animals). A good description of the various methods for measuring water flow are contained in Coyer and Witman (1990). This lab focuses on measuring water flow around the sea anemone *Metridium senile* by releasing florescene dye and tracking it with a video camera. The video is then re-played in the lab and the dye movement is tracked through successive frames of video (1/60 sec) to determine flow velocity.

COURSE REQUIREMENTS

Lab Notebook

This is a detailed notebook containing dive log information, data collected, data analysis, and general notes for the course. The idea of this notebook is to develop the habit of keeping a research notebook used by a research scientist.

Lab Report

A lab report written in the style of a research paper for publication is required for the course. One of the research methods presented in the course must be written up as a research paper with the following sections: Introduction, Methods, Results, and Conclusions.

Written Final Exam

This exam consists of hypothetical situations in which the student must propose research methods to study the situation. There is also a section on Scuba principles including dive table questions.

Summary

The course presented is an example of how to train scientific divers. It started as a team taught course with the advanced diving portion taught by the Northeastern University DSO followed by the research methods portion taught by Northeastern University Marine Science Center faculty. Many of the methods presented are those used by these researchers. The juvenile lobster lab is a data collection session for an on-going research project being conducted by a researcher at the Marine Science Center.

Information on diving research methods are available from the following sources; AAUS Symposium proceedings, The Underwater Catalog: A Guide to Methods in Underwater Research (Coyer and Witman 1990), The NOAA Dive Manual (1993), and The University of Michigan Diving Manual Volume II: Underwater Research Methods (Somers 1990). Other sources include using the methods employed by researchers at the institution. Often the people being trained will be researchers needing use these methods.
Northeastern University has been successfully training scientific divers since 1985 using the program presented. This program constantly evolves to meet the needs of the research being conducted at the Marine Science Center and in the East/West Program.

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LITERATURE CITED


