45 Minutes from Broadway: An Action Approach To Marine Biology

HAROLD SILVERSTEIN
LOU SIEGEL

Fig. 1. Students use various collecting techniques to sample biological populations. Here they are collecting nekton at Coney Island with dip nets.

DESPITE THE MANY new biology curricula that have been developed in the last few years, the question we still all ask ourselves is "How does an instructor in the biological sciences sustain the excitement of learning, the wonder of lab investigation?"

At John Dewey High School (Brooklyn, N.Y.), it was our students—their criticism and suggestions over these past ten years—who helped to focus our thinking in the direction of marine biology. We have come to feel that marine biology allows the student to experience the wonder and excitement of biology through an incomparable fusion of a number of the life and physical sciences.

Our approach is essentially action oriented. Our young New Yorkers first encounter marine biology in the waters off Coney Island, where they measure the height and amplitude of waves. The groups call out their findings to their recorders assigned to write down the data, and then the findings are copied down by all members of the group in the context of the traditional lab report. The following week the instructor meets with the class and evaluates each report. He considers not only organization, presentation, and interpretation but also sentence structure. Good report writing is a valuable skill to develop.

The second and third weeks of field work are devoted to the study of another outdoor area, Plum Beach, which offers a lagoon, marshland, and barrier beach. Here the students study water transport in a stream, measuring density and evaporation.

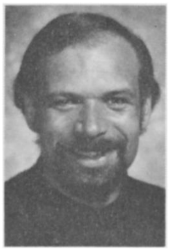
Up to this point we have introduced marine biology through physical measurement: math tables, weighing techniques, density and temperature determinations. We have involved our students in *action* biology. They are doing, recording, and evaluating under novel situations—and away from the classroom. Our intention is to equip them with the ability to handle the parameters needed to understand the homeostasis of the biological organism. We simulate what the senior scientist does in his laboratory: utilize those tools of science and mathematics necessary for undertaking a specific biological investigation.

But each hour and 20 minutes devoted to laboratory or field investigation requires painstaking planning: consideration of travel time available; cooperation of the school administration; anticipation of a variety of student problems (colds, allergy to water, "I-forgot-my sneakers," and the like), and, of course, permission to operate a bus on the parkway from the New York City traffic commissioner.

Scheduling

John Dewey High School provides eight hours of instruction per day. Our classes are modular in design. A typical marine biology class might be programmed thus: Monday—one hour; Tuesday—none; Wednesday—one hour; Thursday—40 minutes; Friday—one hour, 20 minutes. There are five cycles in the school year, with seven weeks per cycle; an optional sixth cycle is offered during the summer.

We have 30-34 students in each of our year-long classes; Marine Biology (for sophomores) has a maximum of six classes and there is one class of Advanced Marine Biology (for juniors and seniors). There are two instructors and a total of 270 students. The advanced students need not necessarily have taken the



The authors teach at Dewey High School, 50 Ave. X, Brooklyn, N.Y. 11223. Silverstein graduated from Long Island University in 1949, and he received an M.A. from New York University in 1950. He has 25 years of experience in high school teaching and is also an adjunct lecturer at New York Community College. Siegel received a B.S. from Hunter College of the City University of New York in 1967, and he is presently an M.S. candidate in marine science at C.W. Post College. Both authors have written a number of articles on marine biology.

sophomore course; chemistry and general biology also serve as prerequisites. There is also a summer course in marine ecology open to all grades, freshman through senior, with up to 120 enrolled. The total number of students taking marine biology may reach 400 in our 2,800-student school.

During the first cycle, our efforts are devoted totally to developing the skills required for the four remaining cycles of lab work. Students learn to pipette, titrate, use the clinical centrifuge, and weigh (via triple-beam balances, single-pan balances, digital readouts, and so on). They are required to use the metric system.

They must learn too to prepare culture media for *Amoeba, Blepharisma, Chlamydomonas, Paramecium, Spirogyra,* and *Stentor.* The students maintain cultures of foraminiferans and diatoms (which are sold to neighboring schools at cost). Our students learn to use a variety of microscopes, and they study a comprehensive range of histological slides. Also accompanying the lab exercises of the first cycle is some theoretical discussion of inorganic and organic chemistry as these relate to media.

In the second through fifth cycles, our approach is phylogenetic. (We take issue with the concept that evolution can be taught most effectively by comparative study of various systems in organisms.) Monera, Protista, Ctenophora, Bryozoa, Rotifera, Coelenterata, Platyhelminthes, Annelida, Mollusca, Arthropoda, Echinodermata, Protochordates, and Chordata —including fish and mammals—are studied. The lab experiences also revolve around the phylogenetic concept. We use live organisms when they are available locally, emphasizing morphology and physiology.

Obviously, we have time for other field trips and lab experiences: a trip to a sewage treatment facility; ship time aboard the research vessel *Commonwealth* (courtesy of the oceanographic department of the City College of New York), where our students can practice techniques aboard ship that they have learned in the lab; studies of the physiology of color change in fish,

Fig. 2. The abundance and variety of benthic organisms serve to characterize and define an area. These students are sampling the organisms at Plum Beach mud flat, in Brooklyn.

Fig. 3. Working in groups, students measure physical and chemical parameters such as the density of this intertidal pool.

the chromatography of algal pigment, the extraction of DNA from *E. coli,* chloride determination, and oxygen determination in water using the Winkler method. As the days grow warmer in the spring, we do more of our experiments at the beach. Further field trips include collection and identification of dune and marsh plants, benthic organisms, microscopic algae, and marsh organisms, and measurement of light penetration with the Secchi disk.

Articulation Programs

Any educational institution is by its very nature an insulated environment. The effect of this insulation is a dilution in interest leading to lessened learning of subject matter. A great deal of our effort is directed to overcoming this dilution effect. That is why we have developed a number of articulation programs with outside agencies.

Our students are a heterogeneous group, ranging from low to upper 5% in family income. They are black, white, Italian, Jewish, Puerto Rican, Chinese, Scandinavian. About 10% read below their established grade level. We manage to involve almost all of them in outside activity.

Our students serve as volunteer guides and lecturers at the famed New York Aquarium on weekends and holidays. Here they are carefully trained by the educational staff. Last summer a number of students volunteered their services to Gateway National Park (the first national park in any urban environment). They were guides and instructors for children of all ages in organized field trips to Plum Beach, Riis Park, the Aquarium.

In the past a number of our advanced course students were assigned to the Aquarium's Osborne Laboratory: some to the biochemical labs to aid senior scientists in the isolation and identification of organic chemicals, others to a department concerned with the culturing of sea urchin embryos.

Our articulation programs continue to broaden. Each semester some of our students—sophomore, junior, and senior—are permitted to take courses in histology at several colleges associated with the Board of Higher Education of New York City. On completing a course, they prepare a DISK (Dewey [High School] Independent Study Kit), a written course of study complete with homework questions, lab assignments, and demonstrations as well as written examinations. The DISK is evaluated by a team of instructors from the college and by faculty of our own school and is then adopted for use in our marine biology classes.

Other students work full-time without pay, for one cycle, at the Aquarium, a hospital, or one of New York's research institutes. A daily log is kept by the student, and at the cycle's end, the student's professor or lab director prepares an evaluation of him. After an informal discussion with an instructor at our school, the student is then eligible for academic credit for one cycle of study. Still another program is our "Four-and-One," in which a student attends school four days a week and is assigned to a particular laboratory, hospital, or institute for the remaining day.

Books are another entry to the outside world. Our sophomores must fulfill a project requirement that includes research in various libraries throughout the city (such as Brooklyn College, New York Academy of Science, and the Downstate Medical College). In addition, this project requires an experiment, either individual or involving two to four other students.

In all cases, the students meet with the instructor several times during the year for consultation on the work in progress. This increased contact develops a closer relationship between student and teacher; this, in turn, develops a cadre of students with leadership ability, permitting a broadening of experimental work and student-directed activities. (This on-going relationship also keeps students in contact with us even when they are no longer taking formal biology courses.)

Towards Sophistication

Our advanced marine biology course has been called remarkable not only for its content but for the *social* function it serves. Basic to that broad (and flattering) statement is the sophisticated training these students experience.

By the time they complete their senior year they know the theory of pH, spectrophotometry, enzyme assay; use of the slide rule; the nature of logarithms. They know thin-layer chromatography, electrophoresis, phase microscopy, tissue culture, specific-ion determination. They know how to culture diatoms and foraminiferans, plus the operation, maintenance, and some trouble-shooting techniques as they concern the equipment involved in the concepts above. (In order to maximize our trouble-shooting capability, we insist that each equipment representative we deal with make available, for at least a day, one of their technicians to train our students.)

Monies for equipment were largely obtained from Title III-NDEA, the competitive federal program administered by the state. Obtaining grants was, of course, a slow process requiring our development of

DEWEY HIGH SCHOOL MARINE BIOLOGY PROGRAM OBJECTIVES

1. To meet the syllabus of the New York State Department of Education for the study of biology. (A Regents Examination in biology, approved by the New York Department of Education, is given at the end of the fifth cycle.)

2. To provide a laboratory – field experience that will maintain student interest throughout the entire course of study.

3. To enrich the curriculum in marine biology by providing sophisticated instruments and techniques within the capability of a heterogeneous group at the secondary level.

4. To provide experiences and training that will be useful in furthering study in the biological sciences at the college level or in entering the occupational area of marine technology.

5. To inculcate in our students—as future citizens—an appreciation of the living environment, giving them techniques in science and community activity that can help them fight for that environment's well-being.

techniques for a productivity study. But our efforts have resulted in our being able to provide our students with experience in using a veritable arsenal of instruments and lab apparatus.

The modular nature of our Zeiss microscope allowed us to modify the basic design so that we can use our TV camera and 16-inch video monitor to demonstrate microscopic organisms as well as increase the visibility of demonstrations from the front of the classroom and laboratory. It is thanks in large part to this closed-circuit TV-microscope assembly that our seniors can help out so extensively with the sophomore students.

Two years ago, we instructors and a student were trained by two consultants (under a $3,000 Title III minigrant) in the culturing of diatoms and foraminiferans. The student, in turn, trained several other stu-

Fig. 4. The velocity of a stream affects the sedimentation rate and the variety of organisms present. Here students measure the velocity of a stream at Plum Beach.

dents, who trained all the others. We now culture the foraminiferans *Allogromia, Rosalina, and Spiroloculina* and the diatoms *Nitzchia, Amphora,* and *Cyclotella.* We have a tank room with around 150 tanks, from two to 150 gallons in size, as well as terrariums, herbariums, and simulated marshlands—*all* student-maintained.

Against this background of activity we are intensifying our training through a serious study of the wetlands bordering Jamaica in Brooklyn and Queens. The parameters studied here include productivity (standing crop), height and weight of *Spartina patens* and *Spartina alterniflora,* the caloric value of the plants on a gram per square meter basis, suspended particulate matter, chlorinity and salinity, and phytoplankton abundance and metabolism (using the methods of Parsons and Strickland [1972]). Phytoplankton are counted with a hemocytometer and Sedgwick-Rafter cell. Photosynthesis is measured by the light and dark bottle methods; oxygen, by the Winkler titration method and a Gem oxygen-meter. Various equations are used to compute gross and net photosynthesis as well as net respiration. The relationship of oxygen, chlorophyll *a* concentration, and photosynthesis are determined.

Fluorescein dyes determine the velocity of the channels within the marshland; Secchi disks, the light penetration. Concentrations of ammonia and nitrate are determined with Orion electrodes and an expanded-scale pH-meter. Bacterial analysis of fecal coliform is made with our Millipore apparatus, and dissolved organics are determined by the methods of Levy (1972). Here too we identify *Atriplex arenaria, Baccharis halimінifolia, Distichlis spicata, Glassort* sp., and *Juncus gerardi.*

Into the Fray

All of these marshland data have been summarized and published by the students. When hearings are held by the Department of Environmental Conservation (DEC) of New York State to determine whether a builder should be approved for marshland filling, or whether the Environmental Protection Agency (EPA) of New York City should be permitted to dump solid demolition material, we—instructors *and* students—participate, offering our data to the hearing officer as well as undertaking to cross-examine witnesses. We are, in fact, the only group in New York City that has attempted to follow the mandate (to preserve salt marshes) of the Tidal Wetlands Act of 1973 from a biological consideration. At these hearings we have the cooperation of the Environmental Law Council of the Columbia University Law School.

In addition, one major oil hearing by the Federal EPA concerning oil runoff in Jamaica Bay resulted in a sizable reduction in the allowable runoff. New York State's DEC had no standards to suggest, and the City's EPA did not even participate! If our students had not submitted a technical brief providing the Federal EPA with the data it needed, the 25–50 milligrams/liter oil concentration suggested by the oil companies would, we were told, have been the standard.

There has been one unforeseen consequence of our marine biology program: communities as far east as the Hamptons, as far north as Massachusetts, have asked our classes to help them in *their* marshland studies. We have, alas, no funding for this and must, at present, turn down "foreign" requests for technical support.

But the point is that various parameters of marine biology *can* be actively incorporated into the study of wetlands and the data accumulated *can* be a social force in protecting natural areas subject to encroachment from contractors, developers, illegal dumpers—even city agencies.

What lies ahead? This year we plan to extend our environmental studies to include cost-benefit analyses. Here we shall be using an industrial-model computer and the social tools involved in "consumer economics." We can hardly wait!

REFERENCES

LEVY, E. M. 1972. Identification of petroleum products in the marine environment by absorption spectrophotometry. *Water Research* 6:57.

PARSONS, T. R., and J. D. H. STRICKLAND. 1972. *A practical handbook of seawater analysis.* Fisheries Research Board of Canada, Ottawa.