A New Approach to Marine Biology on the High School Level

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A unique program in that it involves the training of both teachers and students and allows for a cooperative utilization of military, industrial, and academic personnel and facilities. The author is head of the high school science department and a biologist at the Naval Missile Center, Point Mugu, California.

The need for properly trained marine biologists is becoming more and more important with the research now being undertaken throughout the country. To meet this rising demand for trained personnel, we need to provide a positive program for the more highly endowed and motivated high school students before they have become involved in other areas and disciplines at a university. It is not solely the responsibility of educational institutions to train our superior students. This marine biology program was developed to allow for a cooperative utilization of military, industrial, and academic personnel and facilities in order that this much needed extra-curricular training might be accomplished.

With the passage of the "Marine Resources and Engineering Development Act of 1966," a comparatively new scientific discipline was brought to the attention of school administrators and science teachers who, for the most part, have little or no background in the marine sciences. Two objectives of the act are particularly applicable to secondary school science programs. They are expressed as follows: "The marine science activities of the United States should be conducted so as to contribute to the following objectives: . . . the expansion of human knowledge of the marine environment, and . . . the advancement of education and training in

Fig. 1. Recording data on the spot is essential if accuracy is to be maintained for later studies and reports.

marine sciences."[1]

The Ventura County Program

The Naval Missile Center, Point Mugu, California, is a leading contributor to marine biology research conducted by the United States Navy, and therefore is cognizant of the importance of early training for those interested in pursuing a career in marine biology. In February 1966, the Naval Missile Center in cooperation with Ventura College instituted a one-semester pilot program for high school and junior college students with high ability. In this program, lectures in marine biology were given by leading authorities. These were followed by laboratory sessions in the field which gave students an opportunity to experience at first hand some of the activities involved in marine biology research. This pilot program met with such favorable acceptance that it was expanded in the fall of 1966 to a full year course with a correspondingly wider offering for the participants.

Since then the course has been developed further under the guidance of a steering committee composed of professional research biologists, county school and college administrators, commanders of Naval installations in Ventura County, and college and high school classroom biology teachers. The scientific community in Ventura County has been very active in the program and has given invaluable assistance.

At present, the course is being given at the Naval Missile Center. A grant from the National Science Foundation makes possible an even more diversified and thorough program for both students and teachers than was possible in 1966.

The lectures are given one evening each week by authorities speaking in areas of their primary interest. The laboratory sessions are held on Saturdays and involve the participants in ecological studies of the Mugu

[1] Effective Use of the Sea, Report of the Panel on Oceanography of the President's Science Advisory Committee, page 136, June 1966.

Lagoon and the offshore islands, as well as visits to marine research institutions.

Lecture Sessions

This course is divided into six units: oceanography, marine botany, invertebrate zoology, vertebrate zoology, physiology of marine organisms, and new frontiers in marine biology. This gives the participants in the program an overall view of marine biology, and does not tie them down to a specific area at the expense of achieving the primary purpose of this course, i.e., to provide a basic and introductory course in marine biology.

The lectures are given one evening each week by authorities speaking in areas of their primary interest. By having lecturers who are authorities, the students and teachers have an opportunity to become acquainted with not only the basic knowledge of the subject but also with the latest developments in the research area. These lectures also enable students to discuss at depth with the lecturer any individual questions or problems they may have pertaining to their research.

The week prior to the lecture, outlines of the lecture and a list of suggested references are provided the participants for study. Each lecturer is asked to provide a ten question quiz over the suggested reference material at the beginning of the class period to make possible an evaluation of the students' understanding of the outside reading.

Planning sessions for the lecturers in each unit are held prior to the start of the unit. To achieve a carry-over and integration of one lecture with the next, each lecturer is provided with a syllabus of the course which lists its aims, objectives, and philosophy, and includes the outlines of each lecture in the course.

Laboratory Program

The core of the course is the students' participation in field work with an oppor-

Fig. 2. Trips to offshore islands provide an opportunity to study organisms not commonly found along the exploited coastal beaches.

tunity to develop, organize, and follow through on his own research problem, including the writing and presentation of a paper based on his research. In the first two years of the program, students have done research on diverse subjects as the following titles of papers demonstrate: The Concentration of Enteric Pathogens in Selected Mollusca, The Migration of *Dendraster elongatus* in Mugu Lagoon, The Effect of pH on the Distribution of Foraminifera in Mugu Lagoon, Salinity Tolerances of the genus *Callianassa,* and the Angle of Beach Slope as a Factor in the Distribution of *Emerita analoga.*

From the laboratory work, the students have developed an entirely new concept of what biological research may or may not be. Many have been encouraged by this research to experience and investigate an entirely new field which they may, in the future, wish to enter professionally. For the others, experiencing the challenges, accomplishments, and frustrations that are a part of scientific research has provided them with greater appreciation of science and the place of the scientist in our society. A survey of the graduates of the first two years of the program indicates that 30% are now preparing for careers in marine biology while another 50% are majoring in some field of biology.

Also, through the cooperation of the Naval Missile Center, Naval Civil Engineering Laboratory, and Ventura Industry-Education Council, outstanding students from this course are given employment for the summer to work in some area of biology (wherever possible in marine biology).

Teacher Participation

A persistent demand has been made by science teachers for a course in marine biology which would give them an opportunity to upgrade their teaching. The program includes teachers as well as students. The majority of teachers participating in this course have had no training in marine biology *per se.* The lecture sessions are of

Fig. 3. Population studies, including identification of various species of lagoon fishes, are carried out by a cooperative seining project.

particular interest and value to them as they provide the teachers with an opportunity to delve further into subject matter that is directed toward the marine environment. While the teachers are not expected to participate in all the laboratory sessions, they are expected to participate in certain designated sessions which are structured in such a way as to enable them to apply the factual information of the classroom to field study. The knowledge gained from the field work makes it possible for them to diversify their classroom teaching and to make better use of the county's marine environment. This also allows them to use this marine environment to point out not only biological principles but also the practical applications of these principles.

Facilities and Equipment

The high schools participating in the course are provided with a basic marine biology library and with some equipment needed for field studies such as seines, dip nets, hydrometers, thermometers, specimen bags, etc.

The equipment of the Marine Bioscience Branch at the Naval Missile Center is also available to the class for use when carrying out research projects. At the Naval Missile Center, the main building used for this course houses an extensive study collection of marine organisms indigenous to the area. It also contains 18 tanks ranging in size from 20 to 500 gallons. Nearby are 25 outdoor tanks ranging in size from 20 to 800 gallons. All tanks have a constant supply of fresh sea water circulated through them. Microscopes (dissecting, stereozoom, monocular, and binocular) and photomicrographic equipment are also available. The Naval Missile Center maintains an up-to-date marine biology library and study area which makes it possible for students to carry out reference and research work not otherwise possible in their own school or community.

Laboratory facilities are available to make the various required chemical tests and analyses. A professional laboratory technician is available to instruct and assist in the use of the more refined components of the laboratory. This laboratory makes use of equipment such as a: colorimeter, flame-photometer, ultramicro system (colorimeter-spectrophotometer, titrator, and centrifuge), chloridometer, gas chromatograph with hydrogen flame and recorder, and an oxygen analyzer.

Five 9 foot johnboats, two Boston whalers, and three other small craft are available for use in the Mugu Lagoon. Since this program is sponsored by the Naval Missile Center, it is also possible at times to use some Naval surface craft such as an 85 foot Navy aviation rescue vessel to go to the offshore islands.

The Mugu Lagoon, a part of the Naval Missile Center and open only to those doing scientific research, is one of the few undisturbed lagoons in Southern California. It is the site for most of the laboratory work. A recent survey of the flora and fauna in the lagoon by Prof. and Mrs. George MacGinitie and a study of the deposition of organisms in the lagoon by John E. Warme have laid an excellent foundation upon which the students may develop their research.

Besides the equipment and facilities provided, professional researchers and scientists in marine biology and oceanology from nearby Naval activities are always readily available for consultation and assistance. Through the participation of the Ventura Industry-Education Council, scientists from private industries (General Motors, Northrop Ventura, North American, Westinghouse, etc.) are also easily reached by the students for consultation and assistance in research work.

Selection of Participants

Candidates are selected by a committee composed of the course directors and representatives of the county school offices, the Naval Missile Center, the Naval Civil Engineering Laboratory, and the Ventura Industry-Education Council. This committee makes its selection from nominees provided by each of the participating high schools in the county. Because of the importance of getting quality in the instruction, the course is limited to ten teams (20 students and 10 teachers).

Minimum qualifications for students include completion of high school biology, chemistry, and two years of mathematics.

Experience has shown that students should have three years of mathematics rather than two, and they should be taking physics concurrently with the marine biology course.

Summary

This program has been developed to give high schools an opportunity to up-date their science offerings in the area of marine biology. The student participants are afforded an opportunity to experience a field of study not included in their regular curriculum and to participate in marine research which may suggest future career possibilities.

The teachers are given an opportunity to up-date their laboratory techniques and knowledge in marine biology as well as to lead outstanding seniors in their school in individual research with equipment and materials not normally available to them.

Lectures given by authorities bring out not only basic information but also recent research in marine biology. Laboratory sessions consisting of a study of the comparative ecology of estuarine and open ocean habitats, visits to scientific research facilities, and experiences on oceanographic research vessels supplement the lectures.

Accelerated technological and scientific advances have presented an increasing challenge to educational institutions. This challenge can be met in part by communities willing to assume part of the burden by developing the potential of superior students. In addition, training in the scientific disciplines, which often requires highly specialized equipment and facilities, demands cooperative utilization of community resources. It is not solely the responsibility of educational institutions to train our superior students. This marine biology program was developed to allow for a cooperative utilization of military, industrial, and academic personnel and facilities in order that this much needed extracurricular training might be accomplished.

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Porpoise Hears Seven Octaves Above Man

The bottlenose porpoise can hear sounds seven octaves above those audible to humans, according to a paper read by Dr. C. Scott Johnson at the Symposium on Marine Bio-Acoustics at The American Museum of Natural History.

Scientists have known that porpoises, like bats, can hear ultrasonics of high frequencies, but Dr. Johnson is the first to establish the exact sound levels to which the porpoise responds.

He tested a 380-pound, eight or nine-year-old porpoise named Salty and found that 150,000 cycles per second is the effective upper limit of the animal's hearing capability. Man's upper limit is about 20,000 cycles per second.

Dr. Johnson's experiments also indicated that Salty was able to detect changes in the intensity of sound as small as one decibel, which compares favorably to man's ability.

Dr. Johnson, a physicist at the Naval Ordnance Testing Station at China Lake, California, tested Salty in a tank which had a stall-like enclosure at one end. The porpoise was trained to swim into the stall and push a lever. If he heard a tone, he was to swim out of the stall and push another lever, thus releasing his reward, a smelt. Twelve seconds were allowed for his response to the tone.

Using this method, an audiogram on Salty was obtained over a period of a year and a half. No more than two experiments were made in a day.

Fish Drop

Fish stock in Atlantic coastal waters has suffered a net loss "of critical proportions" because of water pollution and the decay of coastal marshes, the American Littoral Society reports.

50% drop in commercial catches of 18 species of fish in Atlantic waters from 1960 to 1965.

The Society said statistics showed a nearly