

BIOLOGICAL OCEANOGRAPHY FOR HIGH SCHOOL STUDENTS

JOHN A. FORNSHELL<sup>1</sup> AND FRANK FERRARI<sup>2</sup>

<sup>1</sup> THOMAS JEFFERSON H.S., 6560 BRADDOCK RD., ALEXANDRIA, VA. 22312

<sup>2</sup> MUSEUM OF NATURAL HISTORY, SMITHSONIAN INSTITUTION, WASHINGTON, D.C.

A UNIQUE PROGRAM FOR INSTRUCTION IN BIOLOGICAL OCEANOGRAPHY AT THOMAS JEFFERSON HIGH SCHOOL FOR SCIENCE AND TECHNOLOGY AS A COOPERATIVE EFFORT WITH THE SMITHSONIAN OCEANOGRAPHIC SORTING CENTER AND THE U. S. NAVAL ACADEMY WAS BEGUN WITH THE 1989/90 SCHOOL YEAR. TEACHING DUTIES WERE SHARED BETWEEN SCIENTISTS AND TECHNICIANS FROM THE SOSC AND THE TEACHER FROM THE HIGH SCHOOL. THE SOSC ALSO PROVIDED THE SPECIALIZED EQUIPMENT AND ARCHIVED SPECIMENS FOR INSTRUCTION IN PLANKTON IDENTIFICATION. ACCESS TO THE MARINE ENVIRONMENT WAS FACILITATED BY ASSISTANCE FROM THE U.S. NAVAL ACADEMY. THIS PARTNERSHIP OF EDUCATION, INDUSTRY AND BASIC RESEARCH INSTITUTIONS OPENS NEW OPPORTUNITIES FOR SCIENCE CURRICULUM DEVELOPMENT

BIOLOGICAL OCEANOGRAPHY IS A HUMAN ENDEAVOR WHICH IS CONDUCTED ON THE SEA AND IN THE LABORATORY. BY JOINING FORCES WITH THE SMITHSONIAN OCEANOGRAPHIC SORTING CENTER, THE THOMAS JEFFERSON HIGH SCHOOL FOR SCIENCE AND TECHNOLOGY IS ABLE TO OFFER STUDENTS A REALISTIC LEARNING EXPERIENCE NOT POSSIBLE IN A TEXT BOOK BASED TRADITIONAL HIGH SCHOOL SCIENCE COURSE.

THIS UNIQUE PROGRAM WAS BEGUN WITH THE 1989/90 SCHOOL YEAR, AND PROVIDES ONE OPTION FOR SENIORS TO TAKE IN MEETING THE GRADUATION REQUIREMENT FOR A ONE YEAR TECHNOLOGY LABORATORY/MENTORSHIP PROJECT. THE PROGRAM OBJECTIVES ARE TO GIVE THE STUDENTS EXPERIENCE IN WORKING IN THE FIELD OF BIOLOGICAL OCEANOGRAPHY IN THE CONTEXT OF A RESEARCH SCIENTIST. THE STUDENTS LEARN TO SORT AND IDENTIFY ZOOPLANKTON BY WORKING WITH SCIENTISTS AND TECHNICIANS FROM THE SMITHSONIAN OCEANOGRAPHIC SORTING

CENTER BOTH AT THE MUSEUM SUPPORT CENTER IN SUITLAND, MARYLAND AND AT THE HIGH SCHOOL. IN ADDITION STUDENTS DESIGNED AND IMPLEMENTED A RESEARCH PROJECT CULMINATING IN A WRITTEN RESEARCH PAPER AND A POSTER PRESENTATION SUITABLE FOR A SCIENTIFIC MEETING. THE PAPER WAS PUBLISHED IN THE SCHOOLS SCIENTIFIC JOURNAL TECHNOS AND THE POSTER PRESENTATIONS WERE ENTERED IN THE SCHOOL, REGIONAL AND STATE SCIENCE FAIRS. A SPECIAL UNIT ON EVOLUTIONARY RELATIONSHIPS AND METHODS OF STUDYING SUCH RELATIONSHIPS BY THE ANALYSIS OF SELECTED ZOOPLANKTON GROUPS WAS ALSO PRESENTED.

THE STUDENTS AT THOMAS JEFFERSON HIGH SCHOOL FOR SCIENCE AND TECHNOLOGY ARE DRAWN FROM FIVE SCHOOL DISTRICTS IN NORTHERN VIRGINIA. SELECTION IS ON THE BASIS OF PERFORMANCE ON A COMPETITIVE EXAMINATION, TEACHER RECOMMENDATIONS AND PRIOR ACADEMIC PERFORMANCE. THE STUDENTS ARE ACHIEVEMENT ORIENTED AND EXCEPTIONALLY CAPABLE IN SCIENCE AND MATHEMATICS. THEY MUST CHOOSE TO WORK IN ONE OF ELEVEN TECHNOLOGY LABORATORIES OR TO UNDERTAKE A MENTORSHIP STUDY. THIS DECISION IS USUALLY MADE DURING THE THIRD QUARTER OF THE JUNIOR YEAR AND IS A SENIOR COURSE REQUIREMENT FOR GRADUATION. IN GENERAL THE STUDENTS ENTERING THE MENTORSHIP PROGRAM ARE AMONG THE MOST CAPABLE AND MATURE SENIORS BECAUSE, THEY ARE REPRESENTING THE SCHOOL IN THE SCIENTIFIC AND BUSINESS COMMUNITY.

THE BIOLOGICAL SCIENCE COMPONENT OF THE THOMAS JEFFERSON HIGH SCHOOL FOR SCIENCE AND TECHNOLOGY CURRICULUM IS PRIMARILY ORIENTED TOWARDS MOLECULAR BIOLOGY, BIOCHEMISTRY AND PHYSIOLOGY. THIS RESULTS IN THE NEED TO ACTIVELY RECRUIT STUDENTS INTO THE BIOLOGICAL OCEANOGRAPHY PROGRAM. THE STUDENTS HAVE LITTLE DIFFICULTY IN MAKING THE TRANSITION TO NATURAL HISTORY AND FIELD WORK. THEIR

EXTENSIVE PREVIOUS LABORATORY EXPERIENCE ADEQUATELY PREPARES THEM FOR APPLYING THE SCIENTIFIC METHOD TO BIOLOGICAL OCEANOGRAPHY RESEARCH TOPICS.

## PROGRAM OF STUDIES

### FIELDWORK

THE FIRST FORMAL ACTIVITY FOR THE STUDENTS IN THE MENTORSHIP PROGRAM IS A SHORT ONE DAY ORIENTATION CRUISE CONDUCTED DURING THE SUMMER. STUDENTS ARE ENCOURAGED TO START THEIR MENTORSHIP IN THE SUMMER BEFORE SCHOOL STARTS. THIS WAS FACILITATED BY THE GENEROSITY OF THE U. S. NAVAL ACADEMY OCEANOGRAPHY DEPARTMENT WHICH ALLOWED THE STUDENTS AND ONE INSTRUCTOR (JAF) TO GO ON THE ACADEMY'S OCEANOGRAPHIC RESEARCH VESSEL, YP 697, ON AUGUST 25, 1989. THE STUDENTS AND INSTRUCTOR FAMILIARIZED THEMSELVES WITH METHODS OF QUANTITATIVE PLANKTON SAMPLING USING NANSEN NETS WITH A FLOW METER. EIGHT PLANKTON STATIONS WERE SUCCESSFULLY OCCUPIED IN THE MID-REGION OF THE CHESAPEAKE BAY AND THE MOUTH OF THE SEVERN RIVER. SUBSEQUENT TO THIS CRUISE THE STUDENTS WENT TO THE SMITHSONIAN OCEANOGRAPHIC SORTING CENTER AT THE MUSEUM SUPPORT CENTER IN SUITLAND, MARYLAND WHERE THEY PREPARED THEIR PLANKTON SAMPLES FOR SORTING AND ANALYSIS IN THE LABORATORY. THE STUDENTS ALSO TOURED THE FACILITIES OF THE SORTING CENTER AND HAD THE OPPORTUNITY TO INTERACT WITH SCIENTISTS AND TECHNICIANS ACTIVELY WORKING ON BIOLOGICAL OCEANOGRAPHIC RESEARCH AND CURATION OF BIOLOGICAL SPECIMENS.

THE STUDENTS DESIGNED RESEARCH PROJECTS FOCUSING ON POPULATION DYNAMICS OF PLANKTONIC ANIMALS IN THE CHESAPEAKE BAY. TO CARRY OUT THEIR PROJECTS THE STUDENTS PARTICIPATED ON A SECOND CRUISE ON OCTOBER 20, 1989 ALSO FACILITATED BY THE GENEROSITY OF THE U. S. NAVAL ACADEMY. ON BOTH CRUISES THE PRIMARY MISSION OF THE SHIP WAS GROUND TRUTHING FOR SATELLITE OBSERVATIONS. THIS INTRODUCED THE STUDENTS TO REMOTE SENSING WORK. THE NATIONAL OCEANIC AND ATMOSPHERIC SCIENCES ADMINISTRATION PROVIDED THE STUDENTS WITH THREE SATELLITE IMAGES OF THE CHESAPEAKE BAY GENERATED BY SATELLITES OVER FLYING THE BAY CONCURRENT WITH THE STUDENT CRUISES. THE STUDENTS WERE ABLE TO INCORPORATE THIS MATERIAL INTO THEIR PROJECTS. TO EXPAND THEIR KNOWLEDGE OF THE METHODOLOGY OF REMOTE SENSING, A

VISIT TO THE U. S. GEOLOGICAL SURVEY OFFICES IN RESTON, VIRGINIA WAS SCHEDULED DURING DECEMBER OF 1989. ON THIS VISIT, THE STUDENTS TALKED WITH RESEARCHERS WHO REGULARLY WORKED WITH SATELLITE IMAGERY. THE TOPICS WHICH THEY DISCUSSED WITH THE SCIENTISTS AT THE GEOLOGICAL SURVEY INCLUDED IMAGE PROCESSING, IMAGE ENHANCEMENT, ANALYSIS OF SATELLITE DATA AND POSSIBLE SOURCES OF SATELLITE DATA. THE FINAL TRIP WAS A VISIT TO THE CHARLES BRANCH WILSON LIBRARY IN THE U. S. MUSEUM OF NATURAL HISTORY IN WASHINGTON D. C. HERE THE STUDENTS WERE ABLE TO SURVEY THE VERY SPECIALIZED LITERATURE ON THEIR CHOSEN RESEARCH TOPICS.

### SCHOOL CENTERED ACTIVITIES

INSTRUCTION IN NATURAL HISTORY AND IDENTIFICATION OF PLANKTONIC INVERTEBRATES WAS CONDUCTED AT THE THOMAS JEFFERSON HIGH SCHOOL CAMPUS DURING REGULARLY SCHEDULED CLASSES BY FACULTY AND SCIENTISTS AND TECHNICIANS FROM THE SMITHSONIAN OCEANOGRAPHIC SORTING CENTER WHO VISITED THE SCHOOL ON A WEEKLY BASIS DURING THE FALL SEMESTER. TWO TECHNICIANS MS. TJUANA NICKENS AND MS LANA ONG WERE THE MOST FREQUENT OUTSIDE INSTRUCTORS WHO ASSISTED IN TEACHING BIOLOGICAL OCEANOGRAPHY RESEARCH TECHNIQUES.

THE TYPICAL CLASS ROUTINES WERE A MIXTURE OF LECTURE AND TUTORIAL INTERACTION COMBINED WITH LABORATORY WORK. THE STUDENTS LEARNED HOW TO SPLIT AND SORT PLANKTON SAMPLES USING EQUIPMENT LOANED BY THE SMITHSONIAN OCEANOGRAPHIC SORTING CENTER. THIS INCLUDED ESSENTIALLY ALL OF THE EQUIPMENT NORMALLY USED BY THE TECHNICIANS AND SCIENTISTS IN A MARINE BIOLOGY LABORATORY. INCLUDED IN THIS EQUIPMENT WERE TWO NIKON RESEARCH MICROSCOPES, A PLANKTON SAMPLE SPLITTER, SPECIMEN CONTAINERS SORTING SOLUTION, ENUMERATORS FIBER OPTIC LIGHT SOURCES AND ALL PERIPHERAL EQUIPMENT NEEDED FOR RESEARCH ON PLANKTON.

INSTRUCTION ON IDENTIFICATION OF MARINE PLANKTON WAS CARRIED OUT BY SMITHSONIAN INSTITUTION WORKERS USING AN EXTENSIVE TEACHING COLLECTION ASSEMBLED FROM THE ARCHIVED COLLECTIONS AT THE OCEANOGRAPHIC SORTING CENTER. THE STUDENTS BECAME REASONABLY COMPETENT IN IDENTIFYING PLANKTORS IN ABOUT TWO MONTHS. THEY HAD AMPLE OPPORTUNITY TO PRACTICE USING SAMPLES PROVIDED FROM THE SMITHSONIAN INSTITUTION PLUS THOSE

COLLECTED BY THE STUDENTS ON THEIR TWO RESEARCH CRUISES. CLASS ROOM INSTRUCTION WAS ALWAYS REINFORCED BY LABORATORY EXPERIENCES WHICH WERE CONDUCTED ON THE SAME DAY.

A SPECIAL UNIT ON THE STUDY OF EVOLUTIONARY RELATIONSHIPS WAS TAUGHT (FRANK FERRARI). THE UNIT COVERED THE BASIC CONCEPTS OF PHYLOGENETIC RELATIONSHIP AND THE USE OF MORPHOLOGY AS A KEY TO IDENTIFYING SUCH RELATIONSHIPS. THIS WAS DONE BY A TUTORIAL APPROACH WITH TWO LABORATORY ACTIVITIES DESIGNED TO REINFORCE THE CONCEPTS BEING INTRODUCED. THE LABORATORY WORK USED THE SWIMMING LEGS OF THREE DIFFERENT MEMBERS OF THE CLASS CRUSTACEA AS EXAMPLES OF ORGANISMS WITH A COMMON EVOLUTIONARY ORIGIN. THE STUDENTS WERE ASKED TO USE THE SWIMMING APPENDICES TO CONSTRUCT AN EVOLUTIONARY RELATIONSHIP FOR THE THREE FAMILIES IN THE CLASS CRUSTACEA. THE STUDENTS WERE ALSO ASKED TO EXTRAPOLATE TO THE SWIMMING APPENDAGE COMMON TO ALL THREE FAMILIES. THE STUDENTS WERE ALSO ASKED TO DEVELOP EXPLANATIONS FOR THEIR HYPOTHESIZED EVOLUTIONARY RELATIONSHIPS AND ANCESTRAL FORMS. THIS WAS A GOOD INTRODUCTION INTO THE MENTAL PROCESSES INVOLVED IN USING MORPHOLOGY TO INFER PAST EVOLUTIONARY RELATIONSHIPS AND PROCESSES

#### SCIENTIFIC PRODUCTS

THE FINAL PHASE OF THE PROGRAM WAS THE PRODUCTION OF A WRITTEN REPORT AND ORAL PRESENTATIONS FOR THE CLASS. THE STUDENTS ALSO PRODUCED AWARD WINNING PROJECTS AT THE SCHOOL SCIENCE FAIR WITH THE TOP PROJECT RECEIVING FIRST PLACE. THIS PROJECT WAS ADVANCED TO THE REGIONAL SCIENCE FAIR WHERE IT ALSO WAS AWARDED FIRST PLACE AND ADVANCED TO THE STATE SCIENCE FAIR.

THE WORK OF TWO STUDENTS HAS BEEN COMBINED INTO A SCIENTIFIC JOURNAL ARTICLE FOR PUBLICATION IN THE HIGH SCHOOL'S SCIENCE JOURNAL, TECHNOS. THE STUDENTS WERE ENCOURAGED TO THINK OF THEIR MENTORSHIP WORK IN A PROFESSIONAL SCIENTIFIC SENSE, THAT IS, THAT SUCCESSFUL COMPLETION OF A RESEARCH PROJECT IS IN THE FORM OF A PROFESSIONAL PAPER IN PRINT AND PRESENTATION OF THE WORK AT A SCIENTIFIC MEETING, THE SCIENCE FAIR IN THIS CASE.

#### CONCLUSION

THE INTRACTION OF THE FACULTY OF THOMAS JEFFERSON WITH THE SCIENTIFIC COMMUNITY ALLOWS THE SCHOOL TO OFFER A RICHER AND MORE DIVERSE CURRICULUM THAN WOULD OTHERWISE BE POSSIBLE FOR A HIGH SCHOOL. BY USING THE REGIONAL SCIENTIFIC COMMUNITY AS A RESOURCE, THE SCHOOL HAS BEEN ABLE TO INTRODUCE STUDENTS TO REALISTIC WORKING AND LEARNING EXPERIENCES IN SCIENCE AND TECHNOLOGY. THIS PARTNERSHIP BETWEEN EDUCATION, INDUSTRY AND BASIC RESEARCH INSTITUTIONS IS AN OUTSTANDING SUCCESS IN TRAINING YOUNG PEOPLE FOR FUTURE WORK AS SCIENTISTS AND ENGINEERS. THE WIDE RANGE OF TALENTS AND ABILITIES SUCH AS THOSE AT THE SMITHSONIAN OCEANOGRAPHIC SORTING CENTER WHEN MADE AVAILABLE TO STUDENTS PROVIDE FOR TRULY RICH EDUCATIONAL EXPERIENCES WHICH MAY HAVE SIGNIFICANT IMPACT UPON CAREER DECISIONS BY THE STUDENTS.

